SYSTEM OF

PHYSIOLOGIC THERAPEUTICS

VOLUME V

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A SYSTEM

OF

PHYSIOLOGIC THERAPEUTICS

A PRACTICAL EXPOSITION OF THE METHODS, OTHER THAN DRUG-GIVING, USEFUL IN THE PREVENTION OF DISEASE AND IN THE TREATMENT OF THE SICK

EDITED BY

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VOLUME V

PROPHYLAXIS—PERSONAL HYGIENE CIVIC HYGIENE—CARE OF THE SICK

BY

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PREFACE

The following pages contain an epitome of what is essentially the Natural History of Medicine; including the important facts, thus far learned, regarding the origin, dissemination, and prevention of disease.

Beyond its place in the System of which it is a part, the work virtually forms an Introduction to the Science of Medicine. It treats especially of the Preservation of Health and the Prevention of Disease, seeking a basis for intelligent prophylaxis in a study of morbid processes and their causation; but this has necessitated a wide range of inquiry. The discussion of Etiology must take into account the psychic as well as the physical characteristics of men; the heredity as well as the constitution of the individual; the intrinsic failures and perversions, as well as the environmental factors, that may disturb mind and body. The artificial conditions of civilization, the diversity, complexity, and strenuosity of the activities of modern life, the reciprocal influences of individuals upon communities and of communities upon individuals, render it necessary, alike in the study of Personal Hygiene and of Public Health, to consider—at least by allusion—many aspects of Sociology; involving questions of Economics, of Engineering, of Manufacturing, of Architecture, of Pedagogics, of Commercial Intercourse, of Taxation, of Municipal Government. Certain fundamentals of Pathology must be presented, together with the principal facts of Epidemiology, much of Parasitology, and—in view of recent discoveries as to the conveyance of infection by insects—something of Entomology. The Care of the Sick-room is a primary factor in the restriction of epidemics, and in no other connection can Nursing, an important branch of Therapeutics, so appropriately be discussed from the physician's viewpoint. The apportionment of space among the various topics has been influenced chiefly by their relative importance; but in part by practical considerations and in some degree by novelty—recent investigations seeming to call for discussion at greater length than those whose results are more widely known. In the study of morbific agents, micro-organisms demand especial attention. They have been considered with regard to their evolution and life-history, the manner of their diffusion, the ways in which they invade the living organism, the poisons that they produce, the changes in function and structure that they provoke, the environmental and other factors favoring or opposing their activity, and the means by which they can be avoided or destroyed, or the body be defended against them—not the least among the latter being certain peculiar and subtile immune and bacteriolytic serums, culture products and extracts, with which modern research has begun to displace drugs both in the prophylaxis and the treatment of the Infectious Diseases.

As many matters considered at length in one chapter have important bearings on subjects treated in others, the essential data have in many instances been repeated briefly, in order to make the individual chapters as complete as possible and increase the value of the book as a work of reference. Illustrations have been introduced wherever they seemed of value, and in many places have been made to serve in lieu of descriptions. The chapters on "Personal Hygiene," "Nursing," and the "Sick-room" are necessarily dogmatic and practical. It is a common experience that through neglect of apparently trivial matters, disease may arise, epidemics be spread, the recovery of the sick be hindered. No chain is stronger than its weakest link, and this is equally true of domestic as of civic prophylaxis. The 'bigness of little things' might be taken as the key-note of this portion of the book.

In deference to the general plan of the System, specific literary references have been omitted; yet, by other means, the attempt has been made to indicate sufficiently the credit due various authors and investigators quoted, especially upon subjects of recent and controversial nature. Use has been made of every available source of information, medical libraries and periodicals having been consulted freely.

The editor takes a special pleasure in this volume. The importance of measures designed to prevent the development and spread of disease needs not be championed; but the inclusion of a thorough and detailed study of such measures is not usual in Systems of Therapeutics. The present work is a practical contribution in support of the opinion that the subjects of prophylaxis and of treatment should not be divorced in teaching, study, or thought. Moreover, the common principles underlying the prevention of disease and the management of the sick; the dependence of these upon the forces at work in producing natural immunity and natural recovery; the influence of evolutionary processes upon all the phenomena considered; and the essentially vital nature of both morbid and recuperative action will, it is hoped, be made evident by the facts here brought together and arranged according to a definite system of progressive exposition. Although intimately related with one another, and together forming an organic whole, the interdependence of these facts is not at once obvious to the student who meets them only as scattered throughout a host of treatises on various subjects. Much industry has been expended upon their collation and presentation, but if the result shall prove as useful as has been anticipated, it will have been expended to good purpose.

CONTENTS

PART I—THE ORIGIN AND PREVENTION OF DISEASE

SECTION I—THE ORIGIN OF DISEASE

SECTION II—THE DIFFUSION OF DISEASE

SECTION III—THE PREVENTION OF DISEASE

PART II—CIVIC HYGIENE

PART III—DOMESTIC AND PERSONAL HYGIENE; NURSING AND CARE OF THE SICK-ROOM

LIST OF ILLUSTRATIONS

A SYSTEM OF PHYSIOLOGIC THERAPEUTICS

PROPHYLAXIS

PART I

THE ORIGIN AND PREVENTION OF DISEASE

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A SYSTEM OF PHYSIOLOGIC THERAPEUTICS

PROPHYLAXIS

PART I
THE ORIGIN AND PREVENTION OF DISEASE

Section I
THE ORIGIN OF DISEASE

CHAPTER I
HEALTH AND ITS DEFENSES

Definitions.—Prophylaxis; Health; Disease; Infection; Contagion; Inoculation; Endemic; Epidemic; Pandemic; Resistance; Immunity; Susceptibility; Diathesis. The Relation of Nosogeny to Prophylaxis. Etiology.

DEFINITIONS

Prophylaxis

Prophylaxis, the science of the preservation of health or the prevention of disease, is based upon our knowledge of the causation of disease, or **etiology.** This basis includes not merely the consideration of morbific agents, but also the manner of their diffusion, and the ways in which they invade and modify the living (human or animal) organism.

Health and Disease

Health expresses the harmonious relationship of the living organism with its environment. It is a relative rather than an absolute condition, and implies both the adaptation and the power of further adaptability of the organism in structure and function to its surroundings. Of all organized beings, man shows the greatest ability to adjust himself to diverse environments, and for him the torrid atmosphere of the tropics, the extreme cold of the Arctic regions, the altitude of high mountains, the low level of plains, are alike compatible with perfect health. As health presupposes a structural and functional condition suited to the environment, any condition the reverse of this is properly considered an abnormality. **Disease** expresses an inharmonious relation of the individual with the environment. It is structural or functional abnormality of the organism.

Diseases are characterized by metabolic perversions occurring within the body, from the untoward action of physical, chemical, or organized agents or psychic influences. When caused by micro-organisms, they are termed **infectious, zymotic,** or **specific diseases** or **mycoses.** The attempt has been made to restrict the term 'infectious' to diseases produced by bacteria alone; but this is unjustifiable. A number of the most characteristic **infectious diseases,** such as smallpox and yellow fever, may prove, as has malaria, to be due to an animal rather than a vegetable parasite. It seems best, therefore, to include among the infectious diseases all those caused by living micro-organisms, whether bacteria, molds, yeasts, or animalcules.

Infection, Contagion, and Inoculation.—Communicable diseases are those that may be transmitted from one sick person (or animal) to another, in any manner whatsoever. The term **infection** may be applied either to direct disease transmission or to transmission of an indirect character, as by means of air, water, soil, and clothing; by many authors, however, it is restricted to the latter method. Such indirect transmission occurs in typhoid fever, cholera, and dysentery. **Contagion** is a form of infection, implying the more direct mode of transmission, in which the disease is acquired through close proximity of the well to the sick. No lesion of the surface is required. Smallpox, typhus fever, and scarlet fever are classed as contagious diseases. **Inoculation** occurs when the micro-organism enters the body through a break or lesion in the skin or mucous membrane. Rabies, tetanus, syphilis, and malaria are examples of **inoculable** diseases.

With the increase of knowledge of the infectious diseases, these terms have a lessened value. There is no sharp line of distinction between infection, contagion, and inoculation, for in a single disease any one of the three methods may be operative. For example, scarlet fever may be conveyed by milk, and therefore by **infection**; by direct contact, or **contagion**; and by the subcutaneous injection of saliva from the infected into the well, or by **inoculation.** A classification, however, may be made from the predominant natural method of transmission for the special disease. Unfortunately in a number of instances this is as yet obscure.

If a disease be continuously present in a locality, it is said to be **endemic.** Thus, until 1901 yellow fever was endemic in Havana.

"An **epidemic** is an outbreak of a communicable or infectious disease, affecting a dozen or more individuals in quick succession before the recovery of the first case, whether arising from a single focus or several foci in a neighborhood."*

A **pandemic** is an epidemic covering a vast area of territory, perhaps the known globe, and involving great numbers of people. Influenza notably recurs as a pandemic, and the great pandemics of plague are especially impressed upon history.

Resistance, Immunity, and Susceptibility

The health of an organism implies that it is not merely able to cope with the ordinary unfavorable factors that surround it, but that it also has an adaptability to other and less common unfavorable conditions. There is therefore a certain amount of normal reserve power (**resistance**) fortifying the organism, although to a limited extent, against unusual morbific influences. When this excess of resisting power is apparent, it is termed **immunity,** or **insusceptibility.** Immunity is always spoken of in relation to a given morbific influence. Not only does it vary in amount in different animals and in different members of the same species, but it also varies in the same individual at different times; that is to say, it is susceptible of increase and diminution; or, when latent, of evocation. The successful prevention of disease depends upon the inhibition or restriction of the range of action of morbific factors, on the development of an immunity, or on the cooperation of these factors. If we consider health to be represented by a plus, and disease-producing conditions by a

* Committee of American Public Health Association, 1898.

minus quantity, we may assume the possibility of adding immunity units, thus increasing the plus condition; or of adding minus morbific units, thus reducing or annulling the plus condition. Health will be maintained if the sum of the immunity units exceeds that of the morbific factors.

Susceptibility or **predisposition** may be expressed as a great reduction, or absence of, the plus factors, while **immunity** indicates their relative excess. In the former condition the action of a few morbific units will result in disease, while in the latter the active morbific factor may be large without any alteration in health.

Diathesis is a form of predisposition usually inherited, characterized by a tendency to develop a certain disease at some period during life. It suggests that the predisposing causes of a disease are innate in the organism. Thus, gouty diathesis, rheumatic diathesis, tuberculous diathesis, are terms indicating a tendency of the possessors to develop gout, rheumatism, or tuberculosis.

THE RELATION OF NOSOGENY TO PROPHYLAXIS

In the **prevention** of disease it is necessary to take cognizance of the individual, not only before the onset, but also during the entire course of the malady. It is customary to describe the **development and progress of an infectious disease** under the following heads: (1) **Exposure,** a period in which the individual is in proximity with the morbific agents. (2) **Infection,** or that period when the specific factor enters (inoculation) and initiates disease. (3) **Incubation,** the period following infection and lasting until the onset of the earliest symptoms. (4) **Prodromes,** the period of early and indefinite symptoms. (5) **Onset** or **invasion,** when, gradually or rapidly, the definite symptoms of the disease first become manifest. (6) The **acme** or **fastigium**—the period in which the disease reaches and maintains its height. (7) The **decline** or **defervescence**—the period characterized by the abrupt (**crisis**) or gradual (**lysis**) cessation of symptoms. (8) **Convalescence**—the period during which restoration of health or **recovery** occurs.

As variations from the foregoing course, there are: (*a*) **chronicity,** in which there is an indefinite continuation of the morbid process; (*b*) **relapse,** in which, during or preceding convalescence, there is a return to morbid activity; (*c*) **sequels,** or secondary morbid processes;

and (*d*) **death,** either as a direct or indirect result of the original morbid process.

In each of these conditions prophylaxis should play an important part; on the one hand, protecting the individual, and, on the other, the community in which the individual lives or dies.

Exposure.—During the period in which the individual is exposed to the morbific agent, prophylaxis should be directed to combat the action of the causal factor and to develop in the tissues a condition of resistance or immunity. The former is exemplified in the measures of **disinfection,** the latter in the methods of **prophylactic inoculation and antitoxination.** For the benefit of the community, it may also be wise to keep under **surveillance** or **detention** one known to have been exposed.

Infection and Incubation.—After infectious agents have entered the body antitoxin is still applicable, but prophylactic inoculation, as a rule, becomes valueless; for the development of the artificial immunity is usually so long delayed that it is not manifest until the height of the disease. Moreover, the practice may then be dangerous, by increasing the sum total of toxic material in the body. It is possible at times, however, to destroy the causal factors in the affected organism during the period of incubation. Thus, in localized infections, excision or destruction of the focus of infection or the application of a parasiticide may prevent the development of the disease, or, again, the use of bactericidal serums or certain drugs may cause the dissolution of micro-organisms that have entered the body. Thus, gonorrheal ophthalmia is avoided by the instillation of silver nitrate; septic wounds become aseptic under antiseptic dressings; hydrophobia is said to be prevented from developing by the Pasteur inoculations; and malaria is arrested by the administration of quinin. If the disease be a very contagious one, **detention** is advisable during the period of incubation. Probably the danger of infection from the inoculated individual before the appearance of prodromal symptoms, with rare exceptions, as in diphtheria, is not great.

Prodromes and Invasion.—In certain diseases the measures just described may serve to abort the malady during its early manifestations. For example, in localized infections, complete excision, the application of germicides, or the employment of antitoxic and bactericidal serums, may cause a cessation of the disease. Neoplasms completely excised in their early stage are prevented from undergoing their customary evolutions; the course of diphtheria or tetanus may be shortened by the use of the appropriate antitoxin.

Neurasthenia, melancholia, and certain diathetic diseases in their early stages, may be arrested; especially by careful regulation of diet, exercise, and mode of life. From the period of development, if the disease be infectious or communicable, care should be taken, by isolation, disinfection, and at times by quarantine, that the sick may not be a menace to their own or other communities. Patients suffering from certain mental affections, as paranoia, should be isolated for the protection of society; and this may likewise be advisable to limit the spread of such communicable neuroses as hysteria and chorea.

Fastigium.—The disease having fully manifested itself, measures of prophylaxis, so far as the individual is concerned, give way to measures of treatment; but prophylaxis still has a part to play in protecting the community that environs the patient, and in many of the transmissible maladies protective measures having this end in view must be continued until the disease has entirely run its course, and, at times, for a period after recovery. Broadly speaking, prophylaxis also has a place in the prevention of **intercurrent affections** and **complications** during the course of the disease and in averting **relapses** or **sequels.** These phases of prevention, however, are usually considered in connection with the treatment of disease, and are beyond our present scope.

Termination.—Should the disease terminate in **death,** prophylaxis may still be required to prevent the body from becoming a source of danger to the living. It is thus evident that measures designed to prevent disease, although especially applicable before infection has taken place, and in the early stages, also have an important part to play during the entire course of the malady, and at times for a considerable period after its subsidence.

As has already been indicated, the essence of the prevention of disease is included in the knowledge of its cause, and therefore it is difficult to carry out rational prophylactic measures without considering the **origin of disease.**

ETIOLOGY

Causal Factors in General

It is customary to divide the factors involved in the causation of disease into (*a*) **predisposing** or **remote,** and (*b*) **exciting, deter-**

mining, or **immediate** causes. The former lower the vital resistance and favor the action of the latter, yet they often act interchangeably; so that what at one time is a predisposing cause, at another becomes a determining factor. Trauma is usually classed as an exciting cause, yet it is a powerful predisposing factor to many infections. Depressing hygienic conditions may, on the one hand, favor the invasion of the tubercle bacillus, and, on the other, may determine the renewed activity of an old and latent tuberculous focus. Indeed, the time, the method of action, and the condition of the tissue acted upon, rather than the nature of the factor in question, determine whether a cause be predisposing or exciting. The germ, therefore, is no more important than the tissues it invades. Again, the exciting factor of one disease may predispose to the development of a second disease; as shown by the tendency to septic infection in alcoholics, and to tuberculosis in diabetics and lepers, and following measles. It is not possible, therefore, to demarcate sharply between predisposing and exciting factors.

Method of Action of Causal Factors

Predisposing agents all act by diminishing resistance or increasing susceptibility, and their action can usually be circumvented by maintaining or increasing the normal immunity of the individual. This is in largest part accomplished by that mode of life usually termed **hygienic.** The **exciting causes** of infection are the animal or vegetable parasites, and by the methods of **asepsis** and **disinfection** it is often possible to exclude them or to neutralize their action. Other exciting agents are of many kinds.

The causes of disease may come from without, and be **external** or **extrinsic;** or may arise within the organism, and be **internal** or **intrinsic.** The external causes are much better understood than those that are internal, and, therefore, it is mainly against extrinsic factors that prophylactic measures have been developed.

CHAPTER II

THE INTRINSIC FACTORS OF DISEASE

Age. Sex. Race. Heredity. Nervous Influences. Heredity and Congenital Disease—the Transmission of the Infectious Diseases through the Placenta; Lateral Chain Theory of Heredity. Abnormalities of Development—Excess in Development; Deficiency in Development; Developmental Displacements and Duplications. Autointoxication—Faulty Elimination; Incomplete Chemical Transformation; Excessive Production of Certain Glandular Secretions; Substances Imperfectly Absorbed or Absorbed in Excess. Leucomains—Nucleinic Leucomains; Creatinic Leucomains.

Age.—The extremes of life, childhood and old age, show the greatest predisposition to disease. Yet those diseases that are common in childhood do not usually affect the aged, and conversely. The young in the lower animals show the greatest susceptibility to artificial infection, and clinical experience indicates that a similar condition as to many infections exists in the human family. Tuberculosis

THE PROPORTION OF SICK AND DEFECTIVES TO AGE. MASSACHUSETTS, JUNE 1, 1890.—(*Billings.*)

Ages.	Ratio per 1000.	
	Males.	Females.
15 to 25,	9.74	6.90
25 to 35,	12.38	8.84
35 to 45,	21.80	13.11
45 to 55,	57.14	21.76
55 to 65,	71.17	34.19
65 and over,	96.41	60.84

in children is more often wide-spread and rapidly progressive than in the adult, and shows a predilection for the lymphatics, bones, joints, and serous membranes rather than the lungs, which, as a rule, are primarily affected in adults (Louis's law). Apart from tuberculosis, the diseases due to dietetic causes, and certain skin affections, nursing babies show an exemption from infection, probably because of their limited environment. Immediately following babyhood there is a special liability to contract measles, scarlatina, chicken-pox, rubella, and pertussis. Typhoid fever does not usually occur until youth or early adult life. If the adult has not an inherent immunity to the common exanthemata, he has usually acquired it by having had an attack during childhood or youth. He is now, however, exposed to the diseases incident to occupation and dissipation. After thirty-five years predisposition to carcinoma, especially in certain persons, appears; and as age creeps on, the degenerative changes in the organs, especially those involving the heart and blood-vessels, together with their secondary effects, such as hemiplegia, aneurysm, and senile gangrene, are common, as are also gouty and rheumatic affections; there is an increased tendency to insanity; and pneumonia is so common in the aged as to have been described as the 'natural end of old men.'

THE RELATION OF AGE TO THE FATALITY OF DISEASES. COMPILED FROM THE RECORDS OF EIGHTEEN HOSPITALS, FOR FIFTEEN YEARS.—(*Modified from Billings.*)

Ages.	Pneumonia.	Typhoid Fever.	Consumption.	Diphtheria.
	Rate per 100 cases.	Rate per 100 cases.	Rate per 100 cases.	Rate per 100 cases.
0–10, . . .	10.8	8.2	46.5	57.9
10–20, . . .	8.2	12.9	46.3	22.3
20–30, . . .	15.3	17.0	48.9	10.2
30–40, . . .	22.0	25.2	55.4	. .
40–50, . . .	30.2	33.5	57.7	. .
50–60, . . .	40.3	40.6	59.1	. .
60, ...	57.1	65.6	62.8	. .

Sex.—Despite the dangers incident to pregnancy, the death-rate of women is usually less, and the expectation of life greater, than with men. This is probably due largely to the fact that men are more exposed to dissipation and accident, and are more commonly engaged in unhygienic occupations. Up to the fifteenth year the difference between the sexes as to morbidity and mortality is not strikingly apparent, but thereafter there is a marked preponderance among males of certain diseases, such as alcoholism and other forms of poisoning, typhoid fever, rheumatism, urinary and venereal diseases, and scleroses of various organs, including the liver, kidneys, and central nervous system. Forms of anemia, cancer, peritonitis, and intrapelvic tumors having their origin in the sexual organs, are much more common in women. Certain general diseases are chiefly manifest in men, as is hemophilia, or bleeder's disease, while osteomalacia usually affects women.

Race.—Racial types of immunity and predisposition to particular diseases have been observed both in the lower animals and in man. In the former the striking difference in the resistance to bacteria shown by the white mouse and field-mouse is particularly impressive. In the human race the freedom of the Japanese from scarlet fever, the immunity of the Chinese against cholera and of the negro against malaria and yellow fever, are examples. On the other hand, measles and some of the other exanthemata that are mild in civilized races have a high mortality when they afflict certain of the savage types, as the Fiji Islanders. The Jew shows a special predisposition to diabetes, although he seems to possess a greater immunity than others against tuberculosis and other infectious diseases. Races accustomed to the more primitive modes of life are apt to succumb quickly to tuberculosis when brought under the influence of civilization; a fact frequently exemplified among civilized Indians and negroes, and especially among Eskimos brought to more civilized countries. A related form of immunity is that which is developed by the common exposure to certain diseases in certain localities. Thus, few city dwellers reach adolescence without having had, or having been exposed to, diphtheria, scarlet fever, measles, and whooping-cough, and it is therefore not strange that in warfare it has been found that the city regiments show a comparative immunity from these diseases, while regiments composed of men from the country have, in general, a predisposition to them. The immunity of the negro against yellow fever and malaria evidently has a similar basis.

Nervous Influences.—It is impossible to disassociate physical lesions from their relation to changes in the central nervous system. Lesions of one part of the body may, reflexly through the nervous system, originate morbid changes in a distant part. Thus, chilling of one hand will reduce the temperature of the other; cutaneous irritations reflexly affect the kidneys and increase the output of urea. In turn, nervous impairments may originate structural and functional disorders. In the hypnotic state, erythema and even vesiculation of the skin have been induced by suggestion. Fright, grief, great joy, and other mental perturbations may manifest themselves by such functional changes as blanching of the skin, polyuria, glycosuria, vomiting, syncope, diarrhea, and convulsions. Even such complex pathologic changes as are associated with Graves's syndrome may apparently be thus caused. In a number of the personages of history, since the times of Sophocles and Ananias, sudden death has followed mental shock. Certain neurotic conditions are transmitted by imitation. Hysteria, chorea, tetany, and even epileptic attacks have originated from the mental impression produced by seeing an affected person. Alterations of the normal trophic mechanism may cause the development of poisonous products within the body; for example, the milk secreted by mothers immediately after severe fright may be highly toxic. Reflex muscular atrophy in excess of that due to disuse occurs in the muscles about a diseased joint. Mental impressions may produce dyschromias, as in cases of bleaching of the hair following grief or nervous shock. A similar condition may occur from neuritis, and the vesiculation and ulceration in herpes are usually attributed to changes in the nerve-trunks. The appearance of hepatic glycogen in the blood, and its excretion in the urine, are well-known results of injuries to a certain portion of the medulla oblongata. Glycosuria and diabetes mellitus may also occur in sequence to prolonged mental strain; and the discovery of the tubercle bacillus by no means vitiates the observations of Laennec, Louis, Lugol, and others as to the influence of various emotions—rage, greed, ambition, religious gloom, or terror—as factors in the development of pulmonary tuberculosis. The relation of mental disturbance to mental disease need not be dilated upon.

The avoidance of injurious, and the employment of helpful psychic influences, play no mean part in the prevention of disease and in the correction of morbid conditions. It is to be regretted that present materialistic tendencies cause them so often to be overlooked or ignored.

HEREDITY AND DISEASE

Abnormalities in the organism previous to birth may be the result of any one of a number of factors. First, the **germ-plasm** of the fertilized ovum may have acquired, from either paternal or maternal source, modifications of normal developmental tendencies or of structure, leading to disease of the embryo. Such abnormalities may be upon the side of deficiency or on the side of excess. For example, the germ-cells may be impressed with excessive vegetative tendencies leading to gigantism or local hypertrophies, and such functional hyperactivities as epilepsy, neuralgias, etc.; while if the inherent vegetative tendencies be insufficient, dwarfing, cleft palate, harelip, web fingers, etc., may result. Or, if the inherent functional activities be too feeble, idiocy, insanity, forms of neuroses, etc., may occur. These conditions, transmitted from parent to offspring in the germ-plasm, constitute true **hereditary disease.** The term heredity, however, is often misapplied to morbid conditions that have been acquired by the embryo through various **accidental** factors in its prenatal environment. For example, the fetus is not exempt from external **mechanical** injury, and its motility in the uterine cavity may produce twists and knots in the umbilical cord, or otherwise result in its own harm. Monstrosities have been artificially produced by mechanical interference during gestation.

Should the mother's blood contain **toxic** material, the result of disease or from an ingested poison, a portion of this will usually pass into the fetal circulation. In the fetus, the proportion is always less than that in the maternal blood; and as the toxic material must pass through the fetal liver before reaching the organs of the embryo, a part of the poison is destroyed, so that the fetus is usually much less affected than the mother. For this reason the fetus may for a number of minutes survive the death of the mother. Moreover, experimentally the fetus has been found less vulnerable to certain poisons than is the mother; so that it may live after the injection of a poison into its own tissues, while the mother dies from absorbing the toxic substances through the placenta. Although the fetus may not suffer directly from maternal toxemias, it may have its tissues so impoverished that its development is imperfect. Thus, it has been found possible to produce monstrosities by the use of certain chemical measures, while hypoplasia of the circulatory and reproductive systems of the children of parents with tuberculosis or other debilitating diseases is common and may even be associated with recognizable physiognomic and other external characteristics.

Finally, direct **infection** may take place through the placenta. Children have been born with the eruption of smallpox or measles, and with lesions of tuberculosis acquired during the latter months of pregnancy. It seems improbable that a true infection can occur in the germ-plasm, so all these affections are to be considered as arising from causes extrinsic to the fetus, even though present in the maternal tissues; and thus, although congenital, they are not to be considered as true hereditary diseases.

A **congenital disease** is an abnormality existing at birth; and therefore may be caused by any modification of the developing ovum from the time of impregnation to the completion of birth. Such congenital conditions include intrauterine fractures, dislocations, amputations, and specific diseases that are contracted through the placenta or during the parturition. Congenital diseases may or may not be hereditary.

Heredity may be **immediate,** as when the disease is also active in the parent; or it may be **remote,** as when the disease is latent in the parent, although active in some progenitor. In hemophilia, the mother who transmits the defect is herself usually free from it; while the male members of the family suffer from bleeder's disease, but may not transmit it to their offspring. Instances occur of very remote heredity characterized by reversion to a more primitive type in the racial history. This condition is termed **atavism,** and is the explanation offered for certain malformations. The flat foot, receding forehead, peculiar ears, massive jaw, of certain criminals are stigmata of a lower race. The cranial measurements may simulate the simian type. Acromegaly has been similarly explained.

True heredity is the transmission of the disease itself. The condition existing when only the **predisposition** or tendency to develop a disease is passed on by parent to the child has been called **false heredity.** Such a condition may not be overtly congenital, and may not manifest itself for many years after birth. Syphilitic keratitis often develops about the fifteenth or sixteenth year in children otherwise healthy, and yet absolutely indicates the transmission to the child of certain syphilitic weaknesses in its protoplasm. A predisposition to tuberculosis seems to be more common than a congenital infection, and frequently leads to the development of the disease in a number of members of the same family about the time of adolescence.

The Transmission of the Infectious Diseases through the Placenta

That infectious organisms may pass through the uterine sinuses into the placental circulation, and so reach the fetus, has been demonstrated by the presence of smallpox and other infectious diseases in children at birth, and also by laboratory experimentation. This, however, is uncommon in nature. More frequently a disease in the mother gives rise to modifications in the embryo leading to immunity, and, conversely, an infected child in certain cases seems to give rise to a condition of immunity rather than of infection in the mother. This is especially demonstrated in syphilis, in which the nonsyphilitic child born of a syphilitic mother cannot be infected from nursing its diseased parent, although a child of another may readily contract the disease from this mother (**Profeta's law**). Conversely, a child with congenital syphilis, born of a healthy woman, usually will not infect its own mother, although it will infect a wet-nurse or other person exposed to certain of its secretions (**Colles' law**). These facts suggest that intrauterine infections and modifications of the fetus are more frequent and more important than conditions of true inheritance of disease. Indeed Weissmann contended that acquired characteristics are not, and cannot be, transmitted to the offspring. While this view is not tenable, it expresses a measure of the truth, inasmuch as mutilations as well as acquired diseases are rarely transmitted even in the form of a predisposition.

Lateral Chain Theory of Heredity.—Adami has recently suggested an hypothesis to explain inheritance, resembling Ehrlich's

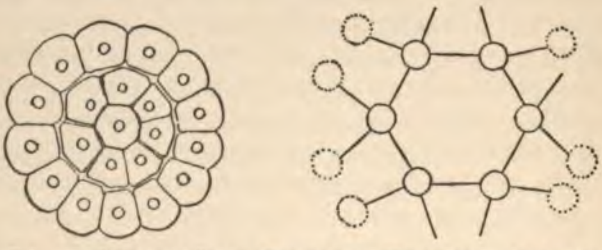

FIG. 1.—LATERAL CHAIN THEORY OF HEREDITY.—(*Adami.*)
Schematic representation of idioplasm with loosely attached side-chain combinations and free points of affinity.

lateral chain theory of immunity. He assumes that the **idioplasm,** by which is meant that portion of the protoplasm possessing vital properties, is composed of a mass of molecules that form a central ring to or from which side rings may be attached or detached without alteration of this primitive center. Environment causes the central ring to have attached certain side-chain combinations, and in this way the modifications of tissue cells are consummated. In the same way environmental conditions lead to further modifications in the form of new side-chain combinations. Those lateral chains that are last developed are the least stable and the most readily lost, while those that have been attached for a long period of time are not readily loosened. Thus it is that recent changes in structure, or alterations of environment, produce with the germinal idioplasm combinations too weak to be transmitted, while lateral chains that have been active for generations tend to persist. In sexual conjugation, idioplasms with different lateral chain combinations and affinities unite, and there results an idioplasm not possessing the identical properties of either parent, but emendated in character and constitution toward the constitution of either one or the other, according to the preponderance in number or chemical activity of the paternal or maternal molecules entering into combination. This hypothesis explains the transmission of a predisposition or a physical abnormality. The transmission may be by intoxication, the intoxication being represented by a combination of toxiferous molecules with the idioplasm, that is transmitted to the offspring. Parasyphilitic lesions in the offspring of the syphilitic are explained as a result of the transmission of an idioplasm chemically altered through parental infection.

Consanguineous marriages and **inbreeding** are dangerous only from their tendency to accentuate family weaknesses. This risk increases with the deviation from the normal of those concerned. While the marriage of near relatives would not be unwise in the absence of family weaknesses, few civilized families are so fortunate. On the other hand, there is equal risk in marriage between persons having no known kinship, but inheriting similar morbid tendencies.

Our concept of inheritance emphasizes the possibilities of **prophylaxis**; for it should be easier to combat the tendencies in predisposition that are usually transmitted than to treat distinct morbid processes that are more rarely inherited.

ABNORMALITIES OF DEVELOPMENT

The complicated differentiation of cells and growth of tissue following the fecundation of the ovum may favor in many cases the production of abnormalities. These are usually congenital rather than hereditary, and may develop after, as well as during, intrauterine life. Indeed, the developmental changes may occur after adolescence, as is seen in **acromegaly,** in which overgrowth of the face, feet, and hands may begin at thirty or forty years, and continue indefinitely.

Excessive Development

A general excess of development produces the so-called giants. These persons usually show diminished powers of resistance when compared with those of mean stature, and rarely are symmetric. Local excesses in development may occur from the increased functioning of a part of the body, as in hypertrophy of the heart from valvular disease; or from some obscure cause, possibly at times associated with disease of certain glandular organs—as in acromegaly, in which lesions of the pituitary gland are common.

Deficient Development

Dwarfing is a result of the general failure of the organism to reach its proper size. As with giants, dwarfs are rarely symmetric beings, nor are they endowed with the average stamina. The failures of tissues, organs, or members to reach their normal size are more common, and are termed **hypoplasias.** These conditions are often the result of deficient use as well as of imperfect development. In chlorotic girls the cardiovascular and genital organs may remain infantile in type. Defective intrauterine development not infrequently produces marked abnormalities of the organism in children, as illustrated by the cleft palate and harelip that result from the failure of certain branchial clefts to close. Patulous urachus, exstrophy of the bladder, atresia of the anus, web fingers, delayed descent of the testicle, hermaphroditism, and similar conditions result from defective intrauterine development. If a member be lacking, the condition is called **aplasia;** it is exemplified in many forms of fetal monstrosities, as the headless (**acephalus**) and limbless (**amelus**) monsters.

Perverted Development

There may also be displacements of contiguous members, as exemplified by cases of transposition of the viscera, or of blastodermic cells. To the latter is ascribed the formation of incomplete monsters or the presence of one organism within another (**inclusio fœtus in fœtu**) and the formation of certain tumors (**dermoids**).

Organs or parts of the body may be duplicated, as is shown in cases of double aortas, double vaginas, and **supernumerary parts,** especially fingers (**polydactylism**) and spleens.

The **prevention** of the congenital abnormalities of development is largely included in measures aimed to improve the social fabric.

AUTOINTOXICATION

Autointoxication is the condition that results when compounds formed by the organism react injuriously against it. The term has been broadly applied to include infectious and putrefactive processes, the result of bacterial action within the intestinal canal or the tissues. But these conditions cannot properly be considered as self-intoxications.

Autointoxication may result from:

1. **Faulty Elimination.**—Normal excrementitious products are sometimes retained within the body. Such a condition apparently occurs in uremia from excretory insufficiency of the renal cells. The suppression of perspiration, by coating the body-surface with an impermeable material, may produce sufficient retention of toxic substances to cause death. In certain conditions normal emunctories may be insufficient to carry off an abnormal excess of effete products.

2. **Incomplete Chemical Transformation.**—The cellular nuclein seems normally to be converted into certain intermediate products, as xanthin, hypoxanthin, and adenin, before its final oxidation into uric acid and urea. Such an oxidation being incomplete, the process may be arrested at any one of the intermediate stages, with the result that a substance much more toxic than uric acid is thrown upon the system. Horbaczewki's theory of gout is based upon this supposition. Injections of hypoxanthin and xanthin for a period of several months have been found to produce in animals granular degeneration of the epithelial cells of the kidney resembling that found in lead-poisoning. This degeneration did not follow when repeated injections of pure urea were substituted. The imperfect decomposition of acetone in the body is common in diabetics. Incomplete chemical transformation may be the result of **deficient glandular secretion;** as in pancreatic diabetes and in myxedema the result of extirpation or disease of the thyroid gland.

3. **An Excessive Production of Certain Glandular Secretions.**—This apparently occurs in exophthalmic goiter from excessive, and possibly perverted, action of the thyroid gland.

4. **Irregular Absorption of Products of Digestion.**—Normally, albumoses and peptones that are formed in the intestinal canal are reconverted into albumins before they enter the blood. Under certain conditions of faulty absorption, albumoses, peptones, and

perhaps other compounds resulting from digestive action, may enter the blood unchanged and produce decided toxic effects.

If the liver be shut out of the general circulation by an Eck's fistula (connecting the portal vein with the inferior vena cava), the ingestion of meats is followed by pronounced nervous disturbance and even death; resembling the symptoms produced when ammonium carbamate is introduced into the circulation. This salt appears to be a final product of tissue oxidation, and is converted by the liver into urea, in which form it is excreted by the kidneys. Chittenden considers it probable that uremia results from the retention of untransformed carbamic acid.

LEUCOMAINS

Leucomains are basic chemical compounds, closely resembling the vegetable alkaloids, that are produced by the metabolic activities of the organism. It is difficult to differentiate them sharply from ptomains and similar compounds resulting from bacterial action, and it is not improbable that certain substances that have been extracted from tissues, and at present are believed to be leucomains, may in time prove to be bacterial products. A number of the leucomains are found not only in the human tissues, but may also be obtained from the lower animals, from the higher plants, and from yeasts. From their chemical relations they have been divided into two groups, the **nucleinic** or **alloxuric** leucomains, and the **creatinic** leucomains.

The Nucleinic Leucomains

Many of the leucomains seem to be derivatives of an important constituent of the nucleus of cells, called nuclein. In nephritis there is a diminution in the amount of nucleinic bases excreted in the urine; in leukemia it is much increased. Kossel and his pupils have shown that nuclein, upon the addition of water or dilute acid, may be decomposed into a number of important leucomains, including **adenin, guanin, hypoxanthin,** and **xanthin.** These are closely related to uric acid, and have been termed **xanthin, alloxin,** or **purin bases.** Cyanogen is shown in the chemical formula of nuclein and of its derivatives, but the reason for its intimate relation with the nuclein molecule is not understood. As a rule, these are whitish, amorphous, crystalline solids, forming neutral solutions in water, in which they are slightly soluble. They are insoluble, or but slightly soluble, in ether, and have variable, but usually feeble, combining powers with alkalies and acids. Our knowledge of leucomains is as yet very incomplete, and their relation to human pathology at present is largely conjectural. It is assumed that they are derived from a hypothetic substance, **purin,** $C_5H_4N_4$.

Adenin (amidopurin), $C_5H_5N_5$, was first isolated from pancreatic glands by Kossel in 1885. It may be obtained from all tissues rich in nuclein, especially that of the thymus gland, the nucleinic acid of which yields only adenin. It has been found in the urine and in the liver in leukemia, probably resulting from the breaking-down of the numerous leukocytes. Little or none is found in muscular tissue. It forms salts with dilute mineral acids, and by the action of putrefaction or nitrous acid it is converted into **hypoxanthin.** Injected into animals it is poisonous, increasing the heart action and producing gastro-enteritis and nephritis with uric acid deposits in the tubules. Similar results follow the feeding of adenin to dogs (Minkowski). Adenin is eliminated in the urine, in part at least, unchanged.

Hypoxanthin, $C_5H_4N_4O$ (sarkin), was found by Scherer in 1850 in the splenic pulp and also in the muscles of the heart. It is found in the blood in leukemia and after death in tissues rich in nuclein. In urine small quantities occur normally, and larger amounts in cases of leukemia and of certain diseases of the liver and kidney. It has also been isolated from pathologic transudates. When administered to animals, it is converted first into xanthin and then into uric acid and allantoin. It is probably an intermediate product in the formation of uric acid, the elimination of which is increased when hypoxanthin is administered to fowls and man. When fed to animals and man, it causes no toxic symptoms.

Guanin, $C_5H_5N_5O$, was isolated from guano by Unger in 1844. It has been found in the liver, pancreas, lungs, retina, in the scales and spawn of fish, in grass, yeast, and other organized substances. In the so-called 'guanin gout' of swine it occurs in the muscles and in the fibrous tissues in and about the joints. By putrefaction, or by the action of nitrous acid, the NH-group of this base is replaced by an atom of oxygen, the guanin being converted into **xanthin.** It is a feeble base and seems to have little or no toxic action. In a single feeding experiment it was not found in the urine, nor was it apparently excreted as uric acid or allantoin.

Xanthin, $C_5H_4N_4O_2$, was discovered by Marcet in a urinary calculus in 1819. In the urine it is normally found in minute amounts, and possibly in larger amounts in the presence of pneumonia and acute nephritis; while very large quantities are found in the urine of leukemics. Occasionally it forms brownish calculi, that show a wax-like surface on being rubbed. It is a muscular excitant, affecting especially the heart. In animals it causes muscular rigidity, and in large doses partial paralysis. It seems more energetic than caffein, which it closely resembles.

Heteroxanthin, $C_6H_6N_4O_2$, was found in urine by Salomon in 1884. It is intermediate between xanthin and paraxanthin. It has never been obtained from plants. A very similar substance has been synthetically produced by Gautier. As it has never been found in the decomposition of nuclein, and as caffein and theobromin are excreted in the urine as methylxanthin, a substance isomeric or identical with heteroxanthin, it has been suggested that the latter is formed in the body by the splitting of the more complex xanthin bases. The physiologic action of heteroxanthin is similar to that of paraxanthin, although feebler.

Paraxanthin, $C_7H_8N_4O_2$, was isolated from urine by Salomon in 1883, and is present in minute amounts in normal urine, but not in that of leukemia. It is isomeric with theobromin. It is believed to be the exciting cause of certain nervous affections. In animals it produces muscular excitability and rigidity, with diminished reflexes, and respiratory paralysis, the heart not being affected until late.

Other alloxuric bases formed in the body are **Carnin,** $C_7H_8N_4O_3$, extracted from meat by Weidel in 1871; **Episarkin,** $C_4H_6N_3O$, isolated from urine by Balke in 1893; **Cytosin,** $C_{21}H_{30}N_{16}O_4 + 5H_2O$, obtained by decomposing adenylic acid by Kossel and Neumann; **Spermin,** C_2H_5N, found by Schreiner in 1878 in semen; **Gerontin,** $C_5H_{14}N_2$, isolated from the liver and kidneys of a dog by Grandis in 1890. Gerontin seems the most poisonous; 0.1 mm. produces death in frogs, with paralysis of the nerve-centers and heart ganglia. Carnin has little physiologic action, except a modification of the pulse-rate.

The Creatinic Leucomains

These are closely related to the nucleinic bases, but show a chemical construction of a somewhat different type.

Creatin, $N(CH_3).CH_2.COOH$, which gives its name to the group, is derived from the muscle albumins of vertebrates. Creatin also occurs in the brain, thyroid gland, blood, and urine.

Creatinin, $N(CH_3).CH_2CO$, the anhydrid of creatin, is found in the muscles in traces. Both creatin and creatinin occur in the muscle tissues in increased amounts after exertion, suggesting that they are specific decomposition products of the muscle albumin. They are readily transformed into urea.

Arginin was obtained by Schulze from muscular tissue. It closely resembles creatinin, and was first found in the sprouts of lupin. It has been isolated from various tissues of the body and from horn gelatin, casein, etc., by the aid of boiling hydrochloric acid.

Lysatin, $C_6H_{13}N_3O_2$, and **Lysatinin,** $C_6H_{11}N_3O$, were obtained by Drechsel by decomposing gelatin, horn, and proteids with HCl. These substances are probably important sources of the metaxanthin bases found in animals and plants. They yield urea upon decomposition.

Gautier has especially studied the leucomains found in fresh muscles, and has isolated a number of compounds, some of which are said to be intensely toxic. Little is definitely known of these latter, and the work requires amplification and corroboration. They include **crusocreatinin,** $C_5H_8N_4O$, which is closely related to creatin, and **xanthocreatinin,** $C_5H_{10}N_4O$, which is the most deadly of muscle leucomains. This produces, in animals, depression, somnolence, vomiting, and diarrhea. It was found by Moroni in the muscles of an exhausted dog and in the urine of fatigued soldiers. It possibly has something to do with the subjective sensations of fatigue.

Amphicreatinin has the formula $C_9H_{10}N_7O_4$; of this leucomain little is known.

Gautier believes that leucomains are constantly being formed in the animal tissues and destroyed by oxidation. If not destroyed, poisonous effects may result.

CHAPTER III

EXTRINSIC FACTORS IN DISEASE—INANIMATE

Physical Causes—Mechanical; Heat; Cold; Electricity; X-rays; Becquerel's Rays; Sound; Light. Atmosphere—Composition; Aqueous Vapors; Toxic Gases; Mine Air; Sewer Air; Atmospheric Pressure. Climate and Season. Toxic Causes—Local Poisons; Parenchyma Poisons; Blood Poisons; Nerve Poisons; Food Poisoning. Sociologic Causes—Density of Population; Dissipation; Occupation.

Extrinsic Causes

Abnormal functional and structural alterations originating from agencies without the body are due to either physical or toxic agents, alone or in combination. They may be **unorganized,** as are all physical causes and the inorganic poisons; or **organized,** as are the vegetable and animal parasites and the poisons of vegetable or animal origin.

PHYSICAL CAUSES

While properly all physical agencies play an important part in the maintenance of health, each may aid the induction of disease. Thus, mechanical violence, heat, cold, electricity, X-rays, atmospheric alterations, metereologic and telluric conditions, may have an important action in the genesis of certain affections.

Mechanical Violence

Mechanical agents include all forces that tend to change the condition of inertia of the whole or part of the body. If the excitation merely cause increased activity of a part, a true development or hypertrophy will usually follow; or if the activity become excessive, exhaustion may lead to atrophy. Frequently repeated or continuous slight irritations lead to overgrowth of tissue or hyperplasia. Callosities developing upon the hands and corns upon the feet are examples of this condition. Inhalation of insoluble gritty particles leads to the fibroid changes in the lungs of coal-miners and stone-grinders. In such conditions irritations may play an important part in predisposing to infection by the tubercle bacillus. Continued pressure, if it be sufficient to interfere with the circulation in a part, may cause wasting or atrophy of the affected structures; or if they cannot receive sufficient nourishment, death of the tissues—necrosis or gangrene—ensues.

The abrupt application of mechanical violence or **trauma** leads to the disruption of tissues and the production of contusions and incised wounds. Such a mechanical lesion or trauma represents the result of a conflict between kinetic energy and resistance. The result may be the same whether the body-surface is the resisting force or the moving object. A blow may produce a lesion identical with that caused by a fall against a resisting substance. The result of mechanical violence depends upon the energy, the method of application of the force, and the character of the resistance. The energy of a force is equal to one-half of the product of its mass into the square of its velocity, and therefore velocity is much more important than mass. The higher the velocity, the more strictly the injury is localized to the area of contact, and the greater is the destruction within this area. The energy of rapidly moving bodies is but partly conveyed to the tissues traversed by the moving agent. On the other hand, bodies of low velocity that fail to traverse the tissues may have their energy entirely transmitted to the organism with which they come in contact, leading to more serious injury than that produced by bodies of greater velocity and force. Thus the modern rifle bullet has a small mass, but its high velocity gives it enormous force, so that it usually perforates the body and expends much of its energy upon other substances than the tissues. Such wounds are small, clean-cut, and the adjacent tissues are but slightly damaged. The old musket ball, with its larger mass, but much lower velocity, has far less energy; yet this is almost entirely expended upon the tissues that it enters, leading to extensive wounds and to much neighboring destruction. High velocities give wounds of a clean-cut character; at lower velocities the tissues are pushed ahead and to the side of the moving object, so that the area of destruction progressively increases as the tissues are penetrated. For this reason the wound of exit is much larger than that of entrance.

Other things being equal, the character of injury varies greatly with the area of application. A force behind the keen edge of a knife may produce an incision with a minimum of tissue destruction, but with free hemorrhage. Blunt the cutting edge, and the area of tissue destruction widens. The hemorrhage is slightly less, and we have a slightly bruised, torn, or contused wound. Broaden the edge of the instrument still more, and the contusion effect is more pronounced, but the depth of injury lessened. Apply the same force over a broader surface, and a bruise or contusion, characterized by rupture of subcutaneous vessels, tissue filaments, and extravasations, occurs without any break in the skin. Apply the same energy over a much broader area, and the force may be so diffused that no injury results. Obliquity of action also decreases the destructive efficiency of mechanical energy.

The lesion produced by an incised wound, a contused wound, or a bruise may take its essential character from conditions within as well as those without the body. Thus, a sharp bony prominence may produce an incised wound of the tissues over it, when these come in contact with a plane surface, resembling an injury produced by a sharp instrument striking tissues over a plane bony surface. The force may be transmitted from the point struck and focus upon a distant area, where the chief lesion is found. Such occurs in fractures by **counterstroke.** The effects of mechanical violence vary with the function of the tissues injured.

Mechanical energy may be transmitted by gases and liquids as well as by solid substances. Thus, the terrible rending effects of violent explosives are produced directly by the enormous pressure of liberated gas; while explosive effects may follow the entrance of bullets into cavities that have rigid walls and liquid contents. More delicate nerve-tissues may be severely injured by violent agitations or commotions, as in **commotio cerebri.**

General Effects.—Besides local lesions, severe **general effects** may result from local injury. The absorption of fibrin ferment or other substances from clean wounds may produce fever. Infected or poisonous wounds lead to general toxic changes. Mechanical violence may cause a general depression of bodily functions resulting in shock, fainting, delirium, maniacal excitement, or, at times, more permanent nervous lesions, such as hysteria, chorea, paralysis agitans, and epilepsy.

Relation of Mechanical Injury to Infection.—Trauma has a very important bearing upon a number of **infectious processes.** Not only do open wounds afford a field for infection, but the growth and increase of virulence of certain pathogenic bacteria are favored by condensation and devitalization of the tissues. Besides this, injured tissues may, by permitting the growth of saprophytes, lead to the absorption of ptomains and the condition of so-called **sapremia.** The liability of inexperienced surgeons to have suppuration in their wounds, is probably often due to the partial devitalizing of tissues from excessive handling and the anemia produced by too tightly drawn sutures, facilitating infection by organisms that would be unable to invade tissues of undiminished vitality. Trauma seems often to determine the **localization** of circulating infectious particles, and experimentally it has been found that when tubercle bacilli are injected into the circulation of animals whose bones are contused the tuberculous process often starts at the seat of injury. This is also illustrated in children in whom tuberculosis of the bones and joints often dates from an injury. Local irritation is a predisposing factor in the determination of certain **tumors,** as carcinoma, and is believed to explain the position of epithelioma of the lower lip in clay-pipe smokers, of cancer of the scrotum in chimney-sweeps and in tar and paraffin workers, and of epithelioma of the cervix in multipara.

Heat

The body is able to compensate for increase of temperature by increased evaporation of water. The respiration and heart action are hastened and the perspiration is increased. If the temperature exceeds 55° C. (130° F.), the normal heat-reducing mechanism becomes insufficient, and life is no longer possible, although for short periods of time temperatures of even 250° C. (400° F.) may be applied without injury to portions of the body by dry radiation. The exposure of the body to moderate increases in temperature leads to dilatation of the blood-vessels and favors certain forms of infection. Thus 'taking cold' expresses an infection often the result of a **reduced immunity** due to overheating. More pronounced exposures to moderately high temperatures, especially when associated with dissipation and overwork, may lead to grave affections of the nervous system, known as insolation, heat stroke, or heat exhaustion.

Local Effects of Heat.—The local application of heat may result in (1) hyperemia, (2) extravasation of blood-serum with solution of certain cells (vesication), (3) coagulation of protoplasm (necrosis), (4) more or less complete oxidation or incineration. The local effects of heat are followed by certain systemic alterations that may partly be due to increased tissue waste, to retained or newly absorbed toxic

products, or to bacterial invasion.
function of important secretory or
affect the general system. Thus, it
even though severe, are less serious th
In the latter case there may be destr
blood (hemolysis), thrombosis, and ed
system, and localized necroses in the
increased destruction of albuminous s
diminished elimination of carbon di
oxidation is also shown by a tendency
parenchymatous organs.

The Effects of Cold

Moderate general or local cooling of
tion in **reducing immunity** to many infe
seen in the common 'colds,' forms of pn
teritis following the chilling of the body-su
plication of cold there is a hyperemia, bu
tissues be markedly reduced, this is succee
tion of the blood-vessels and anemia; unti
become frozen, they are dry and bloodless.

A part may be frozen for a brief period
cial injury. Upon thawing, an intense hy
anemia, and may lead to rupture of blood-ve
extravasations into the tissues. For this reas
of a frozen part is fraught with great danger.
ing the cells fail to regain their functions upon
normal temperature, the blood does not enter th
local death results. It is therefore possible to
directly from the cold itself, or from the second
exudations following the exposure.

Lowering of the temperature of the **entire body**
ished irritability of protoplasm, especially that o
tem, and finally death from the paralysis of vital

Electricity

Within certain limits, continuous, interrupted,
currents entering the body directly, through vari
induction, produce structural and metab
rom the electric current directly,

absorbed, rendering the contamination of the atmosphere ficult to detect.

noxious substances are added to the air in the prosecution s trades and manufactures. The vapor or solid particles y, arsenic, phosphorus, zinc, lead, or their compounds, acids are especially harmful. The presence of vapors lhuric acid in the air is comparatively harmless. In e manufacture of storage batteries in Philadelphia the d with the vapors of this acid that the clothes of the re rapidly destroyed has a reputation for special health- le rooms used for lead burning, the process of fusing re notoriously unhealthful.

of **Carbon Monoxid.**—Carbon monoxid may be de- sing fresh blood to the air to be tested, and then examin- by the spectroscope. If carbon monoxid is present, eristic absorption bands of carboxyhemoglobin will hen a reducing agent such as ammonium sulphid is d, while in unexposed normal blood the reducing the double bands to a single intermediate one.

is the air in mines, which is deficient in oxygen ssive amount of carbon dioxid, together with hane, hydrogen, and hydrogen sulphid. The th the fine carbon dust in the air, are com- onstitutes the dreaded **fire-damp** that may Should death not result from the ex- may be caused by the deficiency of oxy- on monoxid and hydrogen sulphid in the ,' or '**choke-damp**,' results from the nd hydrogen of coal by the oxygen and may lea o fatal asphyxia. nd carbon

rbon dioxid, n sulphid, pecially nounts tering by local tissue destruction, or, according to d'Arsonval, by the heat produced by excessive muscular contraction.

Lightning stroke is most frequent in rural districts, where there are few facilities for the dissemination of the force. It frequently strikes a lone tree or other isolated conducting agent. Lightning may cause peculiar, dendritic, hyperemic lines on the skin (**lightning figures**—see Fig. 2).

Electric accidents from street currents may be **prevented** by thorough insulation, and by the use of rubber or other nonconducting gloves and shoes by the workmen. Linemen should be carefully instructed as to the proper method of handling live wires. Lightning rods protect buildings to which they are properly applied, except under rare circumstances. During thunder-storms the shelter of isolated trees or other tall conductors should especially be avoided.

The Roentgen Ray

The usual lesion from exposure to the X-ray (**Roentgenism**) is the so-called X-ray burn or **focus tube dermatitis.** This is a chronic inflammation of the skin characterized by erythema, pigmentation, hyperplasia, induration, alopecia, and at times ulceration and necrosis. These lesions are most pronounced over the area of entrance of the rays; but at times occur upon the corresponding opposite side of the member, the area of exit. The intervening tissues or organs may also suffer. The bones may develop an osteoplastic periostitis, and instances of cerebral and intra-abdominal disturbance are recorded. The lesions almost invariably follow prolonged or frequently repeated exposures, especially those made by tubes of **low vacuum** placed in **close**

FIG. 3.—FOCUS TUBE DERMATITIS.

proximity to the tissues. Personal **idiosyncrasy** seems to be a predisposing factor. The method used for generating the electricity employed is immaterial. The accompanying illustration, supplied by Dr. Kassabian, shows similar lesions in the hands of two operators; one (*a*) from tubes actuated by a static machine, the other (*b*) from tubes excited by the Ruhmkorff coil (Fig. 3).

The lesions are apparently due to trophic alterations in the tissue cells caused by the radiant energy. The incubation period varies from a few days to a month. Theories ascribing the disease to electric induction; de-electrification; the bombardment of the tissues by particles of platinum or glass; the generation of ozone in the skin; or ultra-violet rays, have either been disproved or have insufficient proof.

Prophylaxis.—The prevention of focus tube dermatitis consists chiefly in using tubes of the highest vacuum ('**hard tubes**') compatible with the resistance of the part of the body examined, and in avoiding a closer proximity of the tube to the skin than 8 inches. A protective cover of sheet-rubber and the use of a grounded aluminum shield have been recommended, but are at most only partially effective. The operator should avoid unnecessary exposure, especially when starting or stopping the current. There is less danger when the rays strike the skin obliquely. This lesion therefore seems to be largely preventable. In 5000 X-ray examinations at the Medico-Chirurgical Hospital no dermatitis has developed, except in the person of the operator.

Becquerel's Rays

In 1896 M. Becquerel discovered that certain uranium salts emit invisible radiant energy resembling the X-rays. Later investigations by Madame Curie have shown that the pitchblende, chalcocite, autunite, cleveite, monazite, and other minerals also possess radiant energy. In pitchblende, a substance (polonium) analogous to bismuth, but having 4000 times the radiant energy of uranium, was found. Later a second ray-emitting element, called radium, was also discovered, and M. Debserne found in pitchblende a third active body, actinum. These rays possess luminosity and actinic and skiagraphic power, and render the air through which they pass a conductor of electricity. They are not capable of polarization, reflection, or refraction, and the rays emitted by the different substances vary in their properties. They excite the phosphorescence of gems. Walkoff and Geisel first noted an energetic action of the Becquerel's rays upon tissues to which the radiant substances are brought in close proximity, and this has since been confirmed by Becquerel and Mme. Curie. The skin becomes hard and painful, and erythema, desquamation, and chronic ulceration have resulted from prolonged exposure to radiferous substances. The burns may persist for months, and have resulted from carrying tubes containing active radiferous radium chlorid and other substances in the pocket. The changes closely resemble those produced by the cathode rays, as well as those due to the solar rays.

Light

Solar rays (sunlight) have a marked influence upon the general nutrition, increasing tissue oxidation and the elimination of carbon dioxid. Locally they alter the accumulation of pigment in the skin, causing freckles and tan. If the action be more intense or prolonged, erythema, desquamation, vesiculation, and even superficial eschars may result except in the habituated. The thickness of the skull in certain Ethiopians has been attributed to prolonged exposure to intense solar rays, and the dark-skinned races of the tropics apparently bear evolutionary evidence of the effects of habitual exposure to sunlight.

The **electric light** may produce similar cutaneous lesions. Although the solar rays have an energetic action after passing millions of miles, the electric light is active only within a few meters, the **cathode rays** only within a few centimeters, and **Becquerel's rays** only within a few millimeters.

Sound

Auditory impressions have a marked effect upon the higher cerebral centers in the way of exaltation or depression. Nervous excitation, joy, or moroseness may result from certain discordant or musical sounds. The street noises of large cities by constant nervous stimulation may predispose to neurasthenia, hysteria, and chorea. The absence of sound, silence, favors abstract thought and melancholy, and is probably a factor in the prevalence of insanity in rural regions. Racking, irritating noises cause insomnia, while the continued repetition of monotonous sounds often has a soporific influence. Various degrees of hypnosis may be produced by auditory sensations, as the cataleptic conditions Charcot evolved at the Salpêtrière by the stroke of a bell. Finally, certain sounds produce remote functional effects, as the irresistible desire to urinate that sometimes results from the sound of running water.

THE ATMOSPHERE

Animal life is dependent upon free **oxygen** as contained in the air. Imperfect supply of oxygen to the tissues produces fatty and other degenerative changes. Complete deprivation of air is followed by a rapid and fatal asphyxia.

Composition

Air is a mechanical mixture of various gases, the relative proportions of which are very closely maintained over all portions of the globe and at different altitudes. The average composition by volume is: Oxygen, 20.96 per cent.; nitrogen, 79 per cent.; carbon dioxid, 0.04 per cent.; argon, 0.75 per cent.; ammonia, ozone, nitrous and nitric acids, slight traces. There are also minute amounts of other elements, such as rypton, neon, and xenon, discovered by Ramsay, and coronium, discovered by Nasini, which have unknown properties, and at present are interesting only scientifically. Besides these elements, air contains a variable amount of aqueous vapor.

Oxygen.—A large number of analyses of outdoor air show that the proportion of oxygen by volume varies from 20.92 to 20.99. The proportion is slightly less at great heights and in towns than in the country or on the sea. In man the oxygen is taken from the air by the hemoglobin, with which it loosely combines and forms oxyhemoglobin, in which combination the oxygen is carried to the tissue cells. These cells return the oxygen to the blood in the form of carbon dioxid, and it is chiefly eliminated as such in the expired air. Inspired air loses about one-quarter of its oxygen. Large quantities of oxygen are also utilized in various inanimate processes of oxidation and combustion. The resulting carbon dioxid is chiefly absorbed by the action of the chlorophyl of plants, free oxygen being returned to the air. The well-known law of the diffusion of gases, which is that a gas expands and diffuses as freely in the presence of another gas as in a vacuum, accounts for the maintenance of the usual proportion of oxygen. The average quantity of oxygen absorbed daily by an adult is about two pounds, this amount being increased under conditions of activity and diminished during repose and in old age. A sufficient reduction in the total amount of oxygen in the air, irrespective of the quantity of other constituents, leads to **asphyxiation.**

Nitrogen.—The nitrogen of the air seems to have no active part in the physiologic chemistry of the body. The same amount is found in expired as in inspired air. It serves as an inert diluent for the oxygen. While the animal kingdom seems unable to utilize nitrogen in its economy, a few micro-organisms are able to produce combinations with it, forming nitrites and nitrates. Plants, especially the legumes, take the nitrates formed by micro-organisms and convert them into albuminous compounds that may serve as food for the higher animals.

Argon.—Argon, discovered in 1894 by Rayleigh and Ramsay, has no known action in the economy. Chemically it seems to be extremely inert, and it is with difficulty that any combination can be produced with it.

Carbon Dioxid.—The amount of carbonic acid gas in the air is much more variable than either oxygen or nitrogen. The average amount in pure air is about 0.03 per cent., but on mountain-tops as little as 0.017 has been found. In parts of Death Valley, California, there is such an excess that the air will not maintain life. It results from the oxidation of organic matter, and is therefore produced in all animal bodies; and in most processes of combustion, decay, and decomposition. It is found in the air in larger quantities at night than during the day. The largest amounts occur during autumn, the smallest during the winter. It is removed from the atmosphere by the action of plants, and by absorption in water, which is able to take up its own volume of the gas. Inspired air should never contain more than 7 parts in 10,000, yet in buildings crowded with people the amount may reach as high as 40 to 50 parts in 10,000. The objection to carbon dioxid is not that it is a poison, for it seems of itself to be inert, but that it displaces oxygen; while if its amount in the inspired air is such as to nearly or quite equal in tension that of the carbonic acid in the venous blood, the blood is less able to give up this gas, and the normal process of oxygenation is incomplete. It is a popular belief that the expired air contains certain organic impurities, and that the percentage of carbon dioxid serves as an indicator of the proportion of these supposedly toxic compounds. As yet, however, it has not been definitely proved that such poisonous substances are excreted.

Ozone.—Ozone is the allotropic form of oxygen in which the molecule is supposed to contain three atoms. It has a peculiar pungent, garlic-like odor and much stronger oxidizing powers than oxygen. In the air it is rarely found in amounts greater than 1 to 700,000. It is more abundant at the seashore, on mountains, and near woods. In proportions greater than 4 in 1000, it produces a marked irritation of the respiratory mucous membrane and death in the lower animals subjected to it. Its value as a health restorer is apparently overrated. When present in the atmosphere, however, it indicates a comparative freedom from organic or oxidizable matters.

Ammonia.—This is the chief product of the decomposition of nitrogenous organic material. It is found in largest amounts where large quantities of manure or other decomposing organic substance are present. It is precipitated from the air in watery vapor and is also removed by combinations leading to the production of nitrites and nitrates. In excess it suggests the presence of an unwholesome decomposition process in the neighborhood.

Aqueous Vapors

Humidity is a term referring to the amount of aqueous vapor suspended in the air. It is usually expressed by relative terms, as the amount of vapor that the air will take up varies at different temperatures. Thus at 0° C. the air can hold $\frac{1}{160}$ of its weight of aqueous vapor, and this amount is doubled by every rise of 15 degrees in temperature. At 15° C., therefore, it will take up twice as much as at 0° C., or $\frac{1}{80}$ of its weight, and so on. When the air at any temperature is saturated, it is said to have a relative humidity of 100. If it is one-fourth saturated with aqueous vapor, the humidity is 25. If the aqueous vapor equals one-half the amount necessary for saturation, the humidity is termed 50. It is obvious that with a decrease in temperature the amount of aqueous vapor necessary to represent saturation, or 100 degrees humidity, rapidly diminishes, and that as soon as the aqueous vapor is in excess of the amount necessary for saturation, it is precipitated. Precipitation may also occur when the humidity is much below the point of saturation, through the action of dust, electric currents, and other agencies. Humidity is of special importance in relation to the perspiration. With low temperatures the perspiration usually evaporates as rapidly as it is eliminated, so that only **insensible perspiration** occurs. As the humidity increases, the transpiration of sweat may go on as before, but the evaporation is progressively retarded until at 100 degrees humidity there is no evaporation and the skin remains constantly wet. This reduction in evaporation diminishes the natural heat dissipation, and also greatly favors heat conduction, so that with a high relative humidity, low or high degrees of temperature are poorly borne, and the extremes of temperature compatible with life are much more circumscribed with a high than with a low humidity. Great humidity, by interfering with the normal heat regulation of the body, may indirectly favor the taking of 'colds' and the development of many of the infectious processes. The presence of aqueous vapor in the air serves a useful purpose by absorbing the heat from the sun during the day and by retarding evaporation and consequent heat dissipation from the earth at night. Consequently, while it intensifies the effect of heat and cold, it prevents sudden temperature changes.*

Toxic Gases

The most harmful of the gases found in the atmosphere is **carbon monoxid,** CO. This is found in large quantities in illuminating gas, and is given off in the burning of coal and charcoal. When sufficient oxygen is present for complete combustion, it burns with the formation of the comparatively harmless carbon dioxid, CO_2, and this combustion is the cause of the blue flame so often seen playing over coal fires. Should the supply of oxygen be insufficient in the burning of coal, charcoal, kerosene, or illuminating gas, portions of carbon monoxid may escape into the air, and as it is odorless, may be inhaled with serious results. Cast-iron stoves, when red hot, absorb from burning coal considerable quantities of the gas and may give off small amounts to the air. When inhaled, it unites with the hemoglobin of the blood, forming **carboxyhemoglobin,** a compound not decomposed by oxygen and carbon dioxid. The blood may turn a cherry-red color. Death results from asphyxiation. In fatal cases parenchymatous alterations in the viscera are found. One of the most frequent forms of serious poisonings in the United States depends upon the intentional or accidental inhalation of illuminating gas. As water-gas may have less odor than coal-gas, it is the more dangerous because it is less readily detected. Leaky fixtures are often present, or the gas may travel long distances underground from defective mains, and from the cellar penetrate the house. In the passage of illuminating gas through the soil, the odorous portion may be

* See also vol. III, chapter II.

largely absorbed, rendering the contamination of the atmosphere more difficult to detect.

Many noxious substances are added to the air in the prosecution of various trades and manufactures. The vapor or solid particles of mercury, arsenic, phosphorus, zinc, lead, or their compounds, or certain acids are especially harmful. The presence of vapors from sulphuric acid in the air is comparatively harmless. Indeed, in the manufacture of storage batteries in Philadelphia the room so filled with the vapors of this acid that the clothes of the occupants are rapidly destroyed has a reputation for special healthfulness; while rooms used for lead burning, the process of fusing lead-joints, are notoriously unhealthful.

Detection of Carbon Monoxid.—Carbon monoxid may be detected by exposing fresh blood to the air to be tested, and then examining this blood by the spectroscope. If carbon monoxid is present, the two characteristic absorption bands of carboxyhemoglobin will not be altered when a reducing agent such as ammonium sulphid is added to the blood, while in unexposed normal blood the reducing agent will change the double bands to a single intermediate one.

Mine Air

Especially noxious is the air in mines, which is deficient in oxygen and contains an excessive amount of carbon dioxid, together with carbon monoxid, methane, hydrogen, and hydrogen sulphid. The latter gases, together with the fine carbon dust in the air, are combustible, while methane constitutes the dreaded **fire-damp** that may lead to serious explosions. Should death not result from the explosion of the fire-damp, it may be caused by the deficiency of oxygen, and the presence of carbon monoxid and hydrogen sulphid in the '**after-damp.**' '**Black-damp,**' or '**choke-damp,**' results from the slow oxidation of the carbon and hydrogen of coal by the oxygen in the air. It extinguishes fire and may lead to fatal asphyxia. Undiluted, it consists of nitrogen and carbon dioxid.

Sewer Air

In the decomposition of sewage, large quantities of carbon dioxid, with some marsh-gas, ammonium compounds, and hydrogen sulphid, are given off. In unventilated cess-pools these gases, and especially the ammonium sulphid, are often present in such large amounts as to jeopardize life, and it is the custom of workers before entering such pits to introduce lighted candles as a test of the ability of the contained air to sustain life. If the lamp is extinguished, the air is of course considered to be irrespirable. In the modern ventilated conduits and mains for sewage the air rarely contains sufficient carbon dioxid or other gases to be prejudicial to life. Carbon dioxid is usually present in from 10 to 50 volumes in 10,000, and in sewers without ventilation the quantity is of course much greater. With proper ventilation these gases rarely cause serious contamination of the air, and it is preferable that they escape into the open air and be largely diluted, rather than be retained in the sewage system to escape when the plumbing is defective and perhaps enter houses in considerable quantities. The experimental evidence as to the influence of this gas upon infection is contradictory. Moderate quantities of sewer air from a well-ventilated system are probably without appreciable effect, while large quantities of this air but little diluted may depress the body-resistance and thereby favor the entrance and growth of morbific agents.

The pathologic condition resulting from the inhalation of emanations from decomposing animal matter is termed **mephitism.**

Bacteria in Sewer Air.—Sewer gases are, of course, in themselves noninfectious, and there has been much investigation to determine if micro-organisms are present in large numbers in the air of sewers. The results of these experiments are almost unanimous in showing that sewer air is freer from micro-organisms than the open air in cities. The organism present in largest numbers in sewage is probably the colon bacillus, but this is rare in sewer air. That bacteria are not given off from sewage to the adjacent air is borne out by our knowledge of the indisposition of bacteria to leave moist surfaces. It has been claimed that the rupture of bubbles upon the surface of the sewage throws into the air minute watery particles containing bacteria, but the specific gravity of these is such that they must rapidly fall again to the surface from which they came. It has also been asserted that cool air entering the sewers, by condensing the aqueous vapor near the surface of the liquid, forms a great multitude of minute droplets, each of which may carry micro-organisms from the liquid. It is to be remembered, however, that this aqueous vapor, as given off from the sewage, is a gas, and therefore free from micro-organisms; and particles condensing in sufficient proximity to the surface of the sewage to become contaminated with micro-organisms probably must also again become incorporated with the liquid.

The pathogenic organisms apt to be conveyed from sewage—the typhoid bacillus and cholera spirillum—are, as a rule, rapidly destroyed by saprophytic bacteria present in the sewage. Moreover, it is a fact that men employed in sewage systems, and breathing sewer air many hours daily, are not infrequently above the average in health and development, so that the tendency to attribute infectious diseases to sewer air seems without scientific, experimental, or clinical evidence. Although disease may not be conveyed by sewer air, no one contends that it is a desirable addition to the air used for respiration, and both from its noxious odor and from the possibility of its being able in certain cases to depress vitality, its exclusion from the ground air and from dwellings is important.

Atmospheric Pressure

At the sea-level the weight of the atmosphere is 1.03 kilos to each square centimeter, or 14.64 pounds to the square inch. This is equivalent to a barometric height of 760 millimeters, or 29.92 inches, at the freezing-point. The human body sustains under these conditions a total pressure of about 18,000 kilos, or 39,683 pounds. The balance between the pressure within the body and that from without permits the support of this vast weight without discomfort. Changes in the external pressure, especially when occurring so rapidly as to interfere with the normal pressure equilibrium, may be followed by symptoms, as exemplified in **barometric neurosis** and **caisson disease.**

Natural barometric fluctuations result from difference in altitude, temperature, humidity, and winds. They may be periodic, as the **diurnal** and **annual variations,** or non-periodic, as the **cyclonic** and **anti-cyclonic** variations.

Increased Atmospheric Pressure

A marked increase in the atmospheric pressure, especially if frequently repeated, often produces bleeding from the nose, ears, and other mucous membranes, delirium, and forms of paralysis. Degenerations in the central nervous system and vaeuolations in the spinal cord have been found. The symptoms appear upon the rapid return to the normal pressure, and the vacuolations have been attributed to the sudden expansion of condensed gases contained in the nerve-tissues. The group of symptoms produced by increased atmospheric pressure has been termed **caisson disease,** as it especially occurs in those working in caissons, and in divers. The condition may be prevented by avoiding sudden changes in the atmospheric pressure. Workers in the caissons should spend at least five minutes in an intermediate chamber, for each 6 pounds of pressure, both on entering the caisson and upon leaving it.

Decreased Atmospheric Pressure

Dyspnea and nervous excitement, as faintness, cyanosis, hemorrhage, and vomiting, may develop when high altitudes are reached. These symptoms occur in mountain climbers and balloonists. There is in the blood a decided increase in the number of red blood-corpuscles, followed by an increase in specific gravity and hemoglobin. Similar conditions may be produced by placing animals in chambers from which the air is partially expelled. A return to the normal barometric pressure (760 mm.) causes a transient decrease followed by an increase of the red cells over the number present previous to the experiment. Ossian, Schaumann, and Rosenquest found that the microcytes were diminished, the macrocytes increased, and the cells of average size unchanged in number. There was a slight increase in the number of nucleated cells, and in pigeons mitotic figures occurred in the red cells. These changes were found in the blood from the liver, aorta, and skin. The increase of hemoglobin was not proportionate to that of the number of erythrocytes. Altitude seems, therefore, to cause a true proliferation of the blood-cells.

Mountain Sickness.—This may occur at a height of 3000 meters (9750 feet), but is most common at 4000 meters, especially when associated with cold. Thus, the ascent of mountains with a high zone of perpetual snow, like the Andes, Rockies, and Himalayas, less often produces mountain sickness than does the ascent of mountains in which the snow line is lower, as the Alps. It is more common when the ascent is made rapidly by unaccustomed climbers, who become overfatigued. Pains in the legs, salivation, nausea, vomiting, and even tormina and diarrhea may develop. The respirations are accelerated, the pulse is rapid and feeble, the surface becomes cold and clammy. Vertigo, headache, and finally apathy and an almost irresistible tendency to sleep may develop. The experiments of Paul Bert indicate that it is not the mere rarefaction, but the diminution in the oxygen of the air, that is the cause of the disease. Aeronauts are less liable to suffer, as they are not exposed to the fatigue.

Climate and Season

The principal features that produce and modify the climate* of a place are its latitude, altitude, proximity to bodies of water, and the prevalent winds and rains. Besides this, climate may be modified by the topography of the land and the character of the soil. The human body has a remarkable ability to adapt itself to different climates, and with proper food, clothing, exercise, and the avoidance of the parasitic causes of disease, the climate has a minor effect upon the health. It is customary to classify climates into **warm,** including the **equatorial, tropic,** and **subtropic; temperate,** with a mean temperature of 60° F.; and **cold;** also into **plain, mountain,** and **marine** climates.

Climate is not an exciting cause of disease, yet by its favoring or inhibiting influence upon the determining factors it may play a somewhat important part in disease production or prevention. Thus, warm, moist climates are favorable to the growth of parasites, and the parasitic diseases are especially common in the tropics. Gastro-intestinal disturbances, cholera, yellow fever, and malaria are also prevalent, measles and scarlet fever comparatively rare, in hot climates. Pulmonary tuberculosis is observed more frequently in moist than in dry regions, at sea-level than at altitudes; while rheumatism, gout, and pneumonia are more frequent in cold, damp climates. Marine climates predispose to rheumatism and pulmonary affections, and aggravate existing neuralgias. When we except certain affections like heat stroke and frost-bite, it will be evident that climate does not act except as a predisposing cause of disease, and with a better understanding of the parasitic nature of disease, the importance of climate as a causal factor has greatly depreciated.

The slight influence of climate on the development of disease is well illustrated in the recent experiments as to the production of malaria upon the Roman Campagna. In a place noted for its unwholesome malarious climate, a number of observers lived in perfect health for months merely by taking precautions to avoid mosquito bites. On the other hand, climatic factors are often of considerable importance in prophylactic therapeutics, as has been fully discussed in volume IV of this series.

Vegetation.—The presence of many trees in a district has an

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* See also vol. III, chapter V.

important regulating effect upon the climate. By their presence the winds are modified, the temperature is made more equable, the air is rendered more uniformly humid, there is little dust, while certain vapors believed to be healthful may be given off by the trees. The danger from floods is much less in woody districts, as the trees serve to regulate the penetration of water into the soil.

Season

Variations in temperature and humidity accompanying changes in season are associated with variations in the **incidence** of certain diseases, that are analogous to the incidence of those diseases in relation to climate.

During the **summer months** gastro-intestinal maladies are prevalent and the tropic diseases make their greatest incursions into the temperate zones. This is usually due to the fact that all causal conditions are coincidently favorable only during these months. Thus, yellow fever is confined to the warm months in temperate climates, for the reason that the contaminating mosquito is active only in warm weather. Probably for a similar reason, or perhaps on account of peculiarities of an as yet unknown stage of the parasite, in which it exists in earth or water, cholera occurs chiefly in the months of August, September, and October. The prevalence of the gastro-intestinal disorders of childhood, such as cholera morbus, cholera infantum, and other forms of enterocolitis, is greatest during July and August, a period in which it is most difficult to preserve properly the foods used for infants.

Typhoid fever and malaria are more wide-spread during August, September, and October than in other months. This is probably due to the activity of the insects transmitting these diseases during the late summer. The fall rains may also aid by sweeping infectious material into the wells and streams from which drinking-water is taken. At all events, the comparative infrequency of typhoid fever during the winter may reasonably be attributed to the facts that then the chances of dissemination by flies and other insects are least, as are also the possibilities of propagation and transmission through the water-supply.

During the **cold damp months,** catarrhal affections, pneumonia, rheumatism, and gout are most frequent. This is to be explained not only by the increased exposure and chilling of the body, but also by the less hygienic method of living; persons being disposed to spend more of their time in overheated and poorly ventilated rooms and to indulge more in overeating and overdrinking than during other seasons of the year. Diphtheria, measles, scarlatina, smallpox, and similar affections are likewise most prevalent during the cold months. This may be due to the greater facilities for infection afforded during the winter time by crowded and poorly ventilated cars, houses, schools, or public meeting-places. We have no good reason for assuming that season alone is the direct causal agent in facilitating the propagation or invasion of the exciting agent.

Excessive dryness or moisture may increase the morbidity during any season. This is apparently well shown in relation to autumnal diarrheas in the following table:

RELATION OF AUTUMNAL DIARRHEA TO RAINFALL—(*Hope*)

Average Rainfall, June to September.	Annual Average of Deaths from Diarrhea in the Third Quarter of the Year.
Average of 6 wet summers, ... 13.8	373
" 14 dry " 10.9	573
Extreme wet summer, 1891, ... 16.0	203
" dry " 1895, ... 7.7	819

TOXIC CAUSES

Poisons are substances that in small amounts are destructive to the functional and structural integrity of the organism. Usually they are **ectogenous,** that is to say, they arise without the body; but they may also be formed, as are leucomains, within the body, and therefore be **endogenous.** Ectogenous poisons may be inorganic or organic and either of vegetable or animal origin. Substances may have no direct injurious action and yet do harm by liberating toxic compounds from the tissues.

Poisons may exert their **predominant effect** (1) **locally** upon the tissues with which they first come in contact; or (2) in passing through the body they may cause marked degenerative changes in the **parenchyma** of organs; or (3) they may alter the character of the **blood,** or (4) show their chief action upon the **nervous system.** The action of many poisons depends upon combinations which they form with the **cytoplasm.** As a general rule, the most marked lesions are found at the points of entrance and exit from the body—where the greatest concentration usually occurs—or in cells especially vulnerable, as those of the central nervous system.

Local Poisons.—The chief **inorganic** local poisons are the caustic acids, alkalis, and certain salts of the heavy metals, especially of mercury, zinc, silver, and antimony. These produce marked chemical changes in the tissues, leading to their death, with protoplasmic coagulation or solution. There also are certain **vegetable** products that produce marked toxic action when locally applied. Croton oil produces an erythema followed by vesiculation and pustulation, and poison ivy and poison oak, in susceptible individuals, cause marked hyperemia and the formation of large bullæ. Pfaff found in both *Rhus toxicodendron* and *Rhus venenata* an oil he termed *toxicodendrol*, the application of 0.001 milligram of which, dissolved and mixed with two drops of olive oil, gave rise to intense local irritation in a susceptible subject; in the lower animals Pfaff also found that these drugs produced generalized fatty degeneration. Many animals elaborate poisons having a local as well as a general action. The venom of serpents and lizards (Gila monster), the cutaneous secretion of toads and salamanders, the poison of arachnids, myriapods, and insects, the salivary secretion of mosquitos, and cantharidin derived from certain beetles are examples of these toxic substances.

Parenchyma Poisons.—Many poisons having a marked local action, such as the mineral acids and alkalis, are practically harmless when diluted. Their effects therefore are only found locally. Other substances, as phosphorus, arsenic, antimony, and many of the animal and vegetable poisons, not only produce local lesions, but when absorbed in dilution cause a high grade of parenchymatous, fatty, or other degenerative change, especially in the liver, kidneys, heart, blood-vessels, and muscles. With these drugs it becomes important not only to control the local effects, but also to prevent their absorption. Protoplasmic metabolism or muscular contractility may be stimulated, depressed, or abolished. Other poisons, as alcohol and lead, as well as those of syphilis and of gout, stimulate the interstitial tissues to harmful overgrowth, thus causing the various **cirrhoses** or **scleroses.**

Blood Poisons.—These act by (1) forming more stable combinations with the hemoglobin, thereby preventing the ordinary oxygen-carrying function of the blood, (2) by causing a solution of the corpuscles, and (3) by inducing changes in the plasma, interfering with its coagulation.

The combination most frequently formed with the hemoglobin is called **methemoglobin.** It is isomeric with the normal oxyhemoglobin, but is so stable that the oxygen is not liberated for the use of the tissues. It gives the blood a sepia-brown color. The formation of methemoglobin is often accompanied by the solution of the corpuscles (**hemolysis**). This change is produced by many of the newer coal-tar remedies, such as acetanilid, phenacetin, trional, and also by chloral, chloroform, amyl nitrite, etc., potassium chlorate, pyrogallol, dinitrobenzene, nitroglycerin. The inhalation of carbon monoxid even in so small a proportion as 0.02 per cent. is injurious, the gas uniting with the hemoglobin to form **carboxyhemoglobin.** The blood acquires a cherry-red color. **Cyanhemoglobin** results from the toxic action of hydrocyanic acid. It gives the blood a bright red color. From the inhalation of hydrogen sulphid **sulphur-methemoglobin** may be formed. Hydrogen arsenid, potassium chlorate, serpents' venom, phallin from poisonous mushrooms, and other poisons may have a marked solvent action upon the corpuscles.

Many poisons, including ricin, abrin, alcohol, ether, and the blood-serum from a different species of animal, will coagulate the blood.

It is rare that a poison acts solely upon the blood. Usually there is also an injurious action upon visceral protoplasm, especially of the central nervous system.

Nerve Poisons.—These may have a predominant action upon the cerebral cortex, the basal ganglia and spinal centers, or the peripheral nerves. Certain of the poisons, as chloroform, ether, chloral, coniin, diphtheria toxin, and the bromids, chiefly depress, while others, as strychnin, tetanus toxin, caffein, cocain, chiefly stimulate nervous excitability. The toxic substance may show a selective action upon certain centers, nerves, or ganglia, as is exemplified in the depression of the motor centers of the cord by physostigmin, and the stimulation of the vagi by digitalis.

Food Poisoning

Besides the injurious effects resulting from its excess or deficiency, food may possess unwholesome qualities from improper selection, age, growth, season, or environment, from disease, from decomposition, and from contamination with vegetable and animal parasites.

Animal Foods.—The meat of embryo calves and of pregnant animals is considered unfit for food. The flesh of animals that are fed upon certain substances may be toxic, as is that of birds that have eaten mountain laurel. Season may affect the wholesomeness of animal foods; for instance, the flesh of certain fish is toxic in the spawning period. Fish or shellfish may acquire toxic substances through living in certain waters. Schmitmann found that oysters placed in the water of the harbor at Wilhelmshaven soon became poisonous, while the poisonous bivalves from this bay lost their toxic properties when placed in the open sea. As Lindener found that the water from this bay when filtered did not render the oysters toxic, it would seem that the process was one of infection rather than absorption of a poisonous substance. These oysters produce disease characterized by paralytic symptoms, and from them Brieger has isolated a ptomain which he calls **mytilotoxin.** Animals are subject to a number of diseases that may be transferred to man in food, including **tuberculosis, helminthiasis,** and **anthrax.** The danger of contracting parasitic diseases is obviated by thorough cooking and careful meat inspection. The flesh from animals affected with tuberculosis, anthrax, glanders, actinomycosis, hog cholera, or with **animal parasites** should never be used for human consumption, no matter how localized the lesion.

Decomposition of food may result in the formation of toxic ptomains, such as the **tyrotoxicon** of milk and cheese. **Botulismus** (**allantiasis** or **sausage poisoning**) may be acquired from improperly preserved sausage, bacon, chicken, ham, and other meats. Ermengen has isolated from toxic meat and from the spleen of a person dead of the disease an anaerobic bacillus, the Bacillus botulinus, that elaborates a powerful toxin.

Other outbreaks of disease characterized by vomiting, diarrhea, and collapse, and attributable to the ingestion of meat, are apparently due to the Bacillus enteritides of Gärtner—an organism resembling those of the colon group.

Vegetable Foods.—Abnormal methods of growth may cause the production of injurious combinations in the metabolism of plants. Vegetables or fruits raised out of season or by unnatural forcing processes are usually less nutritious and more apt to cause gastro-intestinal disturbances than those grown under normal conditions. Food-plants are sometimes attacked by certain fungi, as **ergot of rye** (spurred rye) and **blight of corn,** etc. Grave pathologic changes may follow the ingestion of such diseased cereals.

SOCIOLOGIC CAUSES

Density of Population

The crowding together of large numbers of people in limited areas is usually a result of poverty, and, as a rule, indicates that the individuals involved are less capable of successful existence than those living in more commodious quarters. It therefore follows that crowded areas usually show a high proportion of persons with deficient resistance, of unclean habits, insufficient or improper nourishment, with undesirable occupations and a general lack of care in guarding their bodies against unfavorable influences. Such associations conduce to defective ventilation, improper food, and unhygienic surroundings, and, of course, strongly tend to the development of deficient stamina, and the propagation of various diseases. It is therefore not strange that overcrowding is associated with increased rates of morbidity and mortality.

The **diseases** especially prevalent in areas of dense population are **tuberculosis,** the **acute exanthemata,** and the **gastro-intestinal disorders** of childhood. It is evident that overpopulation is not of itself the cause of the prevalence of these disorders, but rather that they result from the unhygienic conditions that are usually associated therewith. For this reason there are occasional marked exceptions to the rule that overcrowding is associated with a high mortality.

The **prevention** of overcrowding and of its evils, physical, social, and political, especially in great cities, and of what is called 'slum life,' is one of the gravest problems with which our advancing civilization has to deal. Neither material nor moral infection can well be restricted to the unfortunates among whom it finds an environment so favorable for its propagation. As the editor has elsewhere said, "the miseries of Lazarus are visited upon the children of Dives."

The condition, however, is not medical, but economic, in its etiology, and therefore in its prophylaxis and therapy. The prevention of disease, bodily or spiritual, depends upon the discovery and the removal of the cause. Continued failure to recognize the cause in this instance can result in the wreck of our civilization.

Dissipation

Health is maintained without effort only when there is a proper regulation of the food-supply and an absence of abnormal stimulation or sedation of function. Gluttony, sexual erethism, or the abuse of stimulants and narcotics, is a constant menace to the health equilibrium. Not only do such excesses frequently lead to functional and structural abnormalities, but they also tend to increase susceptibility to various pathologic processes. Animals exposed to excesses in physical exercises more readily contract infectious diseases, and the administration of alcoholic beverages may also alter their natural immunity. Abbott's observations indicated that **alcohol** may cause reduction of the natural immunity, and the elaborate experiments of Dr. Taavlaitmen apparently show that in dogs, rabbits, guinea-pigs, fowls, and pigeons alcohol distinctly increases the susceptibility to experimental infection. This diminished resistance results no matter whether the alcohol is given before, during, or after the time of inoculation, or if the drug be administered by the mouth or under the skin. Careful control experiments showed that no temperature changes resulted in the animals, except a reduction after excessive doses of alcohol. In the infected animals that are given alcohol, the abnormal temperature of experimental disease persists longer than in infected animals that do not receive the drug.

The experimental evidence that alcohol increases the susceptibility to infection is strongly corroborated by clinical observation. Pneumonia, tuberculosis, enteric fever, and other infections usually run an exceptionally severe course in alcoholics, and the frequency with which in the dissipated relatively slight injuries develop grave local and general septic manifestations has been repeatedly noted by surgeons. Not only is there a condition of depraved tissue nutrition in those who use alcohol to excess, but the power of assimilation of food is much reduced.

Moreover, alcohol is **directly toxic.** The ingestion of from 500 to 1000 c.c. of whisky (from one to two pints) at one time by an adult has repeatedly resulted in death within a short time, while much smaller quantities have proved fatal in children.

Spirituous beverages may contain, besides ethylic alcohol, more toxic substances, such as propylic, butylic, and amylic alcohol, acetone, and various aldehydes, ethers, and essential oils. The bitters, cocktails, and other so-called mixed drinks may contain a number of these toxic substances. Absinthe is said to contain nine toxic essences. Certain artificial flavors are poisonous or may accidently be contaminated. Malt liquors are also subject to intentional and accidental adulteration with poisonous substances. Thus, cocculus indicus has been used to fortify beer, and the wide-spread epidemic of arsenic poisoning in Birmingham during 1900 and 1901 was traced to beer containing glucose manufactured with sulphuric acid contaminated by that metal. Lead-poisoning has been ascribed to the use of beer contaminated by vessels and pipes.

Prolonged tippling results in a complex series of disturbances, dependent upon the character of the tipple, and the habits and idiosyncrasy of the person. Overindulgence in malt liquors is particularly apt to be followed by parenchymatous and fatty degenerations in the viscera; while distilled liquors most frequently lead to gastro-intestinal disorders, forms of sclerosis affecting especially the liver, kidneys, and central nervous system, neuritis and palsies, obscure neuroses, mania, and dementia. There is a noteworthy relationship between the incidence of alcoholism, the psychoses, insanity, venery, and crime. In part this is due to the favoring influence of alcoholism upon the spread of other forms of dissipation and venereal disease. Alcohol increases sexual desire, obtunds the moral sense, and favors a careless disregard of precaution against infection. Forel found that venereal infection was more frequent in conjunction with occasional than habitual alcoholic indulgence. In over three-fourths of the cases the patients were under the influence of alcohol when infection occurred.

In portions of Ireland **ether** is a preferred tipple. In Philadelphia the theft of **gasolene** from street-lamps led to the discovery that this was inhaled by children for the purpose of inducing intoxication. The physical and moral impoverishment resulting from the **chloral, opium, cocain, cannabis indica, caffein, chloroform,** and **ether** habits is well known. The excessive use of **tobacco** may cause disease of the heart, impairment of vision, and nervous irritability or exhaustion.

Sexual excesses lead directly to diseases of the nervous and circulatory systems, as well as indirectly to the venereal and other infections and their grave sequels.

The occupational spasms, palsies, or neuroses result from physical and mental **overwork.**

So, too, certain psychic or intrinsic conditions, such as **inordinate ambition,** depraved or perverted **emotions,** as well as depressing and exhausting **habits,** and the like, may be mentioned under this head, as they involve dissipation of energy.

In the **prevention** of dissipation especial stress should be placed upon the moral education and the development of self-control. This is the more necessary in the case of those inheriting morbid tendencies to depraving indulgence.

OCCUPATION

The influence of occupation upon disease production is due chiefly to unhygienic environment. Although some occupations are injurious from the overuse of certain functions, and others from the mental stress or the emotional excitement involved, and still others from too long hours of work, injury more often comes through the inhalation of vitiated, irritating, toxic, or even infectious atmospheres, from exposure to trauma, to extremes or variations of temperature, to alterations in the atmospheric pressure, to the action of cathode rays and other forms of radiant energy, or to conditions causing deficient nutrition. Besides these factors, there is a tendency to dissipation associated with many occupations, that distinctly increases the liability to disease.

The Mechanical Effects of Occupation

For the maintenance of health it is essential that all portions of the body be exercised. We are not created to exercise one single function, but to obey the 'law of variety in exercise.' It therefore follows that occupations attended by the disproportionate use of a single part of the body lead to local overdevelopment or neurosis, and favor deficiencies elsewhere. Longevity is associated with those professions giving the greatest amount of moderate general exercise to the entire organism; while the more highly specialized forms of occupation are usually attended with an increased mortality. Disuse, either general or local, is followed by fatty degeneration, deficient development, and atrophy, and, if general, it is often associated with anemia. Excessive use, on the other hand, may be followed by the so-called **occupation neuroses,** in which there occurs either spasm or palsy of the affected muscles. Common examples of these neuroses are the forms of **writer's cramp, pianist's cramp, telegraphist's cramp, typist's cramp, compositor's cramp, milker's cramp, tailor's cramp,** and **sawyer's cramp.** In all these diseases there is a spasm affecting particularly the flexors and abductors of the forearm and hand when they are brought into use. The condition is difficult to relieve, except by avoiding the exciting cause, either by changing the occupation or by means of some mechanical aid that will give rest to the affected muscles. A similar condition of the lower extremity may occur in **sewing-machine operatives, organists, turners, treadlers, dancers,** and **athletes.** More rarely paralysis attacks the overused muscles, as occurs in **scrivener's palsy** and in **hammerman's palsy.** The occurrence of either of these conditions implies an abuse of the muscles involved, and their prophylaxis lies in the adoption of a less narrowly specialized occupation.

Examples of **defective development** as a result of certain occupations are common, and may be so pronounced as to enable one to determine the occupation from the deformity present. The poorly developed and bowed legs of **cowboys, cavalry officers, jockeys,** and **grooms,** associated with a tendency to 'toe-in' in walking, are suggestive of long-continued horseback riding. **Tailors** may show a wasting of the thenar eminences of the palm, a result of their method of holding the cloth. A narrow, contracted pelvis is especially common in **shop-girls,** or in women who have spent much of their time during the developmental period in standing. Long-continued standing also favors the development of varicose veins and ulcers. Those whose occupation causes them to **bend over** much of the time, frequently suffer from engorgement of the abdominal viscera, with associated congestive troubles and headache, and usually have round shoulders and grades of vertebral curvature. Such deformities are found in **shoemakers, students, engravers, miners, laundresses, gardeners,** and may be very appositely contrasted with the erect carriage of those who make it a practice to carry burdens upon the head. **Shoemakers** frequently develop also a depression of the thorax involving the lower portion of the sternum and the false ribs. **Blacksmiths, carpenters,** and others who use one hand very much more than the other usually show a lateral spinal curvature, a result of the constant pull from one side. Other occupational deformities are the flabby, puffing cheeks of **those who blow wind instruments,** the lateral inclination of the head of **violinists,** the exaggerated hands of the **pianists,** and the characteristic condition of the internal metatarsus, or so-called 'onion,' in **toe-dancers.**

Callosities show such a close relationship to the occupation that Vernois has considered them from a medicolegal standpoint, as an important means in the identification of persons. They are found upon the tips of the fingers of the left hand in **violin, guitar,** and

'cello players, upon three fingers of **drummers,** and the entire internal hand of **laundresses;** on the palm and fingers of the right hand in **shoemakers,** on the radial border of the index-fingers in **woodcarvers,** on the index-finger and palm of **compositors.** On the left hand, on the palm, index-fingers, and thenar eminence in **locksmiths,** and over the five metatarsal bones externally in **tailors.** Callosities are also present over the ensiform portion of the sternum in **wheelwrights,** over the ischial region in **horsemen,** and upon the entire surface of the left thigh in **shoemakers.**

Occupations may be associated with characteristic **traumatisms,** as is seen in the peculiarly pigmented hands and faces of **coal-miners,** a result of the embedding of bits of coal beneath the skin. Cataract is especially common in **blacksmiths,** apparently the result of the bright light and flying particles of metal to which they are exposed.

Forms of **hydrarthrosis** or distention of the synovial bursas are associated with certain occupations. The enlarged bursa under the elbow found in **miners** and in **draftsmen** (miner's elbow) and the distended prepatellar bursa in **scrub-women** (housemaid's knee) are examples of this affection.

The **internal organs** are mechanically affected by certain occupations and modes of life. The atrophic groove found in the adipose tissue about the waist of **blacksmiths, butchers,** and others who wear cords tightly tied about the body, and the furrow in the livers of women that practise tight lacing, are the results of continuous external pressure. Persons engaged in occupations associated with the inhalation of large quantities of **dust** have a tendency to certain characteristic lung affections. The black, anthracotic lungs of **coal-miners,** associated with the tendency to pulmonary tuberculosis; and the predisposition to fibroid and tuberculous changes in the lungs of **grinders, polishers, stone-cutters,** and the like, are the results of the inhalation of large quantities of irritating dust. In these cases the predisposition to tuberculosis seems to be brought about chiefly by the continued mechanical irritation, and this is found to be especially marked when the dust, being hard and insoluble, remains as a continued source of irritation. The names **'coal-miner's phthisis,' 'grinder's consumption,'** etc., express the relationships of the grit to the disease. The softer dust from wood and textile fabrics is less harmful. By the adoption of measures that give relief from constrained positions to the workers, that provide proper food- and air-supply, and by the employment of respirators and, especially, proper ventilating and exhaust appliances where dust is generated, many of these injurious effects of occupation may be **avoided.** (See Fig. 4.)

Intoxications Associated with Occupation

Certain occupations involve the use of **toxic materials,** with which the workman is apt to be brought in more or less intimate contact. The lesions produced, of course, depend upon the nature of the poison. In **silver-miners, smelters, potters, lead-burners, file-makers,** workers in **white lead,** and **painters,** the characteristic palsies and intestinal symptoms of lead **(plumbism)**, antimony, and arsenic

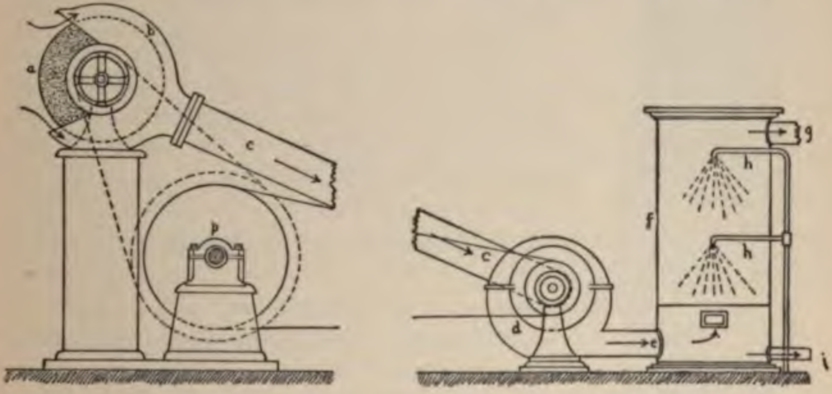

FIG. 4.—APPARATUS FOR THE REMOVAL OF DUST IN MANUFACTORIES.—(*Modified from Bergey.*)

a, Grinding wheel. *b*, *c*, Exhaust hood and dust conduit. *d*, Blower. *f*, Dust precipitating chamber. *h*, *h*, Water sprays. *i*, Exit for dust-laden water. *p*, Power.

are common. Miscarriages, still-births, and infantile convulsions occur in increased frequency in the families of lead-workers. In the extraction of gold and in certain of the arts the use of **mercury** leads to mercurial poisoning. Workers in **copper** rarely suffer from subjective symptoms, but may have the hair, skin, and mucous membranes tinged green by the presence of copper salts. **Brass workers** may develop anemia, tachycardia, nausea, vomiting, pains of the throat and abdomen succeeded by progressive emaciation, and a green line may be present on the gums. Murray attributes these symptoms to the absorption of copper. Those who work in atmospheres exposed to **irritating fumes,** as from nitric and hydrochloric acid, chlorin, and bromin, are prone to develop affections of the upper respiratory tract. The vapors of sulphuric acid, however, seem comparatively harmless, and, indeed, enjoy the repute of conducing to good health. In **match factories** a necrosis of the jaw-bone due to phosphorus (**phossy jaw**) occurs.

FIG. 5.—GANGRENE OF THE FINGER RESULTING FROM THE CONTINUED APPLICATION OF A WEAK SOLUTION OF CARBOLIC ACID. —(*Harrington*.)

In the manufacture of **potassium bichromate,** poisoning characterized by forms of eczema, headache, ulceration, and perforation of the nasal septum among the employees is not uncommon.

The impure hydrogen used for inflating **balloons** often contains considerable quantities of arsenic that may induce serious poisoning in aeronauts.

In the manufacture of **vanilla flavors** workers may develop skin eruptions, pruritus, and furunculosis, headache, nausea, vertigo, insomnia, muscular pains, and irritation of the bladder. This is attributed to molds found upon the vanilla, or to cardol present in the oil of the cashew-nut that is used to improve the appearance of the vanilla bean.

The use of potassium cyanid in certain **photographic** processes occasionally leads to poisoning.

Physicians and their patients have experienced toxic effects from the use of **antiseptics** or surgical dressings impregnated with certain chemicals. Mercuric chlorid, carbolic acid, formaldehyde, iodoform, and bismuth subnitrate are the principal substances that have thus caused poisoning. (See Fig. 5.)

The substitution of aseptic for antiseptic surgery obviates the danger to the patient, and the surgeon who uses toxic solutions may diminish his personal danger by wearing, during the course of operation or dressings, sterile rubber gloves over his previously sterilized hands.

The relatively high **mortality** associated with certain occupations is often traceable to an associated toxic influence. The following table indicates that renal and urinary diseases and gout are closely related to lead-poisoning and alcoholism, and that they frequently express occupational intoxications.

RELATIVE MORTALITY OF GOUT, RENAL DISEASE, URINARY DISEASE, AND LEAD-POISONING IN RELATION TO OCCUPATION—(*After Poole*)

	Gout	Renal Disease	Urinary Disease	Plumbism
Occupied males, ...	2	27	14	1
London, ...	6	37	19	0
Industrial, ...	2	33	17	1
Agricultural, ...	2	21	11	1
Lead-workers, ...	0	85	76	2–11
Plumbers and painters, . .	10	63	0	10
File-makers, ...	0	82	0	75
Farm laborers, ...	0	12	0	0
Potters (earthenware), . . .	0	0	0	17
Glass-makers, ...	0	0	0	14
Law clerks, ...	8	56	35	0
Physicians, ...	8	56	23	0
Building trades, ...	4	0	0	0
Liquor dealers, ...	20–10	70–50	36–23	0

The **prevention** of these toxic effects is rarely difficult, provided sufficient care be taken. Those working in lead and silver mines, or engaged in other occupations in which lead is encountered, should take particular care as to cleanliness. All the water drunk should carefully be covered to protect it from contamination, and the addition of sulphuric acid is advised as a useful prophylactic measure. Workmen should eat their meals outside the factory, and should carefully wash the face and hands and cleanse the nails before each meal.

Great care should be taken that the lead-impregnated dust in smelters is carried off through proper exhaust flues, and that the rooms in which the workmen are engaged are kept in as cleanly a condition as possible. Proper respirators should also be worn if the air is dusty, and the clothing should frequently be changed and washed, that the particles of lead entangled in its meshes be not absorbed. Irritating fumes may usually be carried off by proper flues and hoods. Where this is not entirely successful, respirators impregnated with the appropriate neutralizing chemical should be worn. **'Phossy jaw'** has been found to occur chiefly in those with decayed teeth, and the greatest care should be taken by these workers that any cavities be promptly filled. The use of the red instead of the yellow phosphorus does away largely with the danger of phosphorus-poisoning in the manufacture of matches, and should be generally adopted.

Neurosis from Occupation

The loss of the natural coordinate action of related groups of muscles, already mentioned as occupation spasms or palsies, is most frequent in those exposed to severe mental strain or in those with neurotic tendencies. Occupations associated with great mental effort frequently lead to forms of **hysteria, neurasthenia,** and **paralytic dementia.** To such affections **statesmen, artists, financiers, journalists, authors, lawyers, physicians, teachers,** and **students** are especially predisposed; the more so if they neglect physical exercise, mental diversion, and opportunities for outdoor life, or resort to artificial stimulants to maintain their flagging energies. In the latter event grave psychoses may become superadded, as discussed under the head of 'Dissipation.' The comparatively isolated life of **agriculturists,** with its tendency to brooding and introspection, seems to favor the development of **melancholia** and forms of **insanity.** Neurasthenia, therefore, is often a product of urban life, melancholia of rural life.

The **prophylaxis** of these conditions is obvious: relief from mental strain and a closer association with nature for those predisposed to neurasthenia; the cultivation of the more attractive social diversions and relief from monotony, for those with melancholic tendencies.

CHAPTER IV

THE EXTRINSIC CAUSES OF DISEASE—ANIMATE

Vegetable Parasites—Bacteria: Distribution; Penetration; Biology—Morphology and Classification; Reproduction; Sporulation; Food Requirements; Effect of Physical Agents; Metabolic Properties; Pathogenesis. Yeasts: Morphology; Pathogenic Properties. Molds: Varieties; Pathogenic Properties. Animal Parasites—Protozoa. Diptera. Hemiptera. Arachnidia. Ixodia. Annelida. Entozoa.

Parasites

In the differentiation and evolution of species of both animals and plants the economy of nature has adapted certain forms to derive their nourishment, fully prepared, at the expense of other forms upon which they live as **parasites.** The degree to which parasitism is carried varies greatly; some forms, apparently purely parasitic, not being known to enjoy any independent existence, and having, as the result of continuance of parasitic life, surrendered those organs essential to independence; while other forms are only exceptionally and occasionally parasitic as the result of accidental conditions. Thus, the **tape-worm** is without an alimentary apparatus of its own, and lives by imbibing through its cuticle the nutritious juices in the intestine of its host, while the **maggots** of certain flies are parasitic only when the adult has an opportunity to deposit her eggs upon some part of the animal body into which the larvæ may burrow.

Among plants the same thing seems to be true, and we find that certain bacteria are unknown in nature except in association with the pathologic conditions they cause, while other well-known and widely distributed bacteria of the soil only occasionally enter the body to damage it. Among the former are the bacilli of leprosy and glanders; among the latter, those of tetanus and malignant edema. A hasty consideration of living things enables us to divide them into **purely parasitic, occasionally parasitic,** and **non-parasitic** forms. The great majority are non-parasitic or independent. The occasionally parasitic types usually conform in structure to independent forms, and show little that is peculiar to their occasionally parasitic existence. The purely parasitic forms, however, show some marvelous structural modifications by which they have become adapted to their mode of life. Among these is the loss of digestive organs and a remarkable development of the reproductive organs by which, in spite of their peculiarly sequestered life, offspring is secured. This refers especially to the **entozoa,** or intestinal worms.

Parasitic existence is usually completed in a single host, but in some cases at least two hosts, usually of different species,—sometimes widely different species,—are required. This is best illustrated by the very complicated life history of the malarial parasite, which passes part of its existence in man, and part in the mosquito. Sometimes the parasite lives one period of its existence in an animal, and then spends another period as a free organism in the soil or in water—as the coccidium of rabbits, which is sometimes a parasite of man, and spends its early life in the epithelial cells of the intestine or bile-ducts, and completes its development in moist soil; or the Anchylostoma duodenalis, which in its embryo state lives in the soil, and enters the human body to be an intestinal parasite in its adult form.

Parasitism is widely distributed throughout both animal and vegetable kingdoms. Of the vegetable parasites that are associated with disease in man, the chief interest attaches to **bacteria** and **molds ;** of the animal parasites, the **protozoa, worms,** and **insects** are most important.

VEGETABLE PARASITES

Bacteria

Bacteria are minute unicellular plants, usually devoid of chlorophyl, chiefly multiplying by fission. The small size, wide distribution, resisting powers, ability to live upon any diffusible proteid material, and other essential peculiarities of the bacteria, make them the most common of all parasites. Indeed, these very conditions determine that they shall be invariably present in parasitic existence upon and within every higher animal.

Distribution of Bacteria upon the Surfaces of the Human Body

Bacteria are found almost everywhere that life can exist. Some forms are habitually present in the soil, some prefer to develop in water. From the soil they enter the air as dust, and are thus more widely distributed. From the time of birth every animal receives them upon its skin, inhales them with the air, swallows them with food and drink, and soon becomes regularly inhabited by such species as find residence within or upon him possible. Some species find the moist surfaces of the **skin** most satisfactory, and upon the skin we find a mixed flora consisting of habitually parasitic cocci of several forms; a peculiar bacillus, the Bacillus smegmatis, where the skin is particularly greasy; and, accidentally present, forms simply clinging to the surface upon which they have temporarily lodged. The **mouth,** with its slightly albuminous saliva, and occasional food particles decomposing about the crevices of the teeth, has its own regular and invariable flora, together with a variable mixture of accidentally present organisms recently entered from the air or from food. The **nose** catches many forms from the inspired air, but its mucous membrane seems to have a slowly destructive effect upon them, so that the flora of the nose is not large. The **throat** receives bacteria from the nose, through the posterior nares, and from the mouth, as well as from the inspired air; it has, however, but a scanty flora, whose chief places of habitat are the crypts of the tonsils and various membranous folds.

The **stomach** usually contains few bacteria during health, probably because of its strongly acid secretion. Those present depend upon contributions from the mouth and from swallowed foods and drink, rather than upon multiplication of any single form. The **intestine,** however, having alkaline semi-fluid contents rich in proteids and carbohydrates, affords an almost perfect developing ground, and it is there that the greatest number and largest variety are found. Of the invariable parasites of the intestine may be mentioned the Bacillus coli communis and the Bacillus lactis aerogenes, although others of less importance are always present. The intestine also affords the best possible incubator for occasional pathogenic bacteria, so that numerous infections originate in that viscus. From it they may also ascend the **bile-duct** to the **gall-bladder.** The **conjunctiva,** the **external ear,** and the **female genital organs,** being moist and more or less exposed to infection either directly by dust and by the fingers, or indirectly from the skin, also possess an invariable as well as an accidental flora.

Under ordinary conditions, the **invariable flora** of all these parts of the body is harmless; that is, it consists of parasitic bacteria, yet of organisms devoid of virulence and subject to rapid destruction by the defensive mechanisms of the body. It always remains possible, however, that either through reduction of the vital resistance of the individual, or through the unexpected advent of unusual and virulent organisms, infection may take place and disease result.

Penetration of Bacteria into the Interior Organism

It was formerly taught that the defenses of the body are so regulated that it is impossible, during health, for any of the bacterial parasites to be **absorbed** from the body-cavities or surfaces into the tissue-juices and circulating blood. With a new technic which he adopted, Adami has succeeded in disproving this, and has shown that from the intestine a few bacteria, at least, are continually being absorbed, and do enter the circulation to meet with subsequent gradual destruction in the liver. In many of the wasting diseases, and at the termination of many acute illnesses, the defensive mechanisms of the body seem to fail, and permit the ready entrance of the parasites into the circulation, while it is said, though the evidences are somewhat conflicting, that during the death agony there is a ready admission of intestinal bacteria into the lymph channels and blood-vessels.

The constancy of certain bacteria upon the surface and in the cavities of the body, and the frequency of virulent forms among them, should not be lost sight of when **surgical operations** are to be performed; but should impress upon the surgeon the importance of making no larger exposures than are necessary, of adopting the utmost precautions that nothing is permitted to enter from the surface, and of making sure that every manipulation is preceded by most careful attempts to destroy the parasites in the neighborhood of the site of operation, as well as those upon the hands and instruments of the operator.

Biology of Bacteria

Morphology and Classification.—In the absence of better characteristics by which to classify them, bacteria are usually divided into groups whose morphologic peculiarities are fairly constant. This, however, is far from satisfactory from the botanic standpoint, as it leads to mistakes as embarrassing as would be the inclusion of the whale among fishes. The best attempt at classification is that of Migula, which forms the basis of the following :

A. EUBACTERIA.

I. Order **Coccaceæ.**—Cells globular.

(*a*) Cells without flagella:

1. Division in only one direction of space—Streptococcus.
2. Division in two directions of space—Micrococcus.
3. Division in three directions of space—Sarcina.

(*b*) Cells with flagella:

1. Division in two directions of space—Planococcus.
2. Division in three directions of space—Planosarcina.

II. Order **Bacteriaceæ.**—Cells short or elongate, cylindric, straight. Without a sheath surrounding the chains of individuals; motile or non-motile; endospores present or absent. No true branching.

1. Flagella absent; endospores present or absent—Bacterium.
2. Flagella present:
   (*a*) Flagella arising from any part of the body of the organism (peritricha)—Bacillus.
   (*b*) Flagella attached to one or both poles (monotricha, amphitricha, or lophotricha)—Pseudomonas.

III. Order **Spirillaceæ.**—Organisms elongate, curved or spirally bent, generally motile through polar flagella.

1. Rigid or inflexible organisms:
   (*a*) Without flagella—Spirosoma.
   (*b*) With flagella:
   * With one, two, or three polar flagella—Microspira.
   ** With a bundle of polar flagella—Spirillum.
2. Flexible, often undulating when in motion, motive organs not demonstrable —Spirochæta.

IV. Order **Chlamydobacteriaceæ.**—Cells short or long, cylindric, or filamentous; often clavate-cuneate or irregular in form. Without endospores, but with the formation of gonidia-like bodies at the segmentation of the cells. Without flagella. Division at right angles to the axis of the rod or filament.

(*a*) **Mycobacteria.**—Filaments not surrounded by a sheath; with dichotomous branchings.

1. Cells in their ordinary form, short cylindric rods, often bent and irregularly swollen, clavate or cuneate; at times Y-shaped forms or longer filaments with true branchings. May produce short conoid forms, perhaps gonidia—Mycobacterium (including Corynebacterium).
2. Cells in their ordinary form appear as long branched filaments. Produce gonidia-like bodies. Cultures generally have a moldy appearance due to the development of aerial hyphæ—Streptothrix (Oospera).

(*b*) **Chlamydobacteria.**—Exhibit varied developmental stages; are surrounded by a dense sheath or capsule; show branched and unbranched forms.

1. Cells united in threads which show pseudodichotomous branchings. Division in one direction of space only. Vegetative increase by separation of entire branches. Propagation by swarms of polar ciliated bodies—Cladothrix.

2. Cells united in unbranched threads which, at first, divide only in one, but later in all three directions of space—Crenothrix.
3. Cells at first united in unbranched threads, subsequently dividing in all three directions of space. Later, some of the cells grow out through the very fine, loosely attached capsule and predispose to branching—Phragmidiothrix.
4. Unbranched, non-motile threads inclosed in a fine capsule. Division in one direction of space only. Cells contain sulphur granules—Thiothrix.

B. THIOBACTERIA.

V. **Beggiatoaceæ.**—Cells united into threads, unencapsulated. Division in but one direction of space. Motile by an undulative membrane.

1. Cells containing sulphur granules—Beggiatoa.

The first three orders,—**Coccaceæ, Bacteriaceæ,** and **Spirillaceæ,**—because of their monomorphism, simpler structure, and the lack of any special reproductive organs, are known as the LOWER BACTERIA, while the others are termed HIGHER BACTERIA.

It is among the **lower bacteria** that the great majority of important—pathogenic—bacteria occur, so that with an occasional future reference when necessary, we can dismiss the higher bacteria from consideration.

Unfortunately, the endeavors of systematic writers to secure the adoption of a scientific nomenclature have not met with universal acceptance, and the general rule that has prevailed since the days of Cohn is still applicable, and most writers speak of the spheric or nearly spheric forms as **cocci,** while the elongate forms are called **bacilli,** except when their spiral windings make it necessary to speak of them as **spirilla.**

As the essential peculiarities of the higher bacteria will be easily understood by reference to the table of classification, the **morphology of the lower bacteria** will be described in detail. (See Fig. 6.)

Each bacterium consists of a single cell. This cell is, however, by no means as simple as its diminutiveness might suggest. It is surrounded by a distinct, dense, highly refracting capsule or cell membrane which can for a long time resist the effects of dryness and heat, and which is with difficulty penetrated by chemical agents. There seems to be comparatively little cytoplasm, as nearly the entire substance within the capsule is made up of a large nucleus, which stains faintly with nuclear stains, but much more readily with anilin dyes. This nucleus undergoes certain changes resembling those of karyokinesis, when the cell divides. The cytoplasm sometimes contains granules of pigment, sometimes granules of fat, sulphur, and other substances. When ordinarily stained, the en-

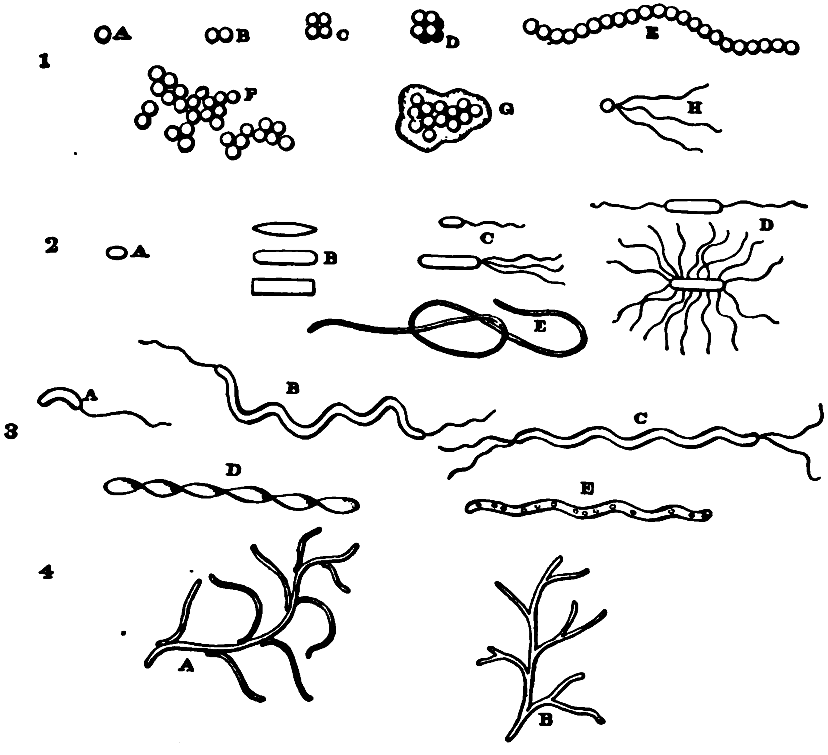

FIG. 6.—VARIOUS FORMS OF BACTERIA.

1. Cocci.—A, Micrococcus—a single organism; B, Diplococcus—two conjoined organisms; C, Tetracoccus—four conjoined organisms; D, Sarcina—cubical bundles of organisms; E, Streptococcus—chains of organisms; F, Staphylococcus—irregularly grouped organisms; G, Ascococcus—irregularly grouped organisms surrounded by a dense capsule; H, Coccus with flagella. 2. Bacilli —A, Bacterium; B, Bacilli of different types; C, D, Bacilli with flagella; E, Leptothrix. 3 Spirilla.—A, Spiromonas—short comma-shaped organisms with a single flagellum; B, Spirochæta—long flexile spiral with terminal flagella; C, Spirillum—long rigid forms with terminal flagella; D, Spirulina—flattened spiral bands; E, Ophidiomonas—spiral organism with sulphur-granules. 4. Mycobacteria—A, Cladothrix—characterized by false branchings; B, Streptothrix—characterized by true branchings.

tire bacterium appears nearly homogeneously colored with the intensely penetrating solutions usually employed for the purpose. By double staining with faint solutions the structure can be brought out.

Some species are peculiar in that their capsules either swell into a mucilaginous mass, or that some such substance is secreted by it, so that each organism when dried and stained appears to be surrounded by a distinct halo. This appearance is best seen in the Bacillus aerogenes capsulatus, Pneumococcus, Bacillus mucosus capsulatus, and Pfeiffer's capsule bacillus. In some cases this mucilaginous substance does not cling closely to the cell, but surrounds masses of bacteria, as in the form known as zooglea. The rare form described by Billroth as 'ascococcus' possessed an encapsulating substance of cartilaginous density.

The chemical composition of the bacterial cell is complex. The old investigations of Nencki showed the chief constituent to be a proteid to which he gave the name mycoprotein, and worked out a formula. At the present time too much attention should not be paid to general studies, as the analyses of particular bacteria show their composition to be quite different. Thus, de Schweinitz has shown that the tubercle bacillus differs from most other bacteria in containing a very high percentage of an irritating fat.

The bacteria are very small and very light. For their measurement the mikron (μ) or 0.001 mm. ($\frac{1}{25000}$ of an inch) is used. Illustrative of their diminutiveness, we may mention that the micrococcus of progressive abscess formation in rabbits (Sternberg) measures 0.15 μ, and that a very large coccus, the Diplococcus albicans amplus, measures only 2.8 μ. The small bacillus of mouse septicemia measures $1 \times 0.2\ \mu$; the large bacillus of anthrax, $5 \times 1.5\ \mu$. Being so small, and in the dry state very light, they may enter the atmosphere as dust and remain suspended in it for a long time.

When actively growing under natural or artificial conditions, many of the organisms are motile, the movement in nearly all cases being achieved through the presence of **flagella** or cilia, which project from the capsule, or from the body of the organism through the capsule. The flagella are very delicate, undulating in most cases, though sometimes short and straight, and in different genera show a different arrangement. Sometimes a single flagellum is attached to one end of an organism (**monotricha**), sometimes there is one at each end (**amphitricha**). In some cases a bundle of polar flagella is seen (**lophotricha**). Many forms show flagella arising from all parts of the body-surface (**peritricha**). Migula has, as will be seen by reference to the table of classification, made use of these peculiarities for the purpose of separating the different genera.

Very rarely an ameboid bacterium is observed (Bacillus megatherium). The motility of forms not possessing flagella is supposed to depend upon an undulating membrane, or upon contractile protoplasm.

The **multiplication** of bacteria takes place by fission; hence they are known as **schizomycetes,** or cleft fungi. The process is preceded by indefinite karyokinetic changes in the nucleus. The organisms which are about to divide are a little larger than usual. Cocci at this time become elongate or oval. The bacilli and spirilla always divide by transverse fission. Some of the higher bacteria occasionally show longitudinal cleavage of the terminal segments by which the branchings are started. The multiplication of bacteria takes place with immense rapidity. In rapidly growing forms the length of a generation has been found to be about twenty minutes. A simple arithmetic calculation will show to what enormous numbers this rate of increase will give rise in a couple of days. (See Fig. 7.)

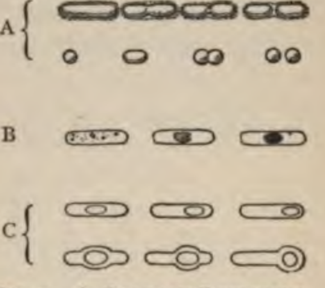

FIG. 7.—A, DIAGRAM REPRESENTING THE DIVISION OF BACILLI AND COCCI. B, DIAGRAMMATIC SCHEMA OF THE DEVELOPMENT OF THE SPORE. C, APPEARANCES PRESENTED BY BACILLI CONTAINING SPORES.—(*After Novy.*)

The permanence of the species is secured in some cases through general ability to resist drying and assume a latent form. In such species the duration of life in unfavorable conditions is probably not long. Other forms produce what Hueppe has called **arthrospores,** an entire bacterium either assuming a specialized condition in which it is more highly resistant than usual, or splitting up into a number of specialized spores. By far the best understood method of securing permanence is by the formation of **endospores,** the ordinary spores of which mention is so frequently made. These spores are formed within the bacterial cell, each bacterium producing a single spore. The spore first makes its appearance as a refractive granule in the cell, gradually increasing in size until usually about its diameter. It then ceases to increase, gradually assumes a regularly ovoid or spheric shape, and develops a distinct capsule. The bacterial cytoplasm and capsule remain for some time surrounding the spore, but ultimately the death and disintegration of the cell liberate it.

The spores are usually formed by bacilli and spirilla, very rarely by cocci. They usually occur centrally in the cell, not increasing its diameter. There are, however, marked exceptions to this. Sometimes the diameter of the spore exceeds that of the bacterium, so that the latter bulges laterally like a barrel to accommodate it. Such a form is called a **clostridium.** It is common among the anaerobic bacilli, and among a few aerobic forms also, for the spore to be situated at one end of the bacillus, where a more or less marked expansion occurs in consequence. These forms, well illustrated by the tetanus bacillus, are called by the Germans 'drumsticks.' The spores may be spherical or ovoid in form.

The spores are extremely resistant to external conditions. They endure drying in many cases for years, so that silk threads saturated with anthrax spores may be kept on hand in the laboratory, always ready to furnish a culture of the organism when dipped in culture-

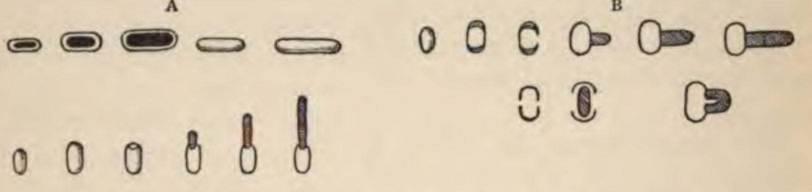

FIG. 8.—DIAGRAM ILLUSTRATING THE ESCAPE OF YOUNG BACILLI FROM SPORES. A, Bacillus anthracis, in which the bacilli escape from the end of the spore; B, Bacillus subtilis, in which the bacilli escape from the side of the spore.—(*After Novy.*)

media. Dry heat up to 150° C. is tolerated by most spores; many resist moist heat to 100° C. for a few minutes. Tetanus spores can tolerate a moist heat of 80° C. for more than an hour. Against chemical agents they are also well defended by an almost impervious capsule, so that they can be stained only with the most penetrating solutions of the anilin dyes, and to kill them by disinfectants requires the application of degrees of concentration far beyond those necessary for the destruction of the bacteria themselves.

When a spore reaches conditions appropriate for the growth of the bacteria, it gradually increases in size by the growth of the young bacillus within it, and ultimately splits open, allowing the organism to escape from its shell. There is a difference in the mode of escape; some species, as Bacillus subtilis, escaping from the side of the spore, which splits transversely; others, as Bacillus anthracis, escaping from the end, which opens to liberate it. Migula has thought this character sufficiently important to adopt as a means of classifying the bacilli. (See Fig. 8.)

The higher bacteria, showing close relationship to the oidiums and molds, not uncommonly produce spore-like bodies (sometimes ciliated) only upon special, usually terminal, reproductive segments.

Physiology

Nutriment.—Inasmuch as the bacteria (with possible rare exceptions among the higher bacteria) contain no chlorophyl, they are usually unable to live upon purely inorganic matter. The least quantity of **organic substance,** however, suffices for them. Diffusible proteid substances are best adapted to their requirements. The species differ very greatly among themselves as to the quantity of food they require, and the quantity and quality they require at different times. Thus, although the lepra bacillus grows successfully in the human body, it is improbable that its experimental cultivation upon artificial media has ever been achieved, no sufficiently well-adapted medium having yet been prepared.

The tubercle bacillus was isolated by Koch upon blood-serum. Roux succeeded in isolating it upon glycerin agar-agar, and Theobald Smith has taught us that dog's blood-serum is the most appropriate medium for the purpose. Having secured a primary growth upon any of these media, the organism grows pretty well when transplanted, and in the course of time becomes so acclimated to its new surroundings as to permit very considerable modifications in its diet. Indeed, Proskauer and Beck succeeded in cultivating it in so simple a mixture as: Ammonium carbonate, 0.35 per cent.; potassium phosphate, 0.15 per cent.; magnesium sulphate, 0.25 per cent.; and glycerin, 1.5 per cent.

Opposed to the requirement for concentrated nutriment shown by these organisms, we find that certain water bacteria succeed in maintaining their existence in commercial (not absolute) distilled water, deriving nourishment from the almost inappreciable pollutions from the containers and the atmosphere.

Similar variations exist regarding the quantity of **moisture** essential to bacterial life. In general, about 80 per cent. of water seems most favorable to them. The Bacillus prodigiosus can grow upon dry crackers.

It makes a great difference to bacteria whether the **reaction** of the substratum is acid or alkaline. In general, a neutral or slightly alkaline reaction is preferred. There are a few bacteria that can flourish in strongly alkaline solutions like putrescent urine, or in strongly acid solutions, such as the fermenting gastric contents in malignant disease of the stomach, when the lactic acid bacillus grows plentifully.

Oxygen is, of course, essential to bacteria, but their manner of securing it is peculiar and interesting. Some forms can live and grow only when in intimate relation to the air. Among these, the tubercle bacillus is a typical example. It grows only upon the surface of culture-media, and only when an abundance of air is present. Other bacteria are inhibited from performing their vital manifestations by the presence of free oxygen, and live entirely upon combined oxygen, which they free from its combinations by chemical means. The tetanus bacillus is a typical example of the micro-organisms of this class. Between the extremes given there are many forms that can exist and multiply with or without free oxygen.

The peculiarities of the bacteria in this respect have enabled us to divide them into certain groups, which materially aid in the recognition of similar species:

I. Aerobic Bacteria, ...	**Obligatory.**—Unable to vegetate except in the presence of uncombined oxygen.	
	Optional.—Able to thrive equally well with or without uncombined oxygen.	
II. Anaerobic Bacteria, ...	**Obligatory.**—Unable to grow where any uncombined oxygen is present.	

Temperature has considerable influence upon bacterial life, though these lowly organisms are by no means so sensitive to the extremes of temperature as are the higher vegetables.

Cold, except it be extreme, simply inhibits bacterial growth. Freezing temperatures destroy most of the bacteria in a culture, but many always survive, and even frequent freezing and thawing fails to kill them all. The extremely low temperature of liquid air kills the majority of the bacteria in an exposed culture, yet a sufficient number to secure the maintenance of the species usually survive even a lengthy exposure. The effect of heat is much more pronounced than that of cold. Bacteria begin to grow at 6° C. (42.8° F.), but only the most vigorous saprophytic forms can develop at such temperatures.

Flügge found that bacilli can grow very slowly at 6° C., and that fission did not occur oftener than once in four or five hours until 12.5° C. (54.5° F.) was reached. At 25° C. (77° F.), fission occurred every forty-five minutes, and at 30° C. (86° F.) every thirty minutes. The saprophytic bacteria, being accustomed, for the most part, to the usual atmospheric conditions, grow at quite low temperatures, but the parasitic forms usually flourish only at temperatures approximating those of the body of the animal to which they are accustomed, so that the tubercle bacillus, gonococcus, pneumococcus, streptococcus, etc., grow best at 37° C. (98.6° F.). The bacteria that produce febrile affections can successfully endure the temperature of pyrexia, and even hyperpyrexia, but as the temperature ascends beyond 40° C. (104° F.) there is a considerable falling-off in their vitality. At temperatures such as 41° and 42° C. (106° and 108° F.) the anthrax bacillus and some other bacteria begin to lose virulence. At higher temperatures they become inactive, and at 50° C. (122° F.) the danger limit to their life is approached. There are many non-sporogenous bacteria that are killed at 60° C. (140° F.) upon any prolonged exposure, and at 70° C. (158° F.) many more die. Few forms without spores can withstand 75° to 80° C. (167° to 176° F.). No non-sporogenous bacterium can endure in the moist state 100° C. (212° F.). The **spores** vary in their ability to withstand heat. Spores of anthrax are killed by exposure to 100° C. for more than five minutes; some spores resist longer.

A few bacteria whose chief peculiarity is to grow in the warm water of 'hot springs' are remarkable for their ability to withstand high temperatures, and are called **thermophilic**. Temperatures of 60° to 70° C. (140° to 158° F.) are appropriate for their development. Other thermophilic forms occur in decomposing manure, etc.

Light is rarely essential, and not infrequently is detrimental, to bacterial growth. Exposure to the direct rays of the sun or to an arc-electric light inhibits the growth of, and destroys many forms of bacteria. Virulent forms are also commonly attenuated by such exposure. A few of the chromogenic forms produce their colors best in the light. The Bacillus mycoides roseus produces its rosy color only in the dark. In investigating which rays of the sun act most energetically upon bacteria, it has been determined that the blue and violet rays have the strongest inhibitive powers.

Electricity has under ordinary conditions no influence upon bacteria. The passage of powerful continuous or interrupted currents through cultures usually produces no effect unless the temperature increases to an injurious height.

The **X-rays** are thought to exert an inhibitive effect upon bacterial growths and, upon prolonged exposure, to destroy their virulence and diminish their vitality. Under ordinary conditions, bacteria are not destroyed by the X-rays.

Movement is prejudicial to bacterial growth. The condition of perfect quiescence is that best adapted to their development. Slow flowing movements have little effect, but violent agitation greatly diminishes or completely retards growth. This affords one explanation of the fact that the water of rivers and streams with frequent waterfalls and rapids is usually freer from bacteria than deep-flowing waters.

Association of different species of bacteria has a profound influence upon their life history. This subject has only recently acquired experimental evidence, but the result of careful observation is convincing of the fact. Sanarelli observed that the growth of Bacillus icteroides was greatly favored by association with certain molds. Coley found a different effect from sterilized cultures of the streptococcus in which Bacillus prodigiosus had been grown for a time. Pawlowski found when the anthrax bacillus and Bacillus prodigiosus were mixed and injected into animals, the anthrax bacilli became less virulent and often failed to kill the animals inoculated. Meunier found that the growth of the influenza bacillus was greatly favored by association with Staphylococcus aureus. Hankin found a micrococcus (Micrococcus ghadialli) which destroyed typhoid bacilli when added to its cultures.

This **modification of virulence** and occasional destruction of bacteria that results from association, is pregnant with interest to both medical and surgical clinicians. It explains why the pathologic processes with which they have to deal, and which are usually mixed infections, so widely differ in course and symptomatology from the experimental infections produced with pure cultures in the laboratory; and it suggests therapeutic possibilities.

The means by which bacteria and their effects upon animals are modified by association are numerous: (1) One organism may be endowed with such active vegetative powers that it at once proceeds to outgrow its associate and appropriate all the nutriment; (2) the toxic product of an organism may be consumed by another, so that its virulence is destroyed; (3) the metabolic products of one species may be injurious to another; (4) some species form enzyms by which other species may be dissolved; (5) the combination of the metabolic products of two organisms may affect the infected animal very differently from the products of either organism singly; (6) the products of different organisms may neutralize one another.

Metabolism

The chemical processes by which bacteria derive their sustenance from the substratum in which they grow are attended with molecular alterations resulting in a number of interesting changes.

1. **Fermentation.**—Chiefly through enzyms, which many of them generate, bacteria are capable of setting up fermentation and putrefaction. By **fermentation** we mean the splitting of carbohydrate substances into alcohol, various acids, and gases. **Putrefaction** is a similar process taking place in proteid substances and leading to more complicated changes associated with more disagreeable odors.

The bacteria by no means agree in the changes they produce. Some generate alcohol, some lactic, some butyric and other acids, from sugars. Some acting in this manner upon carbohydrates are unable to disintegrate proteids, while others can equally well break up both carbohydrates and proteids. The same kind of chemical change—the production of alcohol or of lactic acid, etc.—does not always depend upon the same bacterium, many organisms having similar action in this regard.

The form of chemical change usually brought about is one of **hydrolysis;** but sometimes **oxidation,** and sometimes **rearrangement** of the molecules, is observed.

It is by **hydrolysis** that the invertase generated by micro-organisms changes cane-sugar into dextrose and levulose, the reaction being:

$$\underset{\text{Cane-sugar}}{C_{12}H_{22}O_{11}} + \underset{\text{Water}}{H_2O} = \underset{\text{Dextrose}}{C_6H_{12}O_6} + \underset{\text{Levulose}}{C_6H_{12}O_6}$$

It is also by hydrolysis that urea is changed to carbon dioxid and ammonia:

$$\underset{\text{Urea}}{CO(NH_2)_2} + \underset{\text{Water}}{H_2O} = \underset{\text{Carbon dioxid}}{CO_2} + \underset{\text{Ammonia}}{2NH_3}$$

Oxidation is illustrated by the change of alcohol into acetic acid:

$$\underset{\text{Alcohol}}{C_2H_6O} + \underset{O_2}{O_2} = \underset{\text{Acetic acid}}{C_2H_4O_2} + \underset{\text{Water}}{H_2O}$$

Rearrangement of molecules is seen in the change of dextrose into lactic acid:

$$\underset{\text{Dextrose}}{C_6H_{12}O_6} = \underset{\text{Lactic acid}}{2C_3H_6O_3}$$

and in the alcoholic fermentation in which we find:

$$C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$$
$$\text{Dextrose} = \text{Alcohol} + \text{Carbon dioxid}$$

The formation of butyric acid from dextrose is:

$$\underset{\text{Dextrose}}{C_6H_{12}O_6} = \underset{\text{Butyric acid}}{C_4H_8O_2} + 2CO_2 + 2H_2$$

It is in the rearrangement of molecules by such processes that the **ptomains** of bacteria are formed.

Bacteria of fermentation are frequently described as **zymogenic,** those of putrefaction as **saprogenic.** It is impossible sharply to define either group, as in many cases the power of producing both fermentation and putrefaction is possessed by the same micro-organism. Both groups are commonly described as **saprophytic.**

2. **Chromogenesis,** or pigment production, is a property shared by many bacteria. It is often one of many interesting phenomena manifested. Thus, a micro-organism may be chromogenic, zymogenic, and pathogenic at the same time. All forms of bacteria show chromogenic species. The colors include all possible hues. They occasionally occur in granular form in the cells, but more usually occur as granules outside of the bacteria, formed by the oxidation of certain of their metabolic products. Nearly all pigments are best formed at room-temperature, in subdued light, and with free exposure to oxygen. Some of the pigments are **soluble,** and, being formed upon the surface, gradually extend throughout the media by diffusion; others are **insoluble** and occur only upon the surface.

The chemistry of the pigments has not been investigated thoroughly.

3. **Formation of Enzyms.**—By the production of a definite enzym that can be filtered from fluid cultures, bacteria of many varieties are able to liquefy gelatin, curdle milk, dissolve coagulated blood-serum, invert sugars, dissolve bacteria of other species, digest the casein of milk, split up fats, and produce many other remarkable effects. The study of enzyms is as yet comparatively new, and less definite knowledge is at hand than is desirable. It is

doubtless in part by the production of enzyms that bacteria produce pathogenic changes.

4. **Acid and alkali formation** by bacteria is of great importance, as it is in part by the accumulation of acids and alkalis resulting from their growth that their own processes are controlled. The most common product is ammonium carbonate, resulting from the decomposition of nitrogenous matter upon which the bacteria grow. Sodium carbonate sometimes is formed.

Acids usually occur from oxidation of carbohydrates, especially dextrose. Some organisms transform it into lactic acid, others into butyric acid.

Acids and alkalis may be produced at the same time or at different times by an organism, the final reaction being that of the predominating chemical compound. Thus, bouillon cultures of the diphtheria bacillus are very apt to be acid for a time and then to turn and remain strongly alkaline. In this case the primary acidity is partly to be explained by the fact that the dextrose present is changed to an acid so long as any is present, but that when the dextrose is all used up, enough alkali is formed in other ways to neutralize the acidity and maintain the alkalinity. Lactic acid is probably that most frequently observed, but fatty acids and butyric, acetic, formic, propionic, oxalic, and succinic acids are also formed.

5. **Gases** arise from cultures of bacteria during the processes of fermentation and putrefaction. Carbon dioxid, marsh-gas, hydrogen sulphid, free hydrogen and nitrogen, hydrogen phosphids, carbon monoxid, and ammonium derivatives are all formed. Gas-producing bacteria are described as **aerogenic.**

6. **Nitrification** is a phenomenon of bacterial life which is of interest chiefly to the agriculturist. The organisms vary greatly in this particular, some freeing nitrogen from its compounds, others absorbing and fixing free nitrogen.

Novy divides these bacteria into: (1) Those which cause a fixation of free nitrogen; (2) those which produce nitrites out of ammonia; (3) those which produce nitrates out of nitrites; (4) those which reduce nitrates to nitrites and to free nitrogen.

7. **Phosphorescence** is manifested by some of the rarer forms of the saprogenic bacteria. The organisms are usually found in putrefying salt-water fish, and can be cultivated artificially to best advantage upon sea-water agar-agar. Phosphorescence is only one of the phenomena of these organisms. The amount of light given

off by two ordinary agar-agar cultures may be sufficient to enable one to read the face of a watch.

8. Heat-production occurs during the activity of the fermentative and putrefactive processes. In green hay and in moist cotton, thermophilic bacteria sometimes generate so high a temperature as 70° C. (158° F.), and the spontaneous combustion that sometimes takes place in these substances is said to be due to sudden oxidation of this hot and putrefying material.

9. Pathogenesis, or disease production, as a phenomenon associated with bacterial life, depends upon numerous causes. From the cultures of many forms—**toxicogenic bacteria**—a definite toxic substance can be isolated. In other cases no such product can be recognized, and the pathogenesis must depend upon enzyms or products of some other kind affecting the invaded organism in some manner not yet understood.

Not all bacteria are pathogenic, and those recognized as pathogenic are not equally so for all animals. The phenomena of infection and pathogenesis are, therefore, bound up with the problems of immunity, which will be separately discussed. (See Section III, chapter XI.)

Pathogenesis

In general, the principles of bacteriology teach us that **bacteria are pathogenic:**

1. When they can effect an entrance into the animal and successfully develop there; **deranging the functions** of their host by blocking his circulatory passages, appropriating his nourishment, or interfering with the oxidation of his blood.

2. When, in the body, they eliminate some **metabolic product**—as a toxin or an enzym—by which the cells of the body are depressed or devitalized so that it becomes impossible for the normal physiologic equilibrium to be maintained.

3. When, by a local action of any kind, they lead to the formation of **morbid growths,** which by number, pressure, or subsequent retrogressive changes incite tissue disintegrations or other organic disturbances incompatible with health.

The Yeasts

These organisms, whose reproduction is characterized by budding instead of fission, are unicellular vegetable organisms larger than the bacteria, and not so common. They measure from 5 to 10 μ in diameter, are for the most part flattened elliptic bodies, and in fresh cultures show many cohering individuals of various sizes, formed in budding and not yet detached. (See Fig. 9.)

In addition to budding they form **ascospores,** several rounded spores forming within a cell. While under usual conditions the yeasts consist almost solely of the ovoid cells, they sometimes grow into elongate hyphæ and form branched mycelia-like masses closely resembling some of the oidia.

The yeasts are much less numerous than the bacteria, and no great number of species has been described. They are variable in biology and physiology, some forms, such as the rose yeast and black yeast, being chromogenic, others not so. Some are energetic

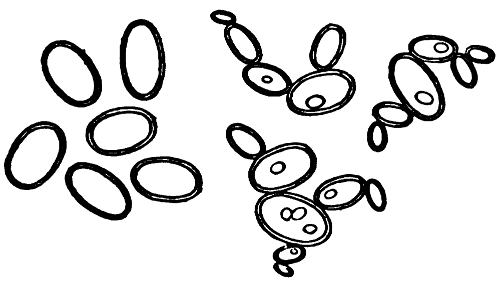

FIG. 9.—COMMON FORMS OF YEASTS, ONE WITHOUT BUDS, THE OTHER SHOWING BUDS AND VACUOLES.

fermenters, being used in the arts in the manufacture of beer and other beverages. They rarely engage in pathologic processes, though a recent tendency is to regard them (blastomycetes) as the cause of tumors. This has not been proved.

A yeast has also been described as the cause of an ulcerative dermatitis investigated by Stokes, Hektoen, and others.

Rabinowitch has described and studied some pathogenic yeasts, but their pathogenic powers fell far short of those of the bacteria.

THE MOLDS

The molds, comprising members of a number of families of much higher fungi than have yet been considered, are characterized by a growth of tangled filaments, forming what are known as **mycelia,** and resembling felt.

The individual threads making up the mycelium are known as **hyphæ.** They usually have a diameter of 5 to 10 μ, and may be divided into cells, or undivided. They branch freely. Certain of the hyphæ which bear the reproductive organs are called **fruit hyphæ.** The formation of the fruit or spores is peculiar, and varies in different species. The male fruit hypha bears an **antheridium,** the female hypha an **archegonium.** Symbiosis of these is followed by the formation of a sporoblast in which the conidia develop. The **conidiophores**, or spore-bearers, differ in the different genera.

Oidia are characterized by thick mycelia composed for the most part of short segments, and by somewhat indefinite conidiophores, upon the ends of which chains of ovoid conidia are situated.

FIG. 10.—FROM A DEPOSIT OF APHTHÆ ON THE TONGUE OF A MAN WHO DIED OF TYPHOID FEVER (× 300). —(*Zeigler.*)

The Oidium lactis causes important changes in the production of cheese, and it is said that the odor of Limburger cheese depends partly upon its presence. It also has the power of gas-production in sugar-containing media.

The Oidium albicans is the cause of the mycotic stomatitis of children known as **thrush.** In general it resembles the Oidium lactis. In the debilitated, it may cause aphthous ulcers of the mouth, pharynx, esophagus, and even a general infection, with lesions in the lungs, brain, and kidneys. (See Fig. 10.)

Mucors.—The globular molds are characterized by a peculiar sporangium of rounded shape and smooth surface attached to the ends of rather long, chiefly aerial fruit hyphæ. The sporangia are usually of a very dark color and can readily be seen by the naked eye. The conidia or spores are contained within the conidiophore, and are released only when it ruptures.

Mucors are of little importance in pathologic processes, and only a few cases of mycoses have been reported in man.

Penicillium.—The brush molds, of which Penicillium glaucum is the common species, are wide-spread molds in nature, but have no known pathogenic representatives.

They are characterized by divided hyphæ in the mycelium, and by the formation of **basidia-spores.** The fruit hyphæ are elongate, aerial, and terminate in basidia, to which the spores are attached in projecting rows. The appearance of each is something like a diminutive brush or broom. The fruit organ is flattened.

Aspergillus, the bulbous molds, of which several species are pathogenic, are beautiful microscopic plants characterized by the termination of the fruit hyphæ in rounded columnella from which

FIG. 11.—VARIOUS FORMS OF MOLDS.

1. Mucor, with undivided hyphæ and spores contained within a membranous case; 2, Aspergillus, with divided hyphæ, spores upon sterigma; 3, Penicillium, with divided hyphæ and broom-like conidiaphores.

sterigma project radially in all directions, the spores extending outward from these in rows. The fruit organ is thus **spherical.**

Aspergillus sometimes occasions an inflammation of the external **auditory meatus,** by growing in the skin of that part; the offending species being Aspergillus niger, as a rule. Aspergillus fumigatus sometimes grows in the **lungs,** into which it is inhaled, and there produces an extending and metastatic pseudo-tuberculous affection —mycosis aspergillosus—which may be fatal.

Tricophyton—of which the important pathogenic species causes '**barber's itch**' and '**ringworm**'—is a large genus including many harmless species and some that are productive of **skin diseases in the lower animals.**

Sabouraud describes two chief forms of this fungus as causing **ringworm** in man: One, the Tricophyton microsporon, the spores measuring 2 or 3 μ in diameter; the other, the Tricophyton megalosporon, with spores 7 or 8 μ in diameter. The former is the fungus of tinea tonsurans of children, especially those cases that are rebellious to treatment. Its special seat of development is the substance of the hair. The spores of this variety are contained in a mycelium which is usually not visible, the spores appearing irregularly piled up, like zooglea masses, growing outside and forming a dense sheath around the hair. Artificial cultures show a downy surface and white color.

The Tricophyton megalosporon is the chief cause of ringworm of the beard and smooth surfaces of the body; also about one-third of the cases of tinea tonsurans of children are due to this parasite. The spores are always contained in distinct mycelial filaments, which may either be resistant when the hair is broken up, or fragile, easily separated spores. When grown artificially, this tricophyton shows a powdery surface with arborescent peripheral rays and often a yellowish color.

Achorion Schonleinii, the parasite of **favus,** is a mold whose artificial development not a little resembles the oidium. It consists of a branched and complicated mycelium, many of whose segments are enlarged and clavate. Upon culture-media the growth is downy, first white, then yellowish, and very pretty. When well grown, it is usually centrally umbilicated. The conidia form upon the ends of aerial and other hyphæ, but no graceful fruit-bearers such as are seen in aspergillus and mucor are produced.

The parasite is wide-spread among the lower animals, from whom it infects man. The spores find their way into the hair-follicles, growing around the hairs and into the epidermis, the density of the growth crushing out the hair, destroying its vitality, and giving rise to atrophic scarring. The disease is characterized by the formation of tiny yellow discs, or **scutella,** depressed in the center and each pierced by a hair.

Microsporon furfur is a parasitic mold which is the cause of tinea versicolor. It is characterized by delicate mycelia with small spores, and lives in the superficial layers of the epidermis, in which in consequence a yellowish-brown color develops.

ANIMAL PARASITES

PROTOZOA

Of the **protozoa,** only a few of the rhizopoda and sporozoa have been found to be pathogenic in man. A number of the infusoria, however, have been found in the intestines. These include Cercomonas or Lamblia intestinalis; Trypanosoma; Megastomium enteri-

FIG. 12.—*a*, MEGASTOMA ENTERICUM; *b*, MEGASTOMAS UPON COLUMNAR CELLS LINING THE INTESTINE; *c*, TRICHOMONAS INTESTINALIS; *d*, CERCOMONAS INTESTINALIS.

cum; and Balantidium or Paramecium coli. Balantidium coli is chiefly found in diarrheal stools, as is also Cercomonas intestinalis. Trypanosoma has also been noticed in the vagina, bladder, and kidneys, and in pulmonary gangrene. Trichomonas intestinalis and Megastoma entericum are found in the intestinal tract, but do not usually produce symptoms. In a case observed by Quincke, Trichomonas appeared to be the cause of a persistent **chronic diarrhea.** It has also been found in the vagina. Catarrhal and ulcerative lesions of the intestine may be caused by Balantidium coli. Balantidium may be acquired from pigs.

FIG. 13.—BALANTIDIUM COLI, FROM THE CONTENTS OF THE INTESTINE. × 500.

Of the **Rhizopoda,** Amœba coli, which is chiefly found in the large intestine, and which seems an important factor in chronic dysentery and hepatic abscess, is the most important. Two varieties are found: one smaller, pathogenic in cats and identical with the tropical form, Amœba coli felis; the other, larger and non-pathogenic in cats, is Amœba coli mitis. Quincke and Roos found that only encysted amebas could survive the passage through the stomach and duodenum—at least in cats, animals from which it is believed that they are acquired.

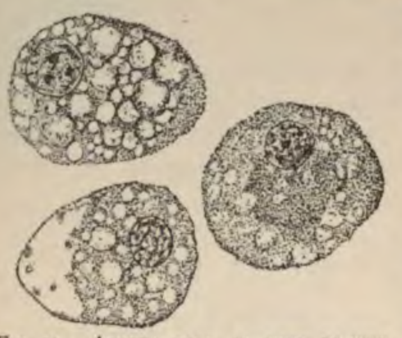

FIG. 14.—AMŒBA COLI, AS SEEN IN THE INTESTINAL CONTENTS.

To the **Sporozoa** probably belongs the parasite of **malaria,** described in Section IV (page 306). **Coccidia** develop in oxen, rabbits, mice, salamanders, cuttle-fish, centipedes, and occasionally, with the production of serious lesions, in the **intestines** and **liver** of man.

Sporozoa belonging to the order of **Sarcosporidia** have been

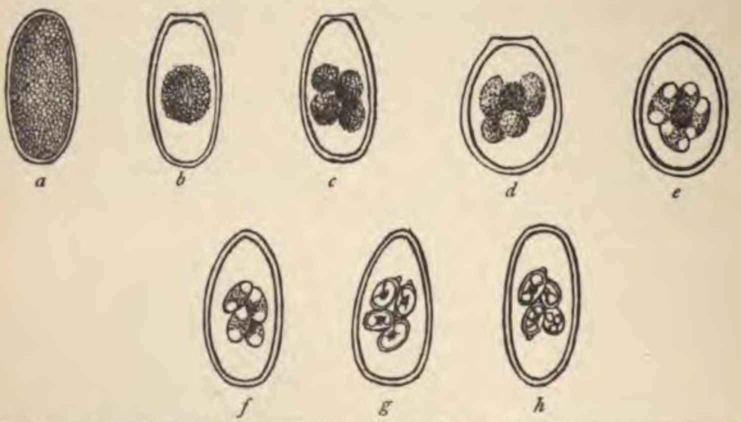

FIG. 15.—EXTERNAL CYCLE OF DEVELOPMENT OF THE COCCIDIUM OVIFORME, (*a* TO *g*) SHOWING THE DIVISION OF THE CYTOPLASM INTO FOUR SPORES, EACH OF WHICH CONTAINS TWO FALCIFORM EMBRYOS (*h*). THIS CYCLE OF DEVELOPMENT OCCURS IN DAMP SOIL OUTSIDE OF THE ANIMAL BODY.

found in the muscle-fibers of mice, cattle, and birds, producing minute cysts that are barely visible as whitish specks or that may only be seen by the aid of the microscope. But two authentic cases in man are at present on record. In one (Kartulis,

Fig. 16.—Section of the Liver of a Rabbit showing Coccidia.

Section passing through a bile-duct badly infected with the Coccidium oviforme, which can be observed as large, round, granular bodies contained within or attached to the columnar epithelium of the bile-duct. In the upper part of the section some adult encysted parasites are seen in the contents of the duct.

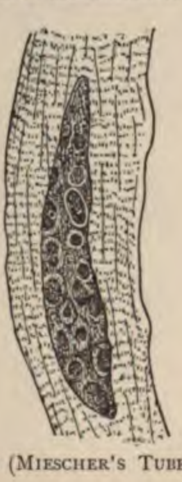

Fig. 17.—Sarcosporidium (Miescher's Tube) in the Muscle-fiber.

1895) an hepatic abscess had formed, and in the other (Baraban and St. Remy, 1894) minute cysts containing falciform sporozoites were found in the muscular fibers of the vocal bands. Theobald Smith has succeeded in conveying the disease from mouse to mouse by feeding the diseased muscle. Other methods of infection are obscure, yet obviously occur, as the disease is not uncommon in cattle. The chief means of human infection seems to be the eating of infected and imperfectly cooked meat. The danger is evidently slight.

INSECTA

Insects may be harmful in both the adult and larval forms. They cause injury mechanically by their presence; by their bites and venom; and by their invasion of the tissues. Their activity in **transmitting disease** is considered in Section II.

The **larvæ** of various insects gain entrance to the body from eggs deposited upon the person, or upon fruits, vegetables, or other foods. These may develop in the nasal passages, in the accessory sinuses, in the intestinal tract, in the vagina, or in wounds. The diseases caused have been divided into:

FIG. 18.—OX BOT-FLY OR WARBLE-FLY (HYPODERMA BOVIS). ENLARGED.—(*After Brauen; Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

1. **Canthariasis,** due to the larvæ of the coleoptera (beetles and weevils).

2. **Myiosis,** myasis, myiasis, or fly disease, originating from dipterous larvæ; and

3. **Scholechiasis**, due to lepidopterous larvæ (moths and butterflies).

Myiosis is most common. J. J. Walsh found the larva of the common meal beetle (Tenebrio obscurans) in the feces of a patient who had been using gluten suppositories. The eggs may have been deposited in the gluten flour. Caterpillars may cause a severe erythema and urticaria through poisonous cutaneous hairs. The irritation of the procession caterpillars (Cnethocampa) of Europe is notorious, and urticaria results without direct contact. In rare instances lepidopterous larvæ have been found in the intestinal contents.

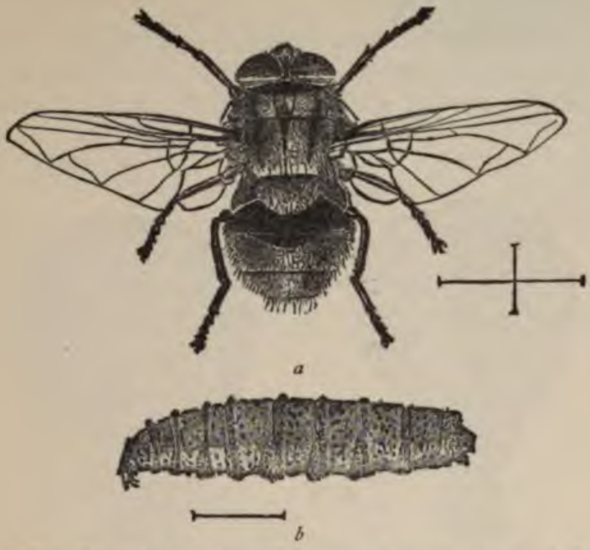

FIG. 19.—*a*, THE SCREW-WORM FLY, COMPSOMYIA MACELLARIA. *b*, SCREW-WORM OR LARVA OF LUCILIA MACELLARIA, AS FOUND IN THE NASAL SINUSES.—(*Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

FIG. 20.—SOUTHERN BUFFALO GNAT (SIMULIUM PECUARUM).—(*Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

Diptera

Most of the **parasitic larvæ** belong to the family of flies. In the **external ear,** in the **nasal fossæ** and their accessory **sinuses,** and in the **conjunctiva,** ova of the blue-bottle fly (Musca vomitoria), the

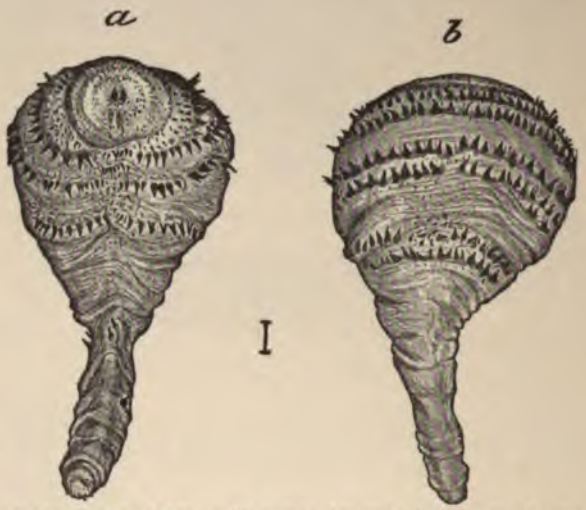

FIG. 21.—DERMATOBIA NOXIALIS. *a*, VENTRAL ASPECT; *b*, DORSAL ASPECT. GREATLY ENLARGED.—(*From "Insect Life"; Osborn, Bull. No. 5, Div. Entomology, U. S. Dept. Agriculture.*)

common flesh fly (Creophila), the bot fly (Gastrophilus equi), and Lucilia macellaria may be deposited and develop into larvæ that cause serious lesions. The presence of maggots in these places is

FIG. 22.—FEMALE JIGGER FLEA (PULEX OR SARCOPEYLLA PENETRANS), AS FOUND EMBEDDED IN THE SKIN.—(*After Blanchard.*)

FIG. 23.—GREEN-HEAD HORSE-FLY (TABANUS LINEOLA).—(*Packard's Guide; Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

much more common in tropic regions, and especially in persons of uncleanly habits. The screw-worm, the larva of Lucilia macellaria, found in tropic and subtropic North America, destroys both the soft and osseous tissues, and may penetrate from the nasal sinuses to the **brain.** In 44 recorded cases there were 30 deaths. Dipterous ova may also be deposited in **wounds,** and in the **vagina** after parturition. After ingestion of the eggs of the common house fly, the blue-bottle fly, or the flower fly, the larvæ may set up a marked irritation in the **intestinal** tract. More or less **local irritation** may be produced by such biting flies as Stomyxes and Tabanus. The larva of the ver Mocaque (Dermatobia noxialis) of Mexico, the Mecaco worm of New Granada, and the ver du Cayor (Ochromyia anthropophaga) of Africa, also burrow beneath the **skin.**

FIG. 24.—SCABIES. SECTION OF SKIN SHOWING BURROWS (*f*) IN THE UPPER LAYER OF THE EPIDERMIS (*a*), CONTAINING FEMALE ITCH-MITES (*d*), OVA (*e*), AND FECES (*f*).

a, Horny layer; *b*, mucous layer and papillary body with cellular infiltration; *c*, infiltrated cutis.—(*After Ziegler.*)

Siphonaptera

The fleas are suctorial, wingless insects possessing great leaping power and closely related to the Diptera. While each kind seems to have a particular animal as its normal host, they often, for a temporary period at least, migrate to other species of animals. Thus, the hen flea, the rat and mouse flea, or the dog and cat flea may affect man. The common house-flea (Pulex irritans) is distinguished from those of the dog and cat by the absence of spinous combs about the head. The jigger flea, or chigoe, occurs in tropic and subtropic regions, infesting lower animals and man. After impregnation the females burrow into the skin, especially under

FIG. 25.—LICE INFESTING MAN.

a, Body louse (Pediculus corporis vel Pediculus vestimentorum), female, showing ventral surface; × 9. *b*, Head louse (Pediculus capitis), female, showing ventral surface; × 13. *c*, Crab louse (Pediculus pubis), male, showing ventral surface; × 13.—(*Küchenmeister and Zürn.*)

FIG. 26.—THE BLOOD-SUCKING CONE NOSE ('BIG BEDBUG'), CONORHINUS SANGUISUGA. *a*, NYMPH; *b*, ADULT.—(*From Amer. Entom.; Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

the toe-nails, producing a vesicular or pustular inflammation. If the insect's greatly distended body be ruptured within the tissues, liberating the larvæ, serious inflammatory changes may follow.

Hemiptera

The Hemiptera are suctorial insects living upon the juices of animals and plants. The bedbug (Cimex lectularis) and various pediculi or lice (Pediculus capitis, Pediculus corporis, and Pediculus pubis) are the chief varieties of hemipterous insects that infest man. The liquid secreted by the crab louse is said to cause slaty blue spots (taches bleuâtres) upon the skin.

Bedbugs are said to occur on domestic fowls, pigeons, swallows, and bats. They are distributed over most parts of the civilized globe. Idiosyncrasy greatly influences the degree of reaction to their bites. The so-called 'big bedbug' (Conorhinus sanguisuga) is a much more formidable insect, found throughout the southern United States and in South America. The adult forms are winged and probably fly from wooded areas into houses at night. Their bites often produce serious inflammation.

ARACHNIDIA

Many of the spiders and scorpions are venomous. Of the arachnids invading the body, the itch mite, or Sarcoptes scabiei,

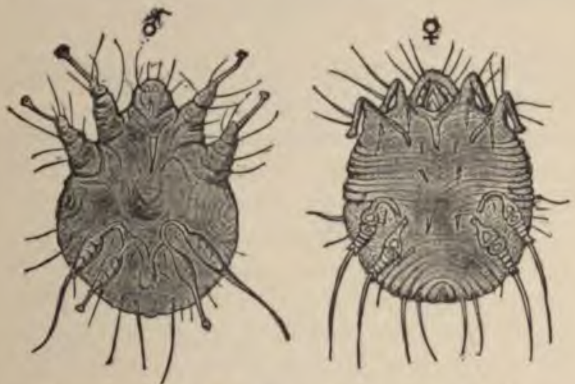

FIG. 27.—ITCH MITE (SARCOPTES SCABIEI), MALE AND FEMALE.—(*Reduced from Fürstenberg, after Murray; Osborn, Bull. 5, Division of Entomology, U. S. Dept. Agriculture.*) × 100.

the cause of scabies or **itch,** is the most important. In the sebaceous follicles, especially of the nose, a minute parasite, 0.3 mm. to 9.4 mm. in length, the Demodex or Acarus folliculorum, is often present. It may be an exciting factor in **acne.**

Ixodes

The ticks, or wood lice, attach themselves to man or beast from grasses or shrubbery which they inhabit. They fill themselves with blood and may transmit disease. Boöphilis bovis is a carrier of **Texas cattle fever.** The bites of the Argas persicus of Persia and Argas moubata of Portuguese

FIG. 28.—ACARUS FOLLICULORUM HOMINIS (*Perls*). × 300.

FIG. 29.—PENTASTOMUM DENTICULATUM, LARVA OF LINGUATULA RHINARIA.—(*After Leuckart.*) × 12.

FIG. 30.—WOOD-TICK (IXODES RICINUS) SUCKED HALF-FULL OF BLOOD. × 2.—(*Zeigler.*)

South Africa are often followed by a severe febrile illness, apparently due to the inoculation of a parasite.

Linguatula rhinaria (Pentastomum tænioides) is found in portions of

FIGS. 31 AND 32.—HARVEST MITES, LEPTUS IRRITANS TO THE RIGHT AND LEPTUS AMERICANA TO THE LEFT.—(*From Riley; Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

Europe, and in the adult form invades the nasal sinuses, rarely in man, commonly in dogs, and occasionally in horses. The larval form (Linguatula serrata, Pentastomum denticulatum) occurs in the **liver, spleen,** and sometimes the **kidneys.**

The harvest bug (Leptus autumnalis), or red flea, the larva of the Trombidium holosericum, is a minute reddish parasite which burrows beneath the skin, usually of the wrist, and produces papular lesions, associated with intense itching.

ANNELIDES

Of the **leeches** certain forms are aquatic and attach themselves to the integument of animals that enter the water. Other forms are found in bushes and grasses, from which they spring upon passing animals. Of the latter the Hemadipsia or **Hirudo Ceylonica** of Ceylon and parts of South America is most important. Not only may the bites cause painful ulceration, but death may occur from repeated small bleedings. In southern Europe and northern Africa the **horse-leech,** Hemopis sanguisuga, occurs, and may invade the nasal chambers, the trachea, or larynx, producing severe pain and repeated hemorrhages. The leech may gain entrance to the body through foul drinking-water.

HELMINTHES (VERMES)

The worms parasitic in man comprise the **nematodes,** or roundworms, the **trematodes,** or sucking worms, and the **cestodes,** or tapeworms. The nematodes have an elongate, cylindrical body, varying in length from a few millimeters to one or more meters ($\frac{1}{16}$ to 60 inches); the head is not differentiated from the body, and they occur in pairs. They are oviparous or ovoviviparous, and are found in the intestinal tract, in the tissues, and in the blood- and lymph-vessels. The embryo or the adult form may cause disease.

The trematodes are leaf-shaped and the head is undifferentiated. They rarely exceed a few centimeters (say, $\frac{1}{2}$ to 1 inch) in length. Certain forms are hermaphroditic. They live in the intestines and blood-vessels.

The cestodes consist of a minute head with suckers for attachment, a narrow neck and many segments or proglottides. They measure from 5 millimeters to several meters ($\frac{1}{4}$ inch to 100 feet). Each proglottid contains both male and female generative organs.

The complete worm is termed a strobile; the embryo, a scolex or measle. The strobile is always found in the intestinal tract; the measle in the tissues, especially the muscles.

NEMATODES

The common **round-worm,** Ascaris lumbricoides, occurs in man chiefly in the **small intestine.** In many instances it causes no disturbance, but occasionally, by migration into the **stomach, biliary passages, appendix, mouth, nose, eustachian tube,** or through the **intestinal walls,** gives rise to serious trouble. If, however, round-worms be present in large numbers, serious reflex disturbances or intestinal obstruction may result.

FIG. 33.—UNCINARIA (ANCHYLOSTOMA) DUODENALIS; MALE.

a, Head; *b*, esophagus; *c*, intestine; *d*, anal glands; *e*, cervical glands; *f*, skin; *g*, muscular layer; *h*, porus excretorius; *i*, triple bursa; *k*, ribs of bursa; *l*, testicular canal; *m*, vesicula seminalis; *n*, ductus ejaculatorius; *o*, groove of latter; *p*, penis; *q*, sheath of penis. × 20.—(*After Schulthess.*)

The **thread-, pin-,** or **seat-worm,** Oxyuris (Ascaris) vermicularis, occurs in the **colon** and **rectum** of children, and occasionally of adults. It rarely leads to serious symptoms, although there may be local irritation, and reflex disturbances.

FIG. 34.—EGGS OF UNCINARIA DUODENALIS.

a, *b*, *c*, *d*, Different stages of cleavage; *e*, *f*, eggs with embryos. In the diagnosis of the disease the stools should be searched for ova of this type. × 100. —(*After Perroncito and Schulthess.*)

Both round-worms and thread-worms gain entrance to the body chiefly by means of food contaminated by their eggs.

Uncinaria (anchylostoma) **duodenalis** inhabits the upper part of the small intestine, affecting chiefly farm-hands, brickmakers, and others whose habits or occupations bring them into direct contact with the soil. This is contaminated by ova or embryos contained in the feces of men or animals. The **ground-itch** of the barefooted frequenters of the tea-gardens of Assam is due to these ova. The symptoms caused by the adult intestinal parasites vary with their number and the duration of their sojourn. They are voracious feeders, making numerous punctures,

FIG. 35.—TRICHOCEPHALUS DISPAR, OR WHIP-WORM, PARTLY BENEATH THE INTESTINAL MUCOUS MEMBRANE.

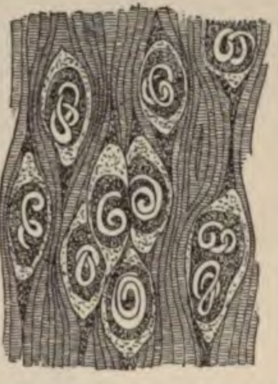

FIG. 36.—TRICHINELLA (TRICHINA) SPIRALIS ENCAPSULATED IN VOLUNTARY MUSCLE. × 40.—(*After Leuckart.*)

that continue to bleed for some time. Loss of blood, digestive disturbance, and the action of toxic substances liberated by the parasites or gaining entrance through the punctures made by them, combine to produce a severe and often fatal form of **anemia** (Egyptian chlorosis, miner's cachexia, tunnel anemia, dirt-eater's disease, tropic anemia). First and most frequently reported from the warmer regions of both hemispheres, **anchylostomiasis** has within the last twenty years been found all over Europe and in many parts of the United States, probably diffused by Italian laborers or domestic animals.

The **whip-worm** (Trichuris trichura, Trichocephalus dispar) occurs often in large numbers in the intestines of Europeans and Asiatics. **Anemia, diarrhea,** and even **beri-beri,** have been ascribed to its action; but it is often present without symptoms.

The **Trichinella** (Trichina) **spiralis** enters the alimentary canal, in a larval form, encysted in diseased pork. Within a few days it develops to maturity in the intestines, and gives rise to broods of embryos that invade, through the tissues or circulatory channels, the voluntary **muscles** of the body, becoming encysted. They first produce severe diarrhea and intestinal disorder, and secondly marked tenderness of the voluntary muscles. If the respiratory muscles are invaded by large numbers of embryos, death may result from asphyxia. Trichiniasis is often, if not always, associated with a marked increase in the number of eosinophiles in the blood.

FIG. 37.—EMBRYO FILARIA SANGUINIS HOMINIS AS FOUND IN THE BLOOD. × 800.—(*Manson.*)

The **Guinea-worm,** 'thread-worm of Medina' (Dracunculus or Filaria medinensis), undergoes an intermediary existence in certain fresh-water crustaceæ. It develops in the subcutaneous tissues of man, and may attain a length of 60 to 100 cm. It produces marked local irritation and at times abscesses. It is usually removed by securing the extremity of the worm, which is near the surface of the skin, and coiling it about a small stick. By slowly winding the stick from day to day the worm may gradually be extracted without rupture. Should the body of the worm break beneath the skin, the liberation of embryos and possibly also of toxic substances leads to abscess formation and severe local disturbances.

FIG. 38.—HUMAN BLOOD FLUKE (SCHISTOMA OR DISTOMA HEMATOBIUM). The female is partially within the canalis gynecophorus of the male. × 5. (*After Leuckart.*)

Several forms of **filaria** live in the **blood-** and **lymph-vessels,** the name Filaria sanguinis being given to all. The four principal varieties are the Filaria nocturna (Filaria bancrofti), Filaria diurna or loa, Filaria perstans, and Filaria demarquayi. The Filaria nocturna (Filaria sanguinis hominis) has been especially investigated by Manson, who has shown that it is inoculated by the bites of certain mosquitos. In man the adult lives in the lymphatics, the embryos entering the circulating blood in large numbers at night, or while the patient is resting. The Filaria diurna is usually found beneath the conjunctiva. The Filaria perstans has been found in the bodies of persons afflicted with the peculiar disease **'African lethargy,'** or 'sleeping-sickness of the Congo.' Its precise relation to sleeping-sickness is as yet unsolved. The embryos of several filarias undergo metamorphoses in the bodies of mosquitos.

Trematodes or Flukes

Bilharziosis, a disease chiefly occurring in Egypt, is caused by the Schistoma or **Schistosomum hematobium** (Distoma hematobium, Bilharzia hematobium). The adult lives in the **blood** and

Fig. 39.—The Liver Fluke, Fasciola hepaticum. × 3.

produces eggs with pointed spurs that lead to ulcers in the walls of the capillaries, and are a frequent cause of the endemic **hematuria** of Egypt. The worms are found chiefly in the portal system and may give rise to **intestinal hemorrhages.** The disease often persists for many years.

Fasciola hepaticum (Distoma hepaticum) is a fluke, inhabiting the biliary passages, giving rise to ulceration, icterus, and severe hepatic disturbances that may end fatally.

Distoma westermanni is a bronchial fluke that is the cause of an epidemic parasitic **hemoptysis** occurring in China, Japan, and Formosa.

Cestodes or Tapeworms

Tænia saginata or mediocanellata, the unarmed or beef tapeworm, is the most common tapeworm in the United States. The measle or scolex occurs in the muscles of cattle, and when ingested, develops into the adult (strobile) in the intestinal tract of man.

Fig. 40.—Adult Tænia echinococcus as found in the Dog. × 16.

Much less common in this country is **Tænia solium,** the armed or pork tapeworm, the measle of which exists in the flesh of swine, the adult in the **intestine** of man. Occasionally, from the ingestion of the eggs, the measle invades the human **muscle,** producing small **cysts,** and is then called the **Cysticercus cellulosæ.** Cysticerci may likewise occur in the **brain.**

Bothriocephalus latus (the fish tapeworm or pit head) is the largest of the tapeworms of man. It is chiefly met with near the lakes of Neufchâtel and in Scandinavia. The measle is found in certain fish, especially pike; its ingestion leads to the development of the adult worm which may occasion severe **anemia.**

Tænia echinococcus, the dog tapeworm, occurs only as an embryo in man, being found as an adult tapeworm in the intestine of the dog. It is the smallest of the tapeworms, having but four segments and being 4 mm. in length. The embryos invade the walls of the intestine, enter the organs, and produce the echinococcus or **hydatid cysts.** These may be multiple and may acquire large dimensions. In man they are more frequent in the liver, but may occur in any organ.

Fig. 41.—Formation of Buds Containing Embryos from the Lining of an Hydatid Cyst.—(*After Leuckart.*)

Rare forms of tapeworm in man are **Tænia nana** (the dwarf tapeworm), that measures 2 to 3 cm. in length, and is believed to pass a larval stage in an insect or snail; **Tænia cucumerina** (Tænia canina, Tænia elliptica), a common tapeworm of **cats** and **dogs,** that passes an inter-

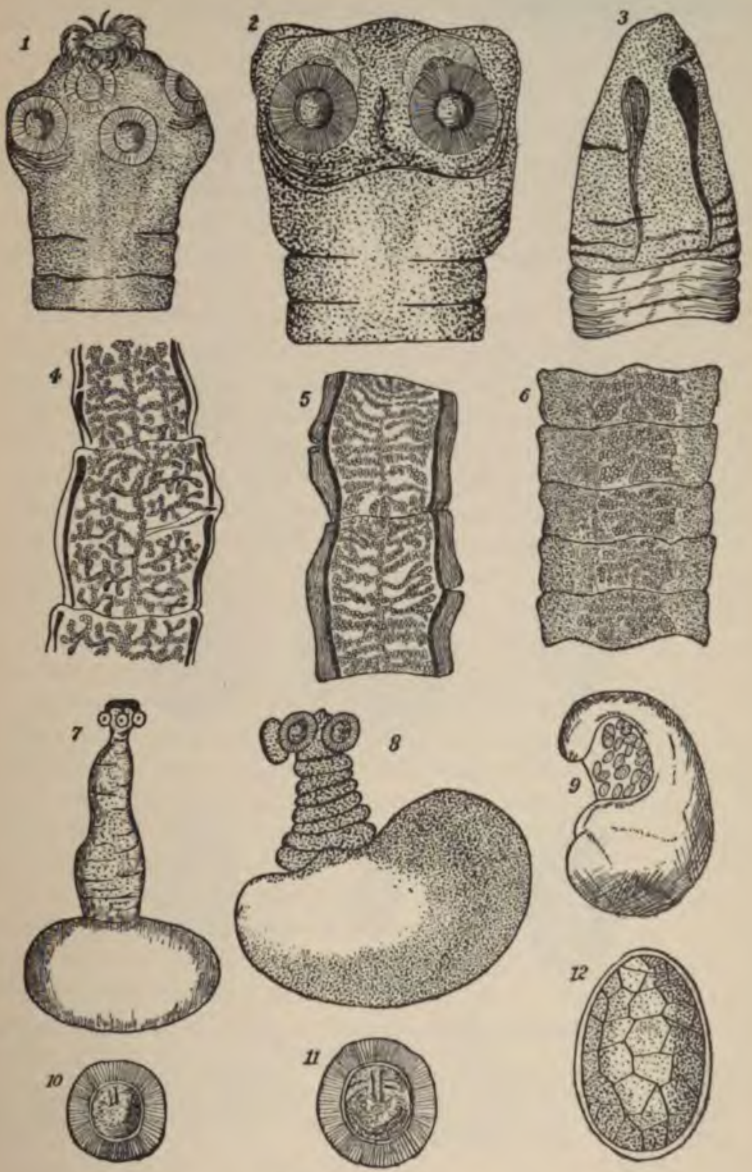

FIG. 42.—TAPEWORMS.

1, 4, 7, 10, Tænia solium; 2, 5, 8, 11, Tænia saginata; 3, 6, 9, 12, Bothriocephalus latus; 1, 2, 3, heads; 4, 5, 6, segments showing uteri with eggs; 7, 8, 9, embryos; 10, 11, 12, eggs.

mediate stage in fleas; and **Tænia flavopunctata,** of which little is known.

FIG. 43.—EGGS OF PARASITIC WORMS FOUND IN THE INTESTINAL CONTENTS OF MAN.—(*After Notter.*)

1, Oxyuris vermicularis; 2, Ascaris lumbricoides; 3, Trichocephalus dispar; 4, Uncinaria duodenalis; 5, Tænia saginata; 6, Tænia solium; 7, Tænia nana; 8, Tænia flavopunctata; 9, Bothriocephalus latus; 10, Fasciola hepatica; 11, Distoma lanceolatum; 12, Schistosomum hæmatobium.

Diagnosis

The recognition of intestinal parasites may usually be accomplished by examining the stools for the adult forms or the eggs, which present certain peculiarities. The eggs of the uncinaria are embryotic ovals with a thin shell, the protoplasm being unsegmented, or in the early stages of segmentation. Similar eggs are those of Ascaris lumbricoides, Oxyuris vermicularis, and Trichocephalus dispar. The first have a thick, gelatinous, often mammillated covering and the protoplasm is not segmented. The second have a thin asymmetric shell, one side of which is nearly straight, while the eggs of whip-worms possess a smooth thick shell, apparently perforated at each pole, and containing unsegmented protoplasm. (See Fig. 43.)

A small drop of the liquefied fecal matter taken from near the surface should be spread out in a drop of water on an ordinary slide, covered with a cover-slip, and examined under a $\frac{1}{3}$ inch or 8 mm. objective. If this examination prove negative, Stiles recommends a method of washing and sedimenting the feces. One or two ounces of dry or fresh feces are mixed with from one to four pints of water, strained, washed thoroughly, permitted to settle, and then decanted down to the sediment. This procedure is repeated as long as any matter will float. Finally the agitation is conducted in a narrow bottle or graduate, and after thorough settling the sediment is examined. If there is much coarse material, this may be removed by washing the finer portions through a sieve. Centrifugation is rarely necessary.

For the detection of Strongyloides intestinalis (Anguilla stercoralis), Leichtenstern suggests that a small excavation, into which a little water is poured, be made in the solid fecês. If the parasites be present, they will usually be found in a short time in the water, especially if the preparation be kept at a temperature of from 30° to 35° C. (86° to 95° F.).

In examining for segments of tapeworm or for the round-worm of larger size, the fecal material should be screened through a coarse sieve of metal or gauze. For Amœba coli, particles of the freshly passed dysenteric stools should be placed on a warm slide and examined at once. When kept warm and in a fresh condition, the amebas continue their characteristic movements, and so are easily recognized. They also may be stained by special methods, but examination of the living micro-organisms is usually preferable.

CHAPTER V

THE EXTRINSIC CAUSES OF DISEASE—BIOLOGIC POISONS

Ptomains; Toxalbumins; Toxins; Venoms

PTOMAINS AND TOXINS

The metabolic processes of bacteria are accompanied by fermentative and putrefactive changes through which proteid, carbohydrate, and hydrocarbon molecules of the **substratum** in which they grow are split up into various gases, bases, acids, etc. Of the basic substances thus produced—the **ptomains**—some are highly poisonous, others harmless, a few of interest and importance.

In addition to these changes in the substratum, the **bacterial cells** seem to elaborate products by their own energy, constructing them out of elements appropriated from the culture-medium. Such products, termed **toxalbumins** and **toxins,** may be intracellular (**bacterial proteid**) or extracellular, that is, an excretion of the bacteria. They do not result from changes in the chemical composition of the substratum, as they are formed in the simple non-proteid culture-medium suggested by Uschinsky.

Not only do independent vegetable cells elaborate these products, but the cells of certain of the **higher plants** are endowed with a similar energy and elaborate such well-known **poisonous substances** as strychnin, nicotin, ricin, abrin, and the like.

Likewise certain cells of **animal** tissue may elaborate powerful poisons, familiar among these being the **venom** of serpents, scorpions, tarantulas, wasps, and bees. As many of these substances are of importance either for prophylactic inoculation or in the production of antitoxins, a brief consideration of their general characteristics is of fundamental importance.

Ptomains are crystallizable, basic compounds resulting from the splitting-up of the proteid molecule of organic matter under the action of bacteria. They closely resemble the vegetable alkaloids. The term ptomain originated with Selmi. The compounds were first well characterized by Nencki, who also first secured them in the pure state. Information regarding them is by no means adequate. According to Vaughan, they all contain nitrogen and most of them contain oxygen.

Ptomains are frequently spoken of as 'putrefactive alkaloids.' It is incorrect to speak of them as 'animal alkaloids,' for not uncommonly they are formed by the decomposition of vegetable substances. They may or may not be poisonous.

Ptomains are probably rarely formed by bacteria growing in living animals and are not responsible for the pathogenetic action of these organisms, being much less important than the toxins and bacterial proteids. Their ingestion in foods may, however, as in the case of **tyrotoxicon,** be followed by profound intoxication.

It is improbable that each micro-organism produces a specific ptomain or generates a particular kind of fermentative or putrefactive change in the substratum. Much more likely is it that there are many bacteria so similar in their metabolism that the products of their growth and the alterations they cause in the pabulum are identical; thus several bacteria may produce the same ptomain. Certain bacteria, however, generate compounds peculiar to themselves, as, for example, the spasm-producing substances that can be separated from cultures of the **tetanus bacillus.**

The poisonous ptomains are called **toxins** by Brieger, but at the present time the term toxin is more commonly used to express a poisonous organic compound excreted by bacteria. The toxic bacterial proteid is similarly designated by some authorities.

Poisonous Ptomains

Peptotoxin, discovered by Brieger, is the toxic principle of many of the poisonous peptones. It is formed by digesting fibrin with artificial gastric juice and also probably by the peptonizing power of bacteria. The chemical composition of peptotoxin is as yet undetermined. It causes death of frogs and guinea-pigs, with paralytic symptoms.

Gadinin ($C_7H_{17}NO_2$) was also found by Brieger in putrefying haddock, and in gelatin cultures of bacteria from human feces. When mice are injected with large doses, they suffer from an acute ascending palsy. According to Vaughan and Novy, in doses of 0.5 to 1 gram this ptomain is decidedly poisonous for guinea-pigs.

Putrescin ($C_4H_{12}N_2$) was first discovered by Brieger, who isolated it from putrefying internal organs, from decomposed fish and shell-fish, and from various cultures of bacteria. It almost always occurs in company with cadaverin. This substance is capable of exciting inflammation and is fatal to mice and guinea-pigs. Putrescin occurs as a clear, watery liquid, with a peculiar odor, described by Vaughan and Novy as 'semen-like.' It fumes in the air.

Cadaverin (Brieger), which appears before or simultaneously with putrescin in the putrefaction of animal tissues, has the formula $C_5H_{14}N_2$. In the pure state it is a thick, clear, syrupy liquid, with an unpleasant odor like semen. It boils at 175° C. (225° F.) and fumes in the air. It has been obtained from human hearts, lungs, livers, from horse-flesh, rotten eggs, decayed shell-fish, decomposed fish of various kinds, and from cultures of various bacteria, notably the cholera spirillum, typhoid, colon, and hog-cholera bacilli. The alkaloid is not entirely without poisonous properties and is said by Behring to be fatal to mice, guinea-pigs, and rabbits, but not fatal to dogs. It produces inflammation with subsequent necrosis.

Cholin ($C_5H_{15}NO_2$) (Brieger) differs from most of the ptomains described, in that it occurs in the early stages of putrefaction. It readily decomposes, forming di- and tri-methylamin. It is probably most readily secured from brain tissues, but occurs in other decaying animal substances, and may be made from the yolk of eggs. In doses of 0.1 gm. to the kilo of rabbit, symptoms similar to those of muscarin-poisoning developed. It also produces paralysis and death in frogs.

Butylamin (Gautier and Mourgues), **Iso-amylamin** (Limprecht), **Hexylamin** (Gautier and Mourgues), and **Dihydrocollidin** (Gautier and Mourgues) are liquid alkaloids of strongly alkaline reaction, obtained from cod-liver oil and other sources. They are all poisonous, **iso-amylamin,** which produces rigor, convulsions, and death, being the most powerful.

Hydrocollidin (Gautier and Mourgues) has been obtained from putrefying mackerel, and also from putrid ox-flesh. It occurs as an oily, alkaline, clear liquid, with an odor like syringa. Its poisonous properties are shown by vomiting, unsteadiness, weakness, palsy, tetanic convulsions, and death. The heart stops in diastole.

Ethylenediamin ($C_2H_8N_2$), of Brieger, was found in decomposing haddock. The alkaloid is poisonous for warm-blooded animals, which suffer from a periodic secretory flow from the nose, mouth, and eyes. The pupils dilate, the eyes project, and violent dyspnea increases until the death of the animal, which follows in about twenty-four hours after taking the poison.

Trimethylenediamin ($C_3H_{10}N_2$) (?) was obtained by Brieger from cultures of the cholera spirillum in beef-broth. It is formed in very small quantities. It produces violent contractions and muscular tremors.

Susotoxin ($C_{10}H_2N_2$) (?) was isolated by Novy from cultures of the hog-cholera bacillus. It has not been obtained in the uncombined condition. Large doses of it are poisonous, producing irregular respiration, weakness, convulsions, and death in about an hour and a half.

Methylguanidin ($C_2H_7N_3N$) was obtained by Brieger from horse-meat allowed to decompose for four months in a closed vessel at a low temperature. It has also been found in cultures of Vibrio proteus, contaminated with ordinary putrefactive bacteria. Vibrio proteus in pure culture, however, seems to be unable to form the alkaloid. Methylguanidin occurs as a colorless, easily deliquescent mass, possessing a strong alkaline reaction. It is highly poisonous.

Asellin ($C_{25}H_{32}N$) is one of the bases isolated by Gautier and Mourgues from cod-liver oil. It occurs in the form of amorphous white floccules, almost insoluble in water. In large doses it produces fatigue, shallowness and rapidity of respiration, stupor, and death.

Mydatoxin ($C_6H_{13}NO_2$) was obtained by Brieger from human organs which had been allowed to putrefy at a low temperature for several months. In the pure state the base is a strongly alkaline syrupy liquid, insoluble in alcohol or ether. In large doses it kills guinea-pigs and white mice, with marked muscular depression, lacrimation, diarrhea, dyspnea, and convulsions.

Mydalein was isolated from putrid internal organs by Brieger. It is usually formed about the third or fourth week of putrefaction. Its true composition has not been determined, nor is it known in the pure state. It has a specific physiologic action, described by Vaughan and Novy as follows: "Small quantities injected into guinea-pigs or rabbits produce, after a short time, a moistening of the under lips and an abundant flow of secretion from the nose and eyes. The pupils dilate gradually to a maximum and become reactionless; the ear vessels become strongly injected and the body-temperature rises 1° or 2°. The hairs bristle and the animal occasionally shudders. Gradually the salivation ceases, the respiration and heart-action, which were at first hastened, now decrease; the temperature falls, the ears become pale, and the animal finally recovers. During the action of the poison the animal shows a tendency to sleep and the peristaltic action of the intestine is heightened. Larger doses (0.5 gram) induce an exceedingly violent action, which invariably results in the death of the animal."

Neurin ($C_5H_{13}NO = C_2H_3N(CH_3)_3OH$) occurs in putrefying flesh after about five or six days. It almost invariably occurs associated with cholin, from which it differs in having one less molecule of water. The free base is strongly alkaline in reaction and fumes with hydrochloric acid. Neurin is extremely poisonous for frogs as well as for mammals. The fatal dose seems to be about 5 milligrams to the kilo. The symptoms which it produces are salivation, dyspnea, acceleration followed by retardation of the heart's action, diarrhea, convulsions, and collapse. The clinical picture closely resembles that of muscarin-poisoning. The prostration in Addison's disease is by some ascribed to neurin.

Muscarin ($C_5H_{15}NO_3 = C_5H_{13}NO_2 + H_2O$) is the active principle of the poisonous mushrooms. First found by Schmiedeberg and Koppe, it has also been found by Brieger in decomposed fish and decomposing human organs about the second and third weeks of decomposition. Its formation seems to begin about the seventh day. This alkaloid is very poisonous and produces a violent diarrhea, profuse salivation and lacrimation, contraction of the pupil, and involuntary passage of urine and semen. After large doses the animal dies in convulsions. In frogs the ptomain produces paralysis, with subsequent death, the heart stopping in diastole.

Mytilotoxin ($C_6H_{15}NO_2$) was separated by Brieger from the poisonous mussel. The free base is alkaline and has a peculiar odor. In mussels containing it this odor develops when the mussels are treated with an alkali. In its physiologic action the poison resembles curare. The symptoms are chiefly paralytic. Mytilotoxin is not produced during putrefaction of the mussels, but during their fresh, active state. It is therefore a product of the mussel itself.

Tyrotoxicon was isolated by Vaughan from vanilla ice-cream, milk, and cheese, and also by Stanton from cream-puffs. The formation of the poison probably depends upon butyric acid fermentation, of which it is one of the products. Chemically it approximates the diazobenzoles. Tyrotoxicon is very poisonous and in the intestinal canal excites violent diarrhea accompanied by vomiting and profound prostration, headache, and drowsiness. It is the cause of ice-cream, cream-puff, and other milk-product poisonings, and may be responsible for many of the summer diarrheas of children.

Typhotoxin ($C_7H_{17}NO_2$), obtained by Brieger from pure cultures of the typhoid bacillus, is toxic for guinea-pigs, causing salivation, diarrhea, accelerated respiration, dilatation of the pupils, and, ultimately, death.

Tetanin, isolated by Brieger from cultures of the tetanus bacillus, is an oily substance that produces tonic spasms with fatal termination.

Tetanotoxin, another product of the tetanus bacillus, also isolated by Brieger, has a similar toxic action.

Spasmotoxin (Brieger) is of unknown chemical composition. It produces tonic spasms. In addition to tetanin, tetanotoxin, and spasmotoxin, Brieger discovered a basic substance producing spasms accompanied by marked salivation and lacrimation.

VENOMS

The most important venoms are those secreted by the snakes. All snakes possess poison glands, but in the majority these are rudimentary or are without outlet. In North America there are but four **venomous snakes.** Three of these, the **rattlesnake** (genus Crotalus and Sistrurus), the **copperhead** (Agkistrodon contortrix), the water moccasin or **'cotton mouth'** (Agkistrodron piscivoris), distinguished by a deep depression between the mouth and eye, belong to the pit vipers, family Crotalidæ. The **coral snakes** belong to the family Elapidæ. They are very venomous, although usually described as amiable in disposition. The rattlesnake rarely bites except under provocation, but the copperhead and moccasin are more aggressive. Other venomous serpents are the **cobra** (Naja naia), chiefly found in India, the most destructive of serpents; the deadly West Indian 'fer de lance' (Bothrops lanceolatus); the **vipers** of Europe, the bites from which rarely cause death in adults; the Egyptian **asp** (Naja haje) and the **Cerastes** (Vipera hasselquisti), made notorious by the legend of Cleopatra's death. In India about 20,000 people die annually from snake bites, chiefly from that of the cobra. Snake venoms have been studied by Weir Mitchell and Reichert, Calmette, Phisalix and

Bertrand, Fraser, Flexner and Naguchi, and others. They contain toxic globulins, albumoses, and peptones—compounds that may produce marked local lesions, characterized by great edema, and at times gangrene, serious blood changes, and profound depression of the nervous centers, leading to convulsions or paralysis. Death usually results from respiratory failure. If recovery take place, the cicatrix may in certain cases annually become painful and ulcerate.

The **effects of snake bite** depend upon: (1) The virulence of the venom; that of the cobra, for example, being more toxic than the rattlesnake's, and the rattlesnake's than the copperhead's. About 40 per cent. of cobra bites are fatal, and they have been known to cause death within two minutes. About 6 per cent. of rattlesnake bites are fatal; Mitchell and Reichert mention a case of death in forty minutes. Moccasin bites occasionally kill, but the bite of the copperhead rarely causes death even in children. The harlequin or other variety of coral snake rarely bites, but ensuing unconsciousness and death are mentioned in the reports of cases. (2) The size of the snake. Other things being equal, a large snake has the power to inject a larger quantity of venom than a small one. (3) The part bitten. The injection of the poison into a vein or an artery or into a very vascular part of the body may result in death within a very few minutes, while if the venom be injected into adipose tissue, the general effects are delayed, often are milder, and at times only local symptoms are noticed. (4) The quantity of poison possessed by the snake at the time it strikes. By excitement or repeated efforts to bite, snakes lose much of their venom; while those that have recently fed have venom less in quantity and strength than those that have fasted for some time. (5) The hold secured by the snake. Only one-half the quantity of venom is injected by one fang that can be injected by two, and much more will enter the part when the snake retains its hold and continues to inject the poison than when a viper strikes and immediately lets go. (6) The age, size, and general stamina of the individual attacked. Probably those that have indulged freely in respiratory depressants, such as alcohol, are more susceptible to the added depression of the venom.

Certain animals, as the **Gila monster** of Texas and Central America, secrete a poisonous **saliva.** Bites of the **salamander, toad,** and **triton,** and the bites of certain **fish** are followed by phlegmonous and gangrenous inflammations. Many of the **spiders** inflict bites that are poisonous, the bite of the tarantula of tropic countries being especially serious. Of the **myriapods,** the centipede and scorpion cause painful and at times serious bites. The effects of the **stings of insects** are well known. In a number of recorded instances the sting of a single bee, hornet, or wasp has caused death. The venom of these insects consists of formic acid united with the hydrocarbon undecane, $C_{11}H_{24}$. Less serious are the bites of certain other insects, as mosquitos, flies, bedbugs, fleas, and ants.

Prophylaxis

For convenience the prevention of venom-poisoning may be considered at this point. The effects of snake bite should be combated (1) by localizing the poisons by tying a tight band around the limb above the bite and removing as much of the poison as possible by incision or excision and suction; (2) the poison bites, according to Calmette, should be treated by hypodermic injections of substances that locally neutralize the venom, as calcium chlorid, gold chlorid, or potassium permanganate. Most efficient is the use of **antivenene,** the value of which has been worked out by Fraser, Phisalix, Bertrand, and Calmette. This antidotal serum is obtained from horses that have been immunized by progressively increasing doses of venom. Antivenene of one snake-venom is also efficient against other forms; that prepared from the rattlesnake protecting against the cobra, and vice versa, as shown by McFarland. Antivenene is a perfect antidote, provided it can be injected before serious injury has been done to the central nervous system. As, in biting, the hollow fang of the serpent sometimes penetrates a blood-vessel so that the venom is thrown directly into the circulating blood, death may occur within a few minutes; but, as a rule, even after the most poisonous snake bites recovery usually follows when antivenene is used within half an hour. Venoms are not injurious when swallowed unless they come in contact with broken mucous membranes. They are usually destroyed by high temperatures.

Section II

THE DIFFUSION OF DISEASE

CHAPTER VI

THE DIFFUSION OF DISEASE THROUGH AIR, WATER, AND SOIL

Air—The Transmission of Bacteria by Liquid Particles in the Air; Dust. Water—Drinking; Bathing; Washing of Clothes; Introduction of Contaminated Water within the Tissues. Soil—Ground Air; Ground Water; Bacterial Contamination of Soil; Burial.

From the viewpoint of preventive medicine, the methods by which the exciting causes of disease are **transmitted** are of primary importance. Necessarily it is in regard to recognized infections that our knowledge is the largest. The agents of infection may be carried from place to place and from person to person by the air, by water, through the soil, by food, by animals, by objects of all kinds, and in the present state of knowledge some such methods of transmission seem to be unavoidable incidents of civilization and of extended human intercourse. Nevertheless many of them are entirely preventable, even now, and others may be reduced to a minimum until increasing knowledge shall permit us either to obviate them or by immunization and other means discussed elsewhere in this work to protect ourselves against their ill consequences.

AIR

The early theories as to the method of disease transmission assumed the presence in the air of a vaporous principle or miasm, which rose from the earth or water, or was given off from the sick. We now know that the infectious diseases are not conveyed by gaseous principles. With the proof that malaria is transmitted by mosquitos, the last of the so-called miasmatic diseases has passed out of the nomenclature, and it may definitely be said that the term miasm has only an historic place in scientific literature. The theory of infectious diseases attributing their origin to definite, organized particles, implies that the air must contain particles of a liquid mist or of dust in order to transmit these diseases.

The Transmission of Bacteria by Liquid Particles in the Air

Many experiments have shown that bacteria are not ordinarily given off to the air from moist surfaces. In exceptional cases by the action of violent winds, distinct particles of water with bacteria inclosed may be picked up and carried. In the vaporization of water, although the aqueous vapor may almost immediately condense after entering the air, the definite interval in which it is in the form of a gas prevents it from carrying bacteria from the liquid. When, however, in fermenting liquids there is gaseous evolution, with rupture of bubbles upon the surface, minute particles of the liquid may be thrown into the air by the rupture of these bubbles. It has been assumed that in this way sewer air may be contaminated from sewage, but practically it is improbable that these particles remain in the air for a sufficient length of time to be an important factor in disease transmission. Their specific gravity causes them soon to fall again to the ground or to the surface of the liquid. From the moist surface of the respiratory tract of man and animals liquid particles are ejected by the acts of coughing, sneezing, and speaking. The experiments of Flügge and others have shown that these particles remain suspended in the air for a distance of several meters (20 feet), and then rapidly subside by gravitation. As would be expected, greater numbers of watery particles are thrown off from those speaking the guttural tongues, and in coughing, while in ordinary, quiet respiration no bacteria seem to leave the mucous surfaces. Infection may thus be carried by particles of liquid, the air simply serving as the medium through which they are propelled. The number of diseases in which infection occurs in this manner is not great, the **tubercle bacillus** being one of the most important organisms thus transmitted. **Diphtheria** has repeatedly been conveyed to physicians and nurses, by the patients coughing in their faces during the examination of the throat. As the cause of **scarlet fever** is known to be present in the saliva, this may also be transmitted in a similar manner, as may be the case with **pneumonia, influenza, measles,** and **plague.** There is little reason to believe that such diseases as cholera, typhoid fever, or yellow fever are diffused in this way; and it is obvious that for the occurrence of this form of infection the exposed person must be in close proximity to the one affected.

This method of transmission is to be **avoided,** first, by care upon the part of the patient, who should place a handkerchief over the mouth during the act of coughing, and, second, by care upon the part of those engaged in the examination of the throats of patients suffering from diphtheria or scarlet fever, who should use a glass screen or other protective device. As the saliva of most individuals contains pathogenic organisms, the present tendency of surgeons to avoid talking over the operative field, and to wear pieces of gauze or other material over the lower portion of the face, has a sound basis. The important matter is to know how long disease organisms may remain infective after having been thrown into the air. It is probable that tubercle bacilli, especially when inclosed in particles of sputum, may retain their virulence for months, as has been demonstrated experimentally by the infection of guinea-pigs with dust from rooms previously used by consumptives. The pyogenic cocci resist drying for a considerable time, and yet the fact that wound infection from the air by these organisms very rarely occurs shows that they must rapidly fall to the ground. The colon bacillus, and the organisms of typhoid fever and cholera, quickly die upon drying, and therefore require no special precautions to prevent their transmission through the air. Inoculation with the bacillus of typhoid fever from flying liquid particles has apparently occurred in the washing of clothes and in the performance of autopsies. **Dust particles** floating in the air contain many micro-organisms, but these consist almost entirely of molds, yeasts, and saprophytic cocci. It is only when there is quite a violent commotion of the air that pathogenic organisms seem to be carried in the dust, and then the fact that many organisms die upon thorough drying reduces the liability of infection from such sources. The street dust of cities, laden as it often is with excrementitious particles from man and the lower animals, and carried by the wind into the eyes and upper respiratory passages of persons exposed, is probably the origin of many of the milder catarrhal affections prevalent in the spring and fall, and may also be the origin of tuberculosis or other grave infection.

The importance of **sunlight,** and of fresh oxygen, as provided by thorough **ventilation,** in restoring the purity of air and reducing the danger of atmospheric infection is constantly to be borne in mind. Disproportionately tall buildings, by excluding the sun from city streets, menace public health.

WATER

Disease may be transmitted by water (1) used as a beverage; (2) used for purposes of ablution or in cleansing clothes and utensils; (3) introduced within the tissues through wounds or by the punctures of hollow instruments.

1. The Contamination of Drinking-water

The chief infections believed to be transmitted by drinking-water are **typhoid fever** and **cholera.** The organisms of both these diseases have been demonstrated in waters used for drinking, and their relationship to epidemics clearly proved. It is nevertheless probable that the importance of water as a means of transmission has been overrated in both instances; for the organisms are destroyed in time by natural factors constantly at work in most waters. These factors are: first, the small amount of organic matter present as food for the bacteria; second, the action of sunlight; and, third, the antagonistic effect of many harmless microorganisms indigenous in most waters. There is little reason to believe that pathogenic organisms have multiplied to any degree after gaining entrance to most of the potable waters in which they have been found, but it is possible that the water may be consumed at such an early period after its contamination that the infectious agents have not yet been killed. They may be carried by water through the earth for a considerable distance, although the natural filtering properties of soil tend to reduce the number of bacteria so carried. As is well known, the deposition of **fecal matter** in close proximity to sources of water-supply may be the source of infection. This was strikingly shown by the typhoid epidemic at Plymouth, Pa., in 1885. Drinking-water may also be contaminated from **urine** alone. Thus, Kubler and Neufeld isolated typhoid organisms from a well of water which had caused a small outbreak of typhoid fever, and near which the urine of a typhoid patient had been emptied. The absence of colon bacilli indicated that the contamination was not of fecal origin.

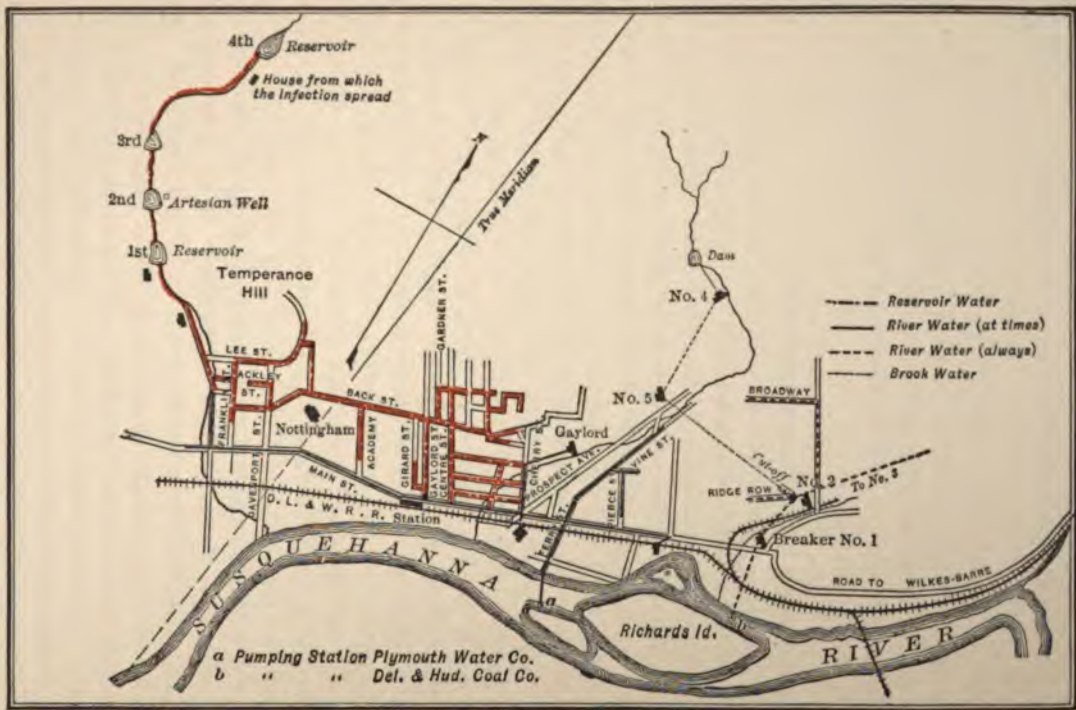

FIG. 44.—MAP OF PLYMOUTH, PA., SHOWING THE SOURCE OF WATER-SUPPLY.—(*Abbott.*)
The distribution of water contaminated by typhoid dejecta emptied near a tributary stream is indicated in red. About 1000 of the 9000 inhabitants were affected; but the disease was limited to those who used water from the infected reservoir.

2. The Transmission of Disease by Water Used for Bathing and for Washing Clothes and Utensils

In **bathing,** water is not only swallowed, but it also enters the various openings of the body. As public baths are often frequented by large numbers of people suffering from various diseases, infection is quite possible, especially if the water be not frequently changed. The affections most commonly transmitted seem to be various forms of acute inflammations of mucous membranes, as **conjunctivitis, rhinitis, pharyngitis,** and **laryngitis.** There is little positive evidence that venereal disease may be conveyed in this manner. Impure water used for the purpose of bathing may also bring in contact with the skin micro-organisms which penetrate it and thus find their way into the blood and deeper tissues. While this occurrence may be rare, its reality seems to have been proved by the experience of A. Looss, at Cairo, who observed that when he allowed water containing the embryos of **Uncinaria duodenalis** to fall upon the skin of his hands, an itching sensation occurred at the point of contact, and as a result of this accident he became infected with parasites whose eggs he subsequently discovered in his stools. He was able later to make an actual demonstration of the penetration of the skin of the cadaver by the larvæ of these parasites, and does not hesitate to conclude that this is the usual method by which they enter the human body. **Washerwomen** are exposed to various infections in the process of rubbing the clothes, when foamy particles are thrown into the air, and frequently alight on the face, in the nostrils, or in the mouth. In these cases, if the infectious organism has sufficient virulence, and has not been destroyed by the action of the heat of the water or by its contained soap, infection may occur. Occasionally infections of **diphtheria, scarlet fever,** and **typhoid fever** seem to have occurred in this way.

Infected water is frequently used to **wash utensils,** and in this way milk, vegetables that are to be eaten raw, and other foods may be contaminated. In the case of **milk** this is especially important, as it offers an excellent culture-medium for many pathogenic organisms. Infection is probably due to contamination occurring in this way much more frequently than to any inherent infectiousness of the milk itself.

3. Infection through Water Introduced within the Tissues

Most water-supplies carry few virulent pyogenic organisms, and thus operative infections are chiefly due to infected utensils, hands, dressings, or suture materials. In many cities, although the number of saprophytic organisms in the water is quite large, it has been found safe to use the general water-supply for operative purposes without sterilization; but as there seems always to be a possibility of infection occurring through this medium, few surgeons are willing to take the risk of using unsterilized water. Muddy water may contain certain of the virulent organisms found in earth, such as the **tetanus bacillus** and the bacillus of **malignant edema,** and Hirst has reported cases of puerperal tetanus in which infection seemed to result from intrauterine douches of such water, to which creolin, an unreliable germicide, had been added.

SOIL

Infection from soil has been attributed (1) to **gaseous or miasmic emanations,** (2) to the **ground or soil air,** (3) to the **ground water,** and (4) to **materies morbi** contained within the **soil** itself.

Ground Air

Ground air, or the gas contained within the interstices of the soil, is usually richer in carbon dioxid than ordinary air, and may also contain ammonia, ammonium sulphid, hydrogen sulphid, and other gases derived from the decomposition of animal or vegetable substances. Its humidity is usually high. That gaseous emanations from soil contain infectious principles is an ancient supposition that has not been confirmed by exact investigations. Although the ascent into houses of ground air with its excessive humidity, small percentage of oxygen, and excess of gases arising from organic decomposition, may be undesirable and may render them damp and unwholesome, it cannot be credited with directly producing specific diseases. Care should be taken that the ground air of dwellings is not contaminated from leaky drains or cess-pools, or from decomposing organized matter present in many made soils ; not because these contaminations directly produce disease, but because such unwholesome surroundings tend to depress the normal immunity of the body and to favor bacterial invasion.

Ground Water

Soils vary in their capacity for absorbing and retaining moisture; humus having marked retaining power, and chalk and loose sand having much less. Much depends, however, upon the permeability of the subsoil, the declivity, and the protection afforded by surface vegetation. Not only is the soil kept moist through rains, but by capillary attraction water is constantly rising from subterranean sources. The subsoil water is subject to movements that occur at different depths in various soils, varying from two feet to several hundred feet from the surface. Pettenkofer and his pupils have affirmed the close relationship of soil water with such diseases as **cholera** and **typhoid fever,** but the opinion that there is a constant and direct relation between the condition of the soil and the occurrence of epidemics is obviously erroneous. The danger from soil water is chiefly its ability to transmit pathogenic bacteria to soils and sources of water-supply. The soil, however, acts as a bacterial filter, greatly reducing the number of bacteria that pass through it for long distances, so that the possibilities for a wide dissemination of disease by ground water are too slight to be considered. Through short distances, as a few feet, or possibly a few yards of space, bacterial conveyance may occur, and Dempster has shown that cholera spirilla may be carried through two and a half feet of porous soil by currents of water. Fortunately, most pathogenic bacteria are unable to live for long periods of time in soil. An **indirect relation** between soil water and certain diseases does, however, occur. **Malaria** is associated with marshy soils, because they are suitable for the propagation of mosquitos. **Chronic rheumatism** is known to be favored by dampness of the soil, probably merely because dampness makes the atmosphere cold ; although the probability of infectious agents being demonstrated for the so-called rheumatic affections must not be overlooked. A few diseases like **goiter, calculus,** and **myxedema** have been attributed to certain mineral constituents entering drinking-water from the soil; but the relationship is too inconstant and variable to warrant the conclusion. Haviland, especially, has studied the geographic distribution of **cancer,** and believes the affection to be much less frequent in elevated places and districts of limestone formation, and most frequent in floody, low-lying, clayey areas. Assuming that carcinoma is due to a parasite, he suggests that the moist soils, especially of alluvial earth, favor the development of microorganisms. Cancer, however, is known to prevail upon elevated and dry lands; and when D'Arcy Powers sowed land, apparently complying with the requirements of Haviland, with bits of carcinomatous tissue, the results were negative in the exposed animals.

Epidemics of **diarrhea** have been attributed to the moisture, heat, or uncleanliness of soils. Ballane says that exclusive wetness or complete dryness are unfavorable to the prevalence of diarrhea. The development of pulmonary phthisis seems to be favored by low-lying, damp soils, which are found also to predispose to colds and catarrhs of the respiratory tract.

Bacterial Contamination of Soil

In portions of the New Hebrides the soil is so rich in the bacilli of **tetanus** and **malignant edema** that the natives employ it as an arrow poison. Garden earth is known to contain these organisms frequently, not however, in large numbers, as a rule, nor do the organisms appear to undergo any considerable multiplication in the soil. When portions of such infected soil enter deep or punctured wounds, where the bacteria may multiply without the inhibition of free oxygen, tetanus results. Nearly all other pathogenic organisms rapidly die in ordinary soil, especially if it be dry. In **damp soils** the organisms of **cholera, typhoid fever,** and **plague** may live a number of weeks. In the damp dirt floors of Chinese and Japanese dwellings that are protected from the action of the sunlight, the bacilli of plague have been found months after the disease has occurred in the house. Rats and other vermin may acquire infection from such contaminated soil and may then transmit the disease to the human family.

Infection from the Buried Animal Body

Pasteur believed that earthworms conveyed the bacillus of **anthrax** from the buried animal body to the surface and led to the infection of grazing cattle, but later experiments tend to disprove this supposition.

Although the chemical study of the **water** yielded by wells and springs in the neighborhood of cemeteries has shown that such water may contain abundant dead organic material in solution, bacteriologic investigations have failed to bring forward conclusive evidence that pathogenic organisms are transmitted from buried bodies, through the ground water, to distant sources of water-supply. Experiments in this respect have been conducted by Klein, Petri, Yokote, and others. Klein found that disintegration of the animal body after burial is chiefly brought about by an anaerobic bacterium that he terms **Bacillus cadaveris saprogenes.** The pathogenic bacteria seem to play but a small part in the dissolution process. Experimenting with the bodies of guinea-pigs infected by various pathogenic organisms, it was found that none of the latter were capable of maintaining vitality for more than a very few weeks after burial. The soil adjacent to the buried body did not seem to be infected, whether the body was incased in a coffin, or wrapped in a piece of fabric, or buried directly in the earth or in sand. In the latter case it is inferred that the vitality and infectiousness of pathogenic organisms contained in the viscera disappear long before the outer skin has become permeable to them. While the putrefactive organisms may prove a powerful and perhaps sufficient barrier to an outward passage, the exact manner in which the saprophyte repels pathogenic organisms has not been shown.

Yokote placed mice dead of plague in wooden boxes and buried them in garden soil that was kept from drying. The longest time that elapsed between the burial and the demonstration of the still virulent organism was thirty days, and this period was considerably reduced under higher temperatures and more active decomposition. In the soil in the immediate vicinity of the boxes plague organisms were not found.

Koch has shown that the bacillus of anthrax and other pathogenic bacteria can be grown in sterilized, but not in unsterilized soil. Wilson has examined graveyard soils and bits of old coffins, without finding any pathogenic organisms. The rapidity of the destructive action of soil upon bacteria varies decidedly, that of peat being especially rapid, and is to be attributed to the character and number of the contained saprophytic micro-organisms.

There is, therefore, no bacteriologic evidence that properly placed and conducted cemeteries are a menace to the adjacent neighborhood. It is conceivable, however, that infection might follow interment with access to subterranean streams.

CHAPTER VII

THE METHODS OF TRANSMISSION OF DISEASE BY ANIMALS

General Considerations. Rôle of Protozoa. Mollusca. Arthropoda. Insecta—as Mechanical Conveyers; as Inoculators of Disease; as Intermediate or Definitive Hosts of Pathogenic Organisms. The Rôle of the Higher Animals.

The development, reproduction and dissemination of many of the pathogenic organisms depends chiefly upon certain animals, in or on whose bodies they undergo stages of evolution, multiply, or are merely carried from place to place. Nearly any type of animal, from the lowly organized ameba to the highly specialized man, may be an active factor in the spread of disease.

The animal concerned may be (1) healthy and act simply as a conveyer of the materies morbi; (2) it may suffer from a disease similar to that which it spreads, or (3) from a different disease, the result of a different stage in the life-history of the same parasite. Thus, the midwife whose hands transmit infectious organisms to a parturient womb, and the fly that conveys the bacteria of cholera or typhoid fever to food, may themselves be healthy; the man that infects his fellow with smallpox or the horse that infects its groom with glanders may suffer respectively from variola and glanders; while the man with tapeworm whose dejections induce cysticercus disease in the hog, and the mosquito—diseased by the presence of blasts—whose bite infects a man with malaria, are both affected with morbid conditions quite different from those that they transmit, although the cysticercus found in the organs of the hog is but the embryonic form of the tapeworm present in the human intestine, and the blasts of the mosquito represent but a further stage in the life-cycle of the malarial parasite found in the blood of the man infected.

The animal in which the parasite acquires its highest development is termed the **definitive host;** the animal in which it undergoes the lower stages of development is the **intermediate host.** For certain parasites, man acts as the definitive host; for others, as the intermediate host. For example, the adult forms of the beef, pork, and fish tapeworms are found in man; the adult form of the dog tapeworm in the dog; the adult form of the malarial parasite in the mosquito. Rarely, as in the case of the pork tapeworm, man may harbor either the adult or the embryo parasite.

At times several animals play a part in disseminating disease, or an animal may spread an infection through its progeny. A rat may be infected by bubonic plague from contaminated soil; the fleas upon the cat that kills the rat may acquire the parasite with the blood of the rodent and may then carry the infection to the human family. The parasite of Texas cattle fever is taken from cattle by ticks, which transmit it to their progeny, that in turn inoculate healthy cattle.

Animals may transmit disease to man by **simple contact,** by **polluting food, water,** or **air,** or by **inoculation** through the bites, punctures, or scratches that they produce. These methods will be considered in detail as the various classes of animals are discussed. The use of animals as **food** likewise involves dangers both from disease of the food animal and from contaminations of various kinds, as discussed elsewhere.

PROTOZOA

Of the lowest form of animal life, the **protozoa,** but little is known as to their relation to the transmission of parasitic micro-organisms. It is known, however, that amebæ frequently take bacteria into their protoplasm, and it is not improbable that future investigations will demonstrate that protozoa play an important rôle in the life-history and dissemination of certain parasites.

MOLLUSCA

There is strong evidence that contaminated **oysters** have been responsible for epidemics of typhoid fever in a number of instances. Oysters have also been thought to transmit Asiatic cholera. In every investigated case the oysters were exposed to sewage. This form of transmission, of course, pertains to the subject of **food contamination** and is considered here for convenience.

Chantemesse has shown that oysters exposed for twenty-four hours in salt water contaminated with **typhoid** dejections or cultures, and kept unopened for a day after removal, will still yield the organisms of the disease. Boyce believes that typhoid bacilli do not occur in the tissues of the oyster, and that they disappear in from one to seven days after being placed in pure sea-water. Foote, however, says that they multiply in the tissues during the first two weeks, and although they then diminish, may still be found after thirty days. The **cholera** organism was found by Klein in oysters four days after their removal from water previously contaminated; although De Giaxa found that this organism was destroyed in from four to thirty-six hours. The bacillus of **anthrax, Staphylococcus aureus, Proteus vulgaris, pneumococcus,** and other pathogenic organisms have been found active in oysters after several weeks' exposure to sea-water.

As oysters are usually contaminated by polluted water, the **location of oyster-beds** is of extreme importance. The self-purification of rivers may be considerably modified by the influence of the sea into which they flow. According to Mosny, beds situated at the mouths of rivers emptying into seas in which tides are either absent or insignificant may be considered as free from possible contamination only when so far removed from sources of contamination that currents cannot carry it to them. This distance varies with the local currents, prevailing winds, and other forces, and must be determined in each case. Where beds are situated at river mouths under tidal influence, sewers should not empty into the river except during the first half of ebb tide, as it is important that the sewage shall be carried out to sea before the flood tide shall have an opportunity to bring it back again. Moreover, the beds should be laid out above the level of low water, that they may remain uncovered during the latter half of ebb and first half of flood. When the beds are not situated in the channel of the river, but near its banks, it should be required of the proprietor that he shall not allow the river water to enter them except at high tides, or during those hours of ebb tide when the sewage thrown into the river is below the entrance of the conduits by which water is conveyed to the beds. These general rules must be modified by the local conditions in each case, and if the source of pollution cannot be suppressed, the beds must be removed.

ARTHROPODA (INSECTA)

Of the arthropods, the **insects** are the most important disseminators of disease.

The Rôle of Insects in the Transmission of Infectious Diseases

The idea that various insects may transmit disease has been suggested frequently in the past. Italians have long considered malaria as due to mosquitos, while certain savage tribes in Africa retire to the mountain heights at night, or protect themselves from gnats by smudges or by anointing themselves with certain oils, in order to ward off the fevers they believe to be conveyed through the agency of these pests. Many years ago attention was also called to the possibility of excluding the 'miasm' of malaria from houses by screening the entering air. Sydenham says that when insects, especially house-flies, swarm in summer, there will probably be an unhealthful autumn. Montfils, in 1877, wrote that anthrax might result from fly bites. Many similar observations have been made by others, but it is only within very recent years that indisputable proof has been collected of the activity of insects in the diffusion of disease among animals and men. The paper by Nuttall* which appeared in 1899 was the first to review the subject thoroughly, and must serve as the basis of all future studies. Its facts have been drawn upon freely in the preparation of this chapter.

Insects may act as (1) **mechanical conveyers of disease,** the micro-organisms being carried upon or within their bodies. Certain biting insects may not only transmit the cause of a disease from place to place, but may, in their puncture of the skin, (2) **inoculate** it. Again, insects may constitute (3) **intermediate or definitive hosts** of pathogenic organisms, the parasite undergoing a certain cycle of development within their bodies, after which it may enter the human host, usually by direct inoculation during a bite or sting. These three means of disease transmission have been positively demonstrated by clinical and laboratory experimentation, for at least a number of diseases. Insects probably have an important rôle in the transmission of other diseases, as yet little understood.

* "Johns Hopkins Hospital Reports" for 1899.

Insects as Carriers of Infection

Many experiments have shown that flies, fleas, roaches, bedbugs, and other insects in walking over infected surfaces pick up bacteria upon their feet, legs, wings, bodies, and other parts, and that they may transmit these organisms for considerable distances, contaminating distant articles with which they come in contact. With certain micro-organisms it has been found that the insect may still transmit the living parasite after a period of several days. Not only may the insect carry the organism upon the outside of its body, but it may ingest large numbers of bacteria, or of the smaller animal parasites or their ova, and later deposit them in its dejections at perhaps a very remote place. The numbers of organisms found in the dejections, in certain instances, have even suggested that the bacteria undergo multiplication in the insect's body, but this has not been proved. More often it seems that the parasite undergoes degenerative changes in the intestinal canal of its host, so that if it be not deposited with the feces within a few hours, or at most a few days, its death occurs. This has been observed especially in connection with the **anthrax bacillus,** but it probably does not hold true for all bacteria. Instead of being discharged from the body, the micro-organisms may be liberated upon the death and disintegration of the insect.

By one of these methods of transmission the parasites are deposited upon the surface or within the orifices of the bodies of men, in wounds, in streams or other sources of water-supply, or upon food. When deposited in certain liquid foods that are excellent culture-media, and especially in milk, if the bacteria multiply and are capable of causing infection through the gastro-intestinal tract, extensive epidemics may result. Not only may the small vegetable micro-organisms thus be carried, but also larger particles, including certain **animal parasites** and their ova.

Tænia cucumerina, a tapeworm commonly found in the dog, but occasionally in man, undergoes a larval stage in fleas and dog-lice, and these insects, when swallowed by a warm-blooded animal, have caused tapeworm infection. Various forms of tapeworm, chiefly those found in the lower animals, have been shown to undergo an intermediate stage in beetles, flies, caterpillars, butterflies, and certain worms, as well as in certain Crustacea. It has also been shown that common flies and other insects may ingest the eggs of various worms, parasitic to man, and may deposit them later in their dejecta, as has been demonstrated by Grassi in the case of the pin-worm

(Oxyuris vermicularis), the pork tapeworm (Tænia solium), and the whip-worm (Trichocephalus dispar), and by Stiles as to the common round-worm (Ascaris lumbricoides).

Allen J. Smith has recently found in the intestines of cockroaches an ameba closely resembling that causing tropical dysentery. The guinea-worm (Dracunculus medinensis) appears to undergo an intermediate stage of development in the fresh-water flea (Cyclops quadricornis).

Dewèvre found that in 50 per cent. of children experimented upon, **impetigo** could be carried from the affected to the well children by the simple transference of **lice** (pediculi). Lice in one instance were taken from a well child and placed upon a child with the disease, and after twenty minutes were replaced upon the healthy child, who later acquired the affection.

Celli, Nuttall, and others have shown that the micro-organisms of **anthrax, cholera, typhoid fever,** and **tuberculosis** may be carried by **flies, fleas,** and other insects, and may still retain their virulence after passing through the insect's intestine. These observations have a special importance in connection with typhoid fever and cholera.

The experiments of Simmond, Neffleman, and Macrae show that flies are able to infect milk with the **spirillum of cholera,** for at least one-and-a-half or two hours after they have been in contact with contaminated substances. Macrae's experiments were particularly interesting. Exposing boiled milk in different parts of the jail at Gaya, India, he found that on the male side of the jail the milk became infected by the cholera micro-organism, while similar infection was not found upon the female side. These two departments of the jail were separated by a high wall, and cases of cholera existed on the male side only. The jail swarmed with flies. Buchanan describes a jail epidemic in Burdwan, India, in June, 1896. Outside this prison there were huts where cholera prevailed. At a certain time a strong wind blew numbers of flies from the side where these huts lay into the prison inclosure, where they settled upon the food of a part of the prisoners. Only those persons who were fed at the jail inclosures nearest the huts became infected.

The study of a large number of cases of **typhoid fever** in the American camps during the Spanish-American War indicates that flies, which were shown to be constantly flying from improperly guarded latrines to the mess tents, were the chief cause of the wide-spread infection.

Flies caught in rooms inhabited by patients suffering with **tuberculosis** have been repeatedly found to contain in their intestines and excreta tubercle bacilli of sufficient virulence to cause the death of guinea-pigs.

Flies have also been credited with the dissemination of **leprosy,** but concerning a disease of such insidious onset the proof is difficult.

Certain forms of **purulent conjunctivitis—Egyptian ophthalmia** and **'Florida sore-eye'**—bear evidence of being disseminated by flies, which are attracted by the discharges, and which may readily carry the infectious material on their proboscides and legs, and

FIG. 45.—HIPPELATES FLY (HIPPELATES FLAVIPES).—(*From Schwartz; Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

deposit it in healthy eyes. The **Hippelates flies,** occurring in enormous numbers in the southern part of the United States, are especially prone to dart into wounds, the eyes, the nose, and other moist parts of the body, and probably are important carriers of contagion.

Infection of wounds may occur through the agency of flies that fall into the solutions or alight upon the instruments used, or upon the wound itself. Although it is difficult, clinically, to demonstrate infection by this means, there is abundant experimental evidence to show that it is not only possible, but ofttimes probable. Infectious organisms deposited upon unbroken surfaces of the body may later gain entrance through abrasions produced by **scratching.** In this way infections may result through the skin, although the person has not been bitten by an insect.

Howard has undertaken a comprehensive work to determine not only the importance of flies as disseminators of typhoid fever, but also to determine precisely the **species of flies** that feed or oviposit upon exposed human feces, and how many of these are attracted to human habitations. During 1899 and 1900, 23,087 flies were caught in and around human dwellings, examined, and classified. Of these, 98.8 per cent. were the common Musca domestica; others of importance were the **stable-fly** (Muscina stabulans), the **little house-fly** (Homalomyia canicularis), and the **fruit-fly** (Drosophila ampelophila),—all of which were found breeding in human feces. While the common house-fly prefers horse manure as a breeding-place, yet in army camps and country places where the box privy nuisance is still tolerated, they will breed in human excrement in vast numbers, and may be attracted to it without oviposition.

The Inoculation of Pathogenic Organisms Through the Bites of Insects

From the conclusive evidence that flies and other insects when feeding upon infectious material may take into their proboscides living parasites, it would seem possible that such insects as **biting flies** (Stomyxes, Tabanus, Hemotopota Simulium), **fleas, bedbugs, chigoes,** as well as **spiders** (arachnids) and **centipedes** (myriapods), could, under suitable conditions, produce infection. As yet there is little indubitable experimental proof, but many clinical instances have been recorded in which infection seemed to originate from the insect's bite. Anthrax has repeatedly been attributed to the bites of flies that have previously feasted on the discharges or carcasses of animals affected with splenic fever. Erysipelatous, phagedenic, and carbuncular inflammations have also been ascribed to the bites of insects.

Joly says that it is a common belief in Guadeloupe that glanders is transmitted by flies. Most of the facts submitted to prove infection from the bites of insects are suggestive rather than positive, and although the proboscis of the insect may teem with bacteria, the current during the blood-sucking would tend to carry the parasite away from the body of the victim. The physiologic mechanism of the insect's bite, however, is not so fully understood as to render this conclusion absolute. Many biting insects discharge saliva into the wound, and it would seem possible that this might wash certain parasites from the proboscis into the puncture. Nuttall, in 1898, permitted bedbugs to bite animals dead or dying of anthrax, plague, chicken cholera, and mouse septicemia, and then transferred them to healthy animals that were repeatedly bitten, but in no instance became infected. Bedbugs were also permitted to bite mice through areas of skin on which the spleen from the body of a mouse that had died of anthrax had been rubbed, yet no infection followed. Similar negative results were also obtained from a few experiments made with fleas. In view of these experiments, Nuttall concludes that infection from the bite of a bug does not occur, or at least is exceptional. That infection might occur were the bug crushed while in the process of biting, or the bitten area afterward scratched, is admitted. Joly, in 1898, working with anthrax, obtained similar negative results.

It should be remembered, however, that these experiments are too limited to prove a general negative. They indicate that the ability of biting insects to inoculate disease is not an universal one, but is at most restricted to certain species, and depends perhaps, also, upon the association of special favoring conditions, such as a particular length of time after contamination and other environmental factors. It is known that a number of these insects during the process of biting, discharge in their excreta, upon the skin of the animal bitten, ingested pathologic organisms. That special conditions may be required is suggested by the observations on the **tsetse-fly disease,** or nagana, which is due to a flagellated micro-organism that has been found in certain of the wild animals, especially the Ungulata, in Africa. Experimental observations of Bruce and others, conclusively demonstrate that the tsetse-fly, comprising several species of Glossina, carries the parasite from the infected wild animal, and in biting inoculates such

FIG. 46.—GLOSSINA MORSITANS, THE AFRICAN TSETSE-FLY.—(*Lydekker.*)

domestic animals as the horse, mule, donkey, and cat. Although the bites are painful, they are not infectious to man.

Other flies seem unable similarly to convey this disease, and for successful inoculation it is also essential that the fly should bite the healthy animal soon after having been on the diseased animal, for if the glossinæ are kept hungry for a few days, they then fail to convey the disease. This indicates that the fly acts simply as a carrier and inoculator, and is not an intermediate host of the parasite. The disease may also be conveyed by direct inoculation of the blood. **Trypanosoma** infection of rats seems to be consummated by the inoculation of the parasites by the bites of contaminated fleas.

It will be observed that these, and other parasites later to be mentioned that are positively known to be inoculated by the bites of insects, are animal parasites and not bacteria; yet the possibility of inoculation of the vegetable parasites in this manner should be considered, and, until it is positively disproved, precautionary measures should be taken to prevent its consummation. Dewèvre reports the development of tuberculosis in guinea-pigs inoculated with the contents of **bedbugs** collected in the bed of a phthisical patient.

Insects as Intermediate Hosts of Parasites

It has been demonstrated beyond cavil that certain varieties of **mosquitos** act as intermediate hosts for **malaria, yellow fever,** and **filariasis.** In each of these diseases the parasite is removed from the blood of an infected person by the mosquito and undergoes a certain developmental cycle in its body; after which the parasite may be returned into the body of a susceptible person next bitten. The evidence in proof of this mode of conveyance by the mosquito is conclusive. The experiments, particularly in relation with yellow fever and malaria, are striking. Grassi protected 10 houses containing railway employees and their families—numbering, in all, 104 persons, including 33 children under ten years of age—in a very malarious district on a plain of Cappacco, Italy. The protection consisted merely in adopting precautions against mosquito bites, by properly screening the houses, and by causing the occupants to retire within them before sundown. Of the 104 persons, all but three remained free from malaria during the malarial season. During the malarious season of 1900, Drs. Sambon and Low, of the London School of Tropical Medicine, lived in a very paludous part of the Roman Campagna, in a specially constructed and carefully screened house. No quinin was taken, and no health precautions observed beyond retiring within the house from sundown each day until daylight the following morning. Despite the general prevalence of the fever in the surrounding country, and although the experimenters exposed themselves to the night air and to the wet and cold of the rainy season, their health remained perfect. About the same time mosquitos that had bitten a patient suffering with malaria in Rome were sent to Liverpool, and permitted to bite a son of Dr. Manson, who had never been in a malarious country since he was a child. These mosquito bites were promptly followed by a well-marked infection of the double tertian type. Many other experiments have likewise indicated the transmission of malaria by Culicidæ,* and it remains to be demonstrated that malaria is contracted in any other way—except experimentally, when blood is transferred directly from the sick to the well.

The experiments of Drs. Finlay, Reed, Carroll, Agramonte, and Lazear † in relation to **yellow fever** are, if anything, more striking. These observers repeatedly transmitted yellow fever from the ill to the well through the bites of certain mosquitos. It was found that twelve days were required from the time that the mosquito bit the infected person before its bite could transmit the disease, and that after this period it maintained its ability to infect the well for at least fifty-nine days. To carry out the experiments more thoroughly, two buildings were erected. One, known as the infected mosquito building, was divided into two rooms by a wire screen partition extending from the floor to the ceiling. The door and windows were screened, but so placed as to give thorough ventilation. All articles introduced within the building were previously carefully disinfected by steam. In the large room of this building mosquitos that had previously been contaminated by biting yellow fever patients were placed, and persons who were not immune to yellow fever entered both rooms. In the room free from mosquitos the experimenters remained in perfect health, while in the other room six out of seven persons bitten promptly contracted yellow fever. The second building erected was a small frame house with a capacity of 2800 cubic feet, tightly sealed and battened, provided with small windows to prevent thorough ventilation, and with wooden

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* 'Culicidæ,' the family name for all mosquitos, should not be confused with the generic term 'Culex.'

† By permitting himself to be inoculated by mosquitos Dr. Lazear sacrificed his life.

shutters to avoid the disinfecting action of sunlight. The house was carefully screened to prevent the entrance of mosquitos. The average temperature in the house was 76.2° F., and care was taken to keep the atmosphere humid. On November 30, 1900, three large boxes filled with sheets, pillow cases, and blankets that had been used on the bodies and beds of patients suffering from yellow fever, and were soiled by their discharges, were placed in the room. This soiled linen was not disinfected and was used in preparing the beds upon which nonimmune persons slept during sixty-three days. Later a fourth box of clothing and bedding was added, this being so vilely soiled with the bloody stools of a fatal case of yellow fever that for

FIG. 47.—TRANSVERSE SECTION OF THE HEAD OF A MOSQUITO SHOWING FILARIA IN POSITION TO BE INOCULATED DURING THE ACT OF BITING.—(*From Howard, after Manson.*)

a time it was difficult to remain in the house after the box had been opened. Two nonimmunes occupied the beds from December 21st to January 10, 1901, every night wearing the garments worn by yellow fever patients during their entire attacks, and making exclusive use of their much-soiled bed linen. Each night this linen was shaken to diffuse adhering particles in the air and each morning packed away in the cases. At the end of twenty-one nights, two other nonimmune persons occupied the same beds for twenty days more. In all, seven nonimmune persons were exposed in this building during the period of sixty-three days, yet all were finally released from quarantine in perfect health. In these experiments the greatest care was taken to avoid anything that would militate against the accuracy of the results, and the evidence is conclusive that a mosquito (Stegomyia fasciata) serves as the intermediate host for the parasite of yellow fever. Considered in conjunction with the mosquito's ability to live and retain the virus for several months, to hibernate during cold weather, and to be transmitted in various vehicles and on shipboard, many features relating to the development of epidemics of yellow fever are for the first time satisfactorily explained.

Manson was the first to show that the mosquito acts as the intermediate host of the parasite of **elephantiasis.** In this disease the adult worm (Filaria sanguinis hominis), living in the lymphatics, gives birth to broods of embryos that are disseminated in the lymph stream and finally enter the blood. They occur in abundance in the blood when the patient is asleep, and apparently retire to the lymphatics during his hours of activity. The mosquito, in biting, seems to entangle these embryos in its proboscis, and to draw them into its stomach, where the embryos lose their hyaline envelopes, penetrate the gastric walls, and enter the muscles of the thorax. Here they remain until the seventeenth day, when they collect in the connective tissue of the anterior part of the thorax, and by the twentieth day are found to have penetrated the neck, the head, and the back of the insect. It seems evident that, if the mosquito bites after this time, the filaria may be inoculated into the tissues of the individual bitten. It is supposed that in the skin the embryos reach adult development, then burrow, enter the lymphatics, and give rise to broods of embryos, thus completing the life-cycle.

Each of these three diseases is transmitted by its particular mosquito: malaria by certain Anopheles, yellow fever by Stegomyia fasciata, and the filaria by a Culex, and possibly by Anopheles. Experiments indicate that Anopheles will not transmit yellow fever; nor Culex, malaria. Recently Graham has apparently shown that **dengue** likewise depends on a hematozoon carried and inoculated by mosquitos.

In the case of **Texas fever** of cattle, Theobald Smith has shown a remarkable phase in the rôle of cattle ticks as intermediate hosts. The causal parasite of this disease is a very minute hematozoon (Pyrosoma bigeminum). The cattle tick (Boöphilus bovis), having filled with blood, drops from the animal, and a few days later lays her eggs. After twenty to forty-five days, the embryos escape from the egg and attach themselves to cattle. Two weeks later the young tick is sexually mature, becomes fertilized in twenty-one to twenty-three days, and it, also, drops to the ground and in turn lays eggs. A tick generation has an age, throughout, of from forty-one to sixty-eight days. The experiments of Smith and Kilburn, which have since been confirmed by Koch, show that the embryos developed from eggs laid by a tick which had fallen from a diseased animal are capable of infecting other animals. There is here, therefore, a remarkable transmission of the parasite of the disease from the parent tick to its ovum. There is no evidence that this occurs in the mosquitos that serve as hosts for the parasites of yellow fever or malaria.

It has yet to be determined in how many diseases insects serve as intermediate hosts, or the number of different hosts that a single pathogenic organism may have. Thus, Grassi (1890) found that the embryo of Filaria recondita (Hematozoon of Lewis), which closely resembles Filaria sanguinis hominis, undergoes a metamorphosis in the dog, cat, and man fleas (Pulex irritans). Grassi did not succeed in infecting animals from these fleas. Vicenté believes that a louse (Aspidiotous nerii) that infests the oleander may be a vehicle for the transmission of malaria. He mentions a certain family which included a person who had for several years been subject to malarial attacks. Some oleanders were added to the ornament of the house, and three children promptly developed malaria. It is asserted that the hematozoon was found on the lice parasitic on the plant. This observation as yet lacks confirmation.

CONVEYANCE OF DISEASE BY RATS

Not only are rats subject to various parasitic skin and muscle diseases that are communicable to man, but they are especially subject to **plague,** and are believed to be important agents in spreading this affection. It has been shown that the appearance of plague in certain cities, as Santos, was preceded by a large mortality among the rats.

The rats may contract plague from infected soil, from contaminated fleas, or from eating portions of the bodies of those dead of the disease. From the rat the bacillus may be carried to man by fleas. Loir concluded that the immunity enjoyed by oil-carriers in plague epidemics was a result of the flea's aversion to oil. It is possible that in rather rare instances the infected rodents may directly inoculate man through their bite; thus, Bell relates the case of an adult Chinaman who developed plague three days after having been bitten in the thumb by a rat.

Rats are said to be so susceptible to plague that they may be infected by merely touching their nasal mucosa with a smooth glass rod that has previously been touched to a culture of the Bacillus pestis. The death of many rats in a neighborhood or on shipboard may be the first evidence of the presence of plague.

CONVEYANCE OF DISEASE BY THE DOMESTIC ANIMALS

The domestic animals suffer from a number of diseases transmissible to man, and may also convey pathogenic organisms to man without themselves being affected. This may occur in various ways, as follow:

FIG. 48.—TETANUS BACILLI SHOWING CHARACTERISTIC TERMINAL SPORES IN THE DISCHARGE FROM AN INFECTED WOUND.—(*Muir and Ritchie.*)

1. **Direct Contact.**—Most of the human parasitic **skin diseases** occur in the dog, cat, and horse, and are transmissible by contact to man. These include forms of **ringworm** or tinea, caused by Trichophyton tonsurans; **favus,** produced by Achorion schoenleinii; and **pityriasis versicolor,** resulting from the action of Microsporon furfur. **Scabies** has been observed upon the nose of dogs and of rats. If the roundworm of the dog (Ascaris suilla) be, as some suppose, identical with Ascaris lumbricoides, the dog may be a source of this infection in man, as it is known to be the source of infection by Tænia echinococcus.

2. **Inoculation.**—The most important disease inoculated by bites of domestic animals is **rabies.** This malady occurs most frequently in dogs, but may affect cats, horses, cows, and other domestic as well as wild animals. The infectious principle is present in the saliva of the animal affected. Inoculation may result from the entrance into the body of fluids or discharges

from animals suffering from **tetanus, anthrax, glanders, actinomycosis,** or **foot-and-mouth disease.** In December, 1901, a number of deaths occurred in St. Louis from **tetanus** following the subcutaneous injection of diphtheria antitoxin obtained from a horse afterward found to be affected by this disease. The prevalence of tetanus after vaccination during the winter of 1901–02 in a number of North American cities has suggested that the infection may be carried in vaccine matter. It has now apparently been proved that this has occurred by the statistical studies of McFarland and the reported finding of tetanus bacilli in vaccine. Tetanus bacilli are frequently found about stables, and cattle, although less susceptible than horses, are not immune. Tetanus following surgical operations has been attributed to the use, for ligatures, of so-called kangaroo-tendon, in reality horse-tendon—taken from infected animals. Gelatin also is at times contaminated. Punctures by splinters, nails, or other objects about stables are often followed by lockjaw, these objects apparently being contaminated by the dejections of horses. It was by milking that the Jennerian **cow-pox** was first transferred to man.

3. **Aerial Infection.**—In coughing and snorting, horses suffering from **glanders** throw into the air liquid particles laden with Bacillus mallei. These particles may be inhaled by persons or by lower animals, may fall upon wounds, or contaminate various inanimate objects in the immediate neighborhood. In this manner, or by direct contact with the discharges from the nares or from farcy-buds, this virulent disease is spread. In a similar manner organisms of **actinomycosis, tuberculosis,** and **aspergillosis** may be conveyed from cattle to other cattle, or to man. **Psittacosis,** a pulmonary disease of parrots, may likewise be transmitted to the human family, producing a serious pneumonic disorder. From sick parrots imported from South America to France, seventy persons in Paris became ill with psittacosis and thirty-four died.

4. **General Contagion.**—By various methods, for example, directly through the contact of fondling and play, and possibly indirectly by the soiling of furniture, carpets, and garments, domestic animals, and especially pets, as cats, dogs, rabbits, etc., may convey to human beings the ova of parasites—as in the case of the echinococcus of the dog, giving rise to **hydatid disease** in man—developed parasites—as the itch-mite—or the germs of specific diseases, as **influenza, diphtheria,** and possibly **scarlet fever** and other epi-

demic infections. The animal may itself suffer with the disease transmitted, or may be merely a mechanical conveyer of the germs; or, as already set forth, it may convey fleas or other insects which may cause the infection in any of the ways discussed.

Animals suffering from diseases communicable and harmful to man should be killed, and their bodies burned, quicklimed, or buried deeply. The methods of dealing with insects and vermin that carry disease will be discussed in Section III, "Prevention."

CHAPTER VIII

CONVEYANCE OF PARASITES BY FOODS*

Animal Parasites. Beef and Milk as Sources of Tuberculosis; Other Infections Conveyed by Milk; Protection of Milk. Infected Vegetables.

Flesh containing encysted **animal parasites** is termed **'measly.'** From the ingestion of imperfectly cooked or cured measly pork one may become infected with **trichinæ,** the **pork tapeworm** (Tænia solium), or, rarely, **sarcosporidia;** from beef one may acquire the **beef tapeworm** (Tænia mediocanellata), or, of vegetable parasites, **anthrax** and **tuberculosis;** from eating certain European and Asiatic fish, the **fish tapeworm** (Bothriocephalus latus). All these parasites are destroyed by thorough cooking of the meat.

Beef and Milk as Sources of Human Tuberculosis

The pathogenicity of the tubercle bacillus from cows when introduced into the human body was disputed by Koch at the Tuberculosis Congress held in London in 1901. Both the older clinical and experimental observations and the more recent publications of Ravenel, Behring, and others, oppose this view. In brief, the evidence shows: (1) That the bovine tubercle bacillus is more virulent in the lower animals, including monkeys, than the human tubercle bacillus. (2) That accidental inoculations of the bovine tubercle bacillus have occurred in man and have produced fatal tuberculosis. (3) That, contrary to the observations of Koch, tubercle bacilli isolated from lesions in the human body do produce widespread tuberculous lesions when fed to cattle. (4) That cattle may be immunized against the bacilli of bovine tuberculosis by progressive inoculation with cultures of the bacillus from human tuberculosis. (5) That of children in hospitals in which cows' milk is used as a food, not less than one-third of the deaths may occur

* See also references to infected oysters, pages 131 and 132.

from tuberculosis, and that over one-third of these bodies show evidence of a primary intestinal infection, as indicated by the post-mortem studies of Still. (6) The relatively greater frequency of pulmonary over intestinal tuberculosis is not sufficient proof that the predominant mode of infection is by inhalation. On the contrary, it is probable that infection by contaminated food chiefly affects the most vulnerable organs—the lungs. Of four animals in which wide-spread forms of tuberculosis resulted from food containing tubercle bacilli, Ravenel found intestinal lesions in but one.

INFLUENCE OF TEMPERATURE UPON THE BACTERIAL CONTAMINATION OF MILK.—(*From Wm. H. Park.*)

No. 1 = 3000 bacteria in each cubic centimeter when received; milk collected under best conditions.
No. 2 = 30,000 bacteria in each cubic centimeter when received; milk collected under ordinary conditions.

Temperature, Degrees Fahrenheit	After 24 Hours		After 48 Hours	After 96 Hours	After 168 Hours
32°	1, . . .	2,400	2,100	1,850	1,400
	2, . . .	30,000	27,000	24,000	19,000
39°	1, . . .	2,500	3,600	218,000	4,200,000
	2, . . .	38,000	56,000	4,300,000	35,000,000
42°	1, . . .	2,600	3,600	500,000	
	2, . . .	43,000	210,000	3,760,000	
46°	1, . . .	3,100	12,000	1,480,000	
	2, . . .	42,000	360,000	12,200,000	
50°	1, . . .	11,600	540,000		
	2, . . .	89,000	1,940,000		
55°	1, . . .	18,800	3,400,000		
	2, . . .	187,000	38,000,000		
60°	1, . . .	180,000	28,000,000		
	2, . . .	900,000	168,000,000		
68°	1, . . .	450,000	25,000,000,000		
	2, . . .	4,000,000	250,000,000,000		
86°	1, . . .	1,400,000,000			
	2, . . .	4,000,000,000			
94°	1, . . .	25,000,000,000			
	2, . . .	25,000,000,000			

It is generally admitted that cows showing emaciation, or having diseased udders, in association with tuberculosis, are especially likely to give milk containing tubercle bacilli. The danger from cows free from udder disease and emaciation, and with a stage of tuberculosis only recognizable by the tuberculin test, is much less marked. Ostertag found no tubercle bacilli in the milk of 49 cows reacting to tuberculin but without other symptom of disease. He advises a fortnightly examination of such cows, weeding out all emaciated and all those with diseased udders, in whose milk he usually found tubercle bacilli. As it is difficult to detect emaciation and udder disease in its early stages, the risk of following out this advice is evident. Upon the other hand, there is little doubt as to the general safety of milk from cows that do not respond to the tuberculin test. Lydia Rabinowitsch found no tubercle bacilli in the mixed milk from large herds of such cattle. In herds guarded by mere clinical observation, virulent tubercle bacilli were found in a number of instances. MacFadyen estimates that 30 per cent. of the cattle in Great Britain are tuberculous. In various tests throughout the United States from 2.2 to 50 per cent. of the cows were found to react to the tuberculin test. Milk, therefore, should only be taken from cows in good health that do not react to tuberculin.

Other Infections Conveyed by Milk

Milk may also be contaminated by the virus of **measles, scarlatina,** and **diphtheria.** Epidemics of all these diseases have been traced to certain milk routes. The contamination almost invariably results from the handling of milk by those who are sick or convalescent, or who have been exposed to these diseases. Milk may become infectious through the addition of polluted water, or the washing of the containers therein. Diseases simulating diphtheria and scarlatina have been noticed in the lower animals, but thus far the identity of the two remains unproved. Milk may be contaminated after leaving the udder by various pyogenic bacteria, or, through faulty refrigeration, a harmful number of saprophytic bacteria may develop. The foregoing table on page 148 shows the influence of temperature upon the bacterial purity of milk and also the relation of sanitary precautions in collecting milk, to its purity. That mixed milk from a herd contains fewer bacteria than that from individual cows is shown in the following table:

BACTERIAL CONTAMINATION OF MIXED MILK FROM HERDS AND FROM INDIVIDUAL COWS.—(*Park.*)

Number of bacteria in each 1 c.c.:

	5 Hours after Milking	24 Hours	48 Hours	72 Hours (Not entire)
A. From individual cows (average), .	6,000	1,938	17,816	
B. Mixed of the entire herd (average),	4,333	2,766	10,583	329,000

The Avoidance of Bacterial Contamination.—The bacterial contamination of milk results from filth upon the cow's body or the milker's hands, or in the air or the containers. To avoid these sources of contamination, excrement should be removed promptly, and care be taken that the cow's bedding is clean, and that the udder is cleansed with a clean damp cloth before each milking. The milkers should be free from tuberculosis or other infectious disease, nor should they associate with people suffering from such infections. Their clothes should be clean and their hands well washed before each milking, and milk or saliva should not be used to lubricate the teats. No sweeping should be permitted about the time of the milking hour. The use of impervious floors that are kept clean by washing rather than sweeping is advisable. All milk receptacles should be well cleansed and scalded before use, and the milk-pail should have an opening not over six inches in diameter, protected by fine gauze. After collection the milk should promptly be cooled to at least 46° F., which temperature should not be exceeded. It should not contain over 12,000 bacteria per cubic centimeter in warm weather, or 5000 in cold weather, and at the end of thirty-six hours the number of bacteria should be less than 50,000 per cubic centimeter; or if the milk has been kept at a temperature not exceeding 40° F., less than the original number of bacteria should be present.

Milk products, such as cream, butter, cheese, ice-cream, and 'hokey-pokey,' may convey the same germs as those present in the original milk, plus those that may gain access through uncleanly manipulations.

TRANSMISSION OF DISEASE BY INFECTED VEGETABLES

Uncooked green vegetables may have animal or vegetable parasites deposited upon them from the soil, in fertilizers, in dust, or by contact with living or dead animals (including insects), or human beings. It is believed that the eggs of the common **round-** and **pin-worms** often gain entrance to the body upon improperly washed celery, lettuce, water-cress, or other greens.

Forms of the **Amœba coli** may likewise be acquired in the same way. This form of infection is especially to be feared when gardens are sprinkled with fresh solutions of fecal matter. Manure from the lower animals may contain parasites pathogenic in man. Insects may deposit parasites upon plants.

Of the **bacteria,** members of the **colon group,** especially the **typhoid bacillus,*** seem to be the organisms most frequently transmitted by vegetables. The **tetanus bacillus** may thus be conveyed, but seems to be innocuous when swallowed.

Fruits and vegetables may be contaminated by **handling** or by exposure to bacteria-laden **dust.** Fruit displayed for sale on street stands in the larger cities is often coated by a layer of the dust blown from the pavement and consisting largely of horse-droppings; is a rendezvous for insects of the street; is polished by filthy hands, often upon filthier cloths or clothing; and is otherwise exposed to soiling by the unclean habits of venders. To contemplate the many patrons of these stands who escape disease is but to develop admiration for the high degree of insusceptibility of our genus.

Precautions against Conveyance of Disease by Vegetables

Rinsing in cold water or wiping with a damp cloth are untrustworthy methods of cleansing fruits and vegetables that are to be eaten uncooked. So far as possible, the outer rind or cuticle should be discarded and not brought in contact with the mouth. It has been suggested that fruits be dipped in an antiseptic solution, such as one of tartaric acid, formaldehyde, or corrosive sublimate; but frequently such solutions are either uncertain in germicidal power or are otherwise objectionable. Ten per cent. of the commercial solution of formaldehyde in water is a powerful germicide, and will not cause toxic symptoms if by a secondary rinsing in weak ammonia-water the formaldehyde is neutralized.

A sufficient superficial sterilization of fruits may be consummated by dipping them for from five to ten seconds in boiling water. Even grapes suffer little damage during this procedure.

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* The State Board of Health of Massachusetts apparently demonstrated that an outbreak of typhoid fever at the State Hospital for the Insane at North Hampton was spread by celery raised upon the premises in beds watered with filtered sewage. The disease occurred only in those who had eaten celery, and the avoidance of this vegetable was effective in checking the spread of the infection. Ferre has reported a similar outbreak that occurred in a girl's school at Jurancon, affecting only the boarders and not the day scholars. It was found that the vegetable garden from which the school was supplied was watered with the contents of a cess-pool.

CHAPTER IX

SOCIAL INTERCOURSE AS A FACTOR IN THE TRANSMISSION OF DISEASE

Fomites; Household Utensils; Surgical and Dental Instruments; Mail Matter; Transportation; Commercial Intercourse, Money; Personal Contact; Sexual Impurity.

Fomites

The transmission of infection or diseases to the well from the sick of the human species has been attributed to **fomites,** or porous substances capable of retaining virus, such as articles of wearing apparel and bed-clothing, fabrics of linen or cotton, leather goods, and the like. The possibilities of infection through such contaminated articles have probably been much overrated, and we have little exact experimental evidence showing precisely its importance. For example, **yellow fever** was considered, until recently, to be in large measure conveyed by fomites; but the recent experiments at Camp Lazear in Cuba show this mode of infection to be improbable. As a rule, porous substances do not retain living infectious bacteria for any considerable time, as their dryness leads to the death of the organisms. Articles that have recently been contaminated by pathogenic discharges may be dangerous, especially when brought in contact with open wounds; or if violently agitated, as in sweeping, dusting, or beating, infectious particles may be thrown into the air, that are injurious if inhaled. Fomites are at present thought to be the chief means of transmission of **scarlet fever, smallpox,** and **measles.** Numerous instances are on record in which fabrics have apparently retained the virus of scarlet fever for months. It must be admitted, however, that although extremely probable, the evidence is entirely clinical and is without the proof of rigidly controlled experiment. Observations that seemed equally conclusive were brought forward to prove the similar conveyance of yellow fever.

Toys, Tableware, etc.—Household utensils and toys, when used in common by two or more persons, may carry the virus of a number of diseases. Infants have acquired tuberculosis from the nipples of feeding-bottles moistened in the mouths of unclean and infected nurses. Toys that a sick child has played with may carry disease. Infected tableware may render the dining hazardous. It is important that one affected by a communicable disease, such as **syphilis, tuberculosis, diphtheria,** or **scarlet fever,** should have an individual tray reserved for his own use and kept apart from the service of the other members of the household. Such utensils should first be immersed in boiling water or other efficient disinfectant before being washed. In the regular disinfection of the ordinary table utensils the method of the careful housewife, of thorough washing in hot, very soapy water and rinsing in scalding water, does not require improvement. In this connection the agitation for **individual communion cups** must be indorsed; and the necessity for caution in the matter of using the cups and glasses at public fountains, at the stands of lemonade 'fakirs,' and the like, should be mentioned.

Surgical and Dental Instruments.—Imperfectly disinfected instruments may transmit organisms of **erysipelas** and **suppurative** processes, of **syphilis, gonorrhea, scarlet fever, diphtheria, tuberculosis,** and **actinomycosis.** It is difficult to estimate the frequency of infection by this means. Up to this time the instruments used by careless dentists seem to bear the greatest distinction for gross filthiness. A large number of cases of infection by syphilis and other serious affections have been directly traced to the filling or extraction of teeth. Physicians and surgeons are not exempt, however, from similar blame. Septic fever and purulent urethritis from the use of unclean catheters are not rare occurrences. Syphilis has been conveyed by Eustachian catheters, tongue depressors, and the like; and although reports of actual instances are lacking, it is quite possible that pathogenic germs of many kinds may be transmitted from mouth to mouth by clinical thermometers. As all forms of instruments may now be thoroughly disinfected with but little trouble, there is no excuse for such transmission of disease. Indeed, patients infected by the criminal carelessness or ignorance of their dental or medical attendants have means of legal redress. Similarly, chiropodists, manicures, and barbers should observe the rules of sanitary cleanliness.

Mail Matter.—The conveyance of pathogenic organisms by the postal service is evidently rare. The dryness of the paper sent by mail is unfavorable for the perpetuation of life of most of the bacteria. It is difficult to prove that a reported case of infection occurred in this way, although cases similar to the following one, related by Gripat, are very suggestive: A mother living at Angiers received from her sister-in-law, in a northern city, a letter in which the concluding sentence read, "I am writing, holding upon my knee my little girl, who has just developed **measles.**" The sister-in-law at Angiers also happened to have her daughter upon her knee when she was reading the letter, and the child seized the envelope, played with it, and carried it to her mouth. The letter was burned at once, but twelve days later the child developed an indubitable measles rash. At this time there was no other case of measles known to be in Angiers.

Letters may be **disinfected** without injury by means of formaldehyde gas, which has been found to penetrate envelopes readily. This is best accomplished in a chamber connected with a vacuum apparatus to facilitate the penetration of the formaldehyde. Dry heat also may be applied. More efficient is dry steam, provided care be taken to expose the mail to hot dry air, immediately following the steam, in order to prevent watery condensation.

Transportation.—The measures adopted to prevent the spread of disease during travel are usually imperfect. In the berths of sleeping-cars and vessels one may come in close personal contact with the same utensils and bedding that but a few hours before were used by a consumptive or a victim of other infectious disorder. To prevent repeated use without washing it has been advised that only white blankets be furnished in such public conveyances. In railroad or street-cars vibration tends to keep the air constantly filled with dust from the floor and other parts of the car. If the regulation against spitting is not enforced, or if the car be soiled in other ways, it is likely that dry, pulverized infectious material will be carried into the air, deposited on or taken into the bodies of the occupants of the car. The use in common of lavatories and drinking-cups should be supervised. Purulent ophthalmia, tuberculosis, the acute exanthemata, syphilis and infectious cutaneous disorders, and many other diseases may be transferred in this way. Insects may transmit infection from one traveler to another.

Commercial Intercourse.—The commercial relations existing between individuals, communities, and countries may serve as an important means for the spread of infection. The regulation of the importation, inspection, and disinfection of fabrics and foodstuffs is a part of State and municipal hygiene. Coin or paper **money,** checks, tickets, letters and the like all may serve to convey disease. The abominable habit of many persons of wetting the fingers with saliva to facilitate the counting of paper or cloth fabrics should, as far as possible, be abolished by educational training. Fortunately letters, textile fabrics, scrip, and coin may be effectually disinfected by formaldehyde * or by steam.

Personal Contact

Personal contact is responsible for many of the infections. A disease may be transmitted from a person who is ill or who has recently had the disease, or, at times, from one who has merely been in contact with it. Thus, **diphtheria** is frequently communicated from those who have the malady, from convalescents, and from association with apparently healthy members of the household. A healthy individual with virulent bacilli in his throat may be just as dangerous as a patient with mild diphtheria, or in the convalescent stage. It is important, therefore, to make cultures from the throats of all who have been exposed to diphtheria and to isolate persons in whose throats, under such circumstances, the organism is found. This bacillus may remain for months in the mucous membrane of the nose, pharynx, and larynx without any clinical sign of the disease developing.

In the statistics generally quoted, diphtheria bacilli were found in 18.8 per cent. of persons who had been exposed. Kober † studied in Flügge's laboratory 128 healthy persons who had been in contact with cases of diphtheria, and 600 who were not known to have been so exposed. Of the former group, 8 per cent. were found to have virulent diphtheria bacilli in their mouths or throats. Of the latter group, 15, or 2.5 per cent., showed the presence of the bacilli, as compared with 7 per cent. in other statistics. Further inquiry showed that 10 of the 15 could be considered to have been exposed directly or indirectly, thus reducing the proportion of unexposed individuals who carried the organism in their throats to 0.83 per

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* A two per cent. solution of formalin may be kept in the 'sponge-cups' of cashiers in retail stores, bank-tellers, and others who handle much money.

† "Zeitschrift für Hyg.," 1899, S. 433.

cent. Besides, in the 15 cases of the second series, the bacilli were non-virulent in 10.

Although we have less definite knowledge in regard to many of the other infectious diseases, such as **scarlet fever, smallpox,** and **typhus fever,** the importance of isolating those who have had the disease, for a considerable period after their recovery, and of supervising the personal intercourse of others exposed, is obvious.

A **lesion** of the skin or mucous membrane may or may not be necessary to infection, but, as a rule, favors the invasion of a virus. The **itch mite,** for example, penetrates the unbroken skin, the **gonococcus** invades intact mucous membranes, while inoculation with **vaccinia** or the **syphilitic virus** is favored by local lesions, although often very small and superficial. The chancre of syphilis is chiefly found upon portions of the generative organs most exposed to abrasion during the sexual act; upon the lips it often occurs in the situation of a chronic fissure; upon the hands, at the site of a scratch or abrasion, as evidenced by the not infrequent infection of surgeons and obstetricians in this manner.

Sexual impurity is the chief factor in the spread of a number of the most virulent and wide-spread diseases. Besides syphilis, gonorrhea, and the chancroidal ulcer, it has been claimed—upon evidence, however, that is not entirely conclusive—that **leprosy, tuberculosis, elephantiasis,** and even **carcinoma** may similarly be conveyed. The one reliable defense against venereal infections is sexual purity, and to this end a higher moral education of the race is of first importance.

No satisfactory method for the municipal **suppression** or **regulation of prostitution** has yet been devised. In the United States no city will tolerate open licensing and inspection of prostitutes. Although European statistics indicate that such methods may diminish the prevalence of venereal disorders, they cannot be entirely efficient, and are open to much criticism upon other than sentimental grounds. The infectious elements of syphilis or gonorrhea are with difficulty eradicated from a person involved; and it may be practically impossible to ascertain their presence. Gonorrhea may be transmitted by man or woman years after the original infection has subsided, and despite continued treatment.

CHAPTER X

MODES OF PARASITIC INVASION, ACTION, AND ELIMINATION

The Evolution of Parasitism. Relative Resistance of the Different Tissues. Results of Bacterial Action—Local; Diffuse; Specific. Invasion of the Body by Micro-organisms: Portals of Entry—the Skin, Wounds; Nose, Mouth, and Accessory Cavities; Digestive Tract, the Liver; Respiratory Tract; Genito-urinary Tract. Rôle of Lymph-adenoid Tissues. Destruction and Elimination of Micro-organisms by the Body.

The Evolution of Parasitism

For the most part evolutionary changes taking place in organized beings tend to a greater dependence of one form of life upon another. The primitive types of organized beings must have subsisted entirely upon inorganic substances. Indeed, the first forms probably made use in large part of free elements or the simplest available compounds obtained therefrom, and by a process of synthesis produced gradually more and more complex combinations. As the compounds thus elaborated were much more akin to the bioplasm of which organized beings are formed, it was but a simple step for certain forms of life to utilize them rather than perform the more difficult task of building up bioplasm out of the elements. Thus may have developed dependent forms of life subsisting upon products formed by other organized beings. In the natural tendency toward conservation of energy, certain life forms acquired a yet more direct method of obtaining nutriment by merely transferring and transforming to their own use the bioplasm more or less laboriously constructed by other living things. From an independent existence, therefore, organized beings became at first messmates, then guest and host, and finally the guest ate the host. Thus were developed, on the one hand, forms predatory in greater or less degree and extent, but preserving their independent habitat; on the other hand, **parasites**—organized forms living within or upon, as well as at the expense of, other living beings. Evolution is characterized by a continued tendency to the progressive increase of this latter, dependent form of existence. Indeed, the well-known formula of Mr. Spencer anent "the survival of the fit" expresses in one aspect a progressive and triumphant parasitism.

Among the **bacteria** the changes outlined are known to take place with great rapidity. A few of the soil bacteria represent quite primitive forms of life, being able to use such elementary substances as oxygen and nitrogen and to combine these with the elements of water. Other bacteria found in soil are able to use the compounds thus formed and to make from them more elaborate combinations; these final substances being sufficiently complex to serve as food for the higher plants. Again, other bacteria that may have sprung from the same root-stock live only at the expense of the compounds found in these higher plants. Most bacteria live upon dead organic matter, and are called saprophytic; yet a large number may also subsist upon living substances, and therefore may be parasitic. By evolutionary changes consummated in a few generations, a saprophytic organism may become parasitic; while most parasitic forms can accustom themselves to a saprophytic existence. As affecting human pathology, for example, many of the organisms responsible for pus formation rapidly lose their injurious properties when cultivated outside the body. By permitting several generations to live in the bodies of animals of little resistance their virulence against the higher animals is often regained.

There is a group of bacteria, including the **tubercle bacillus** and forms resembling it, that has a special interest in this connection. These organisms resemble each other in form, in manner of growth, and in their reaction to certain stains—being called **acidfast bacteria** because when stained they resist the action of the stronger acids. Besides the tubercle bacillus and the smegma bacillus, the group includes forms found in butter, upon grass, and in the excrement of animals fed upon the grass. These vary widely in their pathogenetic activities. The **smegma bacillus** seems to be almost purely saprophytic. The **grass bacillus** shows limited pathogenetic properties that at times simulate in a milder way those of the tubercle bacillus. It is not unreasonable to suppose that these grass bacilli, at least, may represent an ancestral form of the organism of tuberculosis. Repeatedly entering the alimentary tract of herbivora with food, it is possible that these organisms have gradually accustomed themselves to the higher temperature of this new habitat and to the animal nutriment; have acquired a resistance to the antagonistic action of the animal cells; and finally have been able not only to overcome this resistance, but also to invade the tissues with destructive effects. In this way it is possible that Bacillus tuberculosis has been evolved. Having been disseminated among various species of animals, different properties have been acquired in each; and thus the differentiation into the forms special to the cow, the fowl, and man may have occurred.

While such evolution in this particular instance is in part supposititious and remains unproved, there is abundant evidence of the constant general tendency to the production of parasitic forms by some such process. Moreover, as the editor of this series long ago pointed out, we must also take into account reciprocal evolutionary modifications upon the part of the organism invaded; and it is at least probable that in many cases an abnormality of some kind was necessary, in the first instance, in order to afford lodgment to the invaders that afterward entered upon a parasitic cycle. Edward Jenner, in his comparison of tubercles to vegetable 'galls' produced by insects, anticipated in some degree the developments of twentieth-century research. In considering the invasion of living organisms by bacteria and the means by which it may be prevented, the principle here involved is of great importance; for sanitary science must strive not merely to limit the range of activity of the known parasites, but also to avert the evolution of disease-producing forms out of types now harmless.

Bacteria constantly enter the human body, being inhaled in the air we breathe, being swallowed with our food, and gaining entrance by way of the skin and mucous membranes through the contact of these with contaminated objects. The number of bacteria with which the body has to contend varies greatly with the environment, being largest in urban life, and especially amid the unsanitary environment of 'slums' and 'congested districts,' and as a rule least amid rural surroundings. As will be more particularly discussed in a later section, the body is well supplied with natural defenses, entirely sufficient against ordinary assaults, but becoming inefficient when the number or virulence of the invading parasites is great.

It is probable that the injurious action of bacteria depends chiefly upon chemical poisons (**toxins**) that they elaborate, and not upon their physical activities. These toxic compounds not only alter or inhibit cellular metabolism, but also are capable of coagulating and digesting albuminous substances, of fermenting starches and sugars, and of splitting fats. Thus they may cause profound functional changes and great tissue destruction. To oppose these dangers, the tissue cells supply **antidotal** substances that combine with and neutralize the toxic compounds; surfaces covered by **epithelium** limit or prevent the entrance of bacteria or their products; **lymphoid** accumulations may yield **lysogenic** substances to disintegrate and dissolve parasitic cells; **phagocytes** remove, and perhaps destroy, them; and the **body-fluids** contain principles unfavorable to the growth of many bacteria.

Relative Resistance of the Different Tissues

The different tissues and organs of the body not only vary greatly in their ability to resist pathogenic organisms, but also show degrees of resistance varying with the character of the parasite. For example, the tubercle bacillus most frequently affects the lymphatic glands, the lungs, the bones, and serous membranes. Less frequently it attacks the liver, spleen, kidneys, adrenals, or skin. It infrequently produces serious disease of the heart, thymus gland, nerve-centers, adipose tissues, or voluntary muscles. The pneumococcus invades the mucous lining of the respiratory passages and the serous membranes, but rarely causes disease of other tissues; while the gonococcus finds the mucous membranes especially vulnerable, rarely affects the larger serous membranes, and has no effect upon the skin. On the other hand, there are many forms of parasites, such as those of tinea and scabies, that invade only the tissues of the skin; while trichinæ affect chiefly the muscular tissues. Most of the pus-forming organisms produce the greatest destruction in parts having poor vascular supply, such as the adipose and fibrocellular tissues. The resistance of certain organs may also be influenced by evolutionary and developmental changes. For example, such apparently useless remnants as the vermiform appendix are more vulnerable to parasitic invasion than actively functionating organs. Woods Hutchinson suggests that the greater vulnerability of the lungs to tuberculosis and other infectious processes may be ascribed to the fact that these organs were among the last elaborated in the evolutionary process, the organs of more remote origin having a greater stability and resistance, acquired through ages of functionating.

Remnants of tissue left in the developmental process, such as

Meckel's diverticulum and the paroöphoron, may show diminished resistance to pathologic changes. Supernumerary parts rarely have the resisting powers of normal organs.

THE RESULTS OF BACTERIAL ACTION IN GENERAL

The influence of bacteria upon the body is chiefly a chemical one, and the varying results that follow the entrance of pathogenic organisms into the body are expressions of the alteration or arrest of the normal cellular activities, due to the action of chemical compounds liberated by the invading cells. These chemical compounds or toxins may have a **local action,** producing morbid changes chiefly in the immediate vicinity of the bacteria, probably because the substances are here most concentrated; or the toxic action may be **diffuse,** producing wide-spread functional or structural alterations in the body; or **specific,** picking out certain susceptible cell groups, perhaps in areas remote from the location of the bacteria.

Local Results of Bacterial Action

Chemotactic, hyperplastic, or **degenerative** and **necrotic** changes are initiated in the vicinity of the organisms. These conditions are often associated, although one is predominant.

Chemotaxis.—If the chief action be chemotactic, leukocytes are attracted about the bacteria (**leukocytic** or **round-celled infiltration**), and if there be an associated local liquefaction of tissue, a circumscribed cavity containing a leukocyte-laden liquid (**pus**) results, that is termed an **abscess.** Should reaction occur in the subcutaneous tissues in a more diffuse manner, it is called **cellulitis,** or, if suppurative, **phlegmon.** By the rupture of the abscess or phlegmon through adjacent surfaces, inflammatory channels, open at one end (**sinuses**) or at both ends (**fistulæ**), may be formed; or, if the process be superficial, the destruction of the surface layers produces an **ulcer.** Chemotactic forms of inflammation occurring in serous cavities are termed **empyemas,** while those of mucous surfaces are called **purulent catarrhs.** These conditions are produced by pyogenic bacteria such as the pyogenic staphylococci, Streptococcus pyogenes, Bacillus pyocyaneus, Bacillus typhosus, and others. Should such organisms gain entrance to the blood-stream and give rise to abscesses in various organs, the condition is known as **pyemia.** It is noteworthy that these pyemic abscesses occur only where the bacteria are deposited.

Hyperplasia.—Certain of the bacteria have little chemotactic action, but stimulate in their immediate neighborhood the production of new cells, chiefly of connective-tissue type. Thus there are formed nodes of granulation tissue that, from the action of toxic substances liberated by the bacteria, are atypical, often imperfectly vascularized and prone to degenerative changes. These localized hyperplasias have been called **granulomas** or granulation tumors, and occur in tuberculosis (**tubercles**), in glanders (**farcy buds**), in Madura foot (**Madura buttons**), in leprosy (**lepromes**), in rhinoscleroma, in granuloma fungoides, and other diseases. In these diseases the atypical granulation tissue usually fails to be converted into adult connective tissue, but from other conditions this may occur, and if diffuse, may produce the so-called **scleroses** or **cirrhoses** in the liver, kidneys, central nervous system, and other organs. Cirrhoses seem more often to be due to the action of toxins than to the local colonization of bacteria.

Necrosis.—The local action of another group of bacteria is chiefly characterized by tissue death, a consequence of cell-poisoning. This results in the production of local areas of **necrosis** and **gangrene;** conditions exemplified in noma, malignant phagedena, and hospital gangrene.

Diffuse Results of Bacterial Action

Wide-spread functional or structural changes may result from the absorption and diffusion of bacterial toxins throughout the body. Functional changes are expressed by exalted, depressed, or perverted metabolism. The structural changes are, as a rule, **degenerative,** and usually are characterized by **parenchymatous degeneration,** as occurs in yellow or typhus fevers; **fatty degeneration,** as in yellow fever; **amyloid degeneration,** as in chronic tuberculosis, syphilis, and leukemia; **hyaline changes,** as in prolonged suppuration; and other retrogressive conditions. More rarely the condition is **regenerative** and leads to diffuse tissue overgrowths or **hyperplasia.** When pathogenic bacteria show their chief activities in the circulating blood, the condition is termed **septicemia.** Abnormalities characterized by the circulation of toxins are termed **toxemias,** and the designation **sapremia** has been applied to those diseased conditions in which products of putrefaction are supposed to circulate within the blood.

The Specific Results of Bacterial Action

The circulation of toxins may chiefly affect certain susceptible cells, leading to specific structural alterations, or to abnormalities in function. Thus, in tetanus there is a special stimulation followed by exhaustion of the motor cells of the central nervous system. In diphtheria there may be degenerative changes leading to various palsies, resulting from the specific action of the bacterial toxin upon the motor cells of the central nervous system or upon the peripheral nerves. Many toxins have a specific action upon the thermogenic centers in the medulla; as a result of the action of others, there may be an overgrowth of a special tissue throughout the body. This may be the cause of the lymphadenoid hyperplasia in typhoid fever, leukemia, and other diseases, and the generalized increase of connective-tissue elements which lead to fibrous change in various organs; including arteriocapillary fibrosis, myocardial degeneration, cirrhosis of the liver, chronic interstitial nephritis, locomotor ataxia, progressive paralysis of the insane, and other scleroses.

INVASION OF THE BODY BY MICRO-ORGANISMS

As stated, bacteria may enter the body through the broken or unbroken skin or mucous membrane; from these areas usually passing into the lymphatics, and finally entering the blood-vessels. Within the body they may be destroyed by bactericidal substances, dissolved by bacterial lysins, or expelled in any of the normal secretions or excretions which escape from the body, or be cast off in pus or other pathologic products. Animal parasites enter chiefly through the skin or alimentary tract, but also by other routes as set forth in chapter IV. Certain special facts relating to the various portals of entry and routes of diffusion may briefly be considered.

The Skin

The well-known experiment of Gallé demonstrated that bacteria could penetrate the unbroken skin. After rubbing a culture of the staphylococcus into the forearm, a carbuncle surrounded by isolated furuncles promptly developed. Furuncles usually occur on hairy portions of the body rubbed by the clothing, such as the posterior portion of the neck in apposition to the collar, about the shoulder-blades, where fragments of dirt falling down the neck are caught and retained by the shirt, and portions of the wrist in apposition to the cuff. In such places dust is most likely to be rubbed into the skin. In these infections the causal organisms probably reach the deeper layers of the skin along the hair follicles and sebaceous glands. It is also possible that they may enter through the sweat-glands, but this is less probable, as the flow of perspiration tends to inhibit their entrance, and clinically furuncles are rarely found upon portions of the body, like the palms and soles, that are devoid of hair follicles. Apart from the pathogenic cocci, few bacteria are able to penetrate the unbroken skin in sufficient numbers to cause disease. Persons who handle dead bodies occasionally develop localized tuberculous lesions (dissecting porter's wart), but these occur on portions of the hands subject to abrasion, and it has not been shown that the tubercle bacillus can penetrate the unbroken skin. There is also no clinical proof that infection from syphilitic virus can occur without a superficial lesion of the skin, although instances of syphilitic infection through the skin without perceptible lesion or chancre are recorded.

Among the molds that invade the skin may be mentioned those of **favus, sycosis, herpes tonsurans,** and **pityriasis versicolor.** Of the smaller animal parasites, the embryos of **Uncinaria duodenalis** have been observed to penetrate the unbroken skin. The **itch mite** burrows in the upper layers and the female of the **chigo flea** buries itself in the skin. The ova of various **Diptera** may be deposited in unprotected wounds, causing them to swarm with maggots. **Demodex folliculorum** invades the sebaceous follicles. With the exception of the uncinaria, none of these parasites invades internal organs. Of the micro-organisms that may be carried into the vessels of the skin by mosquito bites, may be mentioned the **malarial parasite** and other **hematozoa,** the organism of **yellow fever,** and forms of **filaria. Dermatobia noxalis** of Central America and the larva of the **cayor fly** of Africa burrow beneath the skin and produce suppurative local lesions.

Wounds.—Those organisms that are able to invade the uninjured skin may enter more readily through breaks in the continuity of the epithelium. In this way there may occur infection by any of the pus-forming bacteria, by the bacilli of tuberculosis, glanders, tetanus, plague, and malignant edema, the fungi of actinomycosis and Madura foot, the virus of syphilis, and other pathogenetic agents. For infection the lesion needs be very slight, the prick of a thorn being sufficient to produce the infection of Madura foot, and a scratch of a rusty nail to cause tetanus. A scratch or slight abrasion will

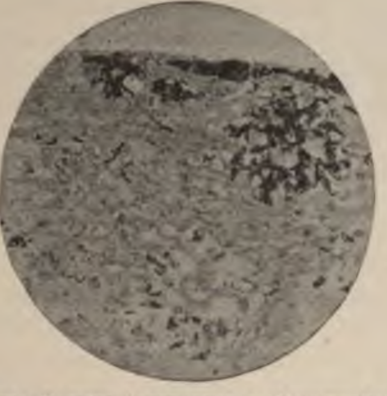

FIG. 49.—DIPHTHERIA BACILLI (APPEARING AS MINUTE RODS) IN THE FALSE MEMBRANE.—(*Muir and Ritchie.*)

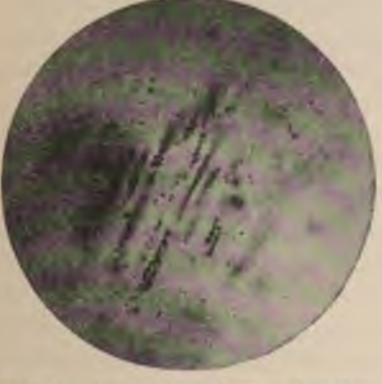

FIG. 50.—SECTION OF DENTIN INVADED BY MICROCOCCI.—(*Miller.*)

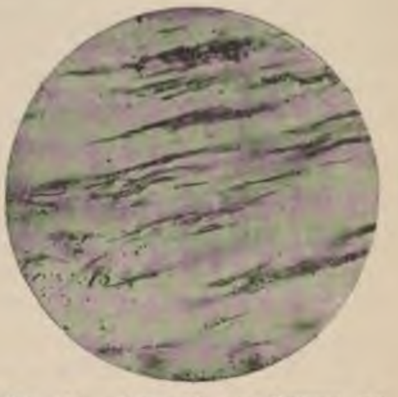

FIG. 51.—INVASION OF DENTIN BY BACILLI AND COCCI.—(*Miller.*)

permit the inoculation of vaccinia, syphilis, or tuberculosis. Mammary abscesses may occur in sequence to slight fissures of the nipples.

In freely open wounds the danger of serious infection is relatively less than in narrow punctured ones, provided no large serous cavity is opened. In such wounds the free access of oxygen inhibits the growth of the bacteria of tetanus, and of malignant or gaseous edema, while the free drainage favors the removal of these and other pathogenic organisms. Accumulations of fluid in wounds, forming the so-called 'dead spaces,' are favorable to bacterial multiplication, and by pressure tend to interfere with the protective action of the adjacent tissues. It is claimed that saprophytic bacteria placed upon fresh wounds may be detected in internal organs within fifteen to twenty minutes, indicating the rapidity of the invasion. When granulations cover the wound, the danger from septic absorption is diminished. The older surgeons, appreciating this, permitted the flaps of amputation wounds to granulate before coaptating them.

The Nose, Mouth, and Pharynx

The **mouth** constantly contains large numbers of bacteria, most of which are harmless. In many mouths there are also present pathogenic organisms of low virulence. These may invade the tissues and produce disease, should any cause sufficiently reduce the cellular resistance. This probably explains the causation of the so-called ether pneumonia. Pneumococci harmlessly present in the secretions of the mouth may be inhaled into the lungs during anesthesia, where, favored by the depressing conditions incident to operation, they may excite inflammation. Diphtheria bacilli often remain for months in the secretion of the mouth and **throat,** especially in those who have had or have been in contact with the disease. Such persons are a constant menace to those nonimmune persons with whom they associate. Diphtheria bacilli may also remain in the pharynx, larynx, or nose for many weeks. The **tonsillar** crypts may harbor various cocci with pathogenic tendencies. Miller has shown that certain saprophytic organisms act upon the starchy food collected about the **teeth,** with the production of lactic acid, which gradually dissolves the mineral part of the tooth structure, whereupon other bacterial forms penetrate and destroy the decalcified portions of the tooth, leading to dental caries. The **nose** is protected against bacterial invasion by the presence of a mucus unfavorable for bacterial growth, and a lining of ciliated cells, that tend to remove foreign particles. Besides this, leukocytes and other cells are present that probably exert a bactericidal action. Parke and Wright found that the nasal mucus contains comparatively few bacteria, and that it has a bactericidal action upon the anthrax bacillus, although little or none upon many other germs studied in this relation. The organisms of **rhinoscleroma** and **glanders** are prone to invade the mucous membranes of the nose and palate. Of the animal parasites, the ova of **dipterous insects** may be deposited in the nose and the larvæ (maggots) may occasion not only marked inconvenience, but even fatal disease. The **screw-worm,** or larva of Lucilia macellaria, may penetrate the nasal mucosa and even destroy the cartilages and bones. More rarely certain **Pentastomes,** as the larvæ of the **Linguatula rhinaria** and **Porocephalus constrictus,** invade the nose, its accessory sinuses, and even the internal organs, as the lungs, liver, and kidneys.

Accessory Sinuses.—From the mouth and nasopharynx, infection may spread to the ethmoidal or frontal cells, to the antrum, the internal ear, or the lachrymal duct and conjunctiva. Such extensions occur in the exanthemata, especially **measles, scarlet fever,** and **smallpox,** and in **diphtheria, influenza, tuberculosis, pertussis,** and other infectious diseases. The most frequent of the serious infections is that of the **middle ear,** which often leads to the perforation of the drum-head, infection of the mastoid cells, necrosis of the temporal bone, and, at times, through contiguity, to septic infection of the lateral sinus and the cerebral substance, with the production of **thrombophlebitis** and **cerebral** or **cerebellar abscess.** For these serious complications, **measles** and **influenza** are especially responsible. The tubercle bacillus may remain dormant in a diseased middle ear for years, and finally take on renewed activity and generalize the infection.

Infection through the **external ear** is less important, and usually results only in localized abscesses or furuncles of the meatus. Infection of the internal ear through the meatus is uncommon. The **lachrymal ducts** are not infrequently involved in rhinitis, with resulting troublesome forms of **dacryocystitis** and even **lachrymal sinusitis.**

The **conjunctiva** is often infected directly through contact with towels, fingers, dust, and other objects carrying infectious organisms. **Gonorrhea, trachoma,** and other forms of **purulent ophthalmia** are the diseases most frequently transmitted in this way.

Antral infection may result from the extension of rhinitis, or through the root of a diseased tooth.

Gastro-intestinal Tract

At birth, no micro-organism is normally present in the alimentary canal, but in the course of some twelve or eighteen hours bacteria appear in the intestinal contents, and thereafter are present throughout the life of the individual. The stomach, with its acid secretion, contains fewest bacteria, while the contents of the large intestines exhibit the largest number. In milk-fed babies two organisms are found to be constant and to predominate over all other varieties—**Bacillus coli communis,** which has been noticed in largest number in the lower bowel, and **Bacillus lactis aerogenes,** which appears to predominate in the upper part of the infantile small intestine. There are also lesser and variable numbers of other bacteria, yeasts, and molds. The constancy with which micro-organisms are found in the stomach and intestines in health has very naturally suggested that they play an essential part in the process of digestion. To determine if this be so, Nuttall and Thierfelder performed with careful aseptic precautions Cesarean section upon four guinea-pigs about to be delivered. The young animals were immediately introduced into a sterile glass chamber, arranged to permit ventilation and feeding without the ingress of bacteria. These animals remained well, gained in weight, and after eight and fourteen days were killed, and the alimentary canals found to be sterile. Schottelius, experimenting upon incubated eggs, obtained contrary results, those chickens kept under aseptic conditions pining away after the twelfth day, while the chickens fed on unsterilized food thrived. These results are contradictory, and neither is conclusive.

Observations made upon infants and adults indicate that bacteria are not essential to normal digestive function. Despite the repeated accessions of large numbers of bacteria through the act of swallowing, the stomach and ileum—portions of the alimentary tube most active in the digestive processes—contain relatively the smallest number of bacteria, while in the colon, in which there is the least digestive action, bacteria are found in greatest number. It is probable that, were it not for the repeated accessions of bacteria through the esophagus, the stomach and upper bowel would speedily become sterile. Van Puteren studied bacteriologically the contents of the stomach in healthy babies, and found that in 18 per cent. of the nursing infants whose mouths were carefully washed out before feeding the gastric contents were sterile, a condition that could hardly be present were bacteria essential to the digestive processes. Many tissues show a constant tendency to inhibit, remove, or destroy the bacterial activity, and, as will be referred to later, the leukocytes seem to be engaged in a continuous warfare with the micro-organisms.

The digestive action of bacteria obtained from the gastro-intestinal tract has been found to be feeble as compared with the action of the normal ferments. Moreover, injurious compounds are frequently produced. For example, the formation of peptones by bacteria is usually but a step in a putrefactive process, the peptones formed being finally converted into various end-products of putrefaction, many of which are toxic. In their action upon carbohydrates, bacteria form such irritating substances as alcohol and acetic and lactic acids; while from the fats and oils various disagreeable and toxic fatty acids are evolved. In addition it has been shown that germ-free solutions of the normal ferments retain their digestive powers. There is, therefore, ground for believing that bacteria are not essential to the digestive process, and it would seem that their constant introduction can scarcely be of evolutionary significance, unless in the development of natural immunity against kindred pathogenic forms, as it necessitates a continuous greater or less expenditure of resistive force on the part of the organism.

Of the bacteria that may directly invade the body through the walls of the alimentary tract, we have the micro-organisms of **typhoid fever, cholera, tropical dysentery** (including the bacillary and amebic forms), and other diseases. Booker believes that excessive numbers of the colon bacillus and of Bacillus lactis aerogenes may be responsible for the milder forms of **diarrhea.** Bacillus proteus vulgaris seems to be responsible for more serious and chronic forms, while the very serious toxic and often chronic types are particularly associated with streptococci and other micrococci.

Most of the **animal parasites,** including the round-worms, flukes, and tapeworms, are acquired by the ingestion of infected food or water, as has been set forth in a previous chapter. The eggs of various **insects** may be swallowed and the larvæ may develop within the intestinal tract; among such, the house-fly, the flower fly, the blue-bottle fly, and other Diptera may be mentioned. Instances in which the larvæ of beetles and moths have occurred in the intestinal tract are also on record.

The Liver

Adami believes that in health a certain number of bacteria are taken up from the alimentary canal by leukocytes and carried into the lymphatic glands or the venules of the portal system. In the lymphatic glands or the liver they are destroyed by the leukocytes or by the endothelial cells. Should any bacteria enter the systemic circulation through the liver or the thoracic duct, the kidneys and perhaps other organs tend to remove them. There may exist, therefore, a condition of latent microbism or latent infection, and this may be accentuated, if there be an excess of bacteria in the intestines, into a condition of subinfection associated with a chronic inflammatory disturbance in the lymph-glands, liver, kidneys, and other organs. Such a condition may be the cause of forms of hepatic cirrhosis. The pigmentation (hemochromatosis) of the liver-cells, lymph-glands, and abdominal wall, Adami attributes to the multitude of disintegrating bacteria deposited in the cells. A similar condition of the liver has been found in cases of pernicious anemia, and this, together with the chronic inflammatory condition in the upper digestive tract, is supposed to be due to the passing into the portal blood of excessive numbers of colon or allied bacilli which subsequently take up iron-containing pigment from disintegrated red corpuscles.

Respiratory (Laryngo-bronchial) Tract

The **nose, mouth,** and **pharynx** have been considered in a former connection (p. 166). That solid particles frequently enter the pulmonary alveoli is proved by the frequency with which postmortem examinations show grit diffused through the lungs.

If such coarse particles may gain entrance to the air-cells during life, it is evident that minute parasites may likewise be conveyed. Experimentally, infections have been produced by inhalation, but as a rule with considerable difficulty, and at present it is generally believed that under the ordinary conditions of life the lungs are rather infrequent portals of entry.

The localization of disease in the lungs is not a proof of primary invasion through the respiratory tract. The causal agents of many respiratory diseases are now believed to enter through the lymphatics from the nasopharynx or, by way of the thoracic duct, from the gastro-intestinal or other remote tracts. The colonization of bacteria in the lungs depends more upon the relative susceptibility of these organs than upon the portal of entry. The lungs are guarded by the various protective devices of the upper respiratory tract, so that pulmonary infection is much more likely after tracheotomy or laryngotomy. An important mode of infection is by the inspiration of infectious mucus or food.

This is especially apt to take place during anesthesia (**inspiration** or **ether pneumonia**) and after intubation, and in conditions of paralysis of the pharynx or of profound asthenia. Parasitic **molds,** including varieties of the aspergillus and mucor, are occasionally carried to the lungs in respiration and produce disease. One of the most important of these is Aspergillus fumigatus.

The evidence that Wasdin puts forward in support of the theory that yellow fever and typhoid are respiratory infections is insufficient, and the view is at variance with established knowledge.

Infections through the External Genito-urinary Tract

The bacteriology of the **female generative organs** has been investigated by Hausmann, Stroganoff, Winter, Döderlein, Kronig, Menge, Williams, and others. It has been shown that in health the secretions of these organs are either sterile or nonvirulent. At birth complete sterility exists, but the external genitals are soon contaminated and the **vagina** becomes the seat of an acid-forming bacillus that usually persists throughout life. This organism apparently produces lactic acid, rendering the vaginal mucus an unfavorable medium for the growth of most bacteria, and the bacillus is also credited with the ability to destroy directly many pathogenic forms. While such organisms as the pyogenic streptococci may contaminate the skin of the external genitals, it is generally admitted that they lose their virulence or disappear as the cervix is approached. Döderlein found that pyogenic organisms experimentally introduced into the vagina disappeared within a few hours; while if an antiseptic douche of sublimate were given, the normal disinfecting action of the vaginal mucus was markedly delayed. The vaginal secretions in pregnancy are also, as a rule, free from pathogenic micro-organisms, so that autoinfection from this source rarely or never occurs. Against a few disease-producing bacteria, notably the **gonococcus,** Döderlein's acid-forming bacillus affords little protection, although even this coccus apparently finds the vaginal secretions the least favorable habitat. In an extensive series of examinations of prostitutes Laser found the gonococcus most frequently in the urethral and in the cervical canal and rarely in the vagina. It is interesting to note that four-fifths of the 111 cases in which this micro-organism was found gave no gross evidence of gonorrhea.

With the normal resisting mechanism inhibited by chemical or mechanical influences, invasion by the pyogenic organisms, the **diphtheria bacillus,** certain **molds,** and perhaps by the causal agent of **carcinoma** may occur. **Tuberculous infection** is a rare but possible condition; **syphilitic** and **chancroidal infection** seem not to be hindered by the normal secretions, although for their occurrence a slight mechanical lesion may be necessary. The **uterine secretion** is normally alkaline and the **fallopian tubes** and the **endometrium** are lined by cells having cilia that wave toward the cervix. The cervix normally contains a plug of mucus that seems to be unfavorable to bacterial growth. The studies of various observers unite in demonstrating that the uterine cavity in health contains no bacteria. Other than the gonococcus, few bacteria invade the uterine cavity from below, except in the presence of mechanical injury.

The **smegma bacillus,** frequently found on the external genitals of both sexes, seems to be free from pathogenic action. It is easily mistaken for the tubercle bacillus, which it closely resembles in form and staining reactions.

The **male urethra** is probably normally free from bacteria except within a short distance from the meatus.

Rôle of Lymphadenoid Tissues

Various collections of lymphadenoid tissues, represented by the faucial and pharyngeal tonsil and the solitary and agminate follicles of the intestine, normally seem to have an action in protecting the body against the invasion of bacteria and their products. When diseased, however, this protective action may not only be lost, but the masses of lymphatic cells may afford portals of entry to bacteria. Thus, in **typhoid fever** it is probable that the bacteria invade the body through **Peyer's patches,** which are also involved in **tuberculous** ulceration of the bowel. The faucial **tonsil** is especially important. When diseased, the enlarged crypts that it contains serve as a nidus for the growth of bacteria, while its substance seems to be but a slight barrier against the invasion of the tributary lymphatic vessels. In the limited number of bacteriologic examinations of the tonsil that have been made by Dieulafoy, Lathan, Friedmann, Ulman, and others, **tubercle bacilli,** or evidences of a primary tuberculous infection through the tonsil, were found in a large percentage. The so-called scrofulous glands of the neck probably result almost invariably from invasion of tubercle bacilli through the tonsils. Pulmonary tuberculosis may also originate through this source. Present knowledge indicates this route as at least as probable as direct aerial invasion. **Diphtheria** usually attacks the tonsils first. Certain of the acute eruptive fevers, as **scarlatina** and **measles,** are believed to have the tonsil as a portal of entry to the system. Acute articular **rheumatism** and its sequels, as well as other forms of **polyarthritis,** are not infrequently preceded by an attack of tonsillitis, suggesting that the invasion occurs at this point. **Endocarditis** or **pericarditis** unassociated with arthritis may have similar origin. In those forms of **typhoid fever** without intestinal lesion it is suggested that infection occurs through the tonsils. Finally, the frequency with which severe **systemic intoxication** results from forms of tonsillitis of uncertain bacterial origin is well known.

DESTRUCTION AND ELIMINATION OF MICRO-ORGANISMS BY THE BODY

Within the body bacteria usually first **enter** the lymphatic channels and are carried to the neighboring lymph-glands. Here they may be **destroyed** by the bacteriolytic action of the cells or may break through the lymphatic barriers and invade the blood. Within the blood they must contend against the germicidal activities of the plasma, the phagocytic action of the leukocytes, and the bacteriolytic properties of both the white and red corpuscles. Should they successfully resist these various agents, there remain certain organs containing cells having well-marked bactericidal properties. Of especial importance is the liver. If suspensions of bacteria be introduced into the portal vein, many organisms otherwise virulent will be overcome by the hepatic cells, so that the blood leaving the liver will be found to contain either no bacteria or bacteria much reduced in virulence. This action has been shown to be well marked against the bacillus of anthrax and Staphylococcus aureus. In general the bactericidal power of the lungs seems to be much less than that of the liver; yet against Streptococcus pyogenes the lungs show a well-marked protection, while the liver has but little. It is believed that the kidneys nearly equal the liver in bactericidal activity, while the brain seems to possess this power in but slight degree. Although not experimentally demonstrated, the action of the red bone-marrow may be very important, and may explain why injuries to bones in the young apparently may determine the localization of tuberculosis. This subject will be further considered in the chapter upon "Immunity."

Bacteria seem to be **eliminated** by the usual emunctories, especially the skin, the intestinal tract, and the kidneys. In health, the mammary glands are apparently not an exit for the bacteria in the blood; but the experiments of Balch, Weleminsky, and others indicate that in severe or long-continued illness they may thus be eliminated. As is elsewhere mentioned, tubercle bacilli have repeatedly been found in the milk from tuberculous cows free from demonstrable disease of the udder. Clinical observations indicate that a similar elimination may occur in women.

Bacteria may remain for long periods of time within the body after the subsidence of the clinical symptoms of infection. This is exemplified in the persistence of diphtheria bacilli in the throat and nose, of tubercle bacilli in encapsulated foci in the lungs, and of typhoid bacilli in the intestines, gall-bladder, and urinary tract.

Section III

THE PREVENTION OF DISEASE

CHAPTER XI

IMMUNITY

Natural Immunity—Its Relativity; Modifying Factors. Acquired Immunity—Ehrlich's Lateral-chain Theory; Active Immunity, Methods of Production; Passive Immunity. Practical Applications.

Immunity, or, as it is sometimes termed, **insusceptibility,**—the ability to resist disease,—has been the subject of earnest and industrious studies by hygienists and bacteriologists, especially during the last decade. The conditions upon which immunity really depends, however, remain yet to be learned, and all that has been thus far attained by most painstaking research and reflection is a knowledge of some of its chief phenomena.

While, no doubt, exemption from many of the diseases of metabolism, and ability to maintain the integrity and physiologic activity of the tissues in the presence of injurious substances—leucomains and the like—depend in large measure upon cellular or local immunity, —that is to say, upon the ability of the cells to resist injurious agents and to exercise proper selection in relation to the nutrient pabulum, as well as upon the harmonious workings of related and correlated groups of cells,—the best opportunities for the study of the phenomena of immunity are afforded by the specific infections and intoxications. In these pathologic conditions, by working with the living causal agents of disease or with those toxic products by which their detrimental influence is exerted, we are able to make accurate observations and deduce justifiable inferences.

NATURAL IMMUNITY

The inoculation of a given pathogenic micro-organism into a number of animals of different species almost invariably results in the demonstration that all are not equally susceptible to its operations. Thus, should a virulent culture of the diphtheria bacillus be inoculated into a rabbit, a guinea-pig, a white rat, and a mouse, the guinea-pig would die first, and the rabbit next; the white mouse might not, and the white rat certainly would not, be injured. When the experiment of inoculating with diphtheria-cultures a large number of guinea-pigs and a large number of rats is made, it follows without fail that every guinea-pig will die, but every rat will remain unharmed. We find, therefore, that the rat is **naturally immune** against diphtheria. A white rat can tolerate a dose of diphtheria toxin large enough to prove lethal to 3 horses, or to 1500 guinea-pigs, yet be scarcely discommoded by the inoculation.

The white rat is, thus, not only able to resist the growth of the diphtheria bacillus in its body, but is also able to resist the physiologic effects of the poisonous substance by which the diphtheria bacillus produces its injurious effects—*i. e.*, the diphtheria toxin. For a long time this important fact was not recognized, and the failure to conceive that animals were immune against infections because they were immune against the poisons generated in those infections, rather than because they were able to destroy the infectious agents, led to most egregious errors.

We have not far to look, however, to determine the truth of this fact; for in investigating the poisonous effects of **serpents' venom** we find the same variations among different species subjected to it that characterize the infectious diseases. Thus, comparing the relative susceptibility of animals to this toxic substance in figures representing the dose required for each kilo of body-weight in order to produce death, we find it varying from 1 for the rabbit and 2 for the dog, to 15 for the mongoose or the ichneumon. Similarly, the ability of dogs to resist the influence of morphin is known to every physiologist; while it is an everyday observation that certain animals regularly feed upon vegetation the juices of which are injurious and often fatal to others.

When an attempt is made to explain this natural immunity, many difficulties are encountered, and no single solution seems sufficient for the problems presented by all cases. Indeed, authorities are prone to speak of the 'various mechanisms' and 'numerous defenses' by which animals escape infection and intoxication.

Concerning **immunity against infection** two theories were extremely popular some years ago. One, suggested by Buchner, was that the blood contained certain bacteriolytic or bactericidal substances by which the destruction of disease germs was brought about. These substances are known as **alexins.** Their presence seems to have been sufficiently demonstrated experimentally, and their importance has never been completely disproved.

The other theory was that of Metschnikoff, who believed that all forms of immunity depended upon the tendency of the leukocytes of the blood to attack and destroy the germs of disease. It seems to have been shown that this **phagocytosis,** or cellular destruction of micro-organisms, is a fact; though it has not been satisfactorily demonstrated that it is an important factor in immunity. Leaving this classical argument out of the present discussion, it seems true that neither of the hypotheses cited reaches the pith of the matter; which is, that immunity depends essentially upon the ability of the animal to **endure the poisons** provocative of the disease, and that when this endurance is present, the bacteria pathogenic for other species are to the immune animal but as ordinary harmless micro-organisms.

The ability to resist intoxication, therefore, is the subject needing elucidation; but here we find difficulties that have not been surmounted. It is suggested that the poisons or toxins are overcome through the agency of neutralizing substances—'antitoxins'—present in the animal's blood; and this may be correct, though the proof is not yet at hand. The obstacles are easily understood. In speaking of venom it has been stated that the dog is twice as resistant as the rabbit—or, in other words, that to kill a dog requires double the dose that is fatal for a rabbit of equal weight. To demonstrate, therefore, that the blood of the dog contained antitoxin by which it neutralized the dose fatal for the rabbit, would require the introduction into the rabbit of a quantity of dog's blood equal to one-half of its entire blood bulk—a task manifestly impossible. Thus, the detection of small quantities of antitoxin is extremely difficult. There are, however, some observations pointing toward the presence of antitoxin in normal bloods. Bolton, Cobbett, Woodhead, Roux, McFarland, and others have found a substance in the blood of normal horses capable of neutralizing diphtheria toxin. Abel has occasionally found antitoxin (diphtheria) in the blood of healthy human adults. Fischel and Wunschheim found it in the blood of new-born babes. Phisalix found that the heated blood of the hedgehog protected other animals against viper venom. In certain instances, on the other hand, immunity may depend not upon chemical neutralization of toxin but on a different form of chemical negation—a complete antagonism, or an utter indifference—in the relation of body-cells to specific disease-poisons, so that no reaction whatever takes place. Metschnikoff's experiments would indicate some such negative relation between the toxin of tetanus and the nervous tissues of animals immune against that disease.

Whatever it may depend upon, there are certain facts concerning natural immunity which are of the utmost importance to all who are engaged in the prophylaxis and treatment of disease. Among these must be mentioned its **relativity** and **variability.**

The Relativity and Variability of Immunity

Animals commonly present one or the other of three conditions as regards natural immunity:

1. They are by inherited physiologic peculiarity able to resist certain diseases.

2. They are totally unable to resist certain other diseases, always succumbing after efficient exposure to the exciting cause.

3. There are a number of diseases against which they may or may not be immune according to circumstances.

The inevitable outcome of the inoculation of guinea-pigs and rats with virulent diphtheria cultures will illustrate the extremes of complete resistance and constant susceptibility. These conditions may be specific or generic, or may have to do with still wider zoologic variations. It is said that while Caucasians are susceptible to scarlatina, Mongolians, and especially the Japanese, are immune. White mice and house-mice resist glanders, but the field-mouse is exceedingly susceptible. Herbivorous animals are commonly susceptible to anthrax and tuberculosis, diseases usually resisted by carnivorous animals. Mammals are more generally susceptible to anthrax and tuberculosis than are birds. Mammals likewise are susceptible to tetanus, while birds resist it. Cold-blooded animals are immune from all diseases whose specific micro-organisms grow only at elevated temperatures.

More important for study are the diseases of the third group against which an animal may or may not be immune, according to circumstances. Before considering these diseases, and the variability of immunity, it will be necessary to fix clearly in mind the conditions under which infection can occur.

Conditions Governing Infection

"**Infection** is the entrance of disease germs into the body and their multiplication there." For its occurrence certain conditions of both disease germ and animal are essential.

I. On the part of the pathogenic organisms it is essential (1) that they be virulent, (2) that they enter the animal through appropriate channels, and (3) that a sufficient number be present.

II. On the part of the animal it is essential that it be susceptible.

Factors Relating to the Pathogenic Germ and Its Mode of Entrance

The **virulence** of the micro-organism is an interesting feature. Bacteria are commonly divided into the **pathogenic,** or disease-producing, and the **nonpathogenic** forms, and in text-books only the well-recognized pathogenic, and for the most part constantly virulent, organisms are described. Of these well-recognized forms, the variation in virulence may be considerable, so that, for example, a streptococcus may at one time produce rapid septic infection and death, at another time an abscess, and at still another time erysipelas.

In the opinion of the authors, the diphtheria bacillus is subject to great variation in virulence; at one time appearing as a highly toxic organism producing rapid malignant diphtheria, at another as a harmless saprophyte, which, as the so-called 'pseudo-diphtheria bacillus,' complicates the diagnosis of throat diseases.

While such variations of virulence are interesting and important from the standpoint of civic hygiene and prophylaxis, it is too often overlooked that there are many known—and probably many more as yet unknown—forms of bacteria usually harmless, but able under the influence of unusual surroundings, as variations in temperature, new nutrient conditions, residence in diseased animals, growth in association with other bacteria, and a number of other circumstances, so to change their habitual tendencies as to become virulent; in some instances probably reverting to an earlier habitually virulent type, in others acquiring virulence as a late quality. The constantly or habitually virulent organisms—speaking of our present recorded experiences—are best known to us as the cause of well-defined and specific conditions of disease. The organisms that at the present day are but exceptionally virulent may lead to ill-defined pathologic processes, turning up most unexpectedly and often under conditions that are very puzzling—thus, the gaseous edema occasioned by Bacillus aerogenes capsulatus, the proteus infections, the pyocyaneus infections, certain of the streptothrix infections, and similar rare processes.

The **avenue of entrance** of micro-organisms often determines the subsequent conditions that shall arise. This is true of poisons as well as of infections. Fraser administered to rats, by the stomach, a dose of cobra venom one thousandfold that which would prove lethal if given subcutaneously, and there resulted only slight somnolence. Infection of the skin by the tubercle bacillus commonly leads to a chronic skin disease known as lupus; the deposition of the same bacillus in the bones gives rise to cold abscess—tuberculous caries, a disease that is in many instances remediable; infection of the organs, especially of the lung, however, usually means serious if not fatal lesions.

Cholera spirilla injected into the vein of a guinea-pig, if virulent, produce septic infection and death. Introduced into the peritoneal cavity, they cause the interesting choleraic peritonitis; but introduced into the quiescent duodenum, with the gastric contents alkalinized, they cause true cholera.

Plague probably illustrates this form of variability better than any other infectious disease. When, as is usual, the bacilli enter by cutaneous inoculation, they invade the lymphatics and cause enlargement of the lymphatic glands—buboes. If, however, the bacilli are inhaled, the pulmonary form, which resembles pneumonia, results.

The **number of micro-organisms** also plays an important part in infection. Fraenkel long ago expressed this very aptly when he said that "because a white rat was immune against anthrax organisms in quantities sufficiently large to kill a rabbit, was no guarantee that it could resist quantities sufficient to kill an elephant."

It can readily be demonstrated in the laboratory that while a certain number of bacteria will invariably occasion infection in a susceptible animal, it is rarely true that the number can be reduced to a single organism and infection still follow.

Conditions of the Animal Modifying Immunity

Infection can take place only when the individual or species is **susceptible.** Immunity, except in rare instances, is a **relative term.** By appropriate manipulation the immunity possessed by animals can be modified. The possibilities regarding the virulence and number of micro-organisms have already been pointed out, but, in addition to these conditions of the infecting agent which appear to influence immunity, there are many modifications of the invaded animal that need consideration.

The conditions modifying immunity, except in the experimental production and exaltation of immunity which will be considered later, are all associated with **diminution of general bodily vigor.** They are chiefly as follow:

1. **Age.**—Infants are said to be immune against many of the infectious diseases. This has been explained as exemption, rather than immunity; but the investigations of Fischel and Wunschheim seem to indicate that it may not depend solely upon their sequestered existence, but in large part upon the presence of antitoxin in the blood. There seems to be a difference in susceptibility between childhood and maturity, certain infections deserving the designation 'diseases of childhood.' Adult life has its particular infections, typhoid and pneumonia being then most frequent, while old age, with the general decline in the vitality of the tissues, makes still other infections possible.

2. **Health.**—During the vigor of health one enjoys the greatest resisting power. Any departure from it paves the way for infection. Diphtheria opens the door for metastatic streptococcus infections; typhoid fever admits the colon bacillus to the system, where it may cause post-typhoid lesions; tuberculosis is commonly complicated by suppurations in the lung. Diabetes predisposes to albuminuria and to tuberculosis. Diabetes and albuminuria predispose to pneumonia and to cutaneous and other infections. Influenza and measles, and in the mulatto especially, typhoid fever, are frequently followed by tuberculosis. Flexner's admirable paper makes clear to us that in a majority of cases the general relaxation of vital forces during the short period before death from various causes, admits bacteria to the circulation, causing what he has styled 'terminal infection.' It is also highly probable that certain definite and indefinite, acute and chronic, temporary and persistent forms of depression—asthenia, hypotrophy, fatigue, exhaustion, malnutrition—diminish the resist-

ing power specifically for certain diseases, as tuberculosis, typhoid fever, and influenza, or in relation to infections generally.

3. **Diet.**—The food of which animals partake determines, in part, what degree of resisting power they have. Hankin found that the resisting power of rats to anthrax was diminished when they were placed upon a strictly vegetable diet. Fraser found that meat-fed rats resisted venom better than rats fed upon vegetables. Herbivorous animals are, in general, less resistant to infection than carnivorous animals. Special articles of diet, like phloridzin, which produces glycosuria, increase susceptibility to infection. It is supposed that the resistance of the mongoose and hedgehog to venoms has something to do with their habit of eating snakes and reptiles.

4. **Fatigue.**—It is well known clinically that individuals are more liable to infection when worn out physically, and Leo has shown the same to be true by his experiments upon rats exhausted by being compelled to revolve a wheel.

5. **Exposure.**—The effect of exposure, while not understood, is universally recognized as predisposing to infection, and every text-book of medicine still gives, among the predisposing causes of a considerable number of the infectious diseases, 'exposure to cold.' The fact that ordinary colds, as well as pneumonia and other troubles, are more frequent in the winter than in the summer, and that in many cases a direct history of exposure is obtainable, confirms the supposition that exposure is an important factor; perhaps by paresis of the neurovascular system or by depression of cellular activity.

6. **Drugs.**—Immunity seems to be reduced by certain drugs. Alcoholic beverages when taken to excess seem to have a profoundly depressing influence upon the vital resistance. Drunkards are predisposed to pneumonia, which in them runs a more severe course than in abstemious persons. Abbott found that alcohol reduced the resistance of rabbits to infection with the streptococcus and colon bacillus. Wagner found that chloral caused pigeons to lose their immunity against anthrax. Platania found that curare, chloral, and alcohol all lessened the immunity of frogs, pigeons, and dogs against anthrax.

7. **Injury and Operation.**—Serious injury seems to diminish local immunity and permit invasion of micro-organisms. Probably the shock and ether-narcosis accompanying operations have something to do with the liability to infection, so commonly observed in surgical cases.

The loss of certain important tissues, with the succeeding changes from which the individual then suffers, favor infection. These factors have not yet been carefully studied, and we are still uncertain what influence such an important organ as the spleen may have upon immunity, the reports of different experimenters being conflicting as to the results following its excision.

Prophylactic Lessons

Several important lessons are to be learned from these considerations of immunity. It becomes of the utmost importance for the good of the general public that all those conditions which favor increase of virulence in micro-organisms shall be avoided. The opportunity for micro-organisms to increase rapidly in filth and in dead organic matter should be prevented by careful scavenging. Opportunity for micro-organisms to become more virulent by rapid passage through one individual after another must be prevented by the segregation of cases of infectious disease; the destruction or disinfection of fomites; the destruction of insects that convey infection; the disinfection of infected premises; and like precautions. The entrance of large numbers of bacteria into wounds is to be prevented by the most strict surgical asepsis, and the association of different bacteria in the body similarly prevented, if possible.

Attention to the individual is no less important, and to maintain in its integrity the degree of immunity with which nature has endowed him every man should be taught that it is his duty to preserve his health against the deleterious effects of the conditions already mentioned. The general health should be kept up as well as possible by cleanliness, open-air life, exercise, and general observance of the laws of hygiene; the diet should be that appropriate for the individual and free from harmful agents. Excessive fatigue should be avoided, exposure minimized, indulgence in alcoholic beverages reduced to the lowest point, excesses of all kinds, physical and mental, eschewed, and traumatism guarded against.

These measures, however, while aiding in keeping down the number of border-line infections, would accomplish very little toward protecting us from those diseases against which no high degree of immunity exists. We are, therefore, most fortunate in possessing the secrets of an **acquired or experimental immunity.**

ACQUIRED IMMUNITY

Acquired immunity depends upon conditions that arise subsequent to birth. Some of its phenomena have been known and commented upon for generations. Thus, it is well known to laymen that an attack of one of the infectious diseases of childhood—scarlatina, measles, varicella, mumps, etc.—is in most cases succeeded by immunity from further attack. Some of the infectious processes of adult life are, however, also followed by immunity. Typhoid fever rarely occurs twice in the same person, and tetanus in man and animals is followed by a prolonged period of insusceptibility.

The first **experimental work** upon acquired immunity was done by Jenner, who found that an attack of cow-pox protected against smallpox. Nearly a century later, working with definite **micro-organismal cultures,** Pasteur opened a new and fruitful field in the domain of protective infection. He clearly proved that inoculation with attenuated cultures of a given micro-organism, that is to say, **cultures of feeble virulence,** induced a degree of immunity against more virulent cultures of the same organism; and that progressive increase in the virulence of the cultures used, was followed by progressive increase in the degree of immunity resulting. By this means he developed practical methods of protecting fowls against chicken-cholera, and sheep against anthrax.

At a subsequent period, Salmon and Smith found that the **products of bacteria,** as well as the organisms themselves, possessed the power of arousing immunity; thus when animals were injected with filtered cultures of the bacillus of hog-cholera, they developed immunity against the living virulent organisms. Upon the same principle of gradually intensifying resistance depends Pasteur's prophylactic inoculation against rabies, by the use of **certain tissues** (the spinal cord) **of artificially infected animals.**

Pasteur believed that immunity depended upon the fact that the micro-organisms, in their development in the body, used up something essential to their future development, thus leaving the animal immune. Chauveau, on the other hand, supposed that they left behind them some metabolic product deleterious to their future development. These theories are known as the **exhaustion** and **retention** theories, respectively.

That neither of these explanations is correct was shown by subsequent developments. Sewall found that it was possible to immunize pigeons against serpents' venom by repeated injections of small doses of the venom, and his observation was subsequently confirmed by Phisalix and Bertrand, Calmette, and Fraser. Ehrlich found that mice and guinea-pigs could be immunized against the toxalbumins ricin and abrin; Kossel, that small animals could be immunized against the effects of poisonous eels' blood. Thus, step by step there accumulated a collection of facts going to show that acquired immunity is a phenomenon having little to do with bacteria, but everything to do with their toxic products, intra- or extra-cellular; and that it exists with regard to many toxic substances of vegetable and animal origin, thus falling into line with the long-common knowledge as to **tolerance** of drugs and of the effects of various physical agents.

Viewing the phenomena from the standpoint of infection, Metschnikoff believed that they could be explained by the same process of **phagocytosis** that explained natural immunity. The difficulty was, however, to comprehend how the leukocytes and other body cells which in the natural condition refused to take up the specific bacteria of the disease, came to acquire a taste for them. He conceived, however, that having once met the micro-organismal enemies in a feeble state and coming off victorious, the leukocytes subsequently ceased to fear and boldly attacked them; and he collected evidence that seemed to prove the supposition. In spite of the subsequent discoveries that minimize their importance, Metschnikoff and his followers continue to believe that in the reactive phenomena of immunity the leukocytes play the chief part, and that it is upon their ability to absorb poisons, liberate neutralizing substances, and thus protect the animal, as well as upon their tendency to devour and destroy bacteria, that immunity depends.

While phagocytosis may be one of the reactions of immunity, and a part of those phenomena that we term active; and while, no doubt, a lessened susceptibility or an increased resistance of the tissue cells in general may form important accompanying phenomena, there is the strongest evidence that neither of these is the most important. Ogata and Jasuhara found that the **blood-serum** of animals immunized against anthrax, when subcutaneously injected into other animals, conferred like immunity upon them. Shortly after this, Behring found that the blood-serum of animals immunized against diphtheria cultures or toxin contained something which was able to annul the effect of the toxin when mixed with it, or separately injected into animals. Kitasato also found the same specific immunity-conferring power to characterize the serum of animals immunized against tetanus. The neutralizing substances Behring called 'anti-Körper,' or anti-bodies. They were found by Ehrlich in the blood of the animals immunized against ricin and abrin, and later were found by Phisalix and Bertrand, Calmette, and Fraser in the blood of animals immunized against serpents' venom.

The anti-bodies appeared to Behring and Ehrlich to be specific—*i. e.*, the anti-body produced by the stimulation of diphtheria toxin was effective only against diphtheria cultures or toxins; that of tetanus, active only against tetanus toxin, and so on. Calmette later disputed this, and endeavored to show that the specificity was only partial, and that while it was true that each anti-body was most active against the particular toxin by which it had been produced, it was partially operative or annulling against several others as well. While it is difficult to show the errors upon which these conclusions are based, the recent exact studies of Ehrlich, Morgenroth, Madsen, Wassermann, and a number of others seem to show that the interaction between the toxin and antitoxin is a specific one and takes place in such exact proportions and under such definite conditions that it is almost certainly of a chemical nature.

The discovery of **antitoxins** seemed to solve the problem of acquired immunity, in demonstrating the fact that animals having such immunity possessed antitoxic blood. The same difficulty of exact proof presented itself, however, that was met in endeavoring to show that natural immunity depended upon antitoxin preformed in the blood, and it may be that the active immunity of these animals depends upon other conditions, or upon a combination of conditions present. Antitoxin is thus chiefly known to us as a specific disease-resisting constituent of the serum of **immunized** animals. An immunized animal possesses a degree of experimentally conferred immunity that would be impossible under natural conditions.

EHRLICH'S 'LATERAL-CHAIN' HYPOTHESIS

Cell Affinities and Antitoxin Formation

No theory yet advanced in explanation of the facts described in the foregoing pages is entirely satisfactory. A widely accepted hypothesis that originated with Ehrlich and is known as the 'lateral-chain theory,' may serve tentatively to correlate the facts thus far determined by experiment. With all its confusing multiplicity of terms, it cannot here be set forth in full; but its essentials may be given with avoidance of unnecessary terminology. The truth will probably be found to be simpler; bearing to Erhlich's theory much the same relation as the Newtonian astronomy to the Ptolemaic cycles and epicycles.

Reasoning from their selective properties, as demonstrated by specific reactions to drugs and staining agents, as well as to toxins, Ehrlich assumes for animal cells a complex molecular structure—represented hypothetically by a central nucleus and multitudes of atomic lateral chains (Seiten-Ketten) or **receptors,** each having its definite affinity, chemical and biologic. Normally the receptors exercise a selective function toward assimilable food substances; pathologically they are liable to the attack of specific toxins. The toxin unit likewise is conceived of as a complex body, possessing at least two parts—a **haptophor** or **fixation** group, by which it may become united to the selective cell receptor, and the **toxophor** or poisonous group, which is the active agent of disease. When the receptor is seized by the haptophor of the toxin, it is thrown out of function; physiologic chemical equilibrium is disturbed, and the organism is stimulated to the production of new receptors of the same kind, but in excess. This excess of receptor substance is thrown off into the blood, where it circulates as **antitoxin** and combining with the fixation groups of the toxin deprives the poisonous groups of access to the cells; thus permitting the latter to escape. The specific receptors thus assumed to exist, each with a single definite affinity, are termed **uniceptors** or 'receptors of the first order.' More complex receptors are assumed in explanation of the phenomena of cytolysis, to be discussed later. Absence of lateral chains having affinity for (receptive to) the fixation groups of their respective toxins is held to explain natural immunity from certain infections; while the special liabilities of certain tissues, as of the nerve-cells in diphtheria and tetanus, are assumed to be due to the predominance in those tissues of receptors suitable for the toxin in question. Experimental evidence goes to support this view. Wasserman and Takaki were able to neutralize tetanus toxin with the brain and cord of rabbits,—susceptible animals,—thus proving combination; while Metschnikoff, using the same toxin but the nervous tissues of immune animals, failed to produce neutralization, thus indicating a lack of combining affinity. Multiplicity of fixation groups in a special toxin, and corresponding multiplicity of cell receptors on the part of the tissues, give rise to multiplication of the resulting phenomena.

Toxins that by age, heat, chemical action, or otherwise have become of lessened virulence, are termed **toxones;** if deprived of their poison groups, and thus rendered incapable of doing harm, they are termed **toxoids.**

Cytolysis

It has been observed that between normal blood and foreign living cells, including bacteria, foreign erythrocytes, spermatozoa, epithelia, etc., an antagonism exists, resulting under different conditions in the victory of one or the other; but when active immunity has been produced in any animal by progressive inoculation with a given cell, its serum develops the property of producing **agglutination** and solution—**cytolysis**—of that special cell (**bacteriolysis, hemolysis, epitheliolysis, spermolysis,** etc.). Thus, in 1894 Pfeiffer observed that if the living vibrios of cholera were mixed with the serum of an animal immunized against cholera, and the mixture injected into the peritoneal cavity of a normal guinea-pig, infection of the guinea-pig would not take place, but, on the contrary, within an hour the micro-organisms would be destroyed. Metschnikoff was able to bring about bacteriolysis *in vitro* with immune serum that had been kept for some time, provided fresh peritoneal exudate were added. Bordet found that with the use of fresh immune serum neither the living guinea-pig nor the exudate was necessary, both the agglutination and the solution of the bacteria taking place; but if the immune serum was permitted to stand, or was heated to 55° C., while the power of agglutination would be retained, that of bacteriolysis was lost. The latter could be repaired, however, by the addition of fresh, unheated serum of the normal non-immunized animal. Thus, two constituents were shown to be present—one existing in the normal serum and destroyed by heat or by standing, the other acquired by immunization and not destroyed at 55° C. Similarly the observations of Belfanti and Carbone, confirmed by Bordet, show that animals may be immunized against the disturbing influences of the red blood-corpuscles of other species by the development in their sera of hemolytic properties; and an analogous power has been demonstrated concerning spermatozoa and other cells. Bordet gave the name of '*substance sensibilisatrice*' to the body found in the immunized serum, which he conceived of as a fixative agent, rendering it possible for the **alexin** existing in the normal blood to attack and destroy the intruding cell, bacterial, hemic, or other.* Ehrlich, confirming Bordet's experiments, has advanced an explanation in line with his lateral-chain theory of antitoxin production. This may for the present be accepted as the best working hypothesis. To the body existing in normal blood Ehrlich gives the name of **'complement'** †; that which is produced by immunization is termed **'immune or intermediary body.'** ‡ The intermediary body has two affinities—a stronger one for the foreign cell (bacterium, erythrocyte, etc.) and a weaker one for the complement. It is therefore called an **amboceptor** or 'receptor of the second order.' The complement has, like the toxin, a **haptophor** or **fixation group** which unites with one of the arms of the amboceptor, and a **'zymotoxic complex'** (**cytolysin, bacteriolysin, hemolysin,** etc.) which acts on the foreign cell seized by the other arm of the amboceptor and destroys it, partly by chemical combination and partly by a fermentative action. The lysins set free as well as the intermediary bodies seem to be specific; each having affinity for a particular form of invading cell. Thus we have 'tetanolysin,' 'diphtherolysin,' 'antihemolysin,' 'autohemolysin,' 'heterohemolysin,' etc.

Amboceptors are assumed to exist in normal cells (blood-cells and fixed tissues), but not always in sufficient quantity to prevent infection. When they are present in such quantity, there is a natural immunity. In other cases their production in excess is stimulated by cellular attack in a manner analogous to the stimulation of the receptors of the first order under the attack of toxins. To be able to destroy invading bacteria, the animal body must contain not only sufficient complement to produce the necessary lysin in efficient quantity, but also the specific form of intermediary (immune) body to render it active. Thus it is that normal animals, lacking the immune body, fail to resist bacterial invasion, while immunized ani-

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* This use of the term alexin is to be avoided, however, as Buchner had previously used the same term for the compound substance causing bacteriolysis before it was shown to be composed of two groups.

† Other terms for this substance are: 'addiment,' 'complementary body'; its ferment has been called 'cytase.'

‡ Other terms for this substance are: 'ceptor,' 'go-between,' 'linking-body,' 'fixator,' 'copula.'

mals may suddenly lose their resistance because they have exhausted the supply of complement. It is believed that it is especially in the maintenance of complementary substance, and in keeping the tissues in condition to produce immunizing substance under the bacterial attack, that the methods of personal hygiene are efficacious in prevention, and those of physiologic therapeutics in treatment.

METHODS OF PRODUCING ARTIFICIAL IMMUNITY

Acquired immunity may be active, in which case it is of a rather permanent character; or passive, in which case the protection is transient. By **active immunity** is meant resistance developed entirely within the body of the animal possessing it (**endophylaxination**); **passive immunity** depends upon the transference to the animal protected of a prophylactic substance developed without its body (**ectophylaxination**), and thus far obtained only from animals actively immunized.

Active Immunity

This is usually a specific form of resistance, and therefore, as a rule, protects against a single disease only. It may be produced by **infection** * with living organisms of usual or modified virulence (*inoculation, vaccination, bacterination, microbionation*), or by **intoxication** with dead bacterial cells (*mycoproteination*) or with bacterial products (*mycotoxination*). Thus it may result from disease accidentally acquired, or be deliberately produced by an experiment or by prophylactic injections.

I. Spontaneous Disease

The natural but accidental infections with which we are familiar, such as smallpox, scarlatina, measles, typhoid fever, and the like, leave behind them a true acquired immunity. It is sometimes brief in duration, sometimes permanent.

II. Experimental or Prophylactic Infection

Animals may be intentionally inoculated with micro-organisms which they might under ordinary circumstances have escaped, and may thus acquire immunity. **Unmodified virus** may be used; and

* Infection is, of course, accompanied with intoxication; but the practical distinction of methods is obvious.

this method was once practised upon human beings, as in protective **inoculation** of smallpox. Usually the virus is **modified,** and upon man the latter method is now employed chiefly in **vaccination.**

In its broad sense, as used especially by French writers, 'vaccination' means the use of any modified virus for the prevention of disease. We prefer to restrict the term, however, to Jenner's protective process against smallpox, and to speak of the general method of which vaccination is an example, as **prophylactic infection.** Its chief varieties are:

1. **The Use of Sublethal Doses of Virulent Virus (Prophylactic Inoculation).**—The effects produced by bacteria often vary with their number; and in the lower animals, at least with certain micro-organisms, when it is possible to introduce fewer than will prove lethal, a sufficient immunity may be awakened. The difficulty in securing exact dosage and in estimating the sublethal dose for man renders this method dangerously inapplicable in human prophylaxis.

2. **The Use of Forms of Attenuated Virus.**—This includes **vaccination** and the principal forms of prophylactic infection or **microbionation** used in human medicine. The **method of attenuation** may be:

(a) By **passage through the body of some partially resistant animal,** as was undesignedly accomplished in the original preparation of vaccine against smallpox; the cow being the attenuating agent. Variola inoculated into the cow may induce the mild, local and comparatively harmless affection, **vaccinia,** which modified form of smallpox inoculated into man safely induces an immunity against virulent variola. Similarly, Behring reports that by inoculating kine with the bacilli of human tuberculosis, he was able to protect them against the more virulent organism of bovine tuberculosis.

(b) By **drying.** This is the method adopted by Pasteur in his prophylaxis against **rabies.** Pasteur found that in rabbits infected by hydrophobia the spinal cord was especially virulent; but if the cord were dried, this virulence diminished, until at the end of ten days it was comparatively harmless. For the prevention of hydrophobia about two grams of an emulsion of a cord, dried from seven to ten days, is used. The injections are repeated each day, using the same dose, but an emulsion from a cord that has not been so long dried, until on the twenty-fifth day the emulsion used is made from a cord dried only three days, when immunity is assumed to have developed. In black-leg vaccination the muscular tissue of a diseased animal, rich in the spores of the bacterium, is dried at a temperature sufficiently high to attenuate the organisms.

(c) By **heat.** Many pathogenic bacteria when exposed to high temperatures diminish in virulence before the lethal point is reached. With certain organisms, notably the **anthrax bacillus,** a persistent reduction in virulence may thus be obtained. Upon this principle, as elaborated by Pasteur, depends the manufacture and use of the anthrax 'vaccine' (bacterin). By growing the organism for fourteen days at a temperature of 42° to 43° C. (107.6° to 109.1° F.) a culture of slight virulence is produced. For practical purposes, two or three cultures of different strengths attenuated in this way are usually employed; being designated as vaccines 1, 2, and 3. These have a graded virulence, No. 3 being the most powerful. The animal is first injected with No. 1, later with No. 2, and finally with No. 3; about 1 c.c. of a well-grown bouillon culture being used at each dose. This method has been employed chiefly in protecting cattle, but owing to the difficulty in 'rounding up' large herds of cattle three times, two injections are often supplied by manufacturers instead of three. These inoculations are not free from danger, and may cause the death of the animal. The uncertainty of gaging the proper dose and comparative virulence in human pathology, and the consequent risk of disastrous results, render it undesirable to employ this treatment on man. Moreover, anthrax is an avoidable disease, provided certain precautions are followed. There is, therefore, no occasion for the use of the anthrax bacterin except on the lower animals.

(d) By exposure to **light,** to certain **chemical substances,** to **different species** of bacteria, to **electricity,** and by development upon certain **unfavorable media.** Some of these expedients to reduce the virulence of bacteria have been employed with a degree of success for immunization against **typhoid fever,** against **cholera,** and against **yellow fever.** The last-named method, in particular, deserves extended study.

III. Experimental or Prophylactic Intoxication

Immunity is rapidly acquired by the systematic injection into the tissues of animals of certain groups of **poisonous substances.** Among these are the toxins of the specific infectious diseases, certain toxalbumins, such as ricin and abrin, and venom. It is acquired immunity of this form that is associated with antitoxin formation. The substances used in its production may consist of:

1. Dead Bodies of Virulent Bacteria (Mycoproteination).—This method of inducing active immunity has been employed for the prevention of **plague** by Haffkine and others. The bacilli of plague are grown in massive culture, usually upon agar-agar or bouillon. They are then killed by exposure to a temperature of 70° C. (158° F.) for one hour. From 1 to 3 c.c. of the bouillon culture is used as a prophylactic injection. While not an absolute preventive, the method seems distinctly to reduce the liability to contract pest. Against **typhoid fever** and against **cholera,** similar preparations have been used with apparent benefit, although without the production of an absolute immunity. Wright uses 1 c.c. of a bouillon culture of typhoid bacilli sterilized by heat. The bacteria used may also be killed by chemical or other agents, but, as a rule, heat is employed because of its certainty and ease of management.

2. Extractives from Bacterial Cultures (Mycotoxination).—These have their chief value for the production of high grades of active immunity in animals, and in the manufacture of antitoxins. They are represented in **tuberculin** and the more recent **tuberculin O** and **tuberculin R** suggested by Koch. Tuberculin is a glycerin extract, prepared by the prolonged heating of massive bouillon cultures of tubercle bacilli in association with glycerin. Tuberculin O and tuberculin R are prepared by grinding the bacilli to fragments in a mortar, washing by adding distilled water, and precipitating the residue with a centrifuge. The tuberculin R is the sediment, tuberculin O the clear supernatant fluid which contains tuberculin. It is claimed that all of these substances have an immunizing power in the lower animals. They are scarcely to be advised in the prevention of tuberculosis in man, nor is their curative power in cases in which the disease is established sufficiently pronounced to justify their indiscriminate or incautious use.

Development and Duration of Artificial Active Immunity

In cases in which an active immunity is induced by one of the foregoing methods, it is slow of development, but usually quite persistent. Thus, the immunity against **smallpox** derived from **vaccination** usually persists for many years. This slow development of immunity renders prophylactic injection, as a rule, of slight value after inoculation with the disease against which its protection is directed. Thus, if a man become infected with smallpox and is promptly vaccinated, it is probable that vaccinia and variola will develop simultaneously; and they may run their course without special influence of one upon the other. A marked exception occurs in the case of **rabies,** for here so long a time intervenes between inoculation and the onset of the disease that time is afforded for the development of immunity. The introduction of toxins or bacterial proteids after the onset of the disease may be not merely useless, but actually harmful by adding to the sum total of toxic material against which the tissues struggle—a fact that has unfortunately been demonstrated in the case of Haffkine's prophylactic against **plague,** and is believed by many clinicians to be true in the case of **tuberculin.**

Passive Immunity

Antimicrobination and Antitoxination

Passive immunity is a form of immunity that is developed outside the body of the animal possessing it. Thus far it has originated only in the bodies of other animals. If certain body-fluids or tissue-extracts taken from an animal having a high grade of active immunity be injected into a nonimmune animal, a degree of resistance may thus almost immediately be produced in the second animal. If the active immunity of the first animal has been developed by introducing the bodies of bacteria, the second animal will receive an **antimicrobic** or **bacteriolytic** form of immunity; while if the active immunity of the first is a result of the use of bacterial toxins, an **antitoxic** form of immunity will be imparted. Thus, in the former case the animal will resist the growth of the bacteria within its body, although it may have little resistance to their toxic products; while in the latter case it will resist the effect of the toxins, although having little action against the bacteria themselves. As **blood-serum** is the most convenient substance for the transfer of the immunity, the terms **antitoxic serum** and **antimicrobic serum (antitoxin, antimicrobin)** have come into use. Both properties are usually present, the one predominating over the other; and of the two, the antitoxic serums are the most valuable. Serums from animals artificially immunized have much greater power than serums from animals naturally immune and are therefore universally employed. Moreover, their use is safer and induces much less discomfort than the various forms of inoculation. Unfortunately, the immunity produced is quite transient, as the immunizing substance is soon eliminated, leaving the body as susceptible as before.

The chief antitoxic serums in use at present are those of **diphtheria** and **tetanus.** These are used mainly as therapeutic agents, yet they are extremely valuable for purposes of prophylaxis. In **diphtheria** the immunity is known to last about thirty days in man; and if a longer immunity be desired, the injection of diphtheria antitoxin must be repeated. The exact immunizing dose is not known, but it is always safe to use a quantity in excess of that believed to be required. Five hundred units may be taken as an average safe amount for a child. The very great value of this remedy as a prophylactic has been shown in children's hospitals, where by its use epidemics have quickly been arrested. The **tetanus** antitoxin is undoubtedly much more valuable as a prophylactic than as a curative agent, but it is so difficult to determine when a person has been inoculated with the bacillus of tetanus that it is rarely employed. In cases of punctured wounds it should be more frequently used. Unfortunately, it is not very stable.

Practical Application of Acquired Artificial Immunization

The extent of the protection that can be attained by increasing the natural resistance to disease through careful attention to general hygiene is, after all, limited. Much further spreads the field that has been opened before us by the researches into acquired immunity and the discovery of methods by which this may be produced. By systematic compulsory vaccination smallpox has now been reduced in Germany to a rare and comparatively benign disease; and in other countries voluntary vaccination has greatly lessened its prevalence and its mortality. The use of antitoxin in the treatment and prophylaxis of diphtheria has decreased the terror of this once appalling malady; the danger of tetanus is measurably set aside; rabies, a certainly fatal disease before the work of Pasteur, appears now to be preventable in many cases by the use of the prophylactic measures which he has suggested. So we find that much of the hope of future prophylaxis is inseparably bound up in the production of acquired immunity through artificial manipulation; and it may safely be said that scarcely any subject is so deserving of thoughtful consideration and patient, persistent research. If the attempts to produce antitoxins and antimicrobins by manipulations in the laboratory without resort to living animals shall be successful, this method of prophylaxis will become susceptible of almost indefinite development.

CHAPTER XII

ARTIFICIAL DEFENSES; ASEPSIS, ANTISEPSIS, AND DISINFECTION

General Considerations. Mechanical Disinfection. Heat—Hot Air; Hot Water; Steam. Cold. Light. Desiccation. Electricity. Chemical Agents: Gases—Formaldehyde, Sulphur Dioxid, Oxygen, Bromin, Chlorin, Iodin; Liquids—Carbolic Acid, Cresols, Alcohol; Solids—Soaps, Mercury Salts, Chlorinated Lime, Sodium Hypochlorite, Iodoform.

It has been shown that the **natural defenses** of the body include provisions to exclude micro-organisms, to inhibit their growth, and to destroy them. That these natural defenses ofttimes fail is evident from the prevalence of infectious diseases, and for this reason the application of **artificial defenses** becomes of great importance.

These latter measures likewise include the prevention of infection by: (1) the exclusion of pathogenic organisms, or methods of **asepsis;** (2) the inhibition of the activities of pathogenic organisms, or the application of **antiseptics;** (3) the absolute destruction of all pathogenic organisms, or measures of **disinfection.** A medium unfavorable to the growth and activities of pathogenic organisms is called an **antiseptic,** while one that destroys them is termed a **germicide,** or, if the organisms be bacteria, a **bactericide.** This destruction of agents capable of causing infection is often termed **sterilization,** while any substance that is or has been rendered incapable of producing infection is said to be **aseptic** or **sterile.** It should be observed that these terms have somewhat different meanings to the bacteriologist and to the sanitarian. The work of the former may be influenced by many of the lower fungi irrespective of their action upon the animal body, while the latter considers micro-organisms only as to their ability to incite disease. Thus, to the bacteriologist the sterile article is one free from all living organisms, while the sanitarian deems the article sterile even though it may be contaminated by many living bacteria, provided none of these bacteria is pathogenetic. To the bacteriologist an antiseptic usually means an agent that prevents the growth of bacteria, while a disinfectant is one that destroys the ability of the organisms to grow. From our viewpoint, the antiseptic is an agent inhibiting the spread of infection, while a disinfectant is one that precludes the possibility of infection irrespective of the viability of the bacteria.

Most of our knowledge relating to the means of artificial defense is based upon experiment *in vitro*, which does not represent accurately the conditions as related to practical prophylaxis. Thus, the amount of heat or the strength of chemical required to prevent the future growth of bacteria may be far in excess of the amount necessary to destroy their pathogenic action, and the fact that a certain temperature or a certain chemical does not prevent the growth of bacteria upon culture-media in the laboratory is no proof that it does not prevent them from inducing disease. Fortunately, the laboratory bacterial standards usually express conditions in excess of the requirements of the sanitarian, so that they may be adopted with the assurance of their efficacy.

The artificial prevention of disease is in essence but the adoption of **sanitary cleanliness.** To produce such a state of cleanliness, **physical measures**—such as the application of heat, light, electricity and mechanical force—or various **chemical agents** may be employed; each having its especial field of usefulness. The efficacy of disinfectants in general, and of individual agents, varies with the special parasite, the character of the associated material, the degree in which heat and moisture are present, and the thoroughness of application. When it is known precisely what organisms are present and what exactly are the actual conditions in general, methods of disinfection may be much simplified. As a rule, non-sporogenous organisms are much more readily killed than those that contain spores; while the presence of heat and moisture, as well as the absence of albuminous material, facilitates the action of disinfectants. The association of disinfectants may enhance or detract from the sum of their respective values.

Of the **chemical agents,** watery solutions are, as a rule, most efficient, alcoholic and oily substances least capable of germicidal action. The addition of mineral acids increases the activity of a number of germicides, while soap solutions increase the efficiency of some agents and decrease that of others. The penetrative or solvent action of the germicides may have an important influence upon the results obtained. Thus, upon greasy skins watery solutions may entirely fail, although effective if first the fat be removed. Mercuric chlorid (corrosive sublimate), which under favorable conditions in the laboratory is an energetic germicide, coagulates albumin and hence is not to be depended upon as a disinfectant of such substances as sputum. Again, bacteria may be protected if growing in a medium that neutralizes the germicide used, and thus mercuric chlorid, being transformed into an inert sulphid upon contact with sulphur compounds, is also found to have little value as a disinfectant of fecal material. It is obvious that absolute reliance cannot be placed upon results of laboratory investigation unless in these experiments care has been taken to reproduce substantially the conditions of practice. Moreover, no disinfectant of general application is known.

Mechanical sterilization should always be used for surfaces, such as the skin, that are unable to endure the application of absolute germicides; but as this is not a positive means of producing asepsis, it is usually desirable to supplement it by the application of other disinfecting measures. By removal of the fat, dirt, and the like, the mechanical cleansing facilitates the penetration of chemical substances later used.

Besides the chemical and physical agents, certain imperfectly understood vital processes are capable of compassing the death of parasites, as exemplified in the action of the lysogenic substances of the blood-cells.

MECHANICAL DISINFECTION

Smooth, polished surfaces may be wiped or washed free from micro-organisms by sterilized cloths; but there is always the danger that the process may not be sufficiently thorough to remove all infectious particles. It has been found that a careful wiping of polished metal surfaces, such as the blades of ophthalmic instruments, with a mixture of ether and alcohol is usually sufficient to render them aseptic, provided there is an absence of depressions such as are caused by the stamp of the maker's name. A few persons with very smooth skins free from gross contamination are able to render their hands practically sterile by so simple a means as thorough washing with soap and sterile hot water, and it has been shown that the number of bacteria upon the hands of any person bears an inverse ratio to the thoroughness and duration of a scrubbing with soap, sterile water, and a hand-brush. This is not, however, a purely mechanical sterilization, for soap possesses a distinct bactericidal action, besides facilitating the mechanical removal of the contaminated outer layers of the skin. Stuttgart sand or other abrasive substance is at times mixed with the soap used.

Liquids are in part mechanically purified by sedimentation, the bacteria falling to the bottom. They also may be purified by filtration through soil, diatomaceous earth, or unglazed porcelain, but no filter seems absolutely germ-proof during prolonged use. Experiments indicate that those of unglazed porcelain of the best type are impervious to Bacillus typhosus, while those composed of diatomaceous earth are gradually penetrated.

HEAT

In the application of heat to produce sterilization, dry hot air (**baking**), hot water (**boiling**), or steam (**steaming**) may be employed. At equal temperatures, moist streaming steam is most efficacious, and hot air least so. Each method, however, has special advantages under different circumstances. Some articles are most conveniently disinfected by baking, others cannot be baked but may be boiled, while steam is applicable to many articles that cannot satisfactorily be baked or boiled. The varying resistance of pathogenic bacteria to heat is shown in the following table:

THERMAL DEATH-POINT OF BACTERIA

	°C.	°F.	Exposure (Min.)
Spirillum choleræ (Sternberg),	52	125.6	4
Bacillus typhosus (Sternberg),	56	138.8	10
Bacillus anthracis (Chauveau),	54	129.2	10
Bacillus mallei [of Glanders] (Löffler),	55	131.0	10
Bacillus diphtheriæ (Löffler),	60	140.0	10
Pestis bubonicæ (Rosenau),	70	158.0	10
Streptococcus erysipelatis (Sternberg),	54	129.2	10
Staphylococcus pyogenes aureus (Sternberg),	58	136.4	10
Diplococcus pneumoniæ (Sternberg),	52	125.6	10
Gonococcus [single observation] (Sternberg),	60	140.0	10
Anthrax bacilli,	54	129.0	10
Anthrax spores (Sternberg),	100	212.0	4
Tetanus spores,	100	212.0	10
Tubercle bacillus (Schatl and Fischer),	100	212.0	4
Tubercle bacillus,	80	176.0	5
Vaccine virus (Carston and Coest),	54	129.2	10
Hydrophobia virus (Sternberg),	60	140.0	10

Hot Air

Air must be heated to a temperature about one-third greater than that of steam to have an equal disinfectant action. It is only adapted to dry articles, that will withstand high temperatures, especially glass and certain forms of earthenware. The temper of surgical instruments is affected, and as hot air has little penetrative action, it should not be used to disinfect closely packed articles, such as bundles of fabrics. The lack of penetrative power is well illustrated in the following table:

WHITELEGGE'S EXPERIMENT WITH RANSOM'S HOT-AIR APPARATUS, SHOWING THE PENETRATION OF HOT AIR THROUGH DIFFERENT LAYERS OF BLANKETS

The air escaping from the apparatus had a temperature varying from 245° F. to 260° F. —(*After Notter.*)

Duration of Exposure	2 Layers	4 Layers	6 Layers	12 Layers	18 Layers
	Degrees F.	Degrees F.	Degrees F.	Degrees F.	Degrees F.
4 Hours, ...	220	206	190	162	139
6 "	226	214	208	174	153
8 "	230	221	215	196	182

Hot air causes evaporation of most liquids, and its sterilizing action may be due to the complete drying of the bodies of micro-organisms. It has been employed to sterilize for surgical purposes catgut and other substances liable to be damaged by boiling in water or by steaming.

Hot Water

Boiling is a very practical means of sterilizing substances not injured by contact with hot water. It enables one to apply a moderately high temperature conveniently for any desired time. The exact temperature at which the boiling-point is reached varies with the atmospheric pressure and with the purity of the water. At the sea level, pure water boils at the temperature of 100° C. (212° F.), and the boiling-point progressively increases or decreases with changes in pressure. At a very high altitude, boiling temperature may fall to 60° C. (140° F.) or lower. By inclosing the water so that it is always under the pressure of the liberated steam the boiling-point may be raised, as shown in the following table:

BOILING-POINT OF WATER UNDER STEAM PRESSURE

Steam Pressure (Pounds)	Boiling Temperature (F.)	(C.)
0	212°	100.0°
5	228°	109.0°
10	240°	115.5°
15	251°	121.5°
20	260°	126.5°
40	287°	141.5°

Boiling water (100° C.—212° F.) is an efficient disinfectant, practically sterilizing within ten minutes all substances to which it has free access. It is true that certain spores will withstand such an exposure, but, so far as known, they do not include any disease-

FIG. 52.—CONVENIENT FORM OF PORTABLE SURGICAL STERILIZER FOR SIMULTANEOUSLY DISINFECTING INSTRUMENTS BY MEANS OF HOT WATER AND DRESSINGS BY STEAM.

producing species. The addition of sodium bicarbonate, borax, or lime, in the proportion of one or two per cent., prevents the oxidation of iron or steel instruments. Boiling in such a solution is the method of **disinfecting surgical instruments** generally preferred. Aluminum, however, is eroded by the presence of the alkali. Syringes, gloves, and other articles made of rubber of good quality may be boiled in water for brief periods of time without serious injury. By the addition of ammonium sulphate or sodium chlorid to saturation, the boiling-point may be raised from 100° C. (212° F.) to about 127° C. (260.6° F.), and the presence of these salts enables one to boil gum-elastic catheters, bougies, and the like without injury. It is claimed that sea sponges may be boiled repeatedly in Elsberg's solution, consisting of potassium hydrate, 1 part; tannic acid, 2 parts; water, 100 parts.

Cumol is a yellowish oily liquid, boiling at about 160° C. (331° F.). Catgut, thoroughly dehydrated by dry hot air, may be boiled without injury in cumol; afterward the cumol may be driven off by dry heating. This is one of the best methods of disinfecting catgut.

Steam

Steam is one of the most efficient and generally useful of all artificial germicides. Sterilization entails the consumption of energy, and as steam contains relatively a much higher potential of energy in the form of latent heat than does boiling water or heated air, it is a much more active sterilizing agent. To convert a given weight of water at the boiling-point into steam requires nearly one thousand times as much heat as is required to raise the temperature of water from 211° F. to 212° F. This great amount of latent heat is stored up in steam and liberated upon its condensation. From this it follows that to obtain the most efficient action of steam necessitates at least a partial condensation. Thus if superheated steam be passed through bundles of fabrics, it will be found that the greatest action occurs in the interior of the bundles, where a partial condensation can take place, rather than upon the exterior, where fabrics are quickly raised to such a degree of temperature that almost no condensation occurs. For the same reason superheated steam, acting at a temperature far above this point of condensation, is relatively much less efficient than streaming saturated steam.

Saturated steam has a temperature corresponding to the pressure under which it is held, so that the slightest cooling will result in condensation. At the pressure of one atmosphere, for example, saturated steam has a temperature of 100° C. (212° F.), and the point of saturation varies with the pressure according to the table previously given. **Superheated steam** has a temperature exceeding that corresponding to the pressure at which it exists. It does not condense until it has cooled to the saturation point. It is obtained by heating saturated steam or by adding certain salts, such as sodium chlorid, to the water in order to raise the temperature at which steam will be liberated. Saturated steam has relatively greater penetrative power and disinfectant action than has superheated steam. In condensing it imparts to the surrounding media a temperature above that at which it exists; for as it comes in contact with, or enters, articles to be disinfected, the cooling produces a partial condensation, and the liberated latent heat is transferred to the material. The successive great reductions in volume resulting from the condensation attract more and more steam to the area, so that penetration through even large bundles of fabrics quickly takes place.

For the use of steam at high temperatures, forms of sterilizers capable of withstanding high pressure, known as **autoclaves** or **steam pressure sterilizers,** are employed. Any air remaining in such an apparatus interferes with the action of the steam. To insure sterilization, therefore, it is essential that all air first be expelled, either by permitting the steam to escape for a considerable time before sealing the apparatus, or else by exhausting the chamber

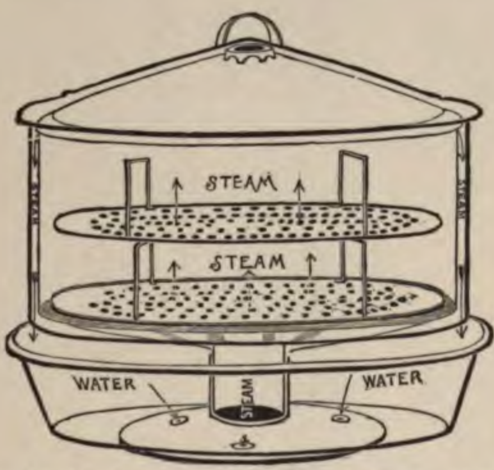

FIG. 53.—THE ARNOLD STERILIZER, OVAL FORM, FOR THE USE OF STREAMING SATURATED STEAM.

two or three times during the process of sterilization. The method of intermitting the action of steam with the formation of partial vacuum is readily carried out by a simple condensing device, and greatly enhances the efficacy of the process.

Superheated steam does not moisten paper or fabrics, and for this reason may be used to sterilize letters and the like. At the ordinary atmospheric pressure, streaming saturated steam rapidly destroys all pathogenic organisms and their spores, and, for general purposes, has been found the most convenient and efficient practical measure. For heavy work with limited space under expert supervision the vacuum method with superheated steam is advantageous.

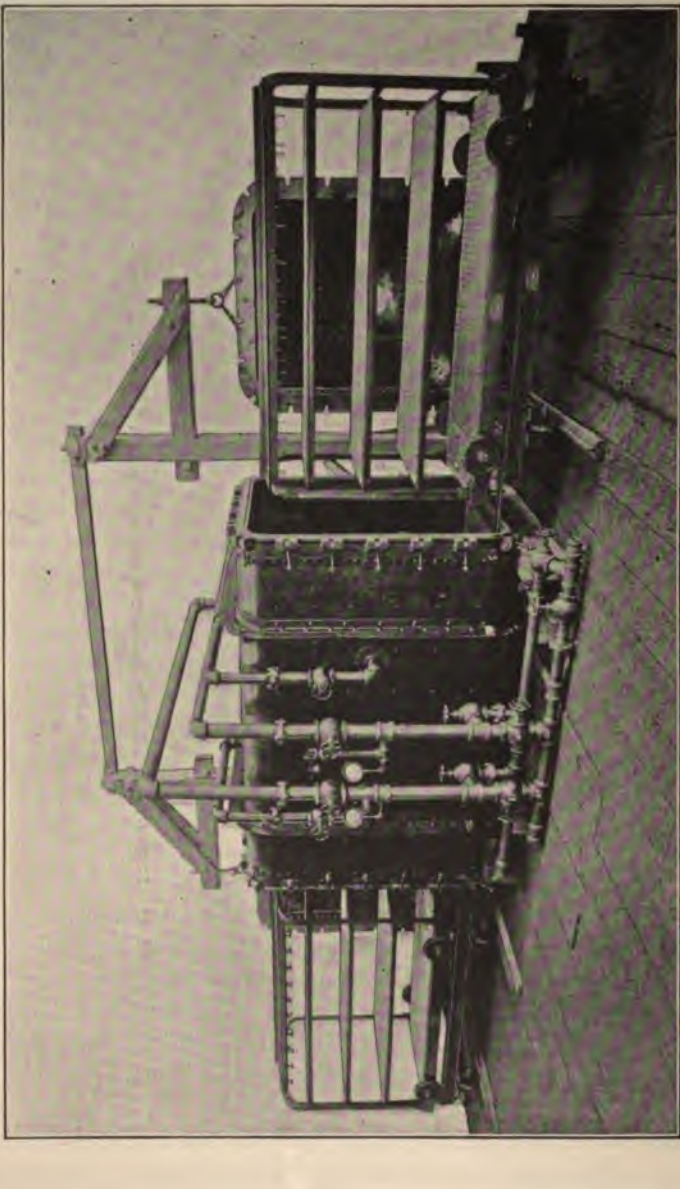

FIG. 54.—STEAM DISINFECTING CHAMBER, ILLUSTRATING THE RECTANGULAR FORM.—(*From Rosenau.*)

Streaming steam tends to wet articles that are closely packed, while employment of the vacuum and of superheated steam prevents wetting.

COLD

It has repeatedly been observed that cold does not destroy pathogenic bacteria, yet the number of micro-organisms progressively diminishes in frozen articles, indicating that cold is a slowly acting germicide as well as an antiseptic. Prudden found that the bacilli of typhoid fever would withstand freezing for one hundred and three days, although the action of alternate freezing and thawing was found to be injurious to their growth.

Ravenel and MacFadyen exposed various bacteria to the low temperature of liquid air (—190° C., equivalent to —310° F.) for periods varying from a few hours to seven days, without destroying their viability. Portions of infected tissue from tuberculous lungs have been kept frozen for four months without destroying their property of infecting guinea-pigs. A few organisms are able to multiply at or below freezing temperature; thus, meats kept in cold storage tend to become moldy.

LIGHT

The **ultra-violet rays** (actinic rays) from the sun or from electric light have a pronounced germicidal action, well marked in the case of the direct solar rays, requiring a much longer time for disinfectant action when diffuse; while the rays from the electric light are much less efficient. The direct sun rays are much more powerful than those from a 100 candle-power electric arc light at a distance of one meter. As the arc light is richer in actinic rays than is the incandescent light, it is the more active. Clearness of the atmosphere, freedom from dust and fog, and the absence of any interposed transparent medium, as glass, which interferes with the transmission of ultra-violet rays, may increase the action of light. The red and infra-violet rays possess almost no practical bactericidal value. The disinfectant action of light has been clearly demonstrated after the rays have penetrated clear water to the depth of at least 30 centimeters; so that it is evident that exposed water, perfectly clear and not of great depth, may be freed from pathogenic organisms by sunlight alone. The germicidal action seems to be due partially to changes in the medium involving its contained oxygen, but chiefly to a direct action upon the bodies of the bacteria. Bacterial toxins are also rendered inert by light. It it evident, therefore, that sunlight will act chiefly as a surface disinfectant of translucent or opaque bodies. Tubercle bacilli are quickly killed by exposure to the direct solar rays, the time varying, according to circumstances, from a few minutes to several hours; while the diffuse rays will kill these organisms in from five to seven days, their virulence diminishing before their death (Koch). Practically all pathogenic bacteria and spores may be destroyed by a sufficiently prolonged exposure to the actinic rays of the sun.

ELECTRICITY

It is extremely difficult to estimate the bactericidal action of **electric currents,** as it is nearly impossible to apply them without inducing chemical changes in the surrounding media. These chemical substances frequently have a marked disinfectant action, but that of electric currents in themselves requires greater proof. Induced currents of from 10 to 20 ampères, acting upon bacteria inclosed in tubes of a diameter of 3.5 centimeters, were found by Spilke and Gallstein to kill micro-organisms in one or more hours, and to restrain their growth if applied for shorter periods. It is probable that of itself electricity is at most a feeble bactericide. The bactericidal properties of **X-rays,** or **Becquerel's rays,** and of the energy of **radium** and like bodies, have not been accurately determined, so that at present they have no practical significance.

DESICCATION

Absolute dryness is probably destructive to all micro-organisms and their spores, and the efficiency of dry heat as a disinfectant seems to depend in a large measure upon this action. The organisms of the colon group, such as Spirillum choleræ, Bacillus typhosus, and Bacillus coli, are more readily destroyed than those of tuberculosis and diphtheria or the members of the sporogenous group. Koch found that the cholera spirillum, if in thin layers, was killed by drying for three hours, and Pfuhl observed that the bacillus of typhoid fever died after eight or ten weeks of drying. The more resistant organisms may withstand ordinary drying for months, and spores may survive it for years.

CHEMICAL AGENTS

For chemical disinfection, gases, liquids, and solids are employed, each form having special applicabilities.

Gases

Formaldehyde.—Formic aldehyde, methaldehyde, oxymethane, is a pungent irritating gas formed by oxidizing vapor of methyl-alcohol over a heated platinum sponge or coke, the reaction being $CH_3OH + O = CH_2O + H_2O$. It is soluble to about 40 volumes in water, this solution being sold under such trade names as 'formalin,' 'formal,' 'formol,' and the like. When it is condensed, if an attempt be made to dissolve more than 40 volumes in water, it tends to polymerize into paraformaldehyde (trioxymethylene or paraform, $C_3H_6O_3$), a white, solid substance, which when gently heated is reconverted into formaldehyde. One pint of a 40 per cent. solution of formaldehyde theoretically develops 166 liters of gas, weighing 225 grams, while 50 grams of paraform develop upon heating 37 liters weighing 50 grams. Three grams of alcohol are required for vaporization of one gram of formalin pastil (paraform). In the burning of this alcohol, at least 3½ grams of water will be formed, that will increase the effectiveness of the gas and prevent polymerization. Formaldehyde combines with albuminous substances, rendering them stable and difficult of gastric digestion, and this tendency to combine with organic compounds renders it a good deodorant. Ammonia neutralizes it and converts it into an inert compound.

Application.—Formaldehyde is the most efficient of the gaseous disinfectants at present known. It has, however, little penetrative power, and its action is therefore chiefly that of a surface disinfectant. It may be applied (1) as a watery solution, being active in 0.4 to 4 per cent. in water (1 to 10 per cent. of the commercial solution); (2) as a spray produced by projecting air or steam through a concentrated watery solution; (3) as a recent gas generated by (*a*) passing the vapor of methyl alcohol over a heated platinum sponge in a special apparatus, (*b*) heating pastils of paraform in a special

FIG. 55.—THE KUHN FORMALDEHYDE GENERATOR.

FIG. 56.—FORMS OF SCHERING'S FORMALDEHYDE LAMP FOR GENERATING FORMALDEHYDE GAS FROM PARAFORM PASTILS.

The pastils are heated in the basket indicated by the dotted lines in form A. The rate of generation of gas is regulated by the height of the flame in the alcohol lamp. Form B has two cups, a shallow one holding one or two pastils for continuous slow evaporation in the sick-room; and a deeper one holding 50 pastils for room disinfection as described in the text. From 2 to 2½ one-gram pastils are advised for every 35 cubic feet of space.

lamp, (*c*) evaporating the gas from a watery solution by means of a special device with the addition of calcium chlorid, glycerin, or other expedient to prevent polymerization (an electric heater may be used); or (*d*) slow evaporation from sheets saturated with formaldehyde solution and hanging in the room. For room disinfection the evaporation of the gas and the method of spraying by a jet of steam have proved the most valuable. The direct generation of the gas from wood-alcohol is usually subject to the

FIG. 57.—THE TRENNER-LEE FORMALDEHYDE REGENERATOR.

A solution of formaldehyde, 40 per cent., with glycerin, 5 per cent., is placed in the retort, the lamp started, and the liberated gas conducted by the tubing through the keyhole into the infected room.

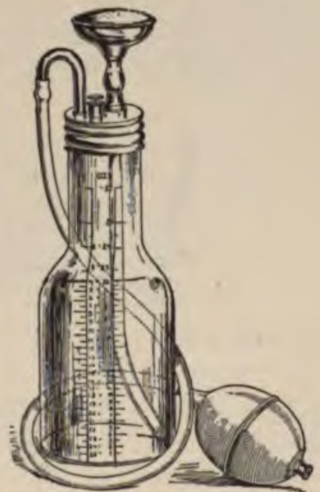

FIG. 58.—FORMALDEHYDE SPRINKLER.—(*From Rosenau.*)

disadvantage that much of the alcohol may be lost through conversion into carbonic oxid or carbon dioxid, and it is difficult to estimate the quantity of formaldehyde generated. The use of paraform pastils is convenient but expensive, and while it may be carried out by any intelligent person, householders as a rule use an apparatus too small to accomplish the desired result. If a large enough lamp or a sufficient number of the smaller lamps be used, the method has much to commend it in its simplicity and safety. Whatever be the expedient employed, it is important for efficient action that the entire quantity of disinfectant enter the room within a short space of time, that the surfaces of all articles to be disinfected be freely exposed to contact with the gas and, when possible, slightly moistened; and that the room should be kept tightly sealed for twenty-four hours. Sheets of paper and envelopes are readily penetrated. Of the gas about 50 to 90 liters (quarts)—of saturated aqueous solution about a pint—and of the commercial pastils of paraform about 60 to 100 (925 to 1543 grains)—should be used to each 1000 cubic feet of air space. Heat and moisture seem to increase the efficiency of the gas. As gaseous diffusion often interferes with a disinfectant action, the gas should be discharged at several different points when large rooms are to be disinfected. Under the best

FIG. 59.—THE POT METHOD OF BURNING SULPHUR.—(*From Rosenau.*)

conditions, absolute disinfection is not usually obtained. Flügge considers the result to be good if 90 per cent. of the pathogenic organisms are destroyed.

Formaldehyde is an unreliable agent for the destruction of **vermin**; mosquitos, flies, and other arachnids usually are killed, but bedbugs, roaches, and possibly fleas secrete themselves in the cracks and crevices less accessible to the gas, and thus often escape. The larger animals are destroyed if left for a number of hours in an apartment in which the gas is present in large amount. For the destruction of vermin, sulphur dioxid is more valuable.

Sulphur dioxid, SO_2

This gas is usually generated by burning brimstone or prepared sulphur candles in the apartments that it is desired to disinfect. It may be used with greater precision if taken from tanks of the liquid gas. Repeated experiments show that as employed, it is unreliable as a germicide. The Committee on Disinfectants of the American Public Health Association advised that at least 4 volumes per cent. of the gas be present in the air of the room to be disinfected for at least twelve hours. When burned in the usual way, it is difficult to comply with these conditions, and as the gas diffuses rapidly, and in the presence of moisture has a bleaching action on many colors, it has been largely abandoned as a disinfecting agent. If used, at least 4 grams (60 grains) should be burned for each cubic meter (yard) of air space, and there should be a simultaneous liberation of aqueous vapor, for the gas is comparatively inefficacious in dry air. The sulphur should be well wetted with alcohol and it should be remembered that, as a rule, only about 20 per cent. of the sulphur used is consumed. It is an effective agent against vermin, destroying flies, fleas, mosquitos, roaches, bedbugs, and other insects, and may also kill rats and other larger animals. For those diseases, therefore, which are transmitted by vermin it may be of greater value than substances having a higher germicidal power but less destructive to animal life.

Oxygen and Ozone

Oxygen in the ordinary form is inefficacious as a germicide, but in the form of ozone, especially in the nascent state, and in the presence of moisture, it has a decided action. The reported value of oxygen as a disinfectant seems traditional, rather than founded upon exact experience. Of the great activity and importance of ozone in nature, there can be no doubt.

Ozone may be generated in large quantities by means of the discharge of high-tension electric currents in the atmosphere, but electric generators, while sufficiently simple in construction, are at present too costly for ordinary use. They might be used by agents of Health Boards in apartments containing electric light fixtures and supplied with currents of ordinary voltage. It was suggested by Sir B. W. Richardson that theaters, churches, and other meeting-places where great numbers of people gather should be disinfected in this way after each assemblage; and that the mild continuous evolution of ozone by electric generation in such places would do much to prevent disease from being contracted by the people frequenting them. The irritating properties of ozone and its action in bleaching fabrics and in tarnishing metal have prevented the adoption of these measures. Ozone added to water is of value as a disinfectant, and is not injurious; the method has been employed in lieu of filtration. Chemically, ozone may be generated by permitting a solution of potassium permanganate (8 grains to the ounce) to drop slowly into a saturated solution of oxalic acid. A Wolff bottle provided with a dripping-funnel forms a convenient generator. The addition of a solution of hydrogen dioxid will increase the yield of ozone, but adds much to the expense.

Bromin, chlorin, and **iodin,** in the gaseous state, are all efficient germicides, but are unsuited for general use by reason of their irritating toxic qualities, and their chemical affinities, which result in the bleaching and deterioration of colored fabrics, and the tarnishing of metallic surfaces.

LIQUID DISINFECTANTS

The disinfectant powers of inorganic agents have been found to bear a relationship to the character of their ionization. This refers to the disassociation of acids, bases, and solids into electropositive or electronegative ions when they are in watery solution. Paul and Krönig have found that most acids act as disinfectants in accordance with their electrolytic disassociation; the bases in accordance with the concentration of the hydroxyl-ions; while oxidizing agents have a disinfecting action related to their electric activity. The halogens, chlorin, bromin, and iodin, have a disinfectant power in inverse ratio to their atomic weight. The theory of ions would seem to explain the inefficiency of many disinfectants when in alcoholic solution or in contact with albuminous material. Other substances, as carbolic acid, are said to have a direct molecular action upon bacteria, ionization not taking place. The bactericidal action of other agents seems to be unrelated to the state of ionization.

Carbolic Acid, Phenol

When pure, phenol occurs in the form of colorless needle-like crystals, but for convenience it is usually liquefied by the addition of a small percentage of glycerin. When pure, it is soluble in about eleven parts of water.

Crude carbolic acid is a dark-colored liquid having a powerful odor and containing cresol and other coal-tar derivatives. Phenol precipitates albumins without entirely losing its disinfective action. It is usually employed in the strength of from 1 to 5 per cent. Its germicidal power is moderate, and at present it has a rather limited use in surgical practice. It decreases tactile sensibility, renders the skin rough, and if applied to portions of the body for long periods of time, even in weak solution, may produce local necrosis and gangrene.

The pure acid is caustic and is used as an antiseptic cauterizant in appendectomy, for swabbing out tuberculous abscesses, and the like. It has also been employed for hand disinfection, the pure acid being immediately neutralized by applying strong alcohol.

Cresol.—The various cresols, **meta-**, **tri-**, **ortho-**, and **para-cresol,** are all disinfectants. Excepting **tricresol,** which has been extensively used as a preservative of antitoxin serums, the cresols are usually employed in combination rather than singly. All combine well with oils and with soaps, and have the advantage of not corroding metallic surfaces.

Creolin.—Creolin contains about 4 per cent. of cresol, together with soap and phenol. It it a black, tarry liquid with a penetrating odor. It makes, if mixed with water, an opaque milky solution. It has been credited with marked disinfectant power, but this is evidently an error, as anthrax organisms will grow after they have been immersed in pure creolin. Hirst has reported the development of tetanus from intrauterine irrigations of creolin solutions made with rather muddy tap-water.

Lysol.—Lysol contains about 50 per cent. of cresol, mixed with the neutral potash soap, and when mixed with water, forms a transparent, soapy solution. It seems to be more valuable as a germicide than carbolic acid, and has had a large clinical use.

Other cresol compounds for which high antiseptic powers have been claimed are **saprol,** consisting of 20 per cent. mineral oil with 80 per cent. of crude carbolic acid; **solveol,** a concentrated aqueous solution containing over 25 per cent. of cresols; and **solutol,** containing 60 per cent. of cresols.

Saprol has been largely advised for the disinfection of excreta and privy vaults. Solveol and solutol are said to be less irritating and more potent than carbolic acid as general surgical disinfectants.

Alcohol

Alcohol is a good antiseptic, but is a weak germicide. In laboratory experiments it has been found most efficient in 50 per cent. solutions, the germicidal value diminishing progressively with the addition or subtraction of water. When heated, the weaker alcohols are found to be more potent, while many bacteria may be boiled in concentrated alcohol without destruction. Alcohol reduces the effectiveness of mercuric chlorid, especially if the alcohol be strong, while sublimate, carbolic acid, lysol, or thymol are said to be more powerful when dissolved in 50 per cent. alcohol than in water. When applied to moist surfaces of the body, the alcohol is of course diluted, and so should be used in greater strengths than those found most efficient in the laboratory.

SOLID DISINFECTANTS

Soaps

Nearly all soaps possess a certain degree of bactericidal power. This is more pronounced in the soft or potash soaps than in the sodium or hard soaps and those that contain resin. As commonly used, their action is so diminished by the hardness of the water employed and the great dilution, that they are comparatively ineffective against such organisms as the spirillum of cholera, the bacillus of typhoid fever, and the pus-producing cocci. The addition of chemical disinfectants to soaps usually does not enhance their germicidal value. This is especially true of carbolic acid and cresol soaps. Mercury biniodid and the double iodid of mercury and potassium in soap in ½ to 3 per cent. strengths have, however, a marked bactericidal action. A 1 per cent. solution of such a soap was found to destroy ordinary pathogenic bacteria in one minute. For the disinfection of hands, Mikulicz strongly commends the German spiritus saponatus,—which contains potash soap, 10.2; olive oil, 0.8; glycerin, 1.0; alcohol, 43; and water, 45,—applied in full strength for five minutes. This is not very different from tincture of green soap.

Mercuric Chlorid (Corrosive Sublimate)

Mercuric chlorid is one of the few antiseptics generally employed by surgeons the world over. It is easily decomposed and rendered inert by contact with metals or organic matter, and a film of oil or albuminous substances may prevent its action. Its use is restricted chiefly to surgical practice, it is used to cleanse the hands and the operative field, and as an irrigating solution for wounds. The first claims made by Koch, and others, about its extraordinary germicidal properties have been modified by later investigations, which show that organisms that apparently have been killed by this salt often regain their vegetative properties when the sublimate is neutralized by the addition of ammonium sulphid. As this neutralization has often been omitted experimentally, many of the tables of germicidal values are useless. To render it more stable and effective, it is usually combined with citric or tartaric acid, or sodium or ammonium chlorid. Objections to its use are its toxicity, instability, and lack of penetrative power. It is used in the strength of from 1:500 to 1:10,000. The former strength is very apt to produce a marked local irritation, the latter is so weak as to be untrustworthy.

Mercuric iodid is insoluble in plain water, but soluble when an excess of potassium iodid is added. It is said to have nearly the disinfective powers of the bichlorid without its irritating action, its destructive effect upon metal instruments, or its instability.

Chlorinated Lime (Chloride of Lime)

This consists of a mixture of calcium chlorid and hypochlorite and owes its efficacy chiefly to the latter. It should contain at least 35 per cent. available chlorin (U. S. P.) and should be dry, friable, and nearly free from the odor of chlorin until moistened. It is an efficient disinfectant in a strength of 1 : 400, and solutions of 1 : 1000 were found by Bolton to destroy the organisms of cholera and of typhoid fever within two hours.

For **excreta** it is one of the most efficient practical disinfectants. The Committee on Disinfectants of the American Public Health Association advises that six ounces of chlorinated lime, containing at least 25 per cent. of available chlorin, should be dissolved in one gallon of water. For use, one quart of this solution should be mixed intimately with the typhoid dejections, and permitted to stand at least one hour before being thrown into the privy or drain. As a hand disinfectant the value of this agent was first practically shown by Semmelweiss in the prevention of puerperal infection. Recently it has been revived for this purpose. About 8 grams (2 drams) of chlorinated lime is placed on the palm of the hand, a crystal of sodium carbonate weighing about 0.5 gram (8 grains) added, the mixture moistened with water, and thoroughly rubbed into the hands and forearms. Especial care is to be taken to carry it under the nails and along the ungual folds, with swabs of cotton. Finally it is washed off with sterile water. Its use should always be preceded by the customary cleansing with brush, soap, and hot water, and it may be followed by the use of other germicides. It has the disadvantage of rendering the skin rough, and the nails brittle. In the dry form it is a valuable agent when dusted in privy vaults, acts as a deodorant disinfectant, and also repels insects.

Sodium hypochlorite solution (Labarraque's solution) consists of chlorinated lime 75, sodium carbonate 150, water to 1000. It should contain at least 2.6 per cent. by weight of available chlorin. It is a useful antiseptic, but is less commonly employed than the simple chlorin solutions that seem to be equally efficient. A solution of chlorin, iodin, and bromin compounds obtained by electrolysis of sea-water, and readily yielding free chlorin, is similarly useful. It is commercially known under the misleading name of 'electrozone.'

A number of other chemical agents formerly in repute as disinfectants, including **ferrous** and **ferric sulphate, ferric chlorid, aluminum chlorid,** and **copper sulphate,** are now known to be inefficient as germicides or practically inapplicable as such. Their use is not to be considered so long as there are other much more dependable agents available.

Iodoform is useful as a surgical dressing and undoubtedly possesses distinct antitoxic and antituberculous properties; but it has slight merit as a germicide. Animals have been infected by subcutaneous injections of pathogenic bacteria mixed with iodoform, so that even the germicidal substances said to be liberated from it in the tissues are not clearly proved to exist.

CHAPTER XIII

THE PREVENTION OF THE TRANSMISSION OF DISEASE BY ANIMALS

Life-history, Recognition and Destruction of Mosquitos; Flies; Fleas; Bedbugs; Lice. Precautions against the Dissemination of Disease by Mammals.

In the previous section stress has been laid upon the activity of **insects** as conveyers of disease. It is of considerable importance in prevention to study the habits, habitat, and development of those species known to be concerned in the transmission of infection, and thus become able to attempt intelligently their restriction or destruction.

THE LIFE-HISTORY OF THE MOSQUITO

Development

Ova.—The female mosquito usually lays her eggs upon the surface of water, although it is possible that at times the eggs are deposited upon grass or other substances from which they may be later washed by rain into pools. In from twelve hours to three or five days after the eggs are laid, the **larvæ** or wigglers emerge. The wigglers breathe air through a projecting segment given off near the anal extremity and containing a double trachea. This must frequently be brought in contact with the atmosphere or the larva will drown. The wigglers feed on free particles in the water, especially upon algæ. After a variable number of days they enter the **pupa stage,** which is characterized by a marked enlargement of the thoracic segment, from which project two ear-shaped respiratory siphons that assume the functions of the former respiratory tubes. A number of days later the insect emerges from the pupa. The entire cycle of development usually occurs in from ten days to four weeks; but if the weather be cold, the larval or pupal stage may be prolonged indefinitely. The larvæ may remain frozen for a long time in ice without being destroyed. They are killed rapidly by drying. Howard found that they died in from twenty-four to forty-eight hours after the water had been drained from mud containing them. Many generations may develop in a single summer, and in warm countries mosquitos continue active during the entire year. Except under unusual circumstances, only the females inflict bites. The males are distinguished by their very feathery antennæ and palpi.

The great bulk of mosquitos never have access to warm-blooded animals, and subsist upon plants, or, possibly, at times upon other insects, fish, or other animals.

Duration of Life

Mosquitos live much longer than was at first supposed. They have been kept in an active state for several weeks, and in a few instances for two or three months. It is well known that at the onset of cold weather they hibernate, remaining in a dormant condition until the following spring. It is not true that death follows their engorgement with blood; a single mosquito may inflict repeated bites during a period of many weeks. Therefore a single mosquito may carry disease to many persons.

Their **distribution** is wide-spread. Not only are they found in the tropic and temperate zones, but almost incredible numbers live in parts of the arctic regions. They are more frequently found in lowlands and are usually absent from mountains, although mountainous regions may become infested through human intercourse.

Powers of Flight

There is considerable evidence to show that mosquitos rarely fly more than a few hundred yards from their breeding-places. As they are not strong of wing, they seek protected places during a breeze, and do not fly while strong winds are blowing. This is supposed to explain the absence of mosquitos at the seashore while there is a sea-breeze, and their presence during a land breeze. They are in the neighborhood all the time, and may be found in large numbers clinging to the leeward side of grasses, shrubbery, and buildings. When the wind subsides, they take wing and invade the adjacent dwellings. Instances have been reported of the migration of enormous numbers of mosquitos for distances so great as 50 to 60 miles; but these are exceptional.

Mosquitos have also been encountered by ships far out at sea.

Although mosquitos seem rarely to fly long distances, they are sometimes blown far by the wind, and it is well known that they are frequently transported many miles by means of railways, ships, stages, and other public conveyances. In numerous instances locations previously free from the pest have been infested after the advent of a railroad.

The Salivary and Poison Glands of the Mosquito

There are two sets of venom-salivary glands, situated in the prothorax of the mosquito, each consisting of three lobes. The intermediate lobe was shown by Macloskie in 1887 to have a peculiar histologic structure, and to secrete the poison of the insect. By

FIG. 60.—CULEX EXCRUCIANS, WALK.
a, Female. *b*, Front tarsal claw.—(*From article by Prof. Geo. E. Beyer in the "New Orleans Med. and Surg. Jour.," Sept., 1901.*)

a duct these glands are connected with the central stylus of the proboscis, and in biting, the poison is injected directly into the wound and is believed to facilitate the sucking process by keeping the proteids of the blood in solution. This injection of venom is of special importance in connection with **malaria, yellow fever, filariasis,** and certain other diseases. In each of these affections the causal parasite seems to undergo a metamorphosis in the insect's body and then to be inoculated into the next person bitten. The hematozoa of malaria are known to emigrate from the stomach of the mosquito and to collect in the salivary glands, from which they are ejected with the saliva into the tissues.

The Varieties of Mosquitos

At present but three varieties of mosquitos are known to serve as the intermediate hosts for parasites noxious to man, and as yet there is little evidence that a special parasite has more than a single genus that may serve as its host. Thus, the hematozoon of malaria apparently is transmitted only by members of the genus Anopheles; the parasite of yellow fever has thus far only been transmitted successfully by what was at first considered to be a variety of Culex (Culex fasciatus), but has since been given by Theobald a new generic name, Stegomyia (Stegomyia fasciata); while Filaria sanguinis hominis is transmitted by a Culex—Culex ciliaris (Culex pipians Linn.). In addition, recent observations apparently indicate that dengue is transmitted by a variety of Culex, and other infections may prove to be conveyed similarly.

As only the anopheles transmit malaria, it is important to distinguish them from the common genus Culex. The most striking differences are found in the palpi. The resting position assumed by the adults is suggestive—although not always diagnostic. The chief discriminating characteristics are given in the table following:

Adult	Culex	Anopheles
Palpi, ...	Female has diminutive palpi with 3 segments. The male has palpi nearly as long as proboscis with 5 segments.	In both male and female palpi are nearly the length of proboscis and have 5 segments.
Wings, ...	Usually devoid of marking.	Usually spotted.

a

b

Fig. 61.

a, Wing of Stegomyia fasciata. *b*, Wing of Anopheles maculipennis.—(*From article by Prof. Geo. E. Beyer in the "New Orleans Med. and Surg. Jour.," Sept., 1901.*)

FIG. 62.

a, Resting position of Anopheles. *b*, Resting position of Culex. (Drawn by C. O. Waterhouse.) This distinction is frequent, but not invariable.

FIG. 63.

a, Eggs of Culex perturbans. *b* and *c*, Eggs and egg mass of Culex pungens. *d*, Eggs of Stegomyia fasciata. *e*, Eggs of Anopheles crucians (hatching).—(*From article by Prof. Geo. E. Beyer in "New Orleans Med. and Surg. Jour.," Sept., 1901.*)

Adult	Culex	Anopheles
Body axis,	Forms a nearly straight line, parallel with the surface on which the culex alights.	Is curved, making the anopheles 'hump-backed,' forming an angle often approaching 90° with the surface on which the insect rests.
Note,	Shrill, high-pitched.	Several tones lower and less clear than that of the culex.
Biting,	Usually pauses before biting.	Bites immediately on alighting.
Time of appearance,	Evening and also during the daytime.	After 6 P. M.
Breeding-places,	Usually artificial collections of standing water, puddles, in tin cans, drains, sewers, etc.	Usually natural collections of water, streams, stagnant pools, puddles, and drains.
Eggs,	Two hundred to 400 arranged vertically with their sides coherent, forming a boat-shaped mass that is concave below, convex above.	Forty to 100. Float on their side loosely connected or isolated. Are not united and the eggs form no characteristic figure.
Larvæ,	Form an angle of about 45° with the surface of the water. Frequently descend and seem heavier than water.	Unless disturbed habitually remain at the surface, with which their bodies lie parallel. Seem lighter than water, so that they descend with effort. The respiratory siphon is longer, the head parts smaller, than corresponding parts of Culex.
Pupa,	Float nearly vertical to the plane of the surface of the water. Respiratory siphons longer and narrower than those of Anopheles.	Body oblique to the surface, respiratory siphons shorter and broader.
Duration of Development,	Ten days.	Twenty-four days.

FIG. 64.

a, Pupa of Culex perturbans. *b*, Pupa of Anopheles crucians. *c*, Pupa of Stegomyia fasciata.—(*From article by Prof. Geo. E. Beyer in "New Orleans Med. and Surg. Jour.," Sept., 1901.*)

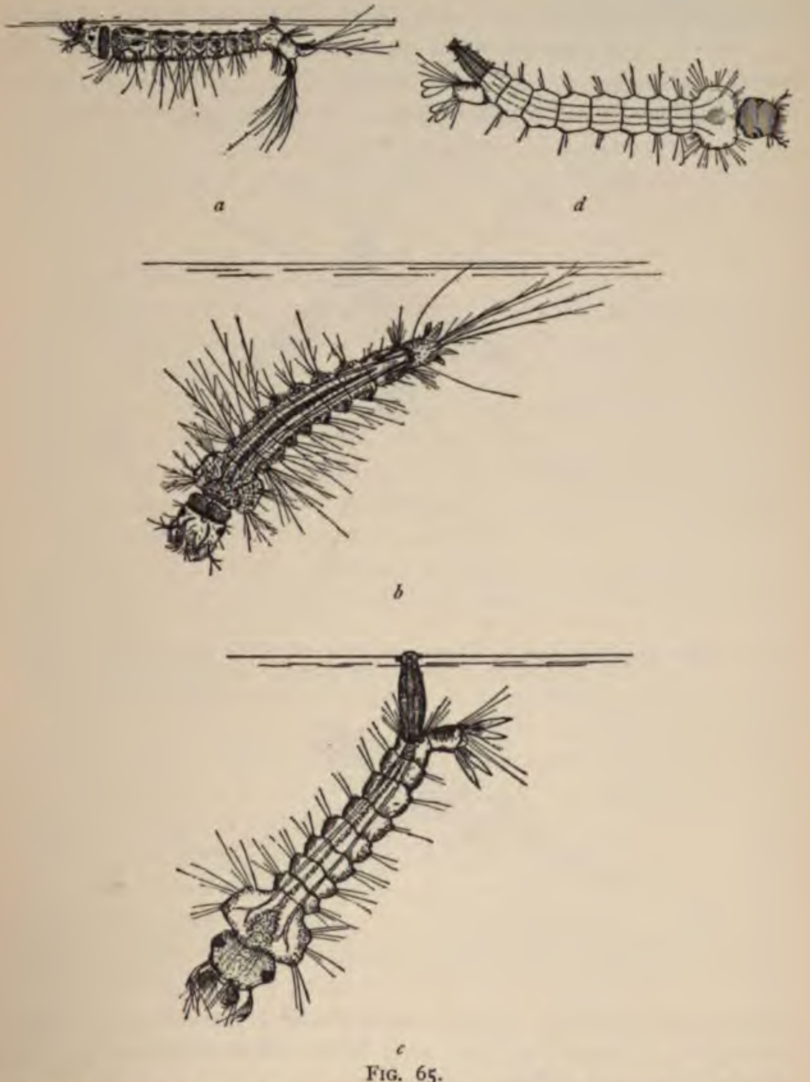

FIG. 65.

a, Young larva of Anopheles crucians. *b*, Mature larva of Anopheles crucians. *c*, Mature larva of Culex perturbans. *d*, Mature larva of Stegomyia fasciata.—(*From article by Prof. Geo. E. Beyer in "New Orleans Med. and Surg. Jour.," Sept., 1901.*)

The **yellow fever mosquito** (Stegomyia fasciata) has been found in tropic and subtropic, but thus far not in the temperate or arctic regions. It is characterized by conspicuous silver stripes upon the thorax and abdomen, and bands upon the legs. The larva and pupa resemble those of the genus Culex. The larvæ have been found in

FIG. 66.—STEGOMYIA FASCIATA, FEMALE.—(*From article by Prof. Geo. E. Beyer in "New Orleans Med. and Surg. Jour.," Sept., 1901.*)

FIG. 67.—STEGOMYIA FASCIATA, FEMALE, FROM THE SIDE.—(*From article by Prof. Geo. E. Beyer in "New Orleans Med. and Surg. Jour.," Sept., 1901.*)

cisterns and in small artificial collections of water in and about houses. As it is active in the early afternoon as well as at night, it has been called the **'day mosquito.'**

THE PREVENTION OF INFECTION BY MOSQUITOS

Bearing in mind that the mosquito does not originate infection, but merely acts as an intermediate host or carrier of the materies morbi, it is evident that prophylaxis may be attained by (1) destruction of all mosquitos; (2) by preventing the contamination of mosquitos from infected human beings or other sources; or (3) by the prevention of mosquito bites. Theoretically the absolute enforcement of a single one of these measures should suffice to prevent such infection, but practically the difficulties in the way of attaining complete enforcement of any one method render it desirable to combine the three.

The Destruction of Mosquitos

In a single summer one female may give rise to twelve generations, and as the females of the genus Culex deposit from 40 to 100 eggs, and of the Anopheles from 200 to 400 eggs at one time, the possibilities of mosquito multiplication in a single season almost exceed comprehension. Assuming that all conditions are favorable, that one-half of the mosquitos hatched are females, and that these are gravid but once and deposit an average of 100 eggs, the progeny of a single season would number 49,824,617,346,938,780,100 mosquitos. Happily many natural agents cause a high mortality in the mosquito family, so that practically this number is far from being approximated.

The Destruction of the Larvæ.—The most effective measures are those directed against the **breeding** of mosquitos. For successful breeding a suitable collection of water is the first essential, for it has not been shown that the larvæ develop apart from water. By filling in hollows, by draining swamps, and by preventing the accumulation of water in discarded cans, pails, bottles, and the like, much may be accomplished. Collections of water that do not remain over nine days may be ignored, as the period from the deposition of the eggs to the emergence of the adult insects probably is rarely less than ten days. Collections of water that are permanent or indispensable should be made inaccessible to the insects or uninhabitable by them. Lakes, pools, springs, watering-troughs, and the like may be stocked with the natural enemies of the mosquito. The fish that have been especially commended for this purpose are top minnows (Gambusia affinis), sticklebacks (Gasterosteus aculeatus), and the common sunfish (Lepomis gibbosus). Salamanders are also useful. The larvæ of the dragon-fly and certain water-beetles prey upon the larvæ of mosquitos, but practical means of introducing these into the breeding-places have yet to be suggested. As the Anopheles seek the protection of water plants, these measures may not be entirely efficient. Tanks, cisterns, and rain-water barrels should be effectively screened to prevent access of the gravid female to the water or, better, the water surface covered by a film of coal oil. This kills the adult females as they attempt to deposit their eggs, prevents oviposition, and destroys the larvæ. The crude 'fuel oil' is by Howard commended as preferable to the more volatile grades. In Cuba the army orders of December, 1901, advise "an application of one ounce of kerosene to each 15 square feet of water, twice a month." Water in cisterns, tanks, and rain-barrels may be treated similarly, and may still be used for washing or drinking purposes, provided it is drawn off from below, so as not to disturb the surface film. On large bodies of water the oil may be sprinkled, sprayed, or spread with swabs. It is important that the entire surface be covered; otherwise the larvæ may collect in the places free from oil. This treatment does not injure the fish. The use of potassium permanganate has been urged, but the quantities required, and its rapid disintegration, render the method impracticable.

Adult mosquitos are caught and destroyed by dragon-flies, bats, and many species of night birds. Houses are best protected from them by accurately fitted window and door screens. A simple and effective means for getting rid of those that have gained entrance is afforded by a tin cup fastened to the end of a stick and containing a small quantity of kerosene. When this is placed under the resting mosquito, it promptly falls into the oil and is killed. Fumigation with sulphur is generally efficacious, and should be applied to holds of vessels, passenger coaches, and other conveyances that come from a malarial or yellow fever center. Chlorin gas generated by pouring sulphuric acid upon chlorinated lime has also been advised for this purpose. Hydrocyanic acid gas is efficient but dangerous. Formaldehyde gas is usually destructive to mosquitos, but is less efficient than sulphur dioxid. Medical officers of the United States Army recommend pyrethrum fumigation. The powdered drug is moistened, fashioned into small cones, and ignited. The stupefied insects should be swept up and incinerated.

Eucalyptus trees and castor-oil plants have been thought to emit vaporous substances distasteful to Culicidiæ. Eucalyptus trees planted about marshy ground may aid by drying the soil, and their foliage may serve as a screen, interrupting the mosquitos' flight. The value of the eucalyptus as well as that of the castor-oil plant is probably overrated. Mosquitos have been observed upon the latter plant, and recently it has even been asserted that its value depends upon the fact that it attracts the insects and thus alienates them from man.

Avoidance of Infection

It is of the utmost importance that mosquitos be **prevented from biting the sick,** especially in cases of yellow fever, malaria, dengue, or filariasis. Patients should be protected by careful screening. By the use of quinin in doses of from 5 to 15 grains or more daily, not only is a prophylactic action against malaria obtained in the individual, but usually the drug also serves to keep the peripheral blood in infected persons free from the parasites, so that there is less danger of their transference to the mosquitos. Koch considers the general use of quinin a feasible means of excluding malaria from a country. Unfortunately, certain forms of the parasite, as the estivo-autumnal variety, are not readily influenced by this measure.

To keep mosquitos from the body, camphor and such essential oils as those of lavender, citronele, pennyroyal, peppermint, and eucalyptus are advised. Howard gives the following formula, which is highly recommended as an application by E. H. Bane: Castor oil, 1 ounce; alcohol, 1 ounce; oil of lavender, 1 dram. An ointment of petrolatum impregnated with peppermint and eucalyptol is also useful and convenient of application. It is said that if cloths saturated with solutions of carbolic acid or of the essential oils mentioned be hung about the bed, mosquitos will keep away.

THE PREVENTION OF THE TRANSMISSION OF DISEASE BY FLIES

In all diseases in which infection occurs through the alimentary tract, flies should be considered as important carriers of the infection, until this possibility is absolutely disproved. As has been previously mentioned, flies have been shown to be capable of carrying not only bacteria, but also the eggs of various parasitic worms that infest the intestines. It has been proved that they may deposit contaminating micro-organisms upon food and in surgical solutions, upon the skin or in wounds. Instead of serving as useful scavengers, their presence seems to be a constant menace, whether in the operating room, ward, camp, barracks, or dwelling.

Life-history

The common fly, **Musca domestica,** usually deposits her eggs, about 120 in number, in the crevices of the dungheaps piled so frequently about stables. Under the influence of heat and moisture, the larvæ are hatched and pass, after several stages, lasting in all from five to seven days, into the pupa stage. Five to seven days later the fly matures from the puparium. Thus the entire period of ovulation lasts from ten to fourteen days, and the reproductive potentialities of a single fly in one season are therefore enormous.

Destruction of Flies

In the larval or pupal stage flies may be killed by gnats or other hymenoptera or by certain beetles or scorpions, while many birds also feed upon them. In the adult condition their chief enemies are spiders and birds, although at times they become diseased from a parasitic fungus (Empusæ muscæ). To rid a community of flies it is of first importance that their natural **breeding-places** be abolished. All forms of excreta, including various manures, together with the soiled bedding from stall or stable, should be made inaccessible to flies, either by proper inclosure or by stacking it in piles covered with earth or quicklime.

Flies in an inclosed place may be killed or stupefied by tightly closing all doors or windows, and burning a cone fashioned out of dampened pyrethrum (Dalmatian or Persian insect-powder). As soon as the cone has been burned, the stupefied flies should be swept up, and incinerated before any revive. Sulphur dioxid and, in a less degree, formaldehyde gas are also effective as insecticides. The use of sticky fly-paper is a slower but useful method of extermination.

The chief source of **contamination** of flies is the excrement of man or certain lower animals. Their favorite places of rendezvous are the stable, privy, or latrine, and the kitchen or mess-room. As thus far it has been impossible to exterminate these pests, it is imperative that they should at least be **denied access** to sources of infection, and to food. In camps, where transmission of typhoid fever by flies is a special danger, the former object may be attained by the chemical disinfection or incineration of feces, by burying the excrement (most easily done in long shallow furrows) or by keeping it well covered with dry earth, ashes, quicklime, or chlorinated lime.

The protection of food is best obtained by the general adoption of screens in the camp. Instead of individual tents a general mess-hall, carefully protected by fly-nets, should be used for dining.

It is of special importance that flies be excluded from operating rooms and from wards, especially if the latter contain patients suffering from contagious disease. Sputum cups, which often attract insects, should contain a disinfectant solution and be provided with lids, that should be closed except during use.

SIPHONAPTERA

Fleas

The facts that adult fleas live upon the blood of warm-blooded animals, possess powerful organs of locomotion, and frequently change their hosts, enable them to play an important part in the

FIG. 68.—COMMON FLEA (PULEX IRRITANS).
a, Larva. *b*, Pupa. *c*, Imago enlarged.—(*From Van Beneden; Osborn, Bull. 5, Div. Entomology, U. S. Dept. Agriculture.*)

dissemination of disease. The common **house flea** (Pulex irritans) and the **cat** and **dog flea** (Pulex serraticeps) most often attack man. The eggs are laid upon the hair of animals, from which they readily fall, or in shaded dusty places. From the eggs larvæ develop; these are transformed into pupæ, and may or may not form cocoons, from which the adult insect emerges. The female house flea deposits eight to twelve eggs at a time, which develop in about four weeks. The reproduction of the dog and cat flea is more rapid. In the larval stage they are readily killed, while the adults are resistant. Carpets, rugs, mattings, and collections of dust and rubbish harbor them. By using bare floors and by frequently sweeping, their development in houses can usually be prevented, provided a new supply is not repeatedly brought in upon the domestic animals. Pyrethrum is efficient against the larvæ, and when rubbed into the hair of animals will stupefy the adults so that they may be removed and destroyed. A cat or dog may be washed with warm water into which has been stirred from one to four tablespoonfuls of kerosene to the gallon; then sponged with warm pennyroyal tea; then combed thoroughly with a fine-toothed comb. A ribbon or collar soaked in oil of pennyroyal may be worn constantly. To kill the pests in carpeted rooms is more difficult. Dusting with pyrethrum, sprinkling with benzine (taking care that there is no means for its ignition), or fumigation with formaldehyde or sulphur dioxid may be tried. The carpet may be strewn thickly with green pennyroyal leaves and the room closed for a day or two; after which the withered pennyroyal is to be swept up and burned. The process may be repeated if one trial is not efficient. Should this fail, it may be necessary to remove the carpet and have the floor scrubbed. It is said that adult fleas may be caught by scuffling along the floor in one's bare feet and seizing them with the wetted fingers as they alight upon the legs, or they may be enticed upon sticky fly-paper affixed above the ankles; but these methods are hardly to be termed pleasant. In the presence of infection that may be conveyed by fleas, domestic animals should be excluded from human habitations, and rats and mice, which so frequently harbor the insects, exterminated.

HEMIPTERA

Bedbugs

Bedbugs secrete themselves in crevices of walls and beds, in which they lay their eggs and from which they emerge at night to suck the blood of animals. It has been asserted that they live in large numbers in woods and are carried by birds and bats. This seems to be insufficiently substantiated. Eternal vigilance is necessary to exclude bedbugs, for they may get upon one's clothing in public conveyances and meeting-places, and thus be carried into the cleanest house. Metallic beds and wire springs are less likely than wooden beds and slats to harbor the insects. Careful housewives 'look over' their beds at regular intervals and wash them with a solution of mercuric chlorid, 1 : 1000; or some form of kerosene oil is often employed. Formaldehyde often fails to reach and destroy the bugs, but sulphur fumigation is usually efficient, and pyrethrum powder is a good palliative. To prevent their return, all crevices in the walls or woodwork should be obliterated by plaster or putty, the walls repapered, or, better, painted, and beds and bed-springs varnished or painted.

Lice

A single species of louse is parasitic only upon a single species of animal. Indeed, certain forms limit their activities to a particular part of the body. Thus, head lice remain in the hair of the head, body lice remain in the clothing or upon hairless parts of the body, while the crab louse infests in general the coarser hairs, more especially those of the pubis, and does not live in the hair of the scalp. The nits or eggs are deposited upon hairs, to which they firmly adhere. From the eggs the insects emerge as adults in miniature. The eggs of the body louse are deposited in the folds of clothing. The use of a mercurial or sulphur ointment, or a lotion of staphisagria (stavesacre) or delphinum (larkspur), for the hairy parts of the body, or sulphur fumigation of the clothes, will readily destroy these parasites.

THE DESTRUCTION OF RATS

When a place is threatened or invaded by plague, it is important that efficacious measures be at once instituted to destroy rats and other vermin; and this may be necessary also under other conditions.

Rats should be **prevented from coming ashore** from infected vessels either by anchoring the vessel far out or by keeping the gang-plank in and the hawsers guarded by properly shaped metal funnels.

In an infested vessel the rats may be poisoned, trapped, or suffocated. **Trapping** is not to be depended upon. **Poisoning** by food is less effectual than that by certain gases. Of these, **sulphur dioxid,** generated by burning sulphur, is effective if in sufficient concentration. For vessels it has been suggested that the hold be filled with **carbon dioxid.** Asphyxiation in this manner is readily accomplished by discharging the contents of cylinders of the compressed or liquefied gas into the lower portions of ships until a lighted candle lowered into the hold is promptly extinguished. This method cannot well be employed in buildings, owing to the specific gravity and diffusive qualities of the gas.

De Farrari, Quarantine Officer of Geneva, has suggested the use of **carbon monoxid** produced by placing burning charcoal in the holds of ships, after all outlets have been tightly sealed. Six kilos (say, 13 pounds) are employed for each 100 cubic meters of space (say, 3530 cubic feet), and are ignited by the aid of kerosene. The hold is kept closed for eight hours, in which time the gas evolved proves fatal to the imprisoned rats.

Hydrocyanic acid has been advised for the destruction of rats as well as insects, and other vermin. It is probably the most efficient agent for this purpose known, but it is dangerous and expensive. Like other gases, it has little penetrative power, and it may discolor and alter the texture of fabrics. Fulton advises the use of 1 kilo (say, 2 pounds) of potassium cyanid for each 1000 cubic feet of space. To each kilo is added 1.5 liters (quarts) of sulphuric acid dissolved in 2.25 liters (quarts) of water. The room should be closed tightly, and, owing to the very poisonous nature of the gas, arrangements should be devised so that the chemicals may be mixed after the operator has left the room. Moreover, devices should be used for the thorough airing of the house before it is again entered by human beings. The time of exposure should be about twenty-five hours, and an equal time should be given for airing. The method is effective against all forms of animal life.

Danysz's Bacillus.—Danysz attempted to exterminate rats by means of a cocco-bacillus resembling Bacillus typhi murium, that is pathologic for mice. He isolated this organism from an epidemic among field-mice, and by intensifying the virulence, obtained cultures that when distributed upon bread were said to be successful in destroying large numbers of rats in sewers, in shops, and on farms. Recent investigations by other observers, however, would indicate the total inefficacy of this method as a practical measure for the purpose designed.

In the presence of **plague** not only should living rats be exterminated, but the **bodies of dead rats** should promptly be burned. It is a current belief in countries where plague is endemic that contact with a dead rat will produce the disease. It is also noteworthy that fleas tend to leave the body of an animal when it dies, thus menacing the health of persons or animals in the neighborhood.

Section IV

PROPHYLAXIS OF THE SPECIAL INFECTIONS

CHAPTER XIV

PRELIMINARY CONSIDERATIONS

General Principles. Special Aims. Differing Resistance of Micro-organisms. Practical Classification of Infections. Table of Etiology, Invasion, Infective Period, Dissemination, and Special Prophylaxis of Infectious Diseases.

General Principles

Certain general principles of prophylaxis have been made evident by our study of the modes of origin and of dissemination of disease and our review of the means of prevention at command. In practice, these principles are not universally applicable, but are restricted by special circumstances; moreover, the choice of specific measures is to be guided not only by considerations of practicability, but also by the most recent knowledge concerning the special pathogenic process involved. For example, measures directed to the destruction of mosquitos are of great importance in the prevention of malaria and of yellow fever, but of no relevance in guarding against tetanus. The maintenance of the purity of the water-supply is chief among measures to restrict the spread of cholera and typhoid fever, but has no bearing upon the prevention of smallpox or venereal diseases. Were it possible constantly to enforce all hygienic precautions, civic, domestic, and personal, there would be little need of considering special measures against particular diseases, but it is probable that for many years to come anything approaching a condition so truly civilized will be far from attainment. Except under the stress of unusual epidemics, measures to facilitate the destruction and impairment of life by war, and misdirected commercial and manufacturing 'progress,' occupy a larger share of the attention of peoples and governments than do the means of safeguarding health in the ordinary routine of daily affairs. Thus it becomes important in the presence of an epidemic to focalize our energies against those conditions that are known to favor the spread of the specific infection concerned, rather than diffuse them among a multitude of hygienic measures whose total magnitude is too great to permit of their thorough and prompt consummation. To this end it is important that the **paths of infection** and the **special vulnerability** of the particular causal agent be known accurately.

Special Aims.—Unfortunately, in regard to many diseases our information is yet too meager to enable us to adopt a single best measure of prophylaxis. We must, therefore, try to interrupt all possible paths of infection and to adopt measures that have been proved to destroy the known parasites, in the hope that these will prove effective against one that is obscure. In any case, the first consideration should be the possibility of producing a **permanent insusceptibility** of those exposed with but slight danger or inconvenience; secondly, our endeavor should be, as stated, to **interrupt all possible paths of disease conveyance;** and, thirdly, to **exterminate the causal agent.** Should none of these objects be attainable in significant degree, and the disease actively threaten, we may then adopt, if feasible, means to produce even **temporary and partial forms of immunity.**

Differing Resistance of Various Micro-organisms

In **disinfecting** it is important to know something of the growth, nutritive requirements, resistance, and favorite feeding- and hiding-places of the parasites, and to adapt our means of protection accordingly. Thus, to destroy certain organisms, thorough dryness is sufficient; against others active chemical or physical agents must be employed; while the pitiful futility, in the presence of diphtheria, of fumigating the house and neglecting the contaminated throats, ought to be obvious.

Sporogenous organisms, such as those of anthrax, tetanus, malignant edema, usually show a greater resistance to heat, drying, light, and chemicals than do those that produce no spores; the former, therefore, require more potent measures of disinfection. **Anaerobic organisms,** such as the tetanus bacillus, the bacillus of malignant edema, and Bacillus aërogenes capsulatus, cannot multiply in the presence of oxygen. If the infected area be frequently exposed to the air, and kept free from contamination by bacteria that absorb oxygen, infection may be prevented. Many bacteria, such as the pneumococcus and most streptococci, rapidly **attenuate** when kept from the animal body, so that infection from diseased animals is most to be feared. Some organisms are unable to resist **desiccation,** so that by maintaining thorough dryness of a house for several days, as with furnace heat at a constant temperature of 40° C. (104° F.), such organisms as those causing plague, diphtheria, glanders, and cholera will probably be killed, even when incased in an albuminous medium. Upon the other hand, the organisms of tuberculosis, anthrax, and tetanus markedly resist drying. Direct **sunlight** is a sufficient disinfectant against the tubercle bacillus and many other organisms.

Working Classification

It is difficult to devise a **classification** for the study of the means of preventing diseases, that shall be at once useful and accurate. The one here adopted as most convenient is based largely upon the **predominant mode of entry** of the causal agent. Where this is obscure, that which seems the most probable has been assumed. Where a number of avenues of infection are definitely known, the disease has been considered under the head of what is supposed to be the predominant portal. Much of this arrangement is necessarily subject to correction by the advance of science. Meanwhile, a convenient working method is provided by considering infections from the viewpoint of prophylaxis, according as the morbific agent enters chiefly by way of (1) the **alimentary** canal; (2) the **respiratory** tract; (3) the **skin;** (4) the **circulation;** (5) the **genitalia;** (6) **obscure** channels. A special chapter will be devoted to each class considered.

Care of the Dead Body

Prophylaxis does not end with the life of the sick person. The community is still to be protected. Bodies dead of infectious diseases should be wrapped in sheets wet with an efficient germicide, such as a 4 per cent. aqueous solution of formaldehyde. The body should then promptly be inclosed in a casket, an excess of formaldehyde poured over the sheets, and the casket closed. Burial or cremation should take place without delay. Sealing in impervious caskets is unnecessary except when the body is to be transported to a distant point, as the processes of decomposition rapidly destroy the pathogenic bacteria. Careful injection of formaldehyde fluids into the body cavities and through the arteries, combined with the surface application described, will practically disinfect any corpse and increase the safety of necropsies and other procedures upon the dead, or, in case of necessity, permit the retention of the body for identification or other important purpose. Solutions containing arsenic, mercury bichlorid, or other substances administered at times with homicidal intent, should not be used. It is not advisable, however, to delay the final disposal of the body.

Tabular Data of Infections

As a preliminary to more detailed study, there is exhibited in the table that follows a condensed statement of the essential data concerning the origin, dissemination, and special prophylaxis of the various recognized infections of ordinary occurrence.

SUMMARY OF THE SPECIAL INFECTIONS

	Infective Agent	Mode of Transmission	Avenue of Entrance	Incubation Period	Day of Disease on which Eruption (or Special Sign) Appears	Period of Quarantine Required after the Latest Exposure to Infection	Period at which Infectivity Ceases	Special Measures of Prophylaxis
Actinomycosis (Lumpy Jaw).	Actinomyces bovis.	Contaminated grains. Pus from infected cattle.	Alimentary or respiratory tract. Wounds.	Unknown; many days or weeks.		Not required.	With the healing of all lesions.	Destruction of diseased cattle. Sterilization of cereals. Disinfection of discharges.
Anthrax (Splenic Fever, Charbon, Wool-sorter's Disease).	Bacillus anthracis.	Insects. Diseased flesh, hair, or wool of infected animals.	Wounds. Intestinal or respiratory tract.	Twenty-four to thirty-six hours.	Pustule appears within thirty-six hours.	Not required.	With complete recovery.	Disinfection of hair, hides, and wool. Incineration or deep burial of infected animals.
Beri-beri (Kakke).	Obscure micro-organism.	Obscure.	Digestive tract (?).	Several weeks or months.		Not required.		Nutritious diet and prevention of overcrowding.
Botulismus.	Bacillus botulismus.	Contaminated meat.	Digestive tract.	A few hours.		Not required.		Careful preservation of meats.
Chickenpox (Varicella).	Obscure.	Direct contact. Fomites. Milk. Air.	Obscure.	Ten to sixteen days.	First day and three following days.	Twenty days.	When every scab has fallen off.	Isolation.
Cholera.	Spirillum choleræ.	Water, food. Insects.	Digestive tract.	Two to five days.		Eight days.	Two weeks after cessation of disease.	Disinfection of stools. Prophylactic inoculation. Insecticides. Protection of water and food.
Dengue.	A hematozoon.	Mosquitos (?).	Through the skin.	Three to five days.		Eight days.	Termination of attack.	Isolation. Screening from and destruction of insects.
Diphtheria.	Bacillus of Klebs-Löffler.	Direct contact. Fomites. Air. Public conveyances.	Mouth.	Two to ten days.		Until the throat is proved to be free from the bacilli.	In four weeks if there is no membrane or no discharge, and if bacteriologic examination of nose and throat be negative.	Isolation. Disinfection of air-passages and all secretions therefrom. Prophylactic injections of antitoxin. Fumigation.

SUMMARY OF THE SPECIAL INFECTIONS—(*Continued*)

	Infective Agent	Mode of Transmission	Avenue of Entrance	Incubation Period	Day of Disease on which Eruption (or Special Sign) Appears	Period of Quarantine Required after the Latest Exposure to Infection	Period at which Infectivity Ceases	Special Measures of Prophylaxis
Dysentery (bacillary).	Bacillus Shigæ.	Probably water or insects.	Digestive tract.	Two or three days?			When the bacteria disappear from the evacuations.	Disinfection of dejecta. Protection of food and water-supply.
Dysentery (amebic).	Amœba dysenterica.	Probably water or insects.	Digestive tract.	Obscure.			When amebæ disappear from the stools.	Disinfection of the stools. Protection of food and water-supply.
Glanders and Farcy.	Bacillus mallei.	Nasal secretions and discharges from infected animals.	Respiratory tract or wounds.	Three to four days.	Ulceration of nasal mucosa and lymphatic inflammation within a few days.	Five days for horses. Not required for man.	With the healing of all ulcers, or cessation of all discharges.	Incineration of diseased lower animals, disinfection of their quarters, and sterilization of all discharges.
German Measles, Rubella (Rötheln).	Obscure.	Personal contact. Fomites. Air.	Respiratory tract (?).	Seven to eighteen days.	Second to fourth.	Twenty days.	In not less than ten days from date of rash and cessation of discharges.	Isolation.
Gonorrhea.	Gonococcus.	Sexual contact. Fomites.	Mucous membrane.	Three to five days.		Not required.	Disappearance of gonococci and shreds.	Sexual purity. Local disinfection.
Hydrophobia (Rabies or lyssa).	Unknown micro-organism.	Bites of rabid animals.	Wounds.	From 2 weeks to many months.		Not required.	Unknown.	The destruction of rabid animals. Pasteur immunization.
Influenza (La Grippe).	Bacillus of Canon and Pfeiffer.	Air (?). Fomites. Public conveyances. Insects (?).	Respiratory tract (?).	Two to three days.		Seven days.	Six to ten days after onset of disease.	Isolation. Disinfection of fomites and discharges. Fumigation.
Leprosy (Elephantiasis Græcorum).	Bacillus lepræ.	Insects.	Skin or digestive tract.	Many weeks or months.	Not known.	Not required.	Probably continues to the end.	Isolation. Destruction of insects and vermin.
Malaria.	Plasmodium malariæ.	Mosquitos (Anopheles).	Through the skin.	Six to sixteen days.		Not required.	When blood is free from parasites.	Avoidance of mosquito bites by both the well and sick. The prophylactic use of quinin.

Measles.	Bacillus of Canon and Pielicke.	Direct contact. Air (?). Fomites.	Respiratory tract (?).	Ten to fourteen days.	Fourth day. The patient is highly infectious for two days before the rash appears.	Sixteen days.	In not less than two weeks from appearance of rash, provided desquamation has ceased.	Isolation. Disinfection of fomites, skin, and of secretions from nose and mouth. Fumigation.
Mumps.	A diplococcus (?).	Direct contact. Air. Fomites.	Respiratory tract (?).	Ten to twenty-two days.	Koplik's spots second or third day.	Twenty-four days.	In not less than three weeks and then only when one week has elapsed since subsidence of all swelling.	Isolation. Disinfection of secretions from nasopharynx.
Plague.	Bacillus pestis.	Rats, fleas. Direct inoculation. Atomized sputum from coughing.	Through skin; respiratory or digestive tract.	Three to six days.		Ten days.	After cessation of cough, diarrhea or other discharges.	Isolation. Destruction of all vermin, disinfection of all discharges.
Pneumonia.	Diplococcus lanceolatus (and other organisms ?).	Fomites. Particles in the air. Insects (?).	Respiratory tract.	A few days.		Not required.		Isolation. Disinfection of sputum. Avoidance of exposure to heat, cold, or dampness.
Relapsing Fever.	Spirillum of Obermeier.	Obscure. Possibly insects.		Eight to twelve days.		Not required.	When blood is free from parasite.	Protection from bites of insects and vermin.
Scarlet Fever.	Obscure.	Direct contact. Fomites. Milk. Air (?). Insects (?).		One to eight days, usually two to three days.	Second day.	Ten days.	When desquamation and sore throat and albuminuria disappear, but never in less than six weeks.	Isolation. Disinfection of skin and fomites. Fumigation. Protection of milk-supply.
Smallpox.	Obscure.	Direct contact. Fomites. Air (?).		Eight to fourteen days.	Third or fourth day.	Sixteen days.	When every scab has disappeared.	Isolation. Vaccination. Disinfection of skin and fomites. Fumigation.
Syphilis (Lues, Pox).	Bacillus of van Neissen (?).	Coitus. Kissing. Infected utensils.	Wounds, mucous membranes.	About three weeks.	Nine weeks.		With onset of tertiary lesions.	Disinfection of secretions. Personal hygiene.
Tetanus.	Bacillus tetani.	Earth or infected splinters and the like.	Wounds, especially punctured wounds.	Three to thirty days.		Not required.	When the wound heals.	Exposure of wound to oxygen. Local disinfection, excision, cauterization. Injections of antitetanus serum.
·hiniasis.	Trichinella spiralis.	Infected pork.	Digestive tract.	Two to five days.		Not required.		Thorough cooking of all pork.

SUMMARY OF THE SPECIAL INFECTIONS—(*Continued*)

	Infective Agent	Mode of Transmission	Avenue of Entrance	Incubation Period	Day of Disease on which Eruption (or Special Sign) Appears	Period of Quarantine Required after the Latest Exposure to Infection	Period at which Infectivity Ceases	Special Measures of Prophylaxis
Typhoid Fever.	Bacillus of Eberth.	Water, milk, food. Insects. Fomites.	Digestive tract.	Seven to twenty-one days, usually ten to fourteen.	Eighth or ninth.			Disinfection of stools and urine of patients and of fomites. Protection of food and wa er-supply. Protection of food and infected material from insects. Prophylactic inoculations (?).
Typhus.	Obscure.	Direct contact. Fomites. Air.	Respiratory tract (?).	Five to fourteen; very variable.	Fifth day.	Fourteen days.	After four weeks.	Isolation. Thorough ventilation.
Tuberculosis.	Bacillus tuberculosis.	Air. Insects. Utensils. Food.	Skin; respiratory, digestive, or genito-urinary tract.	Within several weeks or months.		Not required.	With the cessation of the disease.	Isolation. Disinfection of sputum and discharges. Protection of food-supply. Measures against insects.
Weil's disease (Acute febrile icterus).	Possibly Bacillus proteus fluorescens (?).	Obscure.	Obscure.	A few days (?).				
Whooping-cough.	A bacillus (Afanassieff).	Direct contact. Through particles ejected in coughing.	Respiratory tract.	Seven to fourteen days.	The characteristic whooping may not appear for three weeks, although the patient is before this infectious.	Twenty-one days.	In six weeks from the commencement, provided all characteristic spasmodic cough and whooping have ceased for at least two weeks.	Isolation. Disinfection of sputum. Fumigation.
Yellow Fever.	Obscure.	A mosquito (Stegomyia fasciata).	Inoculation through skin.	Three to six days.		Fourteen days.		Protection of patient and the well from mosquitos. Pyrethrum fumigation.

CHAPTER XV

ALIMENTARY INFECTIONS

General Prophylaxis. Stomatitis; Mumps; Typhoid Fever; Cholera; Dysentery; Intestinal Infections of Childhood; Tuberculosis; Actinomycosis; Helminthiasis—Uncinariosis, Trichinosis; Beri-beri; Malta Fever; Sprue; Foot-and-mouth Disease; Drug Intoxications—Lead, Alcohol, etc., and Their Sequelæ.

General Prophylaxis

The prevention of infection through the digestive tract depends largely upon the care of the food-supply. Boiling of liquids and thorough cooking of solids will disinfect under all ordinary circumstances. Foods in themselves harmless may be contaminated through contact with polluted water, hands, or utensils, or by flies and other insects; it is therefore important that all food-stuffs be guarded against infection until consumed.

STOMATITIS

(Catarrhal Stomatitis; Ulcerative Stomatitis; Aphthous Stomatitis; and Thrush)

Causation

Inflammations of the mouth are most frequent in poorly nourished infants and in the debilitated. They may be caused by traumatism, heat, topical or toxic chemical action, or the invasion of microorganisms. Unduly large doses of mercury or bismuth may produce stomatitis, and it complicates various infectious diseases, including syphilis, tuberculosis, smallpox, scarlet fever, measles, diphtheria, typhoid fever, mumps, and rheumatism. Of special interest here are those forms of disease due to **parasitic organisms.** In the ulcerative or aphthous forms, staphylococci, pneumococci, and other diplococci have been found. In thrush a well-recognized fungus, usually termed Oidium albicans, is present.

Diffusion.—Infective diseases limited to the oral and buccal membrane are usually spread by contaminated food and by infected bodies, such as fingers, nipples, rings, tongue depressors, dental instruments, and the like, that are placed in the mouth. Articles used in common by a number of persons may serve to spread the disease to the susceptible.

Prevention

The hygiene of the mouth is important as a preventive measure in all classes, and especially in the presence of infective fevers, as typhoid fever, pneumonia, and measles. Those forms of stomatitis produced by drugs are to be avoided by care in the administration of medicine, or in the pursuit of occupations involving the use of such agents. Certain persons have constitutional peculiarities (idiosyncrasies) against medicaments that are in frequent use, for example, calomel. Before such drugs are given, inquiry should be made, or if for the first time, due caution be exercised. Mercurial stomatitis may often be prevented by careful cleansing of the mouth and teeth, and is, indeed, erroneously said by some authors to occur only among those who are careless in this respect. The oral and buccal complications of general infectious processes are prevented by scrupulous local cleanliness in addition to the general measures that are used against the respective diseases. As the prominent predisposing cause is usually a debilitated condition of the body, this deserves special attention. Also, and with children especially, care should be taken that articles placed in the mouth are absolutely clean.

MUMPS
(Epidemic Parotitis)

Causation

This specific infection affects chiefly the salivary glands, especially the parotid. Testicular involvement is not uncommon and may occur in the absence of inflammation of the salivary glands. A diplococcus has been isolated from patients with the disease by Netter, Laveran, Catrin, Mecray, and Walsh. Pure cultures of this organism, which seems to be without pyogenic action, have been obtained from the blood, while it seems to be uniformly present in Stenson's duct. Inoculation experiments with isolated bacteria upon the lower animals have, however, failed to produce an affection resembling mumps.

Diffusion.—Infection seems to occur through intimate personal intercourse. The disease is most frequent in the fall and spring, and usually occurs in children between five and fifteen years of age, somewhat more frequently in boys than in girls. It is markedly contagious, often affecting nearly all the children in a household or school. The infectious agent is evidently carried in the saliva and probably diffused through the air to a limited extent, being ejected during coughing, talking, sneezing, etc. The incubation period may be prolonged to three weeks.

Prevention

Isolation of those affected and the use of antiseptic lotions in the mouths, throats, and noses both of the affected and of the exposed, are the most important measures as yet known. Solutions of hydrogen dioxid and other oxidizing agents seem to be specially useful, both locally and internally. After the onset of the disease in order to prevent unpleasant sequels, such as orchitis, oophoritis, mastitis, and otitis, rest, often in bed, is additionally necessary.

TYPHOID FEVER

Causation

Enteric fever is an infectious disease, due to the invasion of the tissues by **Bacillus typhosus** (Eberth, 1881). It is probable that we now group clinically with this infection, related forms due to allied organisms of minor virulence (paratyphoid fevers). The bacillus of Eberth does not produce spores, succumbs to a temperature of 60° C., withstands freezing, and is readily killed by the usual disinfectants. Depression and exhaustion, mental and physical, seem to be **predisposing factors** of much importance.

Diffusion.—Typhoid frequently occurs in an epidemic form, though sporadic cases are not uncommon. It is more prevalent in the early fall and most frequently affects males in early adult life. During the disease the bacilli multiply in the intestinal canal and escape from the body in the feces and urine. Neglect or inefficiency in the disinfection of the excreta, therefore, is the chief cause of epidemics. The mode of infection is nearly always through the alimentary canal. It may be acquired from contaminated water, food, thermometers, syringes, etc. Bathing in contaminated water may also lead to infection, either through the skin or other channels. It has been demonstrated to occur from liquid particles containing the bacilli that spatter upon the face or in the mouth during the washing of clothes or in the performance of autopsies; this form of aerial transmission is probably rare. Eichhorst mentions the case of a patient who contracted typhoid fever through inhalation while beating mattresses used several months previously by the sick. Typhoid bacilli are chiefly conveyed to man by infected water or milk, and, less frequently, by oysters and vegetables that have been contaminated by infected water or alvine discharges. Lettuce, celery, and other greens that are eaten uncooked, are said to be specially likely to convey these organisms. The rôle of insects is important.

While there are recorded instances of the infection of the water of wells through adjacent cess-pools, experimentally the bacillus has been found to be carried through earth by water only a few feet. This distance would, of course, be much increased were there access to subterranean streams. The discharges thrown upon the ground have been swept by rains or melting snows into sources of water-supply and have then given rise to wide-spread epidemics. (See Fig. 44.) Contamination of milk usually results from the addition of water or through the washing of cans with infectious water. Recent experiments indicate that the bacillus will not pass through filters of unglazed porcelain, such as the Pasteur-Chamberland, while after a few days it grows through the pores of those made of diatomaceous earth, such as the Berkefeld filter. As previously pointed out, flies or other insects may carry the organisms upon their bodies or in their intestinal canals from the excreta to food. This is believed to have been the chief mode of transmission in the severe epidemics among soldiers during the Hispano-American war.

Prevention

The most important measure of special prophylaxis is the prompt **disinfection** of all discharges from the sick. This is best accomplished by thorough admixture with a liberal quantity of a strong solution of chlorinated lime as directed on page 215. Infection through food may be obviated by cooking, the boiling of drinking-water and milk, and the exclusion of insects. The experiments of Parkes and Rideal indicate that acid sodium sulphate in the proportion of 1 gram to 500 c.c. (15 grains to the pint) will in five minutes destroy Bacillus typhosus present in water. This they advise for army use when the facilities for securing pure water are inadequate. The amount necessary is not sufficient to produce purgation or to be harmful, and it is claimed that water is rarely so grossly contaminated as to be incapable of disinfection by this measure. Bedding and clothing soiled by discharges should be disinfected by streaming steam or by immersion in boiling water or in a 4 per cent. solution of formaldehyde. Carbolic acid is less useful. Washerwomen should not handle clothing, bed linen, and the like until it has been disinfected. All food utensils, instruments, etc., used by the patient should be disinfected immediately after use. Special care should be taken to keep the sick-room free from flies or other insects and vermin, nor should these have access to any substances that may have been contaminated by the patient. With an observance of these precautions the possibility of aerial infection may be disregarded, and quarantine is unnecessary.

Predisposing factors are to be avoided, especially dissipation and overwork at school or in business, by adolescents and young adults. Suspected water or milk should be boiled and the food-supply in general safeguarded.

Prophylactic inoculations of modified typhoid cultures have been used by Wright and others, especially for the protection of armies in the field. These inoculations seem to afford partial immunity. Thus, Wright publishes the statistics collected by Fawcet, Principal Medical Officer in Egypt, to show the incidence of enteric fever and its mortality for the year 1900 in the inoculated and uninoculated among the British troops in Egypt and Cyprus:

	Average Annual Strength	Number of Cases of Enteric Fever	Number of Deaths from Enteric Fever	Percentage of Cases Calculated on Average Annual Strength	Percentage of Deaths Calculated on Same Basis
Uninoculated,	2669	68	10	2.5	0.38
Inoculated,	720	11	1	0.14	0.014

These figures show a nineteenfold reduction in the number of attacks, and a threefold reduction in the number of deaths from the disease, among the inoculated. None of those inoculated in previous years contracted the disease, although these are included in the table among the uninoculated.

CHOLERA ASIATICA

Causation

The causal agent is the 'comma bacillus' or **spirillum of cholera,** discovered by Koch in 1883. This microorganism does not produce spores. It resists freezing, but is killed in one hour by a temperature of 55° C., and in five minutes by a temperature of 65° C. It does not multiply freely in ordinary sewage, but remains alive for weeks in distilled water or on moist linen. It is rapidly killed by thorough drying and destroyed by acids such as are present in normal gastric juice.

FIG. 69.—THE CHOLERA SPIRILLUM STAINED TO SHOW THE TERMINAL FLAGELLUM.

Diffusion.—The transmission of cholera is similar to that of typhoid fever, being nearly always by means of contaminated water or food. Flies seem to play an active part in producing this contamination.

Prevention

The general prophylaxis, individual and communal, is similar to that for typhoid fever. In the presence of an actual or threatened epidemic, physicians should endeavor to allay popular fears, as depression reduces the resistance to infection. At the same time scrupulous civic, domestic, and personal hygiene must be insisted on. The alimentary tract is specially to be guarded against irritation and the natural acidity of the stomach maintained or reinforced. Alcohol is to be eschewed. Meals should be simple, moderate, and taken at regular intervals. Such foods as cabbage, salads, cucumbers, unripe and laxative fruits, indigestible pastry, clams, oysters, crabs, lobsters, and pork must be prohibited entirely. Bodily and mental excess and fatigue should be avoided. Precautions against sudden chilling are to be taken. The premonitory diarrhea is to be treated at once by rest, recumbency, regulation of diet, administration of acid drinks, irrigation of the bowel, and if necessary anodyne and astringent medication.

Prophylactic Inoculations.—Haffkine has devised a method of inoculation that has been extensively used in India with fair results.

It is not an absolute protective, but seems to reduce the tendency to contract the disease. Cultures of attenuated bacilli are first injected, and are followed by injections of exalted virulence. The first are prepared by growing the spirillum in contact with a current of sterile air. The second by growing the organism in the peritoneal cavities of a series of guinea-pigs. Two or three injections of the attenuated virus are given before the *virus exalte* is employed. In animals, immunity may also be produced by the injection of dead cultures or by the separated bacterial products or toxins.

TROPICAL DYSENTERY

Causation

The acute forms of tropical dysentery are apparently due to **Bacillus dysenteriæ** (Shiga, 1897; Flexner, 1898), an organism belonging to the colon group. The Shiga bacillus seems also responsible for many of the dysenteries of temperate climates. It is less motile than Bacillus coli and gives a more uniform production of indol. In a small percentage of the cases of dysentery **Bacillus coli** may be the causal agent. In the chronic forms **Amœba dysenteriæ** seems to be the active etiologic factor. These organisms may be observed in the recently passed stools. Among factors **predisposing** to both forms of infection are intemperance in food and drink, exposure to heat and moisture, and insufficiency of nutritious food.

Diffusion.—Diffusion is probably chiefly through food and water, or by means of insects. The portal of entry is probably almost invariably the mouth. Dysentery has occurred in laboratory workers, following accidental infection by the Shiga bacillus.

Prevention

The same measures of prophylaxis should be taken as have been advised for typhoid fever and cholera: scrupulous domestic and personal hygiene; care as to food and water; disinfection of discharges; exclusion of insects and vermin.

INTESTINAL INFECTIONS OF CHILDHOOD

(Gastro-enteric Infection, Enterocolitis, Summer Diarrhea, Cholera Infantum)

Causation

Gastro-intestinal inflammations of infants prevail chiefly in the summer, and among those children fed upon artificial and unsterilized food. They are associated with increased numbers and new forms of bacteria in the intestine, and therefore are accepted quite generally as expressions of alimentary infection. These affections have been carefully investigated by Baginsky, Escherich, Van Puterin, Duval and Bassett, and others. Booker, from a study of about one hundred cases, found in the milder and more transient diarrheas, in which the dyspeptic symptoms were the chief features, that **Bacillus coli communis** and **Bacillus lactis aerogenes** were the predominant organisms. In these cases there was litttle toxemia, the stools were acid and nearly free from leukocytes, red corpuscles, and epithelial cells. In another series of cases, **Bacillus proteus vulgaris,** an organism formerly supposed to be purely saprophytic, but now known to acquire occasional pathogenic powers, was the principal organism found. In these cases there was a more serious and more chronic illness, with toxemic symptoms, and frequent, or at times infrequent, whitish, yellowish, or greenish, putrid stools, with a neutral or an alkaline reaction, and seldom containing mucus. Epithelial cells, leukocytes, and streptococci were often present in small number. The cases in which streptococci and micrococci predominated, or at least were present in large numbers, were characterized by a very severe general toxemia, and tended to be chronic in course. From three to twenty or more fluid, slimy, and often greenish stools were passed in twenty-four hours. These were sometimes offensive, and again were not. Besides these ordinary bacilli of the intestine and the large number of micrococci, the stools contained many leukocytes, red blood-cells, and epithelial cells. In cases of this sort, in which an autopsy was made, erosions and ulcerations of the intestinal mucosa were common, as were also degenerative changes in the solid organs. In a minority of cases various other micro-organisms were found in large numbers.

In the summer of 1902 Duval and Bassett isolated **Bacillus dysenteriæ** (Shiga) from the stools of 42 infants with typical summer diarrhea, and as this organism was not found in healthy children or in those with simple diarrhea, and as the agglutination reaction with blood-serum was discriminative, it is concluded that this bacillus is the **specific etiologic agent.**

Diffusion.—There is much reason for believing that infection of the infantile stomach or intestine is chiefly due to contaminated milk, for the conditions are rare in breast-fed babies and those fed only upon sterile food, while measures to improve the purity of the milk-supply in cities have been rewarded by a decided decrease in the infantile mortality from intestinal diseases. Contamination usually results during the handling of the milk, from dust, dirty hands and pails, the addition of filthy water, imperfect refrigeration, and similar faults or imperfections. In a few instances milk has been known to be contaminated by pyogenic organisms and even pus derived from diseased cows.

Prevention

The most important measure of prevention is the careful protection of the purity of infants' food. Directions have elsewhere been given as to the care of the stables, the inspection of cows, and the precautions to be taken during the handling of milk. The experience of the Philadelphia Pediatric Society shows what may be done through united effort of the physicians in any locality. As a rule, however, the consumer cannot depend altogether upon such precautions,—which may be vitiated by the carelessness of a single person among the many concerned,—but should render the food non-infectious before its use. This may be done by pasteurizing or sterilizing. If pasteurizing is attempted, it should not be carried out in the makeshift ways often recommended, such as placing bottles of milk in pails of boiling water and permitting the pail and its contents to cool. Such measures are too uncertain. Dependence is to be placed only upon forms of apparatus that are known positively to maintain the temperature of the milk between 70° and 80° C. (158° and 176° F.) for thirty minutes. If such a measure is impracticable, milk should be boiled for five minutes, or sterilized by steam for at least fifteen minutes. That such high temperatures slightly impair the nutritive or digestive qualities of the food may be true, but it is best to insure safety against infection even at this risk. All utensils used in the preparation of the food should be scrupulously clean. The milk is to be kept in a covered vessel and upon ice; best in cotton-stoppered bottles, each containing the correct quantity for one feeding. It should not be warmed until just before use, for fear of permitting bacterial multiplication.

That the normal immunity be not reduced, attention should be given to the general hygiene of the infant, as is discussed in the section on Personal Hygiene. It is not probable that scurvy will develop in infants otherwise healthy and well-cared for, merely from the use of sterilized or pasteurized milk; artificial foods are far more likely to be the cause. However, one must be on the lookout for the earliest symptoms of this affection, and if they appear, modify the general plan of management accordingly.

TUBERCULOSIS

Causation

Bacillus tuberculosis (Koch, 1881) is aerobic, grows best at the temperature of the body, and probably does not form spores. It resists drying and freezing, but is killed within a few hours by exposure to the direct rays of the sun; dies in fifteen minutes at a temperature of 65° C.; and succumbs quickly to the stronger chemical bactericides, the requisite period of exposure for complete disinfection varying with the concentration of the antiseptic and the amount of protecting albuminous material. Tubercle bacilli are subject to attenuation and exaltation of virulence.

When an animal is invaded by tubercle bacilli, the result depends partly upon the virulence of the particular variety of bacillus concerned and the presence or absence of certain other micro-organisms; partly upon the resistance of the tissues and the species of the invaded animal. To the most virulent type belong especially those bacilli found in tuberculous cattle; while the bacilli found in birds and fishes seem to be relatively non-pathogenic in man; yet the former may be reduced and the latter exalted in virulence by growth under certain conditions. Variations have also been demonstrated in the pathogenicity for lower animals of the bacilli from tuberculous discharges and lesions of different men, or even from different tissues of the same man. Thus Lartigau found that many milligrams of culture of certain forms of tubercle bacilli isolated from cases of tuberculosis in man failed to produce serious lesions in susceptible animals; while the veriest traces of cultures obtained from other persons with tuberculosis produced wide-spread and rapidly fatal disease. Types of feeble virulence occur especially in tuberculosis of the lymphatic structures, while bacilli of great virulence are found in forms of generalized miliary tuberculosis.

Against the most virulent types of bacilli it is probable that no man is immune; while bacilli of moderate virulence may affect persons of lessened resistance. Letting V represent the bacillary virulence; M, the mixed infection; R, tissue resistance, and P, pathologic changes resulting from the invasion, the condition may be expressed mathematically as follows:

$$\frac{V+M}{R}=P$$

therefore:

$$\frac{2\,(V+M)}{R}=\frac{V+M}{\frac{1}{2}R}=2\,P$$

The so-called **tuberculous diathesis** was confused by the older writers with the early stage of tuberculous invasions. As tubercle bacilli may invade the body without the early production of characteristic structural lesions, most modern pathologists hesitate to admit that there is any special depraved condition of the body preliminary to the bacterial invasion, but believe that such supposed conditions represent unrecognized early forms of the disease, possibly toxic, but without definite lesions.

It is now generally conceded that tuberculosis is not inherited and that infection through the placenta (pseudo-heredity) occurs rarely. Most clinicians, however, suppose that a special susceptibility or **predisposition** may be transmitted from parent to offspring. S. Solis Cohen objects to the vagueness of the term 'susceptibility' and insists that there are three principal stages in tuberculosis, including: (1) one of fundamental **trophic failure** (hypotrophy of Jaccoud, or abionergy) characterized by congenital or acquired loss of specific resistance—which is described as an actual disease with chemical and morphologic tissue alterations that escape present methods of research, but are possibly to be explained in accordance with Ehrlich's theory, by defects in certain ceptors or side-chains; (2) a stage of **bacillary invasion** with local infiltration, cellular proliferation, and generally a mild specific toxemia; unless resisted this passes on to (3), a stage of destructive lesions or **phthisis** characterized by local caseation, liquefaction necrosis, or, from mixed infection, suppuration, and also by a generally intensified toxemia.

Predisposing Factors.—Cohen believes that the conditions increasing the activity of bacterial invaders and diminishing tissue resistance—summarized as privation, depression and excess, environmental and personal, physical and psychic—may affect not only the individuals directly influenced, but also their offspring; and that the latter may suffer even when parents escape overt symptoms.

Infection.—This occurs chiefly through the respiratory and digestive tracts, but the bacillus may gain entrance through the skin, the genito-urinary tract, and, exceptionally, the placenta. It is **diffused** chiefly through the secretions and discharges of tuberculous men and animals and in the milk and flesh of diseased cattle. Dust, insects, contaminated food or goods, infected rooms, vessels, and sleeping-cars are the principal **agencies of diffusion.** Details are best considered in connection with the prevention of the special varieties of infection.

Prophylaxis

This, as the editor has elsewhere said, should begin before conception. After birth it naturally divides into two branches of equal and coordinate importance: the **preservation or development of immunity** and the **prevention of infection.**

Natural Immunity.—At present immunity is chiefly to be sought through those means that increase the general health of the community and of the individual, and that are discussed in this volume under the heads of civic, domestic, and personal hygiene; including the avoidance of the factors of depression, privation, and excess. Necessarily, greater care is to be exercised in the case of debilitated children or those known or suspected to be congenitally or hereditarily susceptible, who should from the first be subjected to an invigorating régime of increasing degree, always carefully adapted to the individual and the special circumstances.* When the mother is diseased or debilitated, a healthy wet-nurse should be obtained, if possible; failing which, asses' milk or goats' milk is preferable to cows' milk, and the latter, carefully pasteurized and correctly modified, superior to artificial foods. Specially to be insisted on, are open-air life, preferably in the country, with free exposure to sunlight; the free use of water internally and externally; a nourishing diet, consisting largely of meat, milk, eggs, fruits, nuts, green vegetables, and fats, with but moderate use of starches and sugars; judicious alternation of rest and exercise, especially such exercise as develops and increases breathing capacity; wise choice, both as to matter and time, of study, business, and amusements; due attention to the place of residence, the situation, light, and ventilation of the sleeping-room; with such care of

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* See also Part III of this volume, and consult vol. IV, "Climatology," vol. VII, "Exercise," and vol. IX, "Hydrotherapy," etc., under "Scrofulosis" and "Tuberculosis."

special functions, the circulation, the digestion, the secretions, and the excretions—often deficient in the hypotrophic—as the particular case may call for. **Marriage** in those of tuberculous lineage or predisposition, or in the debilitated, is to be entered upon with great circumspection, not only for the sake of the offspring, but also with regard to its effect upon the health of those about to be wedded.

Artificial Immunity.—The various forms of tuberculin and the anti-tuberculous serums thus far devised have shown little power of producing immunity; and their use by unskilled hands is not without danger. Successful prophylactic infection has not yet been achieved unless the methods pursued in the recently published researches of von Behring upon animals may prove applicable also to man.

Prevention of Infection.—Allusion has already been made to the varying degrees of virulence exhibited by the different types of tubercle bacilli. In the hope of determining the relative importance of the bacilli, on the one hand, and of vital resistance, on the other, by finding some species or variety of animal that would prove entirely immune against all forms of tuberculosis, numerous experiments have been made on beast, bird, fish, and reptile; but while resistance has varied greatly, no animal has been found that does not succumb to some type of the bacillus. The problem of prevention, therefore, is not solely one of 'wise selection of ancestors' and hygienic life. As in the case of any other infectious disease, it involves as well the determination of the most practical and efficient means to inhibit the spread of infection, and if possible to exterminate the infective agent. Two chief obstacles are still to be contended with—popular ignorance of the real source of danger, and inability to guard against it on the part of the vast majority of those exposed and affected. The public in general, as well as individual sufferers and their households, must therefore be instructed concerning the danger that lies in carelessness as to the disposition of discharges from tuberculous patients, and in failure to disinfect fomites and living rooms. When, through ignorance, obstinacy, or inability, such instruction fails to induce the necessary care, the strong arm of authority should be exercised and the patients isolated if necessary. The provision of hospitals for the helpless consumptive poor, and of industrial sanatoriums for those who, under favorable conditions, can be self-supporting, is an absolute necessity.* Often, under the obligation to earn not only their own

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* See volume IV, pp. 259 *seq.* and 320 *seq.*

livelihood, but also that of dependents, phthisical tailors, milliners, bakers, cigarmakers, teachers and others whose occupation makes them liable to become foci of infection, continue at work until prostrated. Thus from both viewpoints, that of the prevention of hypotrophy, and that of the prevention of infection, the prophylaxis of tuberculosis is seen to be largely an economic problem rather than a purely medical question. Poverty, with its unhygienic surroundings, its anxieties, its exhausting labor, and its lack of nutrition, makes men susceptible; and poverty with attendant overcrowding in filthy tenements and sweat-shops not only furnishes the conditions favorable to the spread of infection, but also produces a frame of mind in which the real or fancied difficulties are permitted to paralyze all effort to prevent such spread. But infection is not confined to the poor—it goes forth from them to all classes of society; and if not the compassion, then the self-interest, of the rich should lead to a more intelligent direction of efforts to abolish the disease. Public apathy upon this subject is at last beginning to yield, and here and there we see attempts to solve the problem, yet such provision as has thus far been made, either by private benevolence or by the State, is ridiculously inadequate even as a social palliative.

Special methods of infection and the corresponding preventive measures may now be considered briefly.

Local Infection through the Skin

Diffusion.—Cutaneous entrance is rare, occurring chiefly in those who are obliged to handle fresh tuberculous tissue, such as dissecting porters, pathologists, anatomists, surgeons, and veterinarians. More rarely the infection has been acquired indirectly through articles contaminated with tuberculous sputum, as by scratches of pens or pins or splinters from the stalls of cattle.

Prevention.—Those engaged in handling tuberculous tissues may best avoid the danger of inoculation by wearing rubber gloves and carefully protecting all, even the slightest, lesions of the skin of the hands. Should wounds occur, they should be cleansed to their deepest recesses, and thoroughly irrigated with a 1 : 1000 sublimate solution. To promote careful cleansing, punctured wounds should first be opened freely, and if extensive, lacerated, or of any depth, it is wise to apply for twenty-eight hours, gauze continually wet with a 1 : 2000 sublimate solution. Lactic acid, thoroughly rubbed in, is an excellent application to such wounds; as is also a 10 per cent. solution of formaldehyde. The pain occasioned by such applications soon passes off. Undiluted carbolic acid may be applied with advantage, but dilute solutions of this agent may be so ineffectual as to be dangerous.

Pulmonary Infection

Diffusion.—As tuberculous lesions in man are in great preponderance pulmonary, it has been assumed that infection occurs chiefly by inhalation of tubercle bacilli; but in the adult, at least, the lung is more susceptible to tuberculosis than any other organ, and may show the predominant lesions even when infection has been acquired through some remote channel. It is probable, however, that inhalation is one of the important methods of infection. The air may be contaminated directly by particles of moisture expelled from the respiratory tract of the diseased in coughing, sneezing, or speaking, or the desiccated sputum may be caught up with the dust. This is especially liable to occur in the sweeping of places occupied by the tuberculous, in dusting bedding and carpets, and in other similar ways. Ravenel has shown that even cows with pulmonary tuberculosis discharge particles of infectious mucus in coughing.

Prevention.—Particles expelled in the **violent expiratory** efforts are carried several meters from the patient, but they may be arrested by a handkerchief held before the mouth. The danger from **sputum** is obviated by strict attention to the method of disposal. It should not be received in a dry or open vessel, but in one containing water, or, preferably, an antiseptic solution such as carbolic acid (1 : 20) and provided with a cover that is raised only when the sputum is deposited, so that flies or other insects may not get in and then carry infection. Paper sputum cups may be used, and burned. When patients walk abroad, they should carry pocket sputum-flasks, such as Detwiler's or Knopf's. So far as possible, expectoration into rags or paper napkins should be avoided, but if these are used they should afterward promptly be boiled or burned. Sweeping, dusting, beating of carpets or furniture in rooms used or occupied by the tuberculous should be prohibited, and the cleansing should be carried out by wet scrubbing or wiping with cloths moistened with a solution of mercuric chlorid (1 : 2000). All portions of the house should have frequent and free exposure to sunshine and fresh air. Infected rooms should be treated with formaldehyde.

Ottolenghi found that dry tuberculous sputum could be disinfected completely by spraying it freely with the following solutions: Mercury bichlorid 5 : 1000, with or without the addition of hydrochloric acid or sodium chlorid; milk of lime; 10 per cent. solution of formalin. Chlorinated lime (10 per cent.) in powdered form was found inefficient; in solution, the chlorinated lime tended to reduce the virulence. After using the spray, the room must be closed to prevent rapid drying. If the bichlorid solutions are used, it is advisable to add 2.16 grams (35 grains) of common salt to each liter (quart). It must be remembered that there is distinct danger of mercurial poisoning from the inhalation of this spray.

Places of public resort, ships, cars, cabs, and the like, should be furnished with spittoons containing fine, moist sand and some substance destructive or deterrent to insects; should be guarded against persons given to indiscriminate spitting; and should be ventilated, cleansed, and disinfected with sufficient care and frequency. Spittoons provided with covers lifted by a treadle are less unsightly than the ordinary ones, and give better protection against insects.

Infection by Sexual Intercourse

Genital inoculation occurs but rarely. Tuberculosis of the female genital tract is extremely uncommon, but the bladder is often involved and the external genitals may be contaminated through the urine. In the male, tuberculosis of the penis is also extremely rare, but the semen may be contaminated from a tuberculous orchitis, vesiculitis, or prostatitis. As patients with these local manifestations usually show more serious lesions elsewhere, this mode of transmission is usually of secondary importance, and rarely requires active prophylactic measures. It is obvious, however, that venery may reduce the tissue resistance, upon the one hand, and may also, as by kissing, greatly favor infection through the mouth or nares, upon the other. Novy mentions a man of exceptionally fine physique who died of an acute miliary tuberculosis within three months after he began to cohabit with a phthisical mistress.

Infection through the Alimentary Tract

Invasion.—In children, especially, tuberculous lesions of the lymphatic glands about the neck (so-called scrofulous glands) are common. In many cases the bacilli gain entrance to these glands through **decayed teeth,** or by means of the adenoid tissues found in the pharynx, especially the **tonsils.** A number of cases of tuberculosis of the tonsil are now on record, although this organ is rarely examined for the disease. Of **foods** likely to be contaminated by the tubercle bacillus, milk is the most important. It may contain bacilli derived from the diseased cow; or bacilli derived from tuberculous milkmen, or from human sputum through flies or other insects. It is known through the work of Theobald Smith, that the tubercle bacillus found in cattle has distinct morphologic and other differences from that found in the tuberculous lesions of man; yet in nearly all the lower animals it has proved to be the more virulent of the two. Ravenel has produced in monkeys lesions resembling those of human tuberculosis, by feeding the animals with cultures of bovine tubercle bacilli; and has cultivated tubercle bacilli from human sputum through two generations of calves into practical identity with the bovine bacillus. Notwithstanding the hasty assertions of Koch, therefore, tuberculous cattle must be regarded as a source of serious danger to man. **Vegetables** and other foods exposed to the dust of streets or of rooms frequented by the tuberculous, may contain tubercle bacilli on their exterior. Perhaps the most frequent mode of infection of the alimentary canal is **auto-infection** in those suffering from the pulmonary form of the disease who swallow their own sputum. The acid reaction of the gastric juice is unfavorable to the localization of tubercle bacilli in the stomach, yet is usually insufficient to destroy them, so that while tuberculous lesions are rare in the stomach, they are common in the intestines and the tributary mesenteric glands.

The **percentage of all cases** in which alimentary infection is primary is difficult to estimate, for the lesion may occur not at the point of entrance of the organism, but remotely, as in the lungs. The large proportion (20 to 30 per cent.) developing tuberculosis of the intestine and mesenteric glands, among infants artificially fed in institutions, suggests that in children, at least, this mode of infection is not uncommon.

Prevention.—The possibility of infection through **decayed teeth** is but another important reason for early and continuous attention to dentition in children. Even the temporary set should be watched, and when cavities occur, they should promptly be filled with a material, such as gutta-percha or cement, which acts as a preventive of decay, and also closes atria of possible infection. Hyperplasias of the **adenoid tissue** likewise demand early attention, and if not amenable to medicinal measures should be removed surgically or destroyed by chemical agents or electric cautery. The cleanliness of the mouth should not be neglected.

Cattle reacting to tuberculin should be destroyed. All **milk** from such cows should be rejected, or at least sterilized. By boiling milk of which the purity is not known, or even by pasteurizing it at 60° C. for thirty minutes, any tubercle bacilli contained will be rendered non-virulent. Butter and cream not infrequently contain living tubercle bacilli. If milk be pasteurized, this danger may be obviated without any perceptible injury to the cream or butter.

The **flesh** of tuberculous animals seems rarely to show tubercles, and yet, even though the muscle have no lesion, the contained blood may hold the bacilli. As a matter of safety, it is wise to reject meat from tuberculous animals. This is especially important when we consider that much of the rare roast or broiled meat served at our tables is not heated in its interior to a sufficient degree to destroy organisms if present. The legislative leniency in regard to the meat of diseased animals is lamentable. **'Kosher' meat,** or that which has been killed and inspected according to the Jewish ritual legislation, is likely to be free from tuberculous infection. Even the Rabbinic law, however, does not prescribe thorough inspection of the abdominal viscera, or any examination of poultry. Before cooking any flesh, observant Jewish housewives salt it and soak it for a prescribed time, to remove the blood; this treatment is probably an additional safeguard. While the comparative immunity of Jews from tuberculosis has been exaggerated, there is no doubt that they succumb in less number than neighbors similarly environed except as to hygienic and dietary ritual.

Persons handling milk or other food products, as well as **cooks, bakers,** and the like, should be free from pulmonary tuberculosis, as the danger of contaminating food by coughing over it is a distinct one.

ACTINOMYCOSIS

(Lumpy Jaw, Big Jaw, Swelled Head, Wooden Tongue, Clyers, 'Strahlenpilz')

Causation

This chronic, contagious, inflammatory, and degenerative disease of cattle is caused by **Streptothrix actinomyces** (Bollinger, 1877), and is characterized by nodes of granulation tissue, with necrosis, sinus formation, and production of fibro-connective tissue, involving jaws, tongue, and internal organs. The fungus grows well upon cereals and vegetable media. Growth is arrested at 45° C. and the organism destroyed at 60° C. The spores may live for years upon cereals even under unfavorable conditions.

Diffusion.—Rarely the affection may be contracted from infected animals. Infection seems usually to result through the use of barley and other grains. It may occur through the digestive or respiratory tracts, or through the skin, and thus the morbid process may begin in the mouth, pharynx, lungs, intestine, or cutaneous tissues. The parasites resist the action of the digestive juices. Infection usually takes place through a wound, but in certain forms, as intestinal infection, this is not obvious. The liability to mistake pulmonary actinomycosis for tuberculosis should be mentioned.

Prevention

The avoidance of uncooked cereals for food, the destruction of diseased animals, and the disinfection of discharges from persons that are infected seem to be the best prophylactic measures.

HELMINTHIASIS

(Nematodes; Trematodes; and Cestodes)

Causation

Nearly all intestinal worms are acquired by the ingestion of the eggs and embryos with food. All these parasitic forms are killed by thorough cooking; the ova, as a rule, being more resistant than the embryos.

Diffusion.—The parasites are chiefly carried by meats, by green vegetables, or, more rarely, by water. Flies and other insects may transport eggs or larvæ within their bodies and deposit them in their dejecta upon the food or in fluids. Nearly all of the **tape-worms** found in the intestines are conveyed by 'measly' beef, pork, or fish. In exceptional cases in which the embryo invades the human tissue, the eggs of a worm may have been carried to the mouth upon the hands or upon contaminated food. Most of the **round-worms** living in the intestinal tract seem to be taken into the body with vegetable foods. In such a case the eggs are derived from the discharges of animals that are diseased, and may reach the food by materials used for fertilization, by unsanitary drainage into the source of water-supply, or by the visitation of insects.

Prevention

To avoid infection by the intestinal parasitic worms, sole dependence should not be placed upon the inspection of meats and other foods. Measures of personal cleanliness, the sterilization of foodstuffs by cooking, and the prevention of insect contamination are of great value. The most important of these measures is thorough cooking. Smoking is not an efficient parasiticide, but many of the methods of pickling meats slowly destroy the worms. As the excrement from hogs or other animals may contain ova of some of these parasites, care should be taken in its use as a fertilizer for green vegetables, especially celery, lettuce, and the like. The generally recognized measures to prevent water pollution should be observed.

TRICHINOSIS

Causation

Trichinella spiralis finds its way into the human intestine with meat obtained from diseased swine. In the intestine the mature female throws off embryos that pass through the intestinal wall and into the blood-current, finding their way into the voluntary muscles, where they occasion irritation and inflammation resulting in their encapsulation. Lime salts are deposited in the capsules, and in time the death of the embryos may thus be brought about, although the embryos have been known to remain alive in the muscles for fifteen or more years.

Diffusion.—Hogs are usually infected by eating infected rats or meat. Care should be taken that the pig-pens are kept clean and free from vermin, and that hogs are not fed with contaminated meat unless this has been thoroughly cooked.

Prevention

Food made of uncooked or imperfectly cooked pork should be strictly avoided. Hertwig found that pieces of pork the thickness of the thumb could be boiled for twenty-two minutes without killing the contained trichinæ, and showed that there was greater danger from cooked sausage in which the meat was coarsely minced than from sausage made from finely minced meat. Bloomer and Neumann have reported an epidemic involving nine persons in two Italian families that ate sausage made of coarsely minced pork scraps. The sausage had been boiled in its manufacture, and was usually also fried for the table. This indicates the necessity for very thorough cooking. A temperature sufficient to coagulate protoplasm and turn the meat from the raw brown to the opaque cloudy color of cooked meat will kill the parasites. The methods of pickling and preserving hams and other portions of hogs by immersion and by injection with preservatives seems also to destroy them, for infection from the imported American meat in Germany is practically unknown. Inspection, while a safeguard, is expensive and not absolutely trustworthy, as carelessness or cupidity may permit the sale of diseased meat. Dependence should therefore be placed upon thorough cooking only.

UNCINARIOSIS

(Anchylostomiasis, Tunnel Disease, Miner's Anemia, Brick-maker's Anemia, Mountain Anemia, Egyptian Chlorosis, etc.)

Causation

This serious parasitic disease occurs chiefly in those whose work brings them in contact with earth, as miners, tunnel-makers, brickmakers, diggers, farmers, and the like. It is caused by a parasitic worm, the hook-worm, Uncinaria duodenalis, or Anchylostoma duodenale, belonging to the family Strongylidæ, subfamily Scterostominæ. More common in the Mediterranean countries, as Italy and Egypt, the disease has been found in all parts of Europe, and recently in America, especially in the West Indies.

Life-history.—The adult worm lives in the duodenum of the host, puncturing the mucous membrane and sucking blood first at one point and then at another. The repeated blood abstractions, with the ensuing hemorrhages, the bacterial infection of the damaged intestine, and the interference with assimilation of food, together, according to certain authors, with the absorption of toxic products of the parasite, may lead to anemia of a high grade in the host. The eggs are deposited in the intestinal canal by the female parasites, but do not develop into adult worms within the body. After escaping with the feces each egg, if the environment is favorable, develops a single embryo. This lives in water or moist ground and gradually the sexes become differentiated and approach the adult form.

Diffusion.—The embryos may gain entrance to the body by the swallowing of infected water, food, or dirt (in clay-eaters, or through soiled fingers of earth workers), whereupon they develop into adults, attack the walls of the duodenum, deposit eggs, and the developmental cycle is again repeated. The parasites affect sheep and other animals that may disseminate the infection. It is improbable that they are spread by winds, as drying usually is fatal to them. Penetration of the unbroken skin may occur, as suggested by Looss.

Prevention

The use of uncontaminated or sterile drinking-waters only, and care as to personal cleanliness, particularly as related to the hands, finger-nails, and all substances placed in the mouth, are of primal importance.

To avert the disease in sheep and other live stock, Stiles urges the systematic draining and burning of pastures. To this may be added the importance of segregating or treating diseased animals, that reinfection of the pastures may not result. Infected stools may be sterilized by chlorinated lime or milk of lime.

BERI-BERI

This is apparently a specific form of multiple peripheral neuritis characterized by anesthesia, motor paralysis, and edema. A causative organism has not been isolated. The disease is endemic in most tropic or subtropic climates, especially the Malay Archipelago, China, Japan, India, the Philippine Islands, Brazil, Australia, the Sandwich Islands, the west coast of Africa, and Cuba. It is most common during the hot or rainy season, and is found associated with overcrowding in institutions, jails, or ships. It has been a cause of high mortality among Philippine natives imprisoned by the Spanish or American authorities. It usually occurs about the period of adolescence, and is rare in childhood and old age. The mode of **diffusion** is obscure. The **prophylaxis** includes the maintenance of the best hygienic environment; especially, thorough ventilation and the avoidance of dampness and of overcrowding. Buildings in which the disease has occurred should be thoroughly disinfected, and patients should be isolated.

A dietetic cause has been alleged, especially the use of fish and shelled rice. A marked reduction in the number of cases in the Japanese navy has followed improvement in the dietary.

MALTA FEVER

This disease, known as **indolent fever, Mediterranean fever, rock fever,** and **Neapolitan fever,** is a protracted endemic disease, apparently due to **Micrococcus melitensis.**

The **mode of infection** is obscure, the micro-organism having been found in the spleen, liver, and kidneys of those dying from the disease, and also in the urine of inoculated animals. Apparently the disease is not directly contagious, but its spread is favored by unsanitary conditions. Bruce considers the infection to be water-borne; Manson holds that it originates from the feces and is diffused by air-currents. From our present knowledge it would seem wise to guard the water-supply and to take such measures as will prevent transmission of bacteria by insects. The discharges of the patient should always be disinfected. The best method to determine the presence of the disease is by the serum reaction.

SPRUE

(Psilosis, Ceylon Sore Mouth, Diarrhea Alba, Aphthæ Tropicæ)

Causation

This is a catarrhal affection of the mucous lining of the digestive canal. It chiefly affects Europeans after a prolonged residence in tropic countries. A causal micro-organism is undetermined.

Diffusion

The disease is almost invariably contracted in the tropics, but may not show itself until after the patient returns to the temperate zone.

Prevention

All exhausting conditions favor the development of this disease. Residents of the tropics should carefully combat all depressing factors; full nutrition should be maintained and so soon as any symptom is noted the patient should be sent to the temperate zone, placed upon an abundant milk diet, and carefully protected from cold. As the method of origin is obscure, other prophylactic measures must be largely empirical. Careful attention to the freedom of food from parasitic contamination would seem to be especially indicated.

FOOT-AND-MOUTH DISEASE

Epidemic stomatitis is a disease of cattle, sheep, and pigs that at times affects man, especially when dairy products from diseased animals are ingested or come in contact with the abraded skin. The cause is a micro-organism. Aphthous cows should be destroyed, their milk and flesh should be rejected as food, and all dairy products should be sterilized during an outbreak of this disease.

OCCUPATIONAL AND DRUG INTOXICATIONS

In connection with the alimentary infections, various intoxications, such as result from alcohol, tobacco, lead, bismuth, arsenic, tea, cocain, and other similar substances, may briefly be mentioned. These agents may injure the body directly, or indirectly by increasing the susceptibility of the organism. Thus, the overgrowths of connective tissues taking place in the brain, spinal cord, liver, kidneys, spleen, blood-vessels, and other organs that go by the names of cirrhoses, scleroses, or fibroid indurations may result directly from the action of the poison upon the tissue, or indirectly from a bacterial infection that is favored by the intoxication. Prophylaxis of these various poisonings is embraced in measures considered under industrial, municipal, domestic, or personal hygiene.

CHAPTER XVI

RESPIRATORY INFECTIONS

Infections of the Nasopharynx and Related Mucous Membranes. Laryngitis. Diphtheria. Croupous Pneumonia; Catarrhal Pneumonia; Pleuritis. Endocarditis. Pericarditis. Pertussis. Influenza. Tuberculosis. Glanders. Cerebrospinal Meningitis. Exanthemata—Variola and Vaccinia; Rubella; Morbilli; Scarlatina. Typhus Fever.

General Prophylaxis

The prevention of infection through inhalation is embodied largely in those measures that prevent the pollution of the air by dust, or by the coughing, sneezing, or talking of persons with infectious secretions of the oral or respiratory tract. Autoinfection of the lungs through the inspiration of infected material from the upper respiratory tract or stomach occurs chiefly during anesthesia or after intubation. The careful cleansing of the upper air-passages, the exclusion of food immediately before anesthesia, and skilful anesthetization are important prophylactic measures. After intubation the use of sterilized foods and of measures to secure a relative asepticity of the mouth and pharynx should be observed. Similar precautions are important after certain operations upon jaws, nasopharynx, larynx, or trachea. Feeding by tube, careful packing, and in laryngectomy the stitching of the open end of the trachea to the external wound (J. Solis-Cohen's operation), are especially to be borne in mind.

FIG. 70.—BACILLUS TUBERCULOSIS IN THE PULMONARY SPUTUM OF TUBERCULOSIS.

INFECTIONS OF THE NASOPHARYNX AND THE RELATED MUCOUS MEMBRANES

(Rhinitis; Pharyngitis; Tonsillitis; Laryngitis; Otitis; Conjunctivitis; and Infections of the Nasal Sinuses)

Causation

Besides the chemical and mechanical irritants, various bacteria invade these membranes, producing catarrhal, pseudomembranous, or ulcerative lesions. Local infections result from the action of pneumococci; the pyogenic streptococci or staphylococci; the diphtheria bacillus and its modifications, including the xerosis bacillus; the gonococcus; the bacillus of rhinoscleroma. Most of the acute catarrhal forms of **conjunctivitis** seem to be due to the Koch-Weeks bacillus, while the diplobacillus described by Morax and Axenfeld, or other unidentified organisms, may at times be responsible for the inflammatory condition. In many of the generalized diseases, serious infection of the upper respiratory passages may occur; while generalized infection or intoxication, sometimes affecting the joints specially or involving the heart, may result from bacterial attack in the pharynx, as a mild 'sore throat' or **tonsillitis.**

In **influenza** the conjunctiva, Schneiderian membrane, and middle ear are often severely involved, and the **otitis media** resulting from the influenza bacillus not infrequently is followed by grave complications, including **mastoid disease, intracranial abscess,** and **venous thromboses.** The **middle ear** is also often invaded in **scarlatina** and **measles,** and, at times in **mumps, variola, pertussis, typhoid fever, tuberculosis,** and **syphilis. Glanders** is prone to affect the lining of the nose, which is usually also involved in **leprosy** and **rhinoscleroma,** and more frequently than is realized, in **tuberculosis. Pneumonia** may be associated with pharyngeal, nasal, or aural complications.

Diffusion.—The infectious organisms may be carried by particles in the air, as seems especially to take place in influenza, or by infected hands, utensils or fomites. Thus, granular conjunctivitis and gonorrhea may be carried to healthy eyes by contaminated fingers, handkerchiefs, towels, and the like. In many diseases these local inflammations appear as complicating extensions of the morbid process.

Prevention

Infectious particles may be thrown into the air in coughing, sneezing, or speaking, or may be carried upon handkerchiefs or other fabrics, or upon the hands or person. Measures of prophylaxis should be directed to prevent the spread of the disease in any one of these several ways by covering the mouth and nose during violent expiratory effort and by the prompt disinfection of linen, hands, discharges, and other sources of infection. In the exanthemata or in local infections of the upper respiratory tract the greatest care should be taken to prevent the extension of the disease to the ear, nasal sinuses, or eyes. This is perhaps best accomplished by frequent cleansing of the affected passages with mild antiseptic lotions, such as saturated solutions of boric acid, solutions of the type of those suggested by Dobell or Seiler, or a diluted alkalinized solution of hydrogen dioxid.

Various dipterous insects may invade the nasal passages, ears, or eyes, and deposit their ova or pathogenic micro-organisms. If this has happened, these should promptly be removed by thorough flushing with oil or with antiseptic solutions, solution of chloroform, carbolic acid, salt water, turpentine, and the like, or by the forceps.

FIG. 71.—WESTBROOK'S TYPES OF BACILLUS DIPHTHERIÆ.
Granular types, A, C, D. Barred types, A^1, C^1, D^1. Solid types, A^2, C^2, D^2.—(*Gorham.*)

DIPHTHERIA

Causation

Diphtheria is a contagious and infectious disease caused by **Bacillus diphtheriæ** (Klebs-Löffler, 1883). The organism is readily destroyed by heating to 50° C. or above, and by the usual antiseptics. Usually it does not resist drying. It varies much in pathogenic power and not infrequently is found in the throats of healthy persons, especially those who have been in contact with the sick. The studies of Westbrook, Gorham, and others suggest that there are morphologic evidences of differences in pathogenicity. The granular and barred types appear to be most virulent.

Diffusion.—The diphtheria bacillus may be transferred through the air for short distances by the acts of coughing, sneezing, and talking, but there is no evidence that it is carried long distances in this way. It may be conveyed upon fomites, the hands and bodies of nurses and other attendants, and in food, especially milk. The lower animals, as cats, horses, cattle, and chickens, occasionally suffer from a pseudo-membranous affection of the upper respiratory passages, simulating diphtheria, and from this infection has been claimed. It is rare, however, that true diphtheria bacilli are found in these animals, although they have been found to be susceptible to the disease experimentally induced. Contrary to the prevalent impression, there is no reason to believe that the disease is spread by the air from drains and sewers, although such unwholesome air may increase susceptibility.

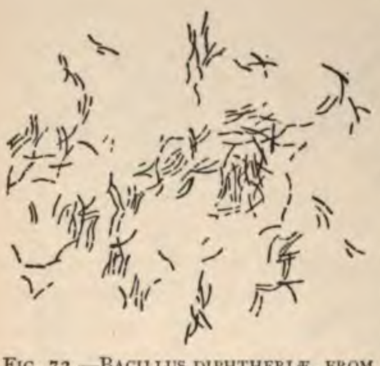

Fig. 72.—Bacillus diphtheriæ, from a Pure Culture from the Throat.

Prevention.—Persons affected with diphtheria or suspected of such infection should be isolated and all articles with which they come in contact, especially food utensils, sterilized by scalding. Attendants should be as few in number as practicable, and should not mingle with well persons. From time to time it is desirable that the secretions from their throats be examined to ascertain if they are harboring the bacilli. The patient should not be removed from isolation until the throat is free from the micro-organisms. As they may persist for several weeks after convalescence, the use of antiseptic throat and mouth washes and nasal sprays is desirable. Special care should be taken as to the cleanliness of the teeth and of any cavities that they may contain. Among the antiseptics advised for the throat are tincture of ferric chlorid, silver nitrate, freshly made chlorin water, Dobell's * solution, Löffler's solution of toluene,† alkalinized solution of hydrogen dioxid, guaiacol (25 per cent.) with menthol (10 per cent.) in glycerin and olive oil, ten per cent. formalin. The stinging of the silver nitrate, guaiacol, or formalin is intense, but soon passes off.

Immunization.—Persons exposed to the disease are protected by the subcutaneous injection of from 300 to 500 units of diphtheria **antitoxin.** This affords a transient immunity lasting about thirty days, and is usually harmless. The use of antitoxin does not free the throat from the bacilli, and therefore does not protect those who associate with the person treated.

CROUPOUS PNEUMONIA

(Acute Lobar Pneumonia, Pneumonitis, Lung Fever)

Causation

Diplococcus pneumoniæ, Diplococcus lanceolatus, or Micrococcus pneumoniæ crouposæ, was found by Sternberg in saliva (1880) and associated with croupous pneumonia by Fränkel (1886). It is a rounded or lancet-shaped diplococcus usually found when in the animal body to be surrounded by a clear area or capsule. It is non-motile, facultative anaerobic, and grows best at the temperature of the body. It varies greatly in virulence and rapidly attenuates in artificial culture. It is often present in the saliva of healthy people; sometimes it gives rise to a special form of arthritis, pleuritis, pericarditis, meningitis, or to other localized and general infections.

Pneumonia less frequently may be due to Bacillus pneumoniæ,

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* *Dobell's Solution:* Pure carbolic acid, 1 grain; sodium borate, 5 grains; sodium bicarbonate, 5 grains; glycerin, 30 minims; distilled water enough to make 1 fluidounce. For use as a detergent spray.

† Löffler's solution:

Menthol,	10 grams
Toluene (Toluol),	30 c.c.
Mix and add	
Creolin,	2 c.c., or
Solution of ferric chlorid,	4 c.c., or
Tincture of ferric chlorid,	3 c.c.
Absolute alcohol sufficient to make	100 c.c.

(Friedländer, 1883), to streptococci, or to other organisms, as the influenza bacillus and Bacillus typhosus, alone or in association with the diplococcus. Friedländer's pneumobacillus is often found in normal saliva, is asporogenous, facultative anaerobic, and grows rapidly at the room-temperature. It varies greatly in virulence.

Associated Factors.—That pneumonia may result from cold or exposure without the action of bacteria is not maintained at the present day; but exposure and chilling certainly co-operate in the result in many instances. Predisposing or determining factors are to be found in traumatism, in alcoholic and other intoxications, in conditions of general debility, and in the existence of certain chronic diseases, as diabetes, tuberculosis, nephritis, and in acute infections, as measles, typhoid fever, influenza, pertussis. Both clinically and pathologically a number of different classes are thus to be established in accordance with the varying combination of etiologic factors.

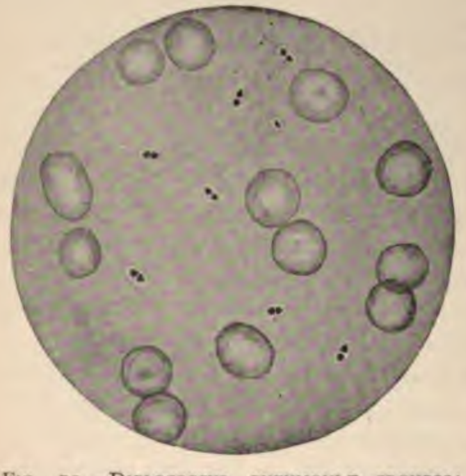


Fig. 73.—Diplococcus pneumoniæ crouposa in the Blood of a Rabbit. The Diplococci are Surrounded by Clear Halos or Capsules.

Diffusion.—A number of the reports of house endemics of pneumonia suggest the possibility of the direct conveyance of the disease. Some of the earlier writers made a separate classification of **contagious pneumonia.** Rarely pneumonia has been transferred to the fetus through the placenta. As many healthy persons carry the specific organism in the secretions of the upper respiratory tract, it is only necessary for them to become sufficiently depressed by exposure to heat, cold, or other debilitating agent in order to have these bacteria invade the tissues and produce disease. Old age, the conditions associated with general anesthetization, or exposure, especially when following dissipation, may sufficiently reduce the immunity to permit such infection.

Prevention

The secretions of the upper respiratory tract should be kept as free from pathogenic organisms as possible, and the normal resistance of the body should be maintained by means described in the section on Personal Hygiene. Especially should the habitual use of stimulants or narcotics and the overprotection of the body by excessive clothing be avoided; while the habituation of the body to cold water and cold air is to be encouraged.

Patients with pneumonia should be isolated from the weak or debilitated and measures taken to disinfect their secretions, to exclude insects, and to prevent the diffusion of bacteria-laden particles during violent expiratory efforts.

CATARRHAL PNEUMONIA

(Bronchopneumonia, Lobular Pneumonia, Disseminated Pneumonia, Scrofulous Pneumonia, Peribronchitis [Balzer], Capillary Bronchitis)

Causation

Inflammation of the terminal bronchi and connected air-passages (pulmonary lobules), whether in disseminated (distinctly lobular) or massive (pseudolobar) form, is usually the result of secondary infection. At times it seems to arise independently through diminution of resistance to pathogenetic germs caused by cold, or, especially in those exposed by their occupation, by irritation due to smoke, dust, or noxious vapors and gases—among the latter irritating products formed when chloroform vapor comes in contact with gas flame. It is thus often associated with, or arises by extension from, inflammation and infection in the upper air-passages. The disease occurs especially in childhood and old age, and at all ages is most prevalent among the poor and debilitated. Local infection is frequently acquired by the aspiration of food or other infected solid particles (deglutition pneumonia; inspiration pneumonia). This may occur during surgical anesthesia, alcoholic intoxication, or coma of any origin; following hemoptysis; following operations about the mouth and upper air-passages; in paralysis of the pharynx or larynx; in tuberculous and malignant ulceration of the pharynx, larynx, and esophagus; and in conditions of marked asthenia such as are not uncommon at the extremes of life or in such exhausting diseases as diphtheria, typhoid fever, tuberculosis, and chronic nephritis. Apart from this method of infection, catarrhal pneumonia is frequently associated with or follows acute infectious diseases, as measles, scarlet fever, whooping-cough, rachitis, influenza, smallpox, tuberculosis, erysipelas, dysentery, meningitis, typhoid fever. In exceptional instances it follows a rupture into the lung of a purulent collection in the pleura, liver, or elsewhere. Tuberculous bronchopneumonia, though often unrecognized, is the most common and most fatal form; the variety associated with the exanthemata of children is also common and is responsible for the greater portion of the mortality of these diseases.

Among the **causal bacteria** are the pathogenic streptococci and staphylococci, Fränkel's and Friedländer's pneumococci, the tubercle bacillus, the bacillus of diphtheria, Pfeiffer's influenza bacillus, and others. It is rare for pure cultures to be found except in the case of the pneumococcus, which is most frequently associated with the pseudolobar type of the disease, streptococci being most common in the lobular type. Mixed infection is the rule. **Capillary bronchitis** is a related condition occurring in children, and has a similar etiology; in fact, many authors refuse to differentiate it.

Prevention

The disease having no single specific organism, the conditions favoring infection, and the low vital resistance which permits or invites it, assume high importance. Prevention must depend upon the prevention of these predisposing and favoring factors, and is largely included in that of the primary infections with which catarrhal pneumonia is associated.

PLEURITIS

(Pleurisy)

Causation

Pleuritis, either dry (fibrinous) or with serous or purulent effusion, may arise as an apparently independent affection following chill or traumatism, but is frequently secondary to pulmonary diseases or to infections elsewhere in the body, whether it occur by direct extension, as from the lungs, mediastinum, or pericardium; or by indirect transmission of the infecting agent. It is often associated with catarrhal or croupous pneumonia. The tubercle bacillus is most frequently the cause of dry pleurisy, and in the course of such diverse processes as rheumatism, gonorrhea, echinococcus disease, smallpox, typhoid and other fevers, perihepatitis, cirrhosis or abscess of the liver, appendicitis, tuberculous peritonitis, septicemia, sarcomatous or carcinomatous diseases, chronic syphilis, and chronic nephritis, the pleura may become involved.

In cases of **empyema** the micro-organisms found in the pus vary considerably with the time of life of the patient. Thus, in children the pneumococcus is most frequently met, while in adults it is the streptococcus. In adults the number of tuberculous empyemas is nearly twice as great as in children. The following table from Netter, who has done the best bacteriologic work upon the subject, will illustrate the differences:

	Children	Adults
Pneumococcus,	53.6	17.3
Pneumococcus and streptococcus,	3.6	2.5
Saprophytic organisms,	10.7	
Staphylococci,		1.2
Bacillus tuberculosis,	14.3	25.0
Streptococci,	17.6	53.0

At times infections occur directly from without, as after wounds or infections of the thoracic walls.

Prevention

The prophylaxis of this condition depends upon the maintenance of the best bodily health, the avoidance of debilitating agents and of chilling exposure, and the prevention and careful treatment of the various diseases of which it is a complication.

PERICARDITIS AND ENDOCARDITIS

Causation

Pericarditis and endocarditis may be associated with pleuritis or occur independently. These affections almost invariably result from pathogenic micro-organisms circulating within the blood; those recognized include the pyogenic cocci, the bacillus of typhoid fever, the bacillus of influenza, the colon bacillus, the pneumococcus, the gonococcus, and the tubercle bacillus. The parasite of rheumatism is among the most frequent causative agents of acute inflammation of the cardiac membranes; chorea is also among the primary conditions. Lead-poisoning and gout are more apt to cause chronic inflammation.

Prevention

As the cardiac affection almost invariably occurs in connection with other disorders, the prophylactic measures applicable are, first, those useful in preventing the causal conditions; and, second, such treatment of the latter as will avert complications. Especial attention should be given in cases of tonsillitis to the detection of the onset of cardiac involvement. In acute articular rheumatism prolonged rest is necessary. Prophylactic blistering between the clavicle and the nipple, and the use of the ice-bag or cold coil over the precordium, seem useful.

PERTUSSIS (WHOOPING-COUGH)

Causation

A very short and delicate bacillus has been described by Koplik and by Czaplewski and Hensel as being almost constantly present in the viscid expectoration of uncomplicated cases of whooping-cough. While this organism has been isolated in many cases, its pathogenicity is as yet unproved.

Diffusion.—The infection in whooping-cough takes place in all probability directly through the respiratory tract. The repeated coughing and vomiting not only lead to infection of the air immediately adjacent to the child, but also contaminate clothing, handkerchiefs, furniture, perchance even foods and candies that are being partaken of by other children. The disease occurs chiefly in the spring and autumn, attacks children under five years of age, and, while uncommon, also occurs in adults. The new-born have been infected by their mothers.

Prevention

The avoidance of the spread of infection consists generally in segregating the diseased from the well. Children should not be permitted to have the toys or other articles used by the infected unless the recognized measures of disinfection are taken to free these from all possible contamination. An attack usually but not invariably affords future immunity.

INFLUENZA (LA GRIPPE)

Causation

Influenza is a highly contagious, toxic infection, affecting especially the respiratory and digestive tracts and the central nervous system. Its cause is Bacillus influenzæ (Pfeiffer, 1892), an extremely small, non-motile, asporogenous rod occurring in pairs, sometimes in threads, growing only upon special media, at about the temperature of the body and in the presence of oxygen. It is readily destroyed by drying. It occurs in the secretions of the respiratory tract between and in the free cells, and may persist in the secretions after the subsidence of the disease.

Diffusion.—'Grip' spreads with great rapidity, especially along the lines of travel, being conveyed by persons and goods. As the organism is unusually susceptible to desiccation, it does not seem that it could be carried alive for any great distance by dry air. The disease occurs in pandemics. Probably it is transmitted from infected persons chiefly by the particles of secretion expelled in coughing and speaking.

Prevention

The respiratory passages, especially the nasal chambers of those affected, should be treated antiseptically, their secretions should be disinfected, and measures taken to prevent the spread of the disease by particles expelled in violent expiratory efforts. It is desirable to isolate the patient at least until the secretions are free from bacilli, or the coughing has ceased. Influenza being especially severe in the very young, the aged, and the debilitated, those conditions that best maintain general resisting powers are the chief measures of defense.

TUBERCULOSIS

Invasion through the respiratory tract is discussed on page 255.

GLANDERS

(Malleus humidus, Maliasmus, Farcy, Morve, Farcin [Fr.], Rotz [Ger.])

Causation

This is a contagious, degenerative, inflammatory disease of horses and asses, characterized by suppurating nodes on the mucous membranes, in the subcutaneous tissues and internal organs, and caused by **Bacillus mallei** (Löffler, Schuetz, 1882). This bacillus is a non-motile, asporogenous, facultative anaerobic organism, a little shorter and thicker than the tubercle bacillus, and growing best at about the temperature of the body. It attenuates rapidly when growing upon artificial media and is killed by drying.

Diffusion.—Men usually contract the disease through association with infected equines. The nasal secretion of animals with glanders is very virulent, and in snorting and coughing the animal may throw this into the faces of adjacent persons. In the chronic form known as **'farcy buds'** suppurating subcutaneous nodes appear, the discharges from which are also inoculable. This disease is one of the most dangerous with which the bacteriologist works. The greatest care should be taken in handling cultures of the bacillus, in the use of experimental animals, and in the performance of necropsies.

Prevention

A diagnosis of glanders in one of the lower animals should immediately be followed by destruction of the animal, with thorough disinfection of its quarters, and, as far as possible, of all things with which it may have come in contact. The disease being so virulent in man, there is no justification for any attempt to treat a glandered lower animal. The body should be burned or buried deeply. Sterilization may be effected by formaldehyde or by other strong chemical antiseptics, or by heat.

In the early stages a diagnosis may be made by injecting mallein, a glycerin extract of Bacillus mallei. This produces in a diseased animal a marked febrile reaction. The presence of the bacillus also may be determined, as suggested by Strauss, by injecting some of the suspected discharge into the abdominal cavity of male guinea-pigs. If the specific bacilli are present, suppuration of the testicles occurs within three or four days, followed by the animal's death in about two weeks. Persons afflicted should be isolated and their discharges and secretions promptly disinfected.

CEREBROSPINAL MENINGITIS

(Cerebrospinal Fever, Spotted Fever)

Causation

Diplococcus intracellularis meningitidis (Weichselbaum, 1887) and **Diplococcus pneumoniæ** are believed to be the exciting agents. The former closely resembles the gonococcus, grows only at the temperature of the body, attenuates rapidly in artificial culture, and apparently is easily destroyed by antiseptics in the usual strengths.

Diffusion.—Spotted fever occurs in subtropic and temperate climates, most frequently in the spring or late winter. It may spread simultaneously over vast areas, taking a victim here and there. At times houses seem to harbor the virus. It varies greatly in virulence. Fulminating or rapidly fatal cases not rarely occur; sometimes in apparent sequence to traumatism.

The mode of diffusion is obscure, but the secretions from the respiratory passages and from the ears may contain the microorganism.

Prevention

As the precise method of diffusion is obscure, measures of prevention must be more or less empirical. The best hygienic environment, including food, clothing, and the like, should be supplied to all persons in an infected community. Although direct transference from person to person seems unusual, the sick should be isolated and their discharges disinfected; while measures should be taken to prevent the possible diffusion of the bacteria by insects.

THE ACUTE EXANTHEMATA

Certain measures of **general prophylaxis** common to the management of this group of infections may be discussed before taking up the various specific diseases :

The Room.—The patient should be placed in a well-ventilated and well-lighted,* plainly furnished room, and isolated from communication with all except those persons necessary for his care.

When possible a suite, including attendants' room and bathroom, should be appropriated for hospital purposes. Only the physician, nurses, and attendants should be permitted in the isolation quarter, and, if possible, these should be immune through a previous attack or through a previous prophylactic inoculation.

The Attendants.—Attendants should avoid close proximity to the patient, especially hanging over the bed. They should not eat in the sick-room, and should observe great care as to their general

* If necessary to exclude actinic rays from the patient, this is best done by appropriate screens about the bed or by a face mask. At all events, there should be facilities for flooding the room with light occasionally.

personal cleanliness, including the toilet of the mouth. The hair of the head should be thoroughly covered. They should mingle with persons outside as little as possible, and then only after bathing, changing their clothes, and disinfecting their hands. Physicians must also observe due care in protecting their persons and clothing during professional visits, and in disinfection before leaving the isolated portion of the house.

The Patient.—The greatest care as to the general cleanliness of the patient should be taken. The skin should frequently be bathed with a weak alcoholic or other mild disinfectant solution. If there is scaling, the particles may be prevented from entering the air by greasing the skin with olive oil, cocoanut oil, cocoa-butter, petrolatum, benzoated or carbolated lard, etc. Sputum and all excreta of the patient should promptly be disinfected by chlorinated lime, carbolic acid, or other efficient agent. Sheets, pillow-slips, clothing, and other material that may be contaminated should not leave the room until they have been boiled, or immersed for at least two hours in some reliable disinfectant solution, such as carbolic acid 5 per cent., or formaldehyde, 5 per cent. Great care should be taken to keep the room free from flies and vermin by the use of screens and other measures, as elsewhere set forth. After convalescence the room should be thoroughly cleansed and fumigated, preferably with formaldehyde gas, or, in case insects or vermin are present, with sulphur dioxid. If a number of cases of the disease occur, the complicated should be isolated from the uncomplicated cases.

The observations of M. Grancher show that attendants often transmit measles, scarlet fever, and other infectious diseases in general hospitals, and that if they observe proper care, the percentage of cases of supposed aerial convection is much reduced. It is said that aerial infection does not exist when there is no expectoration and where the dust is suppressed. By surrounding the bed of the exposed or infected with wire screens, by having the attendant put on special garments on entering within the screen, and washing and disinfecting her hands on leaving it, by serving food to the patients in metal trays that were plunged into boiling water after use, the number of cases infected within the hospital by measles was reduced one-third, and the number infected by diphtheria one-half. To suppress the disease in wards, Grancher also advises properly laid parquet floors, well paraffined, which are washed twice daily with sublimate solution.

VARIOLA
(Smallpox)

Causation

The etiologic agent of smallpox is undetermined. Inoculations with crusts or matter obtained from the pustules convey the disease, and it is probable that the secretions from mucous membranes are also infectious. As the virus of vaccinia is killed by a temperature of 54° C. (129° F.) in ten minutes, it is probable that that of variola is not very resistant to heat. Crusts and dry purulent matter may retain their virulence for many months, but there is no reason to believe that the causal agent is especially resistant to chemical disinfectants.

Diffusion.—The virus may be transmitted directly from the sick to the well; be carried by a third person or upon fomites, such as clothing, rags, bedding and the like. It would seem that the virus may be diffused through the air over greater distances than that of scarlet fever or measles. How far it may be carried is uncertain. Certain observations indicate that the disease may be carried by the air from the smallpox hospitals to the immediate neighborhood, yet this is not positively proved, and there are usually other possible and more probable avenues of such diffusion. It is believed that the epidermic scales thrown into the air by the making of beds, by the movements of the patient, and diffused by winds or by other means, render the period of desquamation dangerous.

Prevention

Inoculation, which, in the modified form of **vaccination,** is the chief measure of prevention against smallpox, has been practised for centuries. The Chinese are said to have long had the custom of inserting crusts from variolous sores into the nasal passages of the well to produce a milder and protecting form of the disease. Methods of **inoculation** seem gradually to have spread to the west, and early in the eighteenth century Lady Mary Wortley Montagu, wife of the British Ambassador at Constantinople, wrote from Adrianople a letter containing this celebrated paragraph: "Every year thousands undergo this operation [inoculation with variolous matter], and the British Ambassador says pleasantly that they take the smallpox here by way of diversion, as they take the waters in other countries. There is no example of any having died of it, and you may believe I am satisfied of the safety of their experiment, since I intend to try it on my dear little son."

This led in 1721 to the introduction in England, and also in America, of the practice of direct inoculation of variolous material into the well. Objections to the method were that it produced a disease from which one might contract virulent smallpox, while in a small proportion (about 0.3 per cent.) of cases a fatal result followed. In 1840 it was abolished by law in England.

Meanwhile **vaccination** had been brought into prominence. Its adoption resulted from the effect upon Edward Jenner's receptive and reflective mind of the observation that milkers who had been accidentally inoculated on their hands with cow-pox remained well during an epidemic of smallpox. In 1796 Jenner for the first time deliberately infected a human being with the virus of cow-pox as a preventive measure against variola. The efficacy of this procedure was proved by repeatedly inoculating the vaccinated lad with matter from smallpox pustules. In all, twenty inoculations with variolous matter were tried, and all failed. Vaccination with cow-pox was introduced into the United States in 1800 by Waterhouse ('the American Jenner'), who first vaccinated his own children and then proved their immunity by having them exposed in a pest hospital and inoculated with the virus of smallpox. He enlisted the active support of President Jefferson. The utility of this preventive measure has been overwhelmingly demonstrated by a century's use.

Recent observations show that it is possible at times to inoculate smallpox into cows, and when this occurs, the animal suffers from a transient and local infection. If inoculations be practised from this cow to others, there is finally produced a disease, apparently identical with cow-pox, that will cause the usual vaccine sore when inoculated into human beings. For these reasons, we may assume that cow-pox is smallpox modified and attenuated by passage through the bovine species.

Vaccination formerly was practised with matter obtained from the vesicles of vaccinated children (*humanized virus*), but the possibility of transmitting syphilis and other diseases in this way has largely caused the disuse of humanized virus in many countries; the vaccine being procured by inoculating the shaven ventral surfaces of calves, under aseptic precautions. About one week after the inoculation, the vesicles are either scraped off and ground into a liquid with glycerin, or bone, quill, or glass points are dipped into the exuded serum and dried. The wisdom of Jenner's injunction that lymph, not pus, be used and that the vaccine be secured before the efflorescence appears, has been abundantly demonstrated. **Glycerinized virus** is usually marketed in small glass tubes. Its advantage is that the glycerin slowly destroys most of the contaminating organisms, so that at the end of about thirty days there is little left but the pure virus, which may be used with slight danger of a mixed infection. Unfortunately the glycerinized virus seems often attenuated, and it is a question whether it affords as thorough a protection against smallpox as do the dry points. Moreover, it may fail to destroy certain contaminating organisms, as those of tetanus. Scabs, formerly much in vogue, have fallen into deserved disuse.

The old-fashioned inoculation is perhaps the most potent protective, although too dangerous and inconvenient for general use. Next in efficacy seems to be the use of humanized vaccine virus. The inoculation of dry bovine virus apparently produces less lasting effects, but is safer and more practicable; while bovine virus attenuated by glycerin or other agents is perhaps least to be depended upon. Unless vaccinations are performed seven days or more before the eruption of variola, little or no protection is conferred.

The **immunity** produced by vaccination with bovine virus, as a rule, seems to last from three to seven years. Second vaccinations are therefore necessary, and third and even fourth vaccinations, desirable. If vaccination 'takes,' we may infer that there has been liability to smallpox. By vaccinating all persons, and repeating the procedure at intervals not longer than ten years, smallpox may practically be eradicated from a country. To show this a small part of the large amount of statistical evidence may be quoted.

The German law commands vaccination at birth and at the tenth year. This law was introduced April 1, 1875. In Prussia from 1816 to 1870 the annual mortality from smallpox varied from 7.32 to 66.0 in 100,000 of population. In 1871 the mortality was 243.20; in 1872 it was 262.67; from 1875 to 1886 the average was 1.91, the lowest, 0.36. The table given on page 282 shows the relative prevalence of smallpox during the latter period in various European cities. In the first five cities mentioned compulsory vaccination was enforced, while vaccination was not required in the last four cities.

To make the distinction evident a change of type has been made in printing the respective names.

DEATH-RATE FOR SMALLPOX
(In 100,000 of population—1875-1889)

BERLIN,	1.16
HAMBURG,	0.74
BRESLAU,	1.11
MUNICH,	1.45
DRESDEN,	1.03
Paris,	26.24
St. Petersburg,	35.82
Vienna,	64.90
Prague,	147.90

The following table, from Lotz, shows the relative mortality from smallpox, dysentery, and typhoid fever in two armies occupying adjoining territory:

DEATHS IN 1000

	PRUSSIAN ARMY	FRENCH GARRISON AT LANGRES
Variola,	**5.8**	**222.6**
Dysentery,	32.3	19.3
Typhoid,	118.8	86.6

In the Prussian army the prevalence of dysentery and typhoid indicates that the hygienic surroundings were probably no better than those of the French garrison, yet the difference in the mortality rate from smallpox is striking. Of 1700 patients with smallpox treated at the Municipal Hospital of Philadelphia during the epidemic of 1901–1902, not one was received who had successfully been vaccinated, as indicated by a characteristic scar, within a period of four years. The following data from the observations of Welch and Schamberg, at this hospital, show the relation of good, fair, and poor vaccination scars with the mortality; the vaccination having been done during infancy and the poor condition of a scar indicating either that the original vaccination was inefficient or that the protection had been exhausted by time:

	ADMITTED	DIED	PERCENTAGE
Vaccinated in infancy (good mark),	268	7	2.61
" " " (fair mark),	83	10	12.04
" " " (poor mark),	98	14	14.28
Vaccinated cases,	449	31	6.90
Unvaccinated,	465	131	28.17
Vaccinated after infection,	63	12	19.04
Total,	977	174	17.80

Method.—For vaccination, any unexposed portion of the body, not subject to muscular movement or friction, may be selected. As a rule, the surface over the insertion of the deltoid is taken. The skin should carefully be cleansed with soap and water and then with alcohol. Chemical disinfectants are not as a rule advisable, as a sufficient residue may be left upon the skin to destroy the vaccine. Having cleansed the skin the upper epidermic layers are removed and the moist mucous layer exposed over an area about 1 c.c. (one-half inch) square, by scraping with the vaccine point, or with a scalpel that has been sterilized by immersion for two minutes in boiling water. The moistened virus is then rubbed into the lesion. The abrasion should be very superficial and it is not necessary or desirable that blood be drawn.

Most of the protecting shields serve to collect dirt and pus and keep the skin macerated. They are best avoided. A non-constricting, ventilated shield may, however, be used for the first few hours. After the virus has been permitted to dry, a simple dressing consisting of several layers of aseptic gauze kept in place by strips of adhesive plaster and replaced as often as it becomes soiled, forms a suitable and efficient protection.

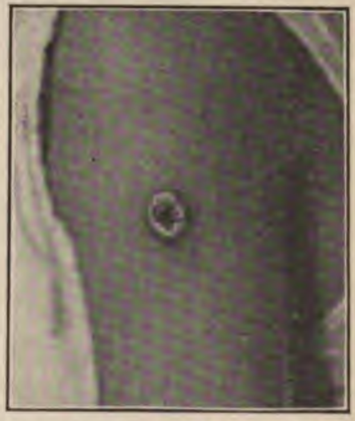


FIG. 74.—TYPICAL PRIMARY VACCINE VESICLE ON TENTH DAY.—(*From Welch and Schamberg.*)

Typical Vaccination.—As vaccine virus rapidly deteriorates and is often marketed when inefficient, it is important to distinguish the **typical lesion** and its **scar** from the spurious forms resulting from other local infections. Three or four days after inoculation a faint erythema, upon which develops a reddish papule, appears at the site of inoculation. The papule enlarges, projects, and by the sixth day is distinctly vesicular, loculated, and umbilicated. Two days later the contained fluid has become cloudy and opaque, giving it a pearly appearance. The surrounding skin becomes red, brawny, painful, and radiating reddish streaks may indicate the course of lymph vessels. The tributary lymphatic glands enlarge and are painful, and there may be a slight rise of temperature, chilliness, insomnia, anorexia, and malaise lasting from one to three days. Rarely, a generalized morbilliform eruption appears over the body. By the

Fig. 75.—Well-marked Result of Secondary Vaccination, Tenth Day. Lesions too Flat and Depressed for Typical Primary Vesicles.—(*From Welch and Schamberg.*)

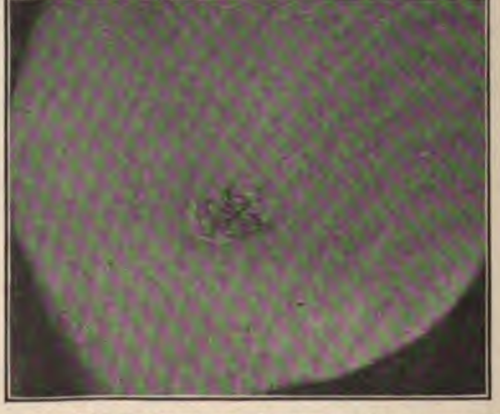


Fig. 76.—Secondary Vaccination of Doubtful Character, Twelfth Day, Followed by a Slightly Pitted Scar.—(*From Welch and Schamberg.*)

twelfth day a brownish depressed crust appears in the center and finally covers the entire lesion. This may not fall off for from three to four weeks. The remaining scar is pitted (foveolated) and may contain radiating ridges of scar tissue. The scar gradually pales, so that finally it has less color than the surrounding skin. **Secondary vaccinations** are often atypical, and frequently it is difficult to determine their true or spurious character.

Isolation and Disinfection.—The smallpox patient should be isolated; preferably in a special hospital situated remotely from other dwellings. All exposed persons should promptly be vaccinated and kept under surveillance for fourteen days. Their persons and clothing should be disinfected. Infected places and their contents should be disinfected with formaldehyde. Care should be taken to secure a relative cleanliness of the mouth and nasal passages of the sick and by use of ointments or antiseptic lotions to prevent the diffusion of the disease during the period of desquamation.

Rubella

(Rötheln, Roseola, German Measles)

Causation

German measles is doubtless a micro-organismal infection, but the specific agent has not as yet been determined. It has an incubation period of from fourteen to twenty-one days.

Diffusion.—The disease is apparently spread, as is measles, chiefly by close personal contact, and possibly also through the air, and at times by fomites.

Prevention

As the affection is mild, as a rule free from complications or unpleasant sequelæ, and as an attack usually confers future immunity, stringent measures of prophylaxis are generally considered less important than in the case of measles or other more serious diseases. Nevertheless there are in a small proportion of cases serious sequelæ or complications. The infected should be isolated and measures taken to disinfect the secretions of the nasopharynx. Contaminated articles should be disinfected or burned.

Measles

(Morbilli, Rubeola)

Causation

The source of this disease is believed to be the bacillus discovered in 1892 by Canon and Pielicke in the blood of patients. The micro-organisms were also found in the secretions from the mouth and nose. Behla reports the successful inoculation of a sucking pig by scratching the interior of its nose with a wire contaminated with the nasal secretion from a case of measles.

Diffusion.—The disease is extremely infectious, and when it gains entrance to a house or hospital it frequently affects the majority of the non-immune. The virus in a dry state is said to retain its infectivity for six weeks. The danger of infection begins in the last days of incubation, and persists during the eruption, subsiding when the exanthem has entirely disappeared. The period of incubation is from eight to ten days. The susceptibility to measles is greatest between the second and tenth year, but the comparative immunity of adults is probably largely due to previous infection, rather than to age. This is borne out by the experience in the Civil War; the urban regiments suffering very little from the disease, while a large proportion of the men from the rural districts contracted it. Doubtless this was due to the fact that most city children have an attack of measles. An attack most frequently protects from future infection. Repeated attacks are not usual, but, on the other hand, are not exceptional.

Prevention

The patient should be isolated and his secretions and all materials used in the sick-room carefully disinfected. During the period of desquamation the body should be anointed, and special care be taken that the particles of skin do not become scattered about.

For the early recognition of measles it is important to search for the spots upon the buccal mucous membrane, first described by Failtow in 1895, and the following year by Koplik. These consist of minute grayish or bluish papillæ, encircled by a red areola, and often appear in clusters opposite the bases of the upper and lower molars or on the inner surface of the upper lip. They appear from one to four days before the cutaneous eruption, and have been found in as high as 90 per cent. of cases of measles, and rather rarely in rubella, follicular angina, and stridulous laryngitis.

Scarlet Fever
(Scarlatina Scarlet Rash)

Causation

The specific micro-organism causing scarlet fever has as yet not been demonstrated. The organism that was described by Cass has not been satisfactorily confirmed. Streptococci are usually present, and these seem to be the cause of the angina. Persons between the ages of three and eight years are most susceptible. In babies under one year of age scarlatina is rare, and it is also uncommon in persons over ten years of age. It is more common in winter than in warm weather. An attack is followed by distinct immunity, so that second attacks are very rare. The period of incubation varies from two to twenty-four days.

Diffusion.—The infectious material was shown to reside in the saliva by the experiments of Stickler,* who in an effort to produce an immunity against the disease, inoculated 10 children with the saliva from a patient with scarlatina, to which he had added $\frac{1}{600}$ part of carbolic acid. All of the inoculated children promptly developed scarlet fever. Although these experiments were not performed with all the desirable precautions, they yet seem quite conclusive. It is commonly believed that the desquamated epithelium contains the virus; but this as well as the infectivity of the blood has not been proved. Clinical experience suggests that the virus may be transferred directly from the patient's body or from articles with which the patient has been in contact, and that fomites may remain dangerous for months. Aerial infection has also been claimed, but there is little evidence to support this. Chambers,† in 1865 spoke as follows: "Although I must allow that a great many instances have occurred of scarlatina spreading, yet as a rule we are able to retain the patients in the general wards without its doing so by the simple practice of allowing a space of 8 to 10 feet between the scarlatinous bed and the next. So that, without expressing an opinion as to the propriety of admitting scarlatina into a general hospital, I do not think the matter of sufficient importance to exclude them by law." Although it would now justly be considered reprehensible to place patients with scarlet fever in a general hospital ward, the extensive experience of this eminent clinician suggests at least that the danger of aerial infection is slight. It must be remembered, however, that particles which are expelled within a short radius of the patient in coughing, sneezing, and speaking are decidedly dangerous. Until transmission by fomites has been disproved, these should

* "Medical Record," N. Y., Sept. 9, 1899.

† Lectures: "The Renewal of Life," Phila., 1866.

be regarded as infectious, and all materials that come in contact with the patient should carefully be disinfected.

Prevention

Isolation of the sick, anointing of the patient's skin, scrupulous disinfection, care on the part of physician and attendants, and the general sick-room precautions elsewhere described, comprise the necessary preventive measures.

TYPHUS FEVER

(Ship Fever, Jail Fever, Putrid Fever)

Causation

The micro-organism responsible for this highly contagious disease is unknown. A number of the great historic epidemics and pandemics, such as the plague of Athens, were probably typhus. It attacks especially those living under the unfavorable influence of poverty and insanitary surroundings, and those crowded into unhygienic quarters. Men are somewhat more seriously affected than women.

Diffusion.—Typhus fever is usually spread by close personal contact. Doctors and nurses, therefore, are especially liable to infection. Rarely are those affected who are not in immediate proximity to the sick, and even here a prolonged and repeated close association is often necessary. While it is believed that infection may occur through clothes worn by the sick or other fomites, or through a third person, this mode of conveyance is probably very rare. With abundant supply of fresh air the danger of diffusion is much less. Debilitating conditions apparently favor infection.

Prevention

Patients should promptly be isolated in well-ventilated quarters, preferably in tents. It is important that those who wait on the sick be well fed and kept from overfatigue and from prolonged and very close attention to their charges. All articles in contact with the sick should be sterilized according to the methods described, and after recovery the rooms should be thoroughly disinfected by formaldehyde or other efficient agent.

CHAPTER XVII

CUTANEOUS INFECTIONS

General Considerations. Parasitic Skin Diseases. Toxic Infections—Tetanus, Hydrophobia. Septicemic Infections—Anthrax, Malignant Edema. Purulent Infections—Erysipelas, Furuncle, Carbuncle, Phlegmon. Gangrenous Infections—Hospital Gangrene, Noma. Granulomatous Infections—Tuberculosis, Leprosy, Madura Foot, Plague, Rhinoscleroma, Oriental Sore, Yaws.

General Considerations

Infections of the derma may or may not depend upon a previous lesion. Some of the animal parasites and the molds are able to penetrate the unbroken skin through the hair follicles or the glandular ducts, or directly through the epithelial layers. Bacterial infection occurs chiefly through wounds or abrasions, but in certain instances may also take place through the glandular ducts or hair follicles. Infection usually results from direct personal contact, but may be brought about also by contact with infected utensils or through conveyance by insects, especially lice, fleas, or flies. Pets and domestic animals may acquire the diseases and become foci of infection.

Many of these infections are favored by a lack of personal cleanliness and by overcrowding in ships, factories, tenements, lodging-houses, prisons, camps, and the like. The use by many persons of the same garments, towels, bedding, or lavatory utensils may result in epidemics of these diseases. They are thus often spread in schools, barracks, camps, bath-houses, barber shops, and similar places, not only from common use, but sometimes from contact of person or garments with contaminated articles. For these reasons they are apt to be more prevalent in the lower walks of life. All are preventable by the isolation and prompt treatment of the sick, the exclusion and destruction of insects, and by attention to domestic and personal hygiene.

MYCOTIC INFECTIONS OF THE SKIN

These conditions have so much in common as regards diffusion and prevention that they may be considered together.

Causation

The chief mycotic infections of the skin are **favus,** caused by Achorion schönleinii (Schönlein, 1839); **herpes tonsurans,** produced by Trichophyton tonsurans (Gruby, Malmsten, 1845); **pityriasis versicolor,** caused by Microsporon furfur (Eichstedt, 1846); **erythrasma, Dhobie itch,** and other tropical ringworms apparently due to Microsporon minutissimum. Other forms of molds, especially varieties of **aspergillus** and **mucor,** less frequently invade the skin. In the United States a number of serious skin lesions (**blastomycetic dermatitis**) produced by a yeast, as first described by Gilchrist, have been reported within recent years.

Diffusion.—Many of the molds affect also dogs, cats, cattle, horses, rats, and mice, and from these and from persons the disease may be conveyed by direct contact, by garments, towels, handkerchiefs and the like, and by vermin, especially lice, fleas, and bedbugs.

Prevention

Mycotic skin diseases are usually associated with uncleanliness and may be prevented by attention to the rules of personal hygiene, by the avoidance of association with animals and persons that are diseased, and by the destruction of vermin. Infected articles should be boiled, treated with formaldehyde, or destroyed by fire.

DHOBIE ITCH

Causation

The ringworms of the tropics are apparently due to a variety of micro-organisms. Manson is convinced that in many cases of Dhobie itch **Microsporon minutissimum** and not Trichophyton is the causal agent.

Diffusion.—The disease may be contracted from the lower animals or from human beings.

Prevention

The avoidance of contact with the diseased, the wearing of clean linen or cotton undergarments, which are changed daily, frequent bathing, and the use of borated dusting-powders upon moist surfaces, as the axilla and crotch, are advised.

TETANUS

(Lockjaw, Wundstarrkrampf [G.], Tetanos [Fr.])

Causation

Bacillus tetani (Nicolaier, 1884) is a large motile organism that tends to form resistant terminal spores giving the bacillus the shape of a drum-major's baton. The organism grows slowly, best at about the temperature of the body, and only under strictly anaerobic conditions. The virulence varies in different cultures and tends to become reduced upon prolonged cultivation.

The bacillus is found in garden and other earths, in dust and animal excrement, and also in the pus from infected wounds. In certain parts of the New Hebrides the soil contains these organisms in such large numbers that the natives poison their arrows with the earth. The spores are killed by a temperature of 100° C. for ten minutes, although prolonged heating at 80° fails to destroy them. They withstand drying for many months and are resistant to the usual antiseptics. They are not destroyed by the glycerin used to sterilize vaccine lymph. The most marked characteristic of the organism is the production of a toxin of tremendous power.

Diffusion.—The bacilli are found in the intestinal canal of horses, cattle, and even milk-fed calves, and are therefore common about stables. Although in the intestinal canal they seem to do no harm, the frequent occurrence of tetanus in horses shows that their presence there does not lead to immunity. The soil is contaminated through the use of manure, and animals may ingest the bacilli in grazing. Wounds made by nails, splinters of wood, or other substances about stables are especially dangerous. Animal products taken from diseased animals and used therapeutically may cause infection. Thus the use of antitoxin obtained from a horse with tetanus recently caused a serious epidemic in St. Louis. The studies of McFarland and others suggest that tetanus bacilli occasionally gain access to vaccine, and that at times the use of contaminated vaccine results in tetanus. Huddleston found the tetanus bacilli in the feces of eight per cent. of the calves used for the production of vaccine. Catgut, the so-called kangaroo-tendon (which is in reality taken from horses), and solutions of gelatin, have all conveyed the disease. Imperfect sterilization of such materials is therefore a source of danger. The inoculation of material containing the bacilli does not invariably cause tetanus, because the organisms cannot vegetate when too few in number, or when the associated conditions are unfavorable. Experimentally it is found that only when a sufficient number of tetanus bacilli are inserted with vaccine into an animal does the disease follow.

For infection to occur it is necessary that the bacillus gain entry through a lesion of continuity of the skin or mucous membrane. Experimentally it has not been possible to infect animals by feeding them with cultures of tetanus bacilli. Intravenous injection, however, produces the disease. As the bacillus does not grow in contact with oxygen, open and superficial wounds may contain it without any untoward effect, while penetrating and punctured wounds are especially dangerous. There is much reason to believe that the injection into wounds of cultures free from contaminating organisms will not invariably produce tetanus, as the tissues may contain sufficient oxygen to prevent the growth of the bacillus. As ordinarily introduced, however, there is a mixed infection, and the contaminating organisms may utilize the oxygen and thus favor the anaerobic development of the tetanus bacillus. The bacillus of tetanus remains at the seat of inoculation. The toxins produced are diffused by the circulation and have an especially injurious action upon the central nervous system.

Prevention

The disease may be prevented: (1) By a careful sterilization of all articles that come in contact with wounds. (2) By freely opening punctures or penetrating wounds, thoroughly cleansing them with solutions of potassium permanganate and hydrogen dioxid or other effective antiseptic, and keeping them loosely packed with gauze until healing occurs. In this way the wound surfaces are constantly exposed to oxygen and the development of the tetanus bacillus prevented. (3) By an artificial immunity produced by injecting certain substances antagonistic to the toxin, such as iodin trichlorid, or the blood-serums of certain artificially immune animals (tetanus antitoxin). The nucleo-histon from the thymus gland also destroys tetanus toxin. Finally subcutaneous injections of a 2 per cent. solution of carbolic acid, about the wound or elsewhere, may also have some inhibitory action. The direct injection of antitoxin into the cerebral substance is advocated, but the results obtained are not convincing. All of these measures have comparatively little efficiency after the development of trismus. The longer the incubation period, the greater the chance of recovery, irrespective of treatment. As to the therapeutic use of antitoxin, the reader should consult the section on the antitoxic serums in volume XI.

RABIES

(Hydrophobia, Lyssa, Hundswuth [G.], Rage [F.])

Causation

Rabies is an inoculable disease affecting man, dogs, cats, wolves, foxes, skunks, horses, hogs, cattle, and other animals. The precise causal agent is unknown, but is found especially in the saliva and spinal cord of animals affected. The virus becomes attenuated and finally is destroyed by drying. By drying the medulla of rabbits (the most virulent part of the body) it is rendered innocuous after fourteen days. With larger cords a proportionately longer time is required. The virus is also destroyed by a temperature of 50° C. (122° F.) for one hour, and by mercuric chlorid, phenol, acetic acid and potassium permanganate in the usual disinfectant strengths. The saliva of dogs may contain the virus two days before the onset of the symptoms. The parotids seem chiefly responsible for the virus in the salivary secretion. It has also been found in the lacrimal and mammary glands, but not in the blood.

Diffusion.—Practically the disease is transferred only by the saliva which is inoculated by rabid animals in biting. Bites made through the clothing, in which case the saliva may be wiped from the teeth, are less frequently accompanied by infection than those upon exposed surfaces. The incubation period in dogs, the animals usually transmitting the virus, is variable; the average being about eight weeks. There is first a stage of depression with loss or perversion of appetite; followed by a stage of excitation or madness, in which the animal utters hoarse howls and shows a desire to run hither and thither biting at every animal that may come in its way. After three or four days, exhaustion and paralysis occur, the mouth drips with bloody, foamy saliva, and death follows. In about one-fifth of the cases there is no excitation, but, instead, a condition of weakness followed by paralysis and death. The best method of quickly determining rabies in the lower animals is by microscopic examination of the pneumogastric ganglia. The distinctive changes found in the peripheral ganglia of the cerebrospinal and sympathetic system were first described by Van Gehuchten and Nélis. The virus causes the proliferation of the layer of endothelial cells lining the capsules, and finally their destruction and substitution by round cells. This examination may be completed within

FIG. 77.—PLEXIFORM GANGLION OF RABBIT DYING OF RABIES PRODUCED BY SUBDURAL INOCULATION. THE CAPSULES ARE FILLED OR PARTIALLY FILLED WITH FOREIGN CELLS.—(*McCarthy.*)

FIG. 78.—NORMAL GANGLION OF DOG.—(*McCarthy, reproduced from Crocq,* "Jnl. de Neuralgie," v, No. 13.)

six hours after the death of the animal. To insure distinctive lesions, it is best that the animal be permitted to die from the disease. The ganglia of the pneumogastric nerve, which is preferred, is hardened in alcohol or in 10 per cent. formalin, embedded in paraffin or celloidin, sectioned, and stained by hematoxylin and eosin. Ravenel and McCarthy report over 50 examinations without a failure. The slower and more positive method of diagnosis is to inoculate a portion of the medulla of the suspected animal under the dura of a rabbit. Rabies will develop in the test animal in from twelve to fifteen days, provided the first animal had the disease. In man the incubation period varies from two weeks to nearly two years, being apparently slower in depressed conditions of the system. Changes in the wound do not occur until the initial stage, when it becomes red, and burning or painful sensations develop. The diffusion of the virus in the animal body seems to take place through the nerves and spinal cord, as experimentally it may be arrested by dividing these structures. For this reason wounds of the trunk and of parts freely innervated are more dangerous than wounds of other parts of the body. Especial danger attaches to bites about the face and head, owing to the proximity to the medulla.

Prevention.—Although only about one-fifth of the bites of rabid animals are followed by hydrophobia, it is advisable that dogs be controlled by registration, be prevented from running at large during the warm months, or be compelled to wear muzzles. Should a person be bitten, it is first important to determine whether the disease was present in the animal inflicting the bite. The spinal ganglia should therefore be studied at once and subdural inoculations of the medulla made in rabbits. For these examinations the animal's head and neck may be removed, packed in ice, and shipped to a convenient laboratory. Should evidence of rabies be found, the person bitten may be given the prophylactic injections suggested by Pasteur. These injections depend upon the fact that the spinal cords of rabbits dead from rabies progressively attenuate when suspended in a dry atmosphere. About 3 c.c. (♏48) of an emulsion made from a cord that has been drying fourteen days are first given, and each day the injection is repeated, using the same amount of emulsion from a more recent cord, until upon the fifteenth day the patient receives that from a cord that has been drying only three days, after which he is considered immune. Should the wound have been inflicted about the head, treatment is pushed by increasing the strength of the virus more rapidly and repeating the process. In dogs the immunity produced by Pasteur's method has been found to last two years or more. The death-rate after this form of inoculation is about 0.77 per cent.

It is always wise promptly to cleanse and disinfect wounds inflicted by the teeth of animals even though there be no suspicion of rabies. Thorough cauterization with heat or stick silver nitrate is advocated.

ANTHRAX

(Wool-sorter's Disease, Milzbrand [Ger.], Charbon [Fr.], Malignant Pustule)

Causation

This acute contagious disease is caused by **Bacillus anthracis** (Pollander and Davaine, 1847), an organism producing highly resistant spores that survive drying for months, exposure to boiling water for several minutes, and the destructive action of many disinfectants. In the lower animals the disease is usually characterized by a general septicemia, the bacillus being found throughout the body, in the blood and organs. The excrement from those affected often contains blood and the specific bacilli.

FIG. 79.—ANTHRAX BACILLI IN THE BLOOD.

Diffusion.—In man anthrax is rarely acquired except by inoculation through scratches or larger wounds. This occurs chiefly in the handling of bodies of diseased animals and their products, such as hides, wool, and hair. More rarely an intestinal infection occurs from the ingestion of infected meat or milk, and, while uncertain, there is thought to be a pulmonary form of anthrax, apparently due to the inhalation of contaminated dust. Insects, including flies, fleas, and ticks, may carry the bacillus. At the point of inoculation a pustule usually develops, characterized by a central dark spot of necrosis, surrounded by an area of inflammatory edema and an eruption of vesicles. If not arrested, the organism may enter the blood and produce death. An associated infection with the pyogenic cocci seems to hinder the process.

Prevention

Animals may be prevented from contracting the disease by the prophylactic inoculation of cultures attenuated by heat as devised by Pasteur. The treatment occasionally proves fatal, but on the whole seems distinctly to reduce the tendency to charbon. For man care should be taken to avoid exposure to infected material. Diseased animals should be killed and their bodies buried deeply or burned. All discharges from them should be disinfected, preferably with a solution of chlorinated lime. Hair, wool, and hides or other substances that may be contaminated should be sterilized by steam, by boiling water, or by immersion in 5 to 10 per cent. solution of formaldehyde. All dressings, discharges, and instruments used in connection with cases of malignant pustule should carefully be disinfected.

SUPPURATION

Causation

The pyogenic or pus-producing micro-organisms include **Staphylococcus pyogenes, aureus, albus,** and **citreus; Streptococcus pyogenes** or **erysipelatis; Pneumococcus;** the **pneumonia bacillus, Bacillus aerogenes capsulatus; Bacillus pyocyaneus;** the **gonococcus,** and other organisms. Most of these organisms attenuate rapidly and are most dangerous when inoculated directly from a diseased animal, while those that have led a saprophytic existence may practically be harmless to the human tissues, provided the latter have not been injured. Wounds inflicted during necropsies upon infected bodies have a special danger, while dissection wounds made while working upon bodies that have long been dead are rarely seriously infected.

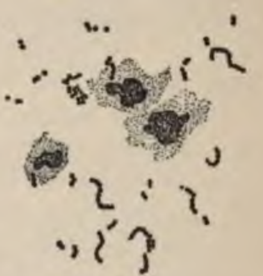


FIG. 80. — STREPTOCOCCUS PYOGENES IN THE PUS FROM AN ABSCESS.

Diffusion.—Staphylococci are usually present upon the skin and pyogenic organisms are frequently present in the mouth, nose, respiratory and intestinal tracts, and are also found in the lower animals and upon various utensils and articles of furniture. For inoculation a scratch, abrasion, or more serious wound is usually required, although the organisms seem able to invade the tissues through the sebaceous glands or hair follicles. The invasion of the subcutaneous tissues results in pustules, furuncles, abscesses, phlegmons, and suppurative sinuses. **Erysipelas** results from the action of the streptococcus. Infection is favored by conditions of local and general depression, and by certain diseases of a toxemic character, as diabetes. Through invasion of the blood, **pyemia** or **septicemia, septic endocarditis, nephritis,** or other grave complication may occur.

Prevention

The maintenance of the highest general nutrition, the observance of sanitary personal cleanliness, and attention to the rules of aseptic and antiseptic surgery in operative procedures, comprise the requisites of prophylaxis.

NOMA

(Cancrum Oris, Gangrenous Stomatitis)

Causation

This serious and rapidly spreading form of gangrene chiefly attacks the mouth, pudenda, and umbilicus. The specific bacterium is undetermined, and it is possible that any one of a number of micro-organisms may be causal. From the lesion **Streptococcus pyogenes,** organisms resembling the **diphtheria bacillus,** and the **colon bacillus** have been obtained.

Diffusion.—The disease occurs principally in children under five years of age, especially those convalescing from exhausting diseases, as measles, scarlatina, and typhoid fever. It seems to be due more to the diminished resistance of the patient than to the virulence of the micro-organisms, and therefore there is little danger of transmission to those who are well nourished.

Prevention

The chief feature of prevention is the maintenance of nutrition in those suffering from exhausting conditions. Care should be taken that there is abundance of fresh air and that the surface of the body and the upper respiratory tract be kept clean. At the onset the diseased area should be destroyed by caustics, supplemented by applications of formalin or Credé's silver products and frequent cleansing with mild antiseptic solutions.

HOSPITAL GANGRENE

Causation

This grave contagious form of gangrene attacks wounds of those debilitated by disease, insufficient nourishment, and overcrowding, especially when treated without aseptic precautions. It was formerly prevalent in army hospitals in times of war,—least frequently, however, in field or tent hospitals,—but, under the modern treatment of wounds, has practically been eradicated.

The precise cause is uncertain, but probably is a **streptococcus** or other bacterium that has acquired intense virulence through repeated cultivation in the human body.

Diffusion.—The disease is spread from wound to wound by means of instruments, fomites, solutions, insects, or the hands of hospital dressers.

Prevention

The disease does not exist where the well-known aseptic and antiseptic precautions are taken in surgical practice. Wounds infected by this process should be cleansed carefully, swabbed with strong solutions of potassium permanganate, with bromin, with formalin, with pure nitric acid, or with carbolic acid followed by alcohol. A protective antiseptic dressing is then to be applied.

GANGRENOUS ULCERS

Phagedenic and chancroidal infections may take place through lesions in any part of the body and give rise to rapidly spreading gangrenous ulcers. The secretions from such ulcers should be disinfected carefully and the causal organism destroyed by penetrating antiseptics such as those advised for hospital gangrene.

LEPROSY

(Elephantiasis Græcorum)

Causation

Lepra is a chronic, progressive, and inflammatory disease, caused by **Bacillus lepræ** (Hansen, 1880), and characterized by nodules in the skin, subcutaneous tissues and internal organs (**lepra nodosa**), and nerves (**lepra anæsthetica**). The bacillus of leprosy resembles the tubercle bacillus in form and in staining peculiarities, but it is not curved, is more readily stained, is found in large clumps in the tissues, and is not readily susceptible to artificial cultivation, while inoculation experiments upon the lower animals have proved unsatisfactory.

Diffusion.—The bacilli are found in enormous numbers in the cutaneous lesions, including the scales of the skin, and in secretions from the nasopharynx and mouth. They have also been found in the urine and milk of patients. The usual mode of transmission is obscure. As the lesion frequently develops first about the nose, it has been thought that inhalation may be a mode of infection. Leprosy may apparently be transmitted by direct inoculation. A condemned criminal into whose body bits of leprous tissue were inserted by Arloing eventually developed characteristic lesions. Instances in which the disease seems to have been conveyed by vaccination have been reported. Although the accuracy of these observations has been criticized, there is no evidence disproving the importance of inoculation as a factor in transmission. The incubation period has a duration of many months or years, rendering it difficult to determine the time or mode of infection. The bacillus may be transmitted by flies, and Morrow maintains the importance of sexual congress as a method of infection. Jonathan Hutchinson believes a fish diet to be largely responsible, but this has not been proved. Leprosy attacks people between twenty and forty years of age, children being rarely affected. There is no proof of the hereditary transmission of the disease, nor are cases of its development in infancy often reported. Leprosy is probably somewhat less easily transmitted than tuberculosis.

FIG. 81.—BACILLUS LEPRÆ.
From a section passing through a subcutaneous node particularly rich in the large lepra cells. The bacilli lie in the lepra cells, many of which are vacuolated, as well as between them.

Geographic Distribution.—Leprosy is present along the coast lines of tropic countries, being common in China, India, Syria, Sandwich Islands, Spain, and Portugal, but also in Scandinavia, Norway, Sweden, Iceland, and portions of Russia. The disease shows little tendency to spread in North America, although there is a small leper colony in Louisiana, and one in New Brunswick.

Prevention

The isolation of lepers has been practised from the remotest antiquity, and it is still considered the most important factor in the prophylaxis of the disease. Children born of lepers should at once be removed from their parents and placed amid healthful surroundings. Not only have the bacilli been found in various secretions of patients, but also in rooms and upon the furniture occupied by them. Care should be taken by cleanliness, abundant lighting, and ventilation, to render these homes as sanitary as possible. Secretions and discharges from leprous sores should be disinfected and rendered inaccessible to flies and vermin. Sexual intercourse between lepers and the healthy should strictly be interdicted.

MADURA FOOT

(Pied de Madura [Fr.])

Causation

This is a chronic, local, infectious, inflammatory disease, caused by **Actinomyces** (or, as formerly termed, **Streptothrix**) **maduræ** (Vincent, 1894), and characterized by the development, usually on the plantar surface of the foot or palm of the hand, of slow-forming inflammatory nodes ('buttons') tending to degenerate with the production of discharging sinuses. Natives of India are chiefly affected, infection often following thorn-pricks. The nodes are dark and congested, at first firm, but becoming soft from degenerative changes. The fungous masses in the discharged pus appear as dark 'gunpowder grains' (**dark** or **melanoid mycetoma**) or light 'salmon-roe' grains (**pale mycetoma**). The organism grows slowly, resists drying for months, and forms spores that are not killed by heating at 75° C. for five minutes (Novy).

Diffusion.—Infection apparently results from inoculation, which is usually attributed to the pricks of thorns and other sharp instruments.

Prevention

The discharges from granulomatous growths should be disinfected carefully, and, in regions where the mycetoma occurs, care should be taken to protect the feet and hands from injury. Should accidental wounds occur, they should immediately be disinfected and covered by a moist antiseptic dressing. Should the disease develop early, aseptic operative intervention is indicated to prevent its spread.

MALIGNANT EDEMA

(Malignes Œdem [Ger.], Septicemie Gangrene Gazeuse [Fr.])

Causation

Bacillus œdematis maligni (Pasteur, 1887) is a motile, flagellate, sporogenous, obligative anaerobic organism, growing rapidly at the temperature of the body. Its virulence varies, but is well retained when artificially grown, and the pathogenic effects are greater when it is associated with other organisms, as Bacillus prodigiosus, Bacillus proteus vulgaris, and the like.

Diffusion.—The bacilli are found in garden soil, in manure, and in discharges from infected animals. Certain clays in the New Hebrides contain so many of these organisms, together with that of tetanus, as to be used by the natives for poisoning arrows. The bacillus almost invariably gains entrance through wounds, although rag-picker's disease has been attributed to inhalation of this organism; apparently from confusion with the anthrax infection.

Prevention

This consists in the prompt cleansing of all contaminated wounds. Punctured wounds should be opened freely and cleansed thoroughly. The wound may be cauterized by pure carbolic acid followed by alcohol, and circumferential hypodermic injections of a 2 to 4 per cent. solution of carbolic acid be given. As an attack does not protect against subsequent infection, there seems little hope of the development of a successful prophylactic inoculation.

PLAGUE

(Black Death, Pest)

Causation

Bacillus pestis bubonicæ (Yersin and Kitasato, 1894) is a small cocco-bacillus, subject to variation in shape, being without motion, flagellate, asporogenous, and optionally anaerobic. It grows at the ordinary room-temperature, readily attenuates, succumbs to prolonged exposures to the temperature of the body associated with dryness, is killed by a moist heat of 58° C. (136.4° F.), and may be destroyed by the ordinary germicides. Rosenau has shown that when dried it remains alive under a heat of 19° C. (66° F.) for long periods, but soon dies at the body-temperature, even in the presence of albuminous matter. It is destroyed by direct sunlight associated with a temperature of over 30° C. (86° F.) within a few hours, but this action is not very penetrating. The virulence is usually lost before the vegetative power. It is therefore unlikely that dry fabrics or first-class mail harbor the infection for any length of time if free from contaminated vermin. In milk, cheese, and butter it may live for a long time, but usually dies rapidly on the surface of fruits and prepared foods. Although not a water-borne infection, the organism long withstands submersion. The bacillus has been found in dust and earth by Yersin and in salt field-water and excreta by Hankin. Although of feeble resistance, it may remain alive for many months in moist soil that is protected from the rays of the sun.

Diffusion.—Except in cool or damp climates there seems to be little danger of disease conveyance by fomites.

Plague is usually contracted by direct inoculation, by ingestion, or more rarely by inhalation. Infection through the intestinal canal seems to be rare in man, but occurs in the lower animals. The disease is epidemic, and certain lower animals, especially rats, have much to do with its distribution. They become infected by feeding upon diseased animals, from contaminated earth, and also possibly through insects. Flies were found by Nuttall to die from plague, and Simmons's experiments suggest that fleas may transmit the disease, at least from rat to rat. It is believed that these insects may convey the infection to man. While there is no evidence that the bites of mosquitos, lice, or bedbugs inoculate the disease, these insects may contain the micro-organisms, and scratching of their bites or crushing them upon the skin may cause inoculation.

FIG. 82.—BACILLUS PESTIS BUBONICÆ IN THE PUS OF A BUBO.

Prevention

Patients and those exposed should be isolated. Nurses or attendants rarely contract the disease and infection during the performance of autopsies does not usually occur except through lacerations of the skin. The most important prophylactic measure seems to be the destruction of all vermin. The use of Haffkine's prophylactic, which is injected in doses of about 3 c.c., seems of value in reducing susceptibility. The prophylactic of Lustig and Galliotti seems less useful. It occurs in powdered form and injections containing about three milligrams are used. These inoculations should never be used after the development of plague, as they may intensify the disease. In such cases the antiplague serum of Yersin, the dose of which is about 5 c.c., may have some value. It also produces a partial immunity that is much more fugacious than that produced by the prophylactic inoculations.

RHINOSCLEROMA

Causation

Bacillus rhinoscleroma (Frisch, 1882) is a non-motile, sporogenous, facultative anaerobic organism closely resembling Friedländer's pneumonia bacillus, than which it is less pathogenic. By its irritation persistent plaques or nodular masses affecting the nose, palate, and pharynx are produced. The disease is not very infectious. The mode of **diffusion** is obscure, and therefore the measures of **prophylaxis** must be empirical. Both sexes are affected, infants and the aged less frequently.

ORIENTAL SORE

(Biskra Boil, Aleppo Boil, Delhi Boil, Bagdad Boil)

Causation

Oriental sore is a contagious, inoculable, granulomatous ulceration, characterized by an initial papule, that is transformed into a slowly spreading granulating ulcer, healing after many months with the production of a pale, depressed, and disfiguring scar. The cause is obviously micro-organismal, but the precise agent is unknown. It affects chiefly uncovered parts of the body, all races of men and some of the lower animals being susceptible.

Diffusion.—The disease is most prevalent in the Orient, especially in urban life, but has also been observed in South America. It is most frequent at the transition from the warm to the cool season. During certain years the majority of the people may be affected. Apparently it may be spread and inoculated by biting insects.

Prevention

Improved sanitation seems to decrease the spread of this disorder. During epidemics care should be taken to prevent susceptible persons from being bitten by flies or insects.

To prevent unsightly scarring of the exposed portions of the body, inoculations have to a limited extent been employed upon young people by Jews in the Orient. An attack usually secures future immunity.

YAWS

(Parangi)

Causation

Yaws is an inoculable, chronic, granulomatous disease of tropic climates, characterized by a pale furfuraceous desquamation, from which develop granulomatous incrusted papules from one-half to several centimeters in diameter. It occurs in tropic Africa, Ceylon, the West Indies, and the islands of the South Pacific. The disease may last for weeks or years and finally disappear with but slight marking. A micro-organismal cause is evident, but has not been precisely determined.

Diffusion.—The disease is very contagious and there is reason to believe that it may be spread by insects. Filthy habitations in which the diseased have lived, are apt to be sources of infection. All ages and classes seem to be susceptible. Men are more apt to contract the disease than women. It is not hereditary or congenital, but may be transmitted by direct inoculation through the skin.

Prevention

Patients suffering from yaws should be isolated, their discharges and secretions disinfected, and measures taken for the exclusion and destruction of insects. Houses occupied by patients should be disinfected or destroyed by fire, and attention given to the hygienic cleanliness and sufficient nutrition of those exposed.

CHAPTER XVIII

CIRCULATORY INOCULATIONS

Malaria. Yellow Fever. Dengue. Filariasis; Elephantiasis; African Lethargy. Relapsing Fever.

General Considerations

These diseases may experimentally be produced by inoculating the blood of the sick into the well. So far as is known, they are conveyed by suctorial insects, especially mosquitos. Although not proved, the possibility of infection through the alimentary tract has been claimed, and in the case of some of these diseases has not been refuted. There is no conclusive evidence that they are spread by fomites, household utensils, or close personal contact.

Preventive measures are chiefly to be directed against mosquitos and other insects, which are to be kept from biting both sick and well and so far as possible to be destroyed. It is important that the diagnosis of these diseases be made early, and that the patient be defended promptly from insects, especially mosquitos, fleas, lice, and bedbugs.

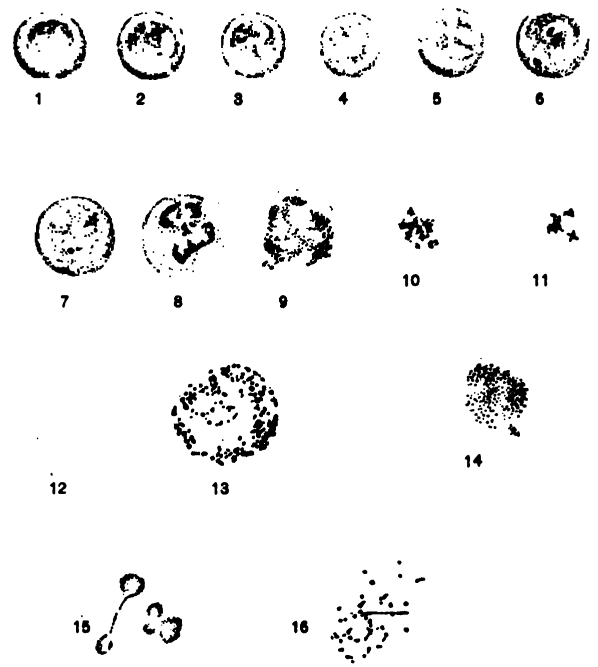
MALARIA

Causation

The cause of malaria is an animal parasite belonging to the protozoa, of the class Sporozoa, order Hemamœbida. It is commonly called **Plasmodium malariæ.**

Diffusion.—The intermediate host of this parasite is man; the definitive hosts, mosquitos of the genus Anopheles, and possibly certain other insects. In man the parasite invades the red blood-corpuscle, appearing as an active ameboid body. It grows, absorbs the pigment of the corpuscle, becoming pigmented itself, and finally upon reaching full growth segments, so that the corpuscle contains large numbers of spores. The rupture of the corpuscle liberates these spores, which enter other corpuscles, and the cycle of develop-

PLATE I.



The Tertian Parasite.

1. *Normal erythrocyte.*
2, 3, 4, 5. *Intracellular hyaline forms.*
6, 7. *Young pigmented intracellular forms.* In 6 two distinct parasites inhabit the erythrocyte, the larger one being actively ameboid, as evidenced by the long tentacular process trailing from the main body of the organism. This ameboid tendency is still better illustrated in 7, by the ribbon-like design formed by the parasite. Note the delicacy of the pigment granules, and their tendency toward peripheral arrangement in 6, 7, and 8.
8. *Later developmental stage of 7.* In 7, 8, and 9 enlargement and pallor of the infected erythrocyte become conspicuous.
9. *Mature intracellular pigmented parasite.*
10, 11, 12. *Segmenting forms.* In 10 is shown the early stage of sporulation—the development of radial striations and peripheral indentations coincidentally with the swarming of the pigment toward the center of the parasite. The completion of this process is illustrated by 11 and 12.
13. *Large swollen extracellular form.* Note the coarse fused blocks of pigment. (Compare size with that of normal erythrocyte, 1.)
14. *Flagellate form.*
15. *Shrunken and fragmenting extracellular forms.*
16. *Vacuolation of an extracellular form.*

Note.—The original water-color drawings were made from fresh blood specimens, a Leitz $\frac{1}{12}$-inch oil-immersion objective and 4 ocular, with a Zeiss camera-lucida, being used.

(From Da Costa's "Hematology.")

(E. F. Faber, *fec.*)

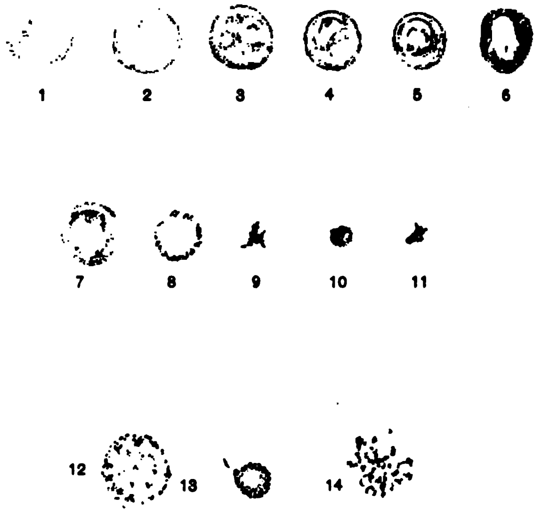
ment is repeated. The length of this cycle varies. In the tertian form it is about forty-eight hours, in the quartan seventy-two hours. The quotidian form is apparently due to the development of two sets of parasites. This cycle of evolution may or may not be repeated indefinitely in the blood. According to the observations of S. Solis Cohen, there is also a larger cycle of thirteen days, the nature of which is not clearly made out. If a single subcutaneous injection

FIG. 83.—ANOPHELES PUNCTIPENNIS. A HOST OF THE MALARIAL PARASITE.—(*Howard.*)

of ten or fifteen grains of quinin-and-urea double hydrochlorate be made just before or after a quotidian or tertian paroxysm, the patient will usually remain free from paroxysms for six and a half or thirteen days. This observation is to be correlated with the experience underlying the old clinical injunction to repeat doses of quinin at intervals of seven days for two or three months after recovery; and with the observations of Italian physicians on 'fourteen-day ague.' In some persons the parasites appear to be driven from the peripheral circulation into the spleen or other viscera, and to have an annual or semiannual cycle of reappearance. Cohen has reported this in several cases in which reinfection could apparently be excluded, and a similar observation was made in the experimental disease produced in the case of Dr. Manson's son. When infected blood is taken by the mosquito into its stomach, **flagella** develop upon some of the organisms, separate from the parent cells and fuse with certain other non-flagellate forms supposed to represent the female parasite. The fertilized organisms then invade the wall of the stomach and finally locate under the outer wall of the gastric muscles. They rapidly increase in size and are known as **zygotes.** Clear spaces appear on their surfaces, and these are rapidly surrounded by minute spindle cells known as **blasts,** which increase in number, until the entire

FIG. 84.—RESTING POSITION OF ANOPHELES.—(*From Howard.*)

zygote is filled, whereupon it bursts and the blasts are liberated from the muscular wall of the stomach into the body-cavity of the mosquito. The blasts show active movement and rapidly penetrate the tissues to the salivary gland, from which they may be discharged with the secretion into the animal next bitten by the mosquito. When inoculated by the mosquito into man, the sexual form of sporulation does not occur, but the simple non-sexual evolution previously described takes place. Although the name 'malaria' must be maintained, the labors of a host of observers have entirely disproved the theory that it embodies. The affection is not due to air or effluvia from swamps, marshes, or other damp or unwholesome places. It is possible to live in the most malarious regions without the development of the disease if care be taken to guard against mosquito bites.



THE QUARTAN PARASITE.

1. *Normal erythrocyte.*
2. *Intracellular hyaline form.*
3. *Young pigmented intracellular form.* Note the coarseness, dark color, and scantiness of the pigment granules.
4, 5, 6, 7. *Later developmental stages of 3.* Note the peripheral distribution of the pigment in all the parasites from 3 to 8. (Compare size and color of the erythrocytes in 5, 6, and 7 with 7, 8, and 9, Plate I.)
8. *Mature intracellular form.* Note that the stroma of the erythrocyte is no longer demonstrable.
9, 10, 11. *Segmenting forms.* In 9 are shown the characteristic radiating lines of pigment. (Compare with 10, 11, and 12, Plate I, and with 10, 11, and 12, Plate III.)
12. *Large swollen extracellular form.* (Compare with 13, Plate I.)
13. *Flagellate form.* (Compare with 14, Plate I.)
14. *Vacuolation of an extracellular form.*

(From Da Costa's "Hematology.")

(E. F. FABER, *fec.*)

Prophylaxis

The prophylaxis of malaria consists in the prevention of inoculation by mosquitos. The measures that have been advised are:

1. The destruction of the breeding-places of the mosquitos.
2. The prevention of mosquito contamination either by isolating from mosquitos those persons afflicted, or by rapidly removing the parasites from the peripheral circulation through the administration of quinin.
3. The withdrawal to a distance of from five to six miles from localities where cases of malaria are present.
4. The prevention of the multiplication of infective parasites by the continuous use of small doses of quinin.

The general methods for mosquito extermination have been referred to. Koch believes that infected children are especially liable to cause the continuance of the disease, and advocates the general use of large doses of quinin in all persons affected. It is considered that doses of quinin of less than 1 gram (15 grains) are insufficient for adults, and the effect is greatly strengthened by giving full doses several days running. Therefore, even after cessation of acute symptoms, 1 gram of quinin is ordered to be given two mornings in succession and to be repeated after an interval of nine days. This treatment must be continued for at least two months, and better three months, for until then one is not safe against relapses. In cases in which the parasite persists, 1 gram (15 grains) of quinin is given daily for three days running, and the interval of omission reduced, if necessary to seven days. In convalescence from quartan, which is well known to be the most obstinate form of malaria, quinin should be given three days running from the first. If ineffective by the mouth, the subcutaneous medication must be resorted to. The patient should not be considered noninfectious until on repeated examination the blood is found free from malarial parasites. Children under six months may generally be given one decigram (1½ grains), and older children more, according to their age. They generally stand quinin in comparatively larger doses than adults, so that a child of five or six years may be given one-half gram (7½ grains) with safety. Quinin by the mouth is most effective if given when the stomach is empty, therefore before breakfast. In the experience of the editor, the best form of the drug, and especially for subcutaneous injection, is quinin-and-urea hydrochlorate. When used hypodermically, care is necessary to inject the solution deeply into the subcutaneous tissues, and to avoid dropping any of it upon the skin in withdrawal of the needle. The point of puncture is to be painted with tincture of iodin or iodoform-collodion. The quinin is continued until examinations of the blood prove freedom from the parasite. Unfortunately in the malignant quartan and the estivo-autumnal types of malaria, the forms that are associated with the greatest danger, any form of quinin may fail to rid the blood of the parasite. Methylene-blue has proved effective in a small proportion of cases and arsenic is of value in certain forms of the chronic infection. Daily doses of from 2 to 5 grains of quinin have been found to protect newcomers in malarious districts. Children and those living in malarious neighborhoods may show a partial or complete immunity.

YELLOW FEVER

Causation

Yellow fever is due to a parasite, presumably animal in nature, but as yet undemonstrated. The causal relation of the bacilli described by Sternberg, Havelburg, and Sanarelli, respectively, has been disproved. Whatever the cause, it resides in the patient's blood during the height of the disease, and may be transmitted to the well by direct inoculation of the blood or by indirect inoculation through certain forms of mosquitos and possibly other insects as yet unknown.

Diffusion.—There is much reason for believing that, as long since suggested by Finlay, the mosquito **Stegomyia fasciata** is the chief factor in the spread of yellow fever. This is borne out by the occurrence of the disease in tropic and subtropic climates where these mosquitos are active; by its disappearance upon the onset of cold weather; and by other peculiar features in its transmission. Moreover, the American Yellow Fever Commission has distinctly proved that yellow fever may be conveyed in this way, and the disease was eradicated from Havana only when measures against mosquitos were enforced.

Prevention

As the mosquito is evidently the chief agent in the transmission of the disease, the important measures of prophylaxis are:

First, to prevent the contamination of the mosquito by the careful screening of persons infected.

PLATE III.

THE ESTIVO-AUTUMNAL PARASITE.

1. *Normal erythrocyte.*
2, 3. *Young hyaline ring-forms.*
4, 5, 6. *Intracellular hyaline forms.* In 4 the parasite appears as an irregularly shaped disc with a thinned-out central area. In 5 and 6 its ameboid properties are obvious.
7. *Young pigmented intracellular form.* Note the extreme delicacy and small number of the pigment granules. (Compare with 6, Plate I, and with 3, Plate II.)
8, 9. *Later developmental stages of 7.*
10, 11, 12. *Segmenting forms.*
13, 14. *Crescentic forms at early stages of their development.*
15, 16, 17, 18, 19. *Crescentic forms.* In 15 and 19 a distinct "bib" of the erythrocyte is visible. Vacuolation of a crescent is shown in 18, and polar arrangement of the pigment in 17.
20. *Oval form.*
21, 22. *Spherical forms.*
23. *Flagellate form.*
24. *Vacuolation and deformity of a spherical form.*
25. *Vacuolated leucocyte apparently enclosing a dwarfed and shrunken crescent.*
26. *Remains of a shrunken spherical form.*

(From Da Costa's "Hematology.")

(E. F. FABER, *fec.*)

Second, to protect the well from mosquito bites by the use of screens, nets, or other measures; and

Third, to destroy mosquitoes so far as possible by methods previously described or others to be discovered hereafter.

Heretofore fomites have been considered to play the most important rôle in the transmission of yellow fever, yet the facts that the American Commission after repeated attempts were unable to convey the disease in this way, that it rarely affects nurses and physicians or those who make autopsies or handle the diseased tissues, together indicate that fomites are comparatively unimportant. Pending more absolute proof, however, that they may never be a source of danger, the usual care should be taken in disinfection of all articles that come in contact with the patient. Finally, attention should be directed to the value of sulphur and pyrethrum fumigation of infected houses and rooms, as well as of ships and cargoes and of traveling coaches, not so much as a means of killing the parasite, but for the purpose of destroying mosquitoes. The repression of yellow fever in New Orleans through the sanitary measures enforced by Butler, and its disappearance from Memphis after the institution of Waring's drainage system, are matters of history, pointing to the importance of civic cleanliness as well, even if its special value in this connection shall prove to be merely its deterrent influence upon the propagation of insects.

DENGUE

(Breakbone Fever, Dandy Fever)

Causation

The observations of Graham * suggest that dengue is due to an animal parasite that invades the red blood-corpuscles. This organism resembles the plasmodium of malaria, and the parasite of Texas cattle fever. It has a longer cycle of development than the parasite of malaria. The organisms were found in over 100 cases in which the blood was examined.

The disease is limited to warm climates, especially the West Indies, the southern United States, the northern regions of South America, and more recently it has been observed in portions of Syria, Asia Minor, Turkey, and Australia. It is especially a coast

* "Medical Record," Feb. 8, 1902.

disease, rarely occurring in mountainous regions. It is usually arrested by cold weather. During the summer season it may invade the temperate zone. It affects all ages and all classes of people.

Diffusion.—Graham found that the spread of the disease apparently did not take place, despite close personal contact, in the absence of mosquitos. Of four healthy young men exposed to the bites of mosquitos taken from beneath the mosquito nets of patients affected with dengue, three contracted the disease. Similar mosquitos were permitted to bite persons in a mountain village where no cases of dengue had ever been observed, with the result that these persons contracted the disease. These experiments were made in Syria with a variety of Culex. The fact that dengue does not tend to spread from certain low regions, and is not carried to the highlands, is also in favor of the theory of mosquito transmission. The disease diffuses along lines of travel and is carried by ships.

Prevention

Hitherto, prophylactic measures have been of little avail owing to the wide and rapid spread of the disease and to the difficulty of isolating the sick from the well. With the evidence that this is a mosquito-borne disease, we have a rational method of prophylaxis in the screening of the sick and general measures to destroy all mosquitos, as elsewhere described.

With few exceptions, an attack is followed by an immunity which apparently is not persistent. In certain regions, there is a tendency for the disease to become pandemic about once in twenty years.

FILARIASIS

The diseases enumerated by Manson as resulting from Filaria nocturna are **abscesses, lymphangitis, varicose veins, varicose groin and axillary glands, lymph scrotum, cutaneous and deep lymphatic varix, orchitis, chyluria and hematuria, elephantiasis of the leg, scrotum, vulva, arm, mamma** and of other parts; **chylous dropsy of the tunica vaginalis, chylous ascites, chylous diarrhea,** and probably other forms of disease depending upon the obstruction or varicosity of the lymphatics or upon the death of the parent filaria.

Diffusion.—So far as is known, a mosquito of the genus Culex is the chief agent for the diffusion of filarial diseases. The insect becomes infected by sucking the blood of a diseased animal. After metamorphosis in the body of the mosquito, the minute worm enters the body of the definite host while the mosquito is biting. In this animal, filaria live in the lymph-vessels and produce embryos that invade the peripheral blood while the patient is resting, returning to the lymphatics during the hours when he is active. The most serious condition resulting from these parasites is the lymphatic obstruction they so often produce.

Prevention

Measures of prevention should be directed chiefly against the mosquito, as in the case of malaria. Quinin, however, is not similarly applicable. Thymol and ammonium-formaldehyde may prove to be of use.

AFRICAN LETHARGY

(Sleeping Sickness of the Congo)

Causation

Filaria perstans has been found by Manson in the bodies of a number of patients. The disease occurs chiefly in tropic West Africa and probably also in British Guiana. It is characterized by a progressive lethargy and drowsiness, usually ending in death. If the disease be due to filaria, as suggested by Manson, the chief prophylactic measures are those directed toward the prevention of bites of insects, especially mosquitos, or contamination of the drinking-water.

RELAPSING FEVER

Causation

Spirillum obermeieri (Obermeier, 1873) is constantly present in the blood of those affected. It is motile, asporogenous, and does not grow upon the usual artificial culture-media. In blood it may remain alive for days. It is rapidly destroyed by heating, by the dilute alkalies, by acetic acid, and by the usual antiseptics.

Diffusion.—The disease may be transmitted by inoculating the blood secured from an affected person. The usual method of transmission is probably through the agency of insects such as bedbugs, mosquitos, and the like. The probability that the disease is spread by insects is strengthened by the fact that no other method of transmission than that by inoculation has been demonstrated, and that infection seems to be favored by filthy surroundings and has chiefly spread in ships, 'slum' lodging-houses, jails, and other places where the beds are used by many persons and are often infested with vermin. By inoculating blood secured from bedbugs that had bitten a patient, the disease has been transmitted. It is found chiefly in certain tropic climates, but also epidemically in Germany, Scotland, and Ireland. It has been almost unknown in the United States, except as an importation limited to the infected immigrants. It prevails especially in the cool months.

Prevention

Special attention should be paid to the destruction of insects and vermin, and from these, all persons afflicted, as well as the healthy, should be isolated.

CHAPTER XIX

VENEREAL INFECTIONS

Gonorrhea. Syphilis. Chancroid. Ulcerating Granuloma of the Pudenda.

The venereal infections include those specific and inoculable diseases that are chiefly transmitted by sexual contact. Each one is dependent upon a specific micro-organism, and in the case of each, infection may be acquired accidentally or experimentally without sexual contact. These affections are with difficulty produced in the lower animals, and it is improbable that they are conveyed or harbored by other animals than man. It is true, however, that an affection resembling syphilis occurs in horses. The spread of venereal diseases has a direct relation to illicit sexual indulgence, and were it possible to abolish prostitution it is probable that these formidable affections would then be swept from the globe.

The measures thus far advocated to check their ravages are based upon two general plans. In the first, vice is considered as responsible for venereal disease, and educational and other measures are taken to maintain sexual purity. Thus far this has not been effectively consummated. In the second, illicit sexual indulgence is considered as an unavoidable evil, and by licensing, inspection, the isolation and treatment of the infected, or other measures, the attempt is made to limit the spread of disease through prostitution. Against this plan there are many objections. The moral effect upon a community of recognizing illicit intercourse as an unavoidable evil is undoubtably bad. By increasing the safety of illicit intercourse the fear that deters from immorality many persons of both sexes not actuated by higher moral principles, is removed. The inspection of prostitutes for purposes of certification is a repulsive business for a self-respecting physician. Moreover, efficient inspection is very difficult to enforce, while the eradication of the disease in the infected is ofttimes a task of Sisyphus. Erichsen mentioned the case of a woman who after remaining for a year in a lock hospital imparted gonorrhea to the first man with whom she had intercourse.

Gonorrhea and syphilis often persist throughout life, and, worst of all, perverted types are found that, finding themselves infected, vow vengeance against the opposite sex and seek satisfaction in spreading the disease from which they suffer. If all the infected of both sexes could be isolated during the period of overt symptoms, a measure of protection might be afforded; but this is evidently impracticable. As it has been shown that contagion is more apt to be spread from young than old prostitutes, it is urged that the age of consent be changed to twenty-one. The necessity of rigorously prosecuting those guilty of proxenitism is obvious. Were it possible to limit venereal disease to the immoral and vicious, the problem would be simpler and less serious. Unfortunately, the sins of the guilty are frequently visited upon the innocent.

Conditions Influencing Infection.—Venereal diseases are usually difficult to cure, and gonorrhea and syphilis may be communicated months or years after gross signs have disappeared. It is noteworthy that sexual contact with the diseased does not invariably convey infection. By attention to cleanliness, and by the use of frequent antiseptic douches, a diseased woman may repeatedly fail to convey infection. Similarly the man who avoids a prolonged sexual embrace, who promptly employs local ablutions, especially of an antiseptic character, and who escapes abrasions may repeatedly fail to become infected. On the other hand inoculation may follow a momentary sexual contact without intercourse.

GONORRHEA

Causation

Diplococcus gonorrhœæ (Neisser, 1897) is a 'semmel-' or biscuit-shaped diplococcus—the flattened or concave surfaces being in apposition—usually occurring in groups within the leukocytes and epithelial cells. It is non-motile, asporogenous, grows best at about the temperature of the body, and seems to be killed easily by a temperature over 50° C., by drying, and by the usual antiseptics. It affects chiefly the mucous membranes, especially of the urethra, bladder, vagina, conjunctiva, and rectum. At times it invades the blood and affects the serous membranes lining the heart, blood-vessels, or joints, as evidenced by gonorrheal endocarditis and gonorrheal arthritis or synovitis. The large serous cavities are much more resistant, but a few instances of gonorrheal peritonitis are recorded. Gonorrheal pleuritis has been suspected. As a rule, the lower animals are immune.

Diffusion.—Inoculation results from the contact of the diplococcus with mucous membrane. This occurs chiefly by coitus, but may also be brought about through hands, handkerchiefs, or other articles soiled by gonorrheal discharges. Except in the cases of autoinfection, as when the conjunctiva is infected in one with specific urethritis, this mode of conveyance is rare. We have observed one instance in which the infection was apparently due to the use of a urinal in a hospital ward. Gonorrheal ophthalmia may occur in the new-born by infection derived from the vagina of the mother.

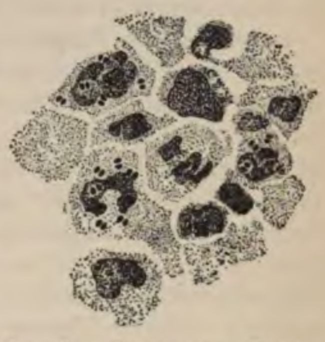


FIG. 85.—DIPLOCOCCUS GONORRHŒÆ IN PUS FROM THE URETHRA.

Prevention

The chronicity of gonorrhea is one of the chief obstacles to its eradication and prevention. This is especially true when it affects mucous membranes covered by a squamous epithelium or with communicating glands. In the deeper layers of such membranes the diplococcus may persist for many years, producing slight symptoms, or none, and yet capable of inoculating healthy mucous membranes.

Unfortunately, the contention of Noeggerath that gonorrhea in men as well as in women is a life-long affection too frequently is true; thus wives are often infected by husbands who believe themselves to have been cured long since. The chief difficulty is in ascertaining when the disease is actually at an end. The cessation of a urethral or vaginal discharge affords no evidence that the diplococcus may not still be present in the deeper layers of the affected epithelium. In such case an indulgence in beer (the beer test), coitus, or other dissipation, or the injection of an irritating solution, such as silver nitrate, may produce a return of the discharge in which the characteristic diplococcus will be found. For men the so-called two-glass test is valuable. The urine is passed in two portions, and the first, which washes out the urethra, will often show whitish threads or filaments (Tripperfäden) if the disease is present, while the second will be clear. No patient should be discharged as cured until these threads have definitely disappeared from the urine and until no gonococci are found in the secretions after the injection test. It is almost impossible to eradicate the disease when the deep urethra and its tributary glands are involved. Such persons may be a source of infection for years.

In women the diagnosis is often difficult. The gonococci tend to lurk about the urethra and the ducts of the glands of Bartholin and the cervix, but the micro-organism is rarely found, unless there be an associated discharge. A red macule ('*flea-bite*') at the orifices of the ducts from Bartholin's gland is very suggestive of the presence of gonorrhea. Mere inspection may be worthless, and even microscopic examinations are of little value in cases in which there is no objective symptom. Gonorrheal infection of the Fallopian tubes is usually considered as incurable, except by surgical ablation, and it is likewise difficult to eradicate the disease before it has invaded the uterine cavity. Thus patients may be infected, all symptoms may subside, and years later they may even reinfect the first infector. The greatest care should be taken that all discharges are promptly disinfected.

To prevent **ophthalmia neonatorum,** all children born of infected mothers should immediately be treated by the Credé method, which consists in instilling one or two drops of a 2 per cent. solution of silver nitrate into each conjunctival sac.

SYPHILIS

(Lues, Pox, the Specific Disease)

Causation

Syphilis is a chronic, acquired or inherited, generalized, contagious disease, characterized by a primary lesion (**chancre**) at the seat of inoculation; by multiple, superficial, homologous secondary lesions (**secondary syphilides**) affecting chiefly the skin, mucous membranes (mucous patches), and lymphatics (indolent bubo); and by deeper non-homologous and more destructive tertiary lesions (**gummata**). The specific cause is evidently a micro-organism (bacillus of van Niesson?).

Diffusion.—Infection results from contact of an abraded surface with the materies morbi, directly, as during coitus, or indirectly, as by use of a utensil contaminated by the secretion from a primary or secondary lesion, or the blood during the secondary stage. Tertiary lesions are probably not infectious.

The chancre usually appears about three weeks after inoculation, the secondary lesions in from six to twelve weeks, and the tertiary manifestations two years or more after inoculation. This course may be modified or atypical. In rare instances there may be no primary lesion; in many it escapes notice. The physiologic secretions, excepting possibly the semen and the ova, are not virulent, but are frequently rendered infectious through the presence of lesions; thus, the saliva is often virulent from the presence of mucous patches in the mouth. The blood, the primary lesion, the secondary lesions, diseased mucous membranes, and the secretions through secondary ulceration are all infectious. Tertiary syphilis rarely is transmitted.

Syphilitic women often abort from lesions of the endometrium, deciduæ, or placenta. As a rule, an apparently healthy mother will not be infected by her syphilitic child (Colle's law), nor will an apparently healthy child be infected by the syphilitic mother that has borne it (Profeta's law).

Hereditary syphilis may be derived from either parent; its manifestations may be congenital, occur in early childhood, or be delayed even so late as the third decennium. Late hereditary syphilis is often overlooked.

Extra-genital infection (*syphilis insontium*) may result from the use of various infected utensils, as knives, forks, cups, glassblower's tubes, wind-instruments, pipes, surgical instruments and the like, that have been used by or upon those with lues. Physicians in examining or operating upon syphilitic patients have acquired the disease through abrasions in the hands, or, conversely, syphilitic physicians may transfer the disease to patients. The use of saliva in tattooing, in the rite of circumcision, or in dressing the umbilical cord may produce inoculation. Syphilis has in rare instances been conveyed in humanized vaccine virus, a danger that has been obviated by the general employment of the bovine lymph. Wet-nurses may convey or receive the disease.

Prevention

As the infectious material is derived chiefly from the primary or secondary lesions, these should be healed as rapidly as possible. For this reason it is important to institute vigorous constitutional treatment promptly in all persons whose associations render them likely to convey the disease to others. All discharges should be disinfected carefully and mercurial ointment or other antiseptic kept constantly applied to the cutaneous lesions. The patient should be cautioned against kissing, and against the use in common with other persons of any article, even household utensils, that he might contaminate. Mercurial treatment or treatment with mercury and iodids should be continued for at least two years.

To guard against unrecognized syphilis, not only surgeons and dentists, but also barbers, chiropodists, and manicures, should be required to disinfect their instruments after these have been used upon each person. In restaurants, bar-rooms, and similar places, dishes, glasses, and other utensils should promptly, after use, be placed in boiling water. Individual communion cups should be provided by churches. As public fountains and the like cannot be guarded, one should avoid using them except under absolute necessity, and then be careful to rinse the cup as well as possible and to avoid bringing the lips in actual contact with it. Care should be taken of telephone mouthpieces, and, in using public instruments, to avoid actual contact of the mouth. Similar precautions are necessary in the use of any other common utensil. Indeed, the use of public drinking-cups, towels, and the like might well be abolished. In operating upon syphilitics, surgeons should wear rubber gloves and be careful to avoid any surface abrasion. Should such occur, it should at once be disinfected by a strong sublimate or formaldehyde solution.

Marriage should not be considered for at least three years after the development of the initial lesion, or until two years have passed free from all symptoms; during the last six months of which probationary period no treatment should have been in progress.

ULCERATING GRANULOMA OF THE PUDENDA

Causation

The specific organism of this disease is unknown. Whilst usually affecting the pudenda, from which it tends to spread slowly over large areas, it may also be inoculated in the mouth and other parts. It is a disease almost impossible to eradicate. It affects especially negroes in British Guiana, West Indies, China, Australia, and other tropic countries. Rarely, Caucasians are affected. It occurs between thirteen and fifty years of age. Women seem especially predisposed.

Diffusion.—So far as is known, the disease is spread by direct inoculation and apparently through sexual intercourse chiefly.

Prevention

Those affected should be treated energetically and all discharges disinfected. According to Manson, complete excision when practicable offers the best chance of a permanent cure. Close personal contact of the infected and the well should be prevented.

PART II

CIVIC HYGIENE

BY

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PART II

CIVIC HYGIENE

CHAPTER I

THE CITY

Site and Plan—Open Spaces. Roadways—Street-cleaning. Nuisances—Noises; Offensive Trades. Buildings—Public Offices; Tenements; Roof-gardens; Recreation Pavilions.

The ancient city was principally important as a political center and as a base for military strategy; the modern city is a collection of people operating under corporate franchises and embodying highly complex business and social relations. The three great cities of the ancient world, Jerusalem, Athens, and Rome, were by no means indifferent to the problems of hygiene, but most of the cities of modern Europe have been evolved from medieval towns, and are embarrassed by many defects: narrow and crooked streets, unprotected water-supply, insufficient sewerage, badly lighted houses, and want of open spaces. The foresight of the founders of a few American cities has avoided some of these evils, but the great sanitary and engineering problems are of too recent development to have had much influence upon any established community.

As the last census of the United States shows that the tendency of population is strongly toward city life, it is evident that questions of civic hygiene and civic government are likely to be among the most important issues of the twentieth century. The influences of a modern populous city are primarily largely unfavorable to health. The impervious roadways exercise no disinfecting action upon animal excreta; the illuminating gas, the scarcity of healthy vegetation, the restriction of sunlight, and the want of free air movement depress the bodily functions. By judicious application of principles of biology and engineering, many objectionable features may be ameliorated, and, hence, even in imperfectly planned and badly managed cities, the death-rate is not noticeably larger than in many country districts. Part of this favorable result may be due to the greater variety of medical skill available in cities and the promptness with which attendance is furnished.

SITE AND PLAN

The **position** and **street plan** of a city have much to do with its comfort and healthfulness. Unfortunately, commercial and manufacturing interests usually determine location, and political boundaries limit the extension. Although these questions are, therefore, of little more than theoretic interest, it will not be amiss to discuss them briefly.

Position

The proximity of a large body of **water** exercises a favorable influence by moderating temperature in both extremes, favoring regular rainfall, furnishing abundant water-supply, and, by no means least, affording opportunities for aquatic sports and recreations. An elevated position is, of course, advantageous, but usually impracticable for trade purposes. Bodies of water subject to much tidal action are rather disadvantageous on account of liability of large tracts of land to be alternately covered and bare, which leads to formation of marshy areas. Similarly, great irregularity of ground is a disadvantage, causing difficulty in sewer construction and damage from heavy rainfall, besides so interfering with the water distribution as to affect indirectly house hygiene. Modern research has shown that stagnant water is objectionable for other than mere esthetic reasons. Where there is much irregularity of level, the extension of streets and railway embankments is sure to establish ponds which become foul and offensive. The best location would seem to be a plateau inclining slightly to a bay or lake, with the shore a few feet above high-water level, and backed at a moderate distance by a range of forest-clad hills.

Street Plan

It needs no argument to show that **wide streets** are of the first importance in a city plan, but it is far from advisable that such streets should be desert areas of impervious paving. The mid-street should be **sodded** and planted with **trees** of low growth. High trees along the curb or close to the houses are far less satisfactory, for they shade the latter unduly. Dwellings need sunshine. Street lines should as far as possible be so **oriented** as to secure some shade throughout most of the midsummer day and some sunshine throughout most of the midwinter day. Philadelphia, an example of a city planned largely by intelligent, individual will, is in several respects well laid out, but the alignment of its numbered streets is such as to cause much midsummer discomfort. In this respect **curved streets** are often better than long straight ones, although the latter are more in favor with municipal engineers as affording imposing vistas. At the same time, the convenience of business must not be overlooked, and **diagonal streets** are needed. Washington, D. C., is a good example of an ingenious arrangement of street lines.

All streets, large or small, should be thoroughfares; that is, be open freely at each end. Blind alleys are highly objectionable.

Open Spaces.—One of the most serious defects in the plan of large cities is the lack of **open spaces.** This lack is not met wholly by the location of large parks on the outskirts, nor even by small ones, so-called squares, at intervals in the built-up portions. The need is not merely for neat lawns, fountains, gravel walks, trees, and statues; **playgrounds** for children are wanted. The ordinary square is a pleasant place, if the police supervision is sufficient to keep away loafers and beggars, but the health of children between five and fifteen years of age, especially boys, requires playgrounds in which active play can go on without risk to property or passers-by. These **'commons'** should be at frequent intervals, and may with advantage be partly shaded, but not cultivated. On the outskirts of a growing city such spaces are often temporarily available in the form of lands waiting for the realization of the unearned increment, but these are too often dumping-grounds for rubbish, the abode of squatters, or the resort of rowdies. Not infrequently, the tract is below grade, and collects stagnant water. To make commons serviceable in the cause of public hygiene they must be under police control, but as free as possible for the intended purposes.

Of course, the development of a municipality along the lines above indicated cannot be expected until a more active interest in local affairs is exhibited by the citizens. It is not opportune to consider such a question here, but in leaving the subject, it may be observed that much of the difficulty would be avoided by thorough reform in the methods of taxation and assessment of property.

Roadways

The manner of **constructing and maintaining streets** is of great importance in sanitary engineering. The original roadway, "built on Adam's plan and not Macadam's," and often merely a narrow path blazed through the forest, had serious disadvantages for transportation, but its absorbent surface acted as a disinfectant for animal excreta. The modern turnpike, and, still more, the impervious city street, offer no such compensating condition, and hence the need for more careful supervision. A useful regulation is to limit heavy traffic to certain streets. The boulevard system of Chicago is an example of this. The numerous parks of that city are connected by a system of ornamental avenues, restricted as to traffic. Wide streets are essential, but the cost of paving and maintenance, apart from the land values involved, is such that municipalities are loath to construct them. The paving and maintenance expenses may be materially lessened by the plan noted elsewhere—namely, occupation of the middle of the street by a sodded area with low trees, broken at intervals by paved paths for convenience in crossing.

The rapid development in the practicability of mechanical appliances for transportation leads to the hope that at no very distant day the horse will be a stranger to city streets, and in such a case marked sanitary benefit will result; for, apart from the objectionable character of the horse-droppings, the abolition of stables will probably be attended with a notable diminution in the breeding of common flies. There is little doubt that the house-fly is more than a mere annoyance (see pages 135 and 136), and it appears from some recent investigations of the entomologists of the U. S. Department of Agriculture that these insects breed largely in horse-manure. The traffic roadway may then be paved with the concrete materials used for footways, the employment of rubber tires will eliminate noise, and there will be little difficulty in keeping the streets clean. Since it will be a long while before these Utopian conditions will be realized, the immediate problem is to minimize the dangers of present conditions.

Street-cleaning.—The nonabsorbent nature of the usual street paving renders constant cleaning necessary. Few cities exhibit satisfactory work in this line, because the business is sacrificed to political intrigue. The best method is that called the '**block system,**' in which an individual workman is assigned to each short section of a main street and connected substreets, and the cleaning is carried on at intervals during business hours, the materials being deposited in suitable receptacles with as little agitation as possible. In one of the later methods on this plan, the cleaner uses a barrow containing a frame holding a canvas bag. The sweepings are dumped into this bag, and can be transferred from this to a larger receptacle. The block system is expensive.

Sweeping machines are much used. The street is sprinkled, the dirt collected in windrows, and these shoveled into carts. Much filthy dust is usually produced, and if the operation is conducted during business hours, a serious and dangerous nuisance is occasioned. Street-sweeping by machinery should be performed at night, but is always, unless great care be taken, a defective method. Each detachment of machines should be under the supervision of an inspector, as the low-class laborers who do the work are usually indifferent to any consideration of sanitation or efficiency.

The removal of snow is a difficult and important question. No one who has lived in cities in which heavy snowfalls occur needs any description of the offensive conditions that develop in the winter season. Traffic requirements cause the snow to be thrown into banks along the curb line, thus obstructing the flow of surface water, interfering with the collection of ashes and garbage, and interrupting street-cleaning. Street railway companies are prime offenders, as their sweeping machines scour the track-ways closely and throw the filth onto the pavements, and even over pedestrians. The use of **salt** along the lines of rail, except at special points, has been forbidden in many cities, but this ordinance is often violated more or less openly, depending on the 'pull' that the company has with the city authorities. There seems to be no reason for regarding the use of salt as dangerous to health, provided the surface of the street is perfectly drained. Objection to its use was originally made on the ground that it caused diphtheria, but such a view would not now be advanced by well-informed persons. If the drainage lines to the sewers and inlets were kept fully open, the use of salt would not be attended with any sanitary danger. Under ordinary conditions the only way of removing snow is to cart it to the outskirts of the city or dump it in the harbor. A speedy and thorough removal of snow is essential to good municipal management. Stringent regulations should be made against throwing any kind of refuse upon the snow as it lies in the streets. One incidental advantage of abundant open spaces in cities, especially the 'commons' noted on an earlier page, is that these afford room for the disposal of snow, since in the inclement season they will be needed less for play or rest.

NUISANCES

City Noises

The noises of a city are numerous and often distressing, but it is not proved that they are directly injurious to health except in specially sensitive persons. In fact, the influence of noise is governed by habit; the regular denizen of a busy city is at first disturbed by the slight but unfamiliar sounds of the rural districts.

Some city noises are unavoidable under present conditions, but many others are wholly unnecessary and should be repressed. Among the latter are the blowing of locomotive and mill-whistles, the ringing of church bells and of fire-alarms, the performance of peripatetic musicians, the use of fireworks containing high explosives, and fast driving with wagons loaded with rattling materials, or with heavy wagons over stone pavements.

Offensive Trades

The offensiveness of trades may arise either from **noises, irritating emanations, dust and dirt production,** or, in rare cases, by operations which attract **vermin,** especially flies, rats, and mice. Occupations of this class need discreet management, for such industries are necessary to modern civilization, besides giving employment to many persons. Much may be done to diminish their offensiveness without seriously hampering their operations, but it is more satisfactory if entire series of offensive trades can be grouped in one section of a city and their detrimental influence thus be limited to those who are directly or indirectly interested in them.

One of the most offensive and persistent of city annoyances is the '**smoke nuisance.**' This is apt to defy abatement or limitation, for the greatest offenders are the steam railroads that often stretch their lines to terminals in the very heart of the city. Smoke-preventing appliances of satisfactory character are now obtainable, but they are not applicable to locomotives. It is probable that cities which suffer from this annoyance will have to await the invention of a highly economical electric traction system before the general abatement of the nuisance can be attained.

BUILDINGS

Public Buildings

In modern cities, a strong tendency is noted toward gathering all administrative offices under one roof. The 'City Hall' is a characteristic feature, and too often a monument of bad architecture and worse sanitation. One point has been shown in the experience of Philadelphia—namely, that it is inadvisable to locate the executive offices of the **health department** at the general building. In spite of all efforts, persons afflicted with contagious diseases will visit the office, and thus bring infection into the corridors and elevators. Moreover, the medical inspectors, constantly passing to and from infected localities, are a source of danger.

Tenement Houses

Tenement houses are in much disfavor among sanitarians, yet when constructed in a proper way and kept under supervision they ought to be as healthful as individual houses and more economical. Indeed, the attitude of the majority of persons on this question is largely a matter of nomenclature. Tenement houses are despised, while hotels, apartment houses, and flats are often approved; yet the difference is one of degree, not of kind.

Among the poorest classes of large cities, especially that portion of the population coming from southeastern Europe and Asia, a strong tendency exists toward serious overcrowding. Houses are sub-let to an extreme degree. In American cities perhaps the conditions rarely, if ever, reach that observed in some parts of Russia, where single rooms are sub-let in sections to separate families, but the actualities are bad enough. These tendencies cannot be overcome simply by affording to the poor the use of neat houses, at a low, even nominal, rent. The sub-letting will still go on. Of course, a landlord who is directly interested in the welfare of the poor may, by selection of tenants and personal supervision, control his own property, but such altruistic spirit cannot be counted as a notable factor in the improvement of the slums. The conditions must be met by recognizing the tendency and its cause, and directing the former, if possible, into sanitary phases.

It seems probable that benefit to both bodily and moral health (the latter by no means of slight moment) could be secured by the construction of large tenement houses. Several conditions must be met in these. As noted under "Hospitals," absolute fire-proof construction should not be attempted, but steel, cement, terra-cotta, and expanded metal now available will reduce the fire risk to a minimum. A central heating and lighting plant will further diminish the danger from fire. Dangerous fuels should be absolutely forbidden. The details of windows, ventilators, water-supply, and drainage are problems easily solved by architects and builders. Overcrowding must be controlled by not allowing less than a certain amount of space to a certain number of people, with absolute prohibition of sub-letting or taking lodgers. Such a tenement house should be located on a block bounded by four streets of fair width, with a central building for the power plant and other general appliances. There is no reason why any of the serious defects of the notorious New York tenement district should be repeated in such an establishment.

The desire to economize land will lead, unless restricted by building laws properly enforced, to the practical obliteration of yard-space, and serious sanitary disadvantages. Extreme instances of this are seen in the New York tenement district, a space of only 45 centimeters (18 inches) being in some cases all that has been allowed between the rear walls of back-to-back buildings.

Roof-gardens

The vast roof-space of modern cities goes almost wholly unutilized. In ancient times the house-top was an important part of the house, and the condition is maintained at present in the East. The older methods of construction of houses in most European and American cities, with strongly pitched roofs, difficult of access, prevented any utilization of the space; but in modern buildings the slope is slight and the manner of internal construction, especially the use of elevators, has brought even the highest roofs within convenient reach of the pavement. A large school-building in Philadelphia has the play-ground on the roof, which is protected by a metal cage to prevent anything falling into the street. The roof-garden as a place of summer amusement has found limited development in some of the largest cities; but what is needed is the general utilization of city house-tops as breathing and play places, especially for those who cannot go to the country or seashore in the summer, and who live in houses that have no yards, or but a small yard-space.

The general cultivation of gardens on the roofs of dwellings would have, in addition, a double advantage: it would afford interesting outdoor employment for some persons in the household and would aid in developing an interest in plant culture.

In **hospitals,** roof-gardens, and even open-air wards on the roof, will prove of great advantage in many ways.

Recreation pavilions along the harbor front are of much value for the poorer classes. They may be constructed without in any way interfering with commerce; in fact, usually facilitate it, for the street level of the wharf is utilized for all commercial purposes, while the recreation pavilion is on the upper floor, high enough to be out of the way of vessels and serving as a roof to the wharf proper.

CHAPTER II

MUNICIPAL HEALTH ORGANIZATION

Sanitary Authorities. Hospitals—Hospitals for Contagious Diseases. Quarantine. Notification. Control of Venereal Diseases.

SANITARY AUTHORITIES

For many years it has been customary to place the sanitary supervision of communities in charge of a special organization, most commonly a limited number of persons exercising definite legislative functions, and usually termed the **Board of Health,** and a regularly commissioned officer exercising executive functions, usually designated **Health Officer.** It is obvious that the medical profession should be well represented in any body exercising sanitary control, but it is far from necessary that such control should be wholly in medical hands. Considerable information as to the proper method of organizing such bodies can be gleaned from the history of the city of Philadelphia, which has had an active and well-organized health department for over a century, and which has passed through many phases of sanitary emergency. Probably the form of organization existing just prior to the adoption of the present city charter was the most efficient. At that time and for many years previously the Board of Health consisted of twelve members, of whom nine were appointed by the local judges and three elected by the city councils. The health officer and special quarantine officers were appointed by the governor of the State, and were subject to the orders of the Board. Several physicians were always among the membership. The plan seemed to work well and prevented the dominating influence of any political leader.

Boards of Health and health officers may, of course, exercise much favorable influence on sanitary conditions, especially if not extremists or abnormally indifferent to scientific methods. A very important part of their work is the collection and prompt publication of correct **vital statistics.** This is done in most cities of the civilized world, but unfortunately the classification of diseases is not uniform and the manner of indicating the locality of each death is often confusing to all but local experts. American cities are usually divided into wards, the boundaries and even the designations of which are determined by political or often personal impulses, and do not conform to geographic, industrial, or demographic conditions. The statistics are reported for each ward. Several cities, notably Chicago and Baltimore, issue with the reports an outline map, showing the location of important cases. The Chicago health authorities have divided that city into '**sanitary districts,**' and report the mortality in each of these, with appended figures as to total population. In this way the prevailing unsanitary conditions in any district are indicated clearly in the report. It would be, of course, a great step forward if, in addition to mortality statistics, the statistics of illness could be secured, but this is impossible under present conditions.

HOSPITALS

Public and private interests will be subserved by an arrangement of hospitals somewhat different from that which prevails at present. The exigencies of life in large cities render necessary small hospitals at many points for the treatment of bodily injuries and sudden illnesses, but many classes of cases, notably those of a mildly communicable character,—as, for example, typhoid fever and tuberculosis,—and also the so-called incurable cases, could with advantage to patient and community be cared for in buildings well outside of the built-up districts. With modern methods of transportation (and suitable vehicles), especially if the electric and steam railways were utilized, the sick could be carried several miles with less discomfort than formerly attended conveyance a few hundred yards. The rubber tire is one of numerous benefits of advance in mechanical construction.

Hospitals caring for actively **contagious diseases** should be placed in sparsely populated districts, and preferably well surrounded by trees, but it is not at all unlikely that, with improved methods of hospital construction, increased efficiency in disinfection, and more accurate knowledge as to the means of diffusion of contagion, cases of actively contagious diseases could safely be treated in a closely populated district. Present methods are, however, too defective to permit this. It has been proposed that the buildings for contagious cases should be made entirely of combustible material and completely destroyed after a few years' use.

In the construction of large **permanent hospital** buildings many points require special attention. Forced draft ventilation is the most satisfactory form. Absolute fire-proof construction is regarded by many architects as unattainable at present, but so-called 'slow-burning' construction is applied to large buildings. It would probably be best to dispense with cellars altogether, storage, heating, lighting, power, and laundry plants being placed in a separate building. If cellars are used, they should be largely above the ground level, well lighted and ventilated, and by rigid and frequent inspection kept free from rubbish. The walls and floors should be well cemented, so as to keep out rats and mice. Especial care must be taken to prevent these animals entering through ventilation shafts or abandoned pipes, wells, or drain connections. In all the wall and floor constructions above the cellar level the importance of preventing the inroads of rats and mice should also be kept in view, for they are carriers of infection not merely in their bodies, but through the agency of parasitic insects that inhabit their fur.

In the general construction of the hospital, especially in the kitchen, laundry, and power-house, in short, wherever warmth and dampness may occur, the danger from roaches, ants, and less common insects should be borne in mind. Crevices must be avoided wherever possible. Washstands, sinks, stationary tubs, and such appliances should be made in single pieces and set so as to leave no crevices between them and the wall and floor. As such ideal conditions cannot always be realized, methods of disinfection by steam, formaldehyde vapor, or insect powders should be provided. All rooms should be constructed with rounded angles and without cornices or fancy molding. Even the now popular picture-molding is objectionable. Board floors as ordinarily laid are receptacles for much dust and dirt. The hardwood close-fitting floors are better. Cement, expanded metal, glazed tile, terra-cotta, and other modern inventions in building material should be utilized as much as possible.

Every year adds to the appreciation of the importance of **light** and **fresh air** in maintaining or restoring health. It is true that the value of these agents has never been forgotten, but they have often been assigned a rather passive agency in therapeutics. We now know, however, that several forms of radiant energy identical with or accompanying light pass into and even through the animal body, and that such forms of energy are more or less antagonistic to microbes.

Hence the value of large open grounds around hospitals, pavilions, and sun parlors, and of the utilization of roof area.

It also seems probable that music has a favorable effect upon health.

Pay Hospitals for Contagious Diseases.—The growing appreciation of the importance of **isolation** in some forms of disease has resulted occasionally in severe restrictions, sanitary authorities insisting upon strict quarantine of houses or upon removal of the patient, and sometimes others of the family, to a hospital for contagious diseases. As such hospitals are almost always, under present-day methods, public institutions, treating mostly the poor and pauper class, well-to-do families are much distressed by the alternative presented of either shutting themselves up as prisoners in the house or going to a public institution where more or less objectionable features exist. To meet this emergency pay hospitals for contagious diseases should be established. They should be located well outside of built-up limits, wholly under private control, although it will doubtless be required that the local authorities most concerned shall have some authority over admissions and discharges, and power to enforce all necessary precautions in regard to disinfection of attendants and visitors, of mail matter and clothing, etc.

QUARANTINE

This term, originally applied only to restrictive measures in connection with commerce, is now extended to cover all methods for **prevention of direct contagion.** The original quarantines were, as the word indicates, detentions for forty days, a barbarous system which rarely accomplished the benefit expected. The rigor of the system has been gradually ameliorated until at the present time among enlightened nations it rarely constitutes a burden. Recent progress in knowledge of the manner of communication of disease leads to still further relaxing the procedure. It may be now assumed that few, if any, articles of cargo will convey disease. Even old rags, about which so much discussion has been held, are scarcely matters of concern for the quarantine authorities. It is not improbable that rags collected within a short distance of the point of their use or manufacture have conveyed **smallpox** and **itch,** but it has not been proved that rags carried on long sea-voyages have been the cause of any trouble. The fear of conveyance of **cholera** by such means can be scarcely maintained now. The personal effects, especially clothing, of infected persons are still regarded as dangerous, but in well-equipped quarantine stations the disinfection of such articles is easily accomplished and, therefore, but little detention should result.

The practice of detaining vessels for several days, for **observation,** as it is termed, is very objectionable. If infected persons be detected or suspected on any vessel, the proper plan is to remove all the crew and passengers, together with their baggage, to commodious and healthful quarters at the quarantine station, disinfect the places occupied by the crew and passengers, send the vessel to its destination, and discharge the cargo.

The liability of railroad traffic to extend disease creates a sanitary problem of great difficulty. In some parts of the United States, bodies of armed citizens have been stationed on all avenues of travel from an infected district, the so-called 'shotgun quarantines,' common during yellow fever outbreaks. No satisfactory method of dealing with railroad traffic from infected districts has been devised, although considerable attention has been paid to the question. The disinfection of ordinary freight is impracticable, but fortunately is not likely to be needed. The disinfection of passenger cars is secured only with such cost and delay as to amount to a suspension of traffic. Recent experiments have shown that even the liberal use of formaldehyde is of uncertain value.

A more important and difficult question is that concerning the prevention of contagion in **communities.** The intimacy that exists among persons of the same neighborhood, particularly among children, and the fact that several of the most dangerous communicable diseases may assume forms in which the symptoms are scarcely noticeable and yet the contagiousness be active, render the restriction of disease very difficult. All progress in this respect is hampered by the ignorance of the mass of the people and consequent indifference to the advice of medical authorities. Not a little interference arises from the indifference or even antagonism of professional politicians.

The establishment of **house quarantine** depends on **notification;** that is, transmitting to the central sanitary authority prompt information as to the location of the patient. It is obvious that such a system will be worse than useless unless it is uniformly observed, a result that can only be attained by the enforcement of penal statutes. The penalty is usually a considerable fine. Many difficulties are, however, encountered, even in the most intelligent and best-ordered communities. The recognition of reportable disease is the duty of the medical attendant, but all sorts and conditions of men and women will be found in the ranks of those practising medicine in a large city. Many persons do not consult a physician except for serious illness, and some of the most contagions forms of disease may be so slight as to be unnoticed. Failure to report is by no means limited to the more ignorant practitioners; educated and experienced persons often mistake diseases, and physicians may be willing to suppress a report and risk being mulcted in a fine rather than subject a wealthy patient to the annoyance of quarantine or interference by the health authorities. A serious difficulty of the notification system is the selection of the diseases. If all contagious diseases are to be included, it will be necessary to report many skin diseases, all venereal diseases, tuberculosis, and whooping-cough. Indeed, influenza and some common catarrhal affections might be in the same category. It seems improbable that any such searching system will be adopted. Some diseases are included not because of any possible contagiousness, but as an index of important sanitary conditions. Typhoid fever and malaria are in this class. The advisability of notification for tuberculosis has been much discussed among medical authorities for several years. It seems that the principal effect of such discussion on the community at large has been to develop an abnormal fear of the affection, and even to lead some sanitary authorities to unnecessarily extreme measures. Such notification, however, has a value similar to that in the case of typhoid fever—namely, as an index of sanitary conditions; and affords to health authorities opportunity to examine premises, institute sanitary reforms in house-arrangements, and give advice as to the means by which the danger of contagion may be lessened. Strict segregation of tuberculous patients or removal to a hospital does not seem to be required in most cases. It is generally believed that the contagion is spread largely by the sputum, hence the necessity of encouraging habits which will secure the destruction of this material. This principle has led to efforts in many cities to prevent spitting on the sidewalk and in public conveyances. It is doubtful if either of these practices has great influence on the distribution of the disease. The drying of the sputum and its exposure to sunlight probably sterilizes it rapidly; if it remains moist, the bacilli do not rise from it. The spitting habit, so common in American cities, must be corrected by appeal to the sense of decency and cleanliness and not by false alarms.

House quarantine may be carried out by simply placarding the house, as a warning to persons not to enter, or by establishing a guard and allowing no passing to and fro. The latter method has been extensively carried out in Philadelphia during the present winter (1901–02) in connection with smallpox cases, but it appears from some recent statements of experienced persons that it has not produced results beneficially commensurate with the hardships it imposes.

Isolation of those sick with contagious disease, with due precautions in the sick-room, and thorough disinfection of the house and its contents after the termination of the illness will usually be efficacious. When the disease is highly contagious (smallpox, typhus fever, plague) or when isolation and sick-room precautions are not likely to be fully enforced, the patient should be removed to a hospital, and the house and its contents, especially the clothing of the other residents, be disinfected. With smallpox, vaccination of all the residents and other persons that may have been exposed should be required, and these kept under such observation as will enable the authorities to determine the course of the vaccination. Persons refusing to be vaccinated should be placed for the incubation period in some detention ward.

Domestic animals, especially **house-pets,** are probably responsible for many cases of transmission of contagion, as are also the homeless cats and dogs so common in cities, and should not be overlooked in local quarantine. This source of danger will probably be best met by laws restricting the keeping of such animals, and by providing for the catching and killing of all homeless ones. The enforcement of such systems must await the development of a much more enlightened public sentiment than now generally obtains among the large mass of citizens.

The **restriction of venereal disease** has been the subject of much discussion among medical and sanitary authorities and of some legislation. Many persons favor a system of registration and examination of prostitutes, but this has not been shown to be of material advantage. It reaches only the regular prostitutes, leaving the large class of clandestine ones uncontrolled. Moreover, the detection of venereal disease in women is often difficult or uncertain, and since inspection can be made only at reasonable intervals, say, a week or ten days, infection may be fully developed between two examination periods. No system of control provides for restraining infected men except in the case of soldiers and sailors. Some authorities have suggested that brothels should be restricted to particular sections of a city, but while advantage in police supervision might thus be secured, it does not seem likely to be of sanitary benefit.

It is sometimes asserted that good may be done by spreading information as to the dangerous character of all venereal diseases, but while the fear of the effects of such diseases does have some deterrent influence, it is not great. Most men are willing to take the risks. The discovery of efficient preventive or rapidly curative measures would minimize the baleful effects of these diseases more than any disciplinary method, though they might operate unfavorably as regards general chastity.

CHAPTER III

FOOD-SUPPLY AND WATER-SUPPLY

Food-supply—Adulteration; Milk; Adulterants and Preservatives; Contamination with Pathogenic Organisms. Water-supply—Source; Pollution; Purification; Filtration.

FOOD-SUPPLY

The **adulteration of food** is a wide-spread evil, and no method of legislation has succeeded in dealing with it satisfactorily. Many forms of adulteration are probably more fraudulent than injurious, but enough of harmful abuse exists to awaken the active interest of sanitarians. Unfortunately, much nonsense has been uttered and written on this topic. Some eminent and influential sanitary authorities unfamiliar with the principles of physiology or pathology have pronounced positive judgments without good reason. Moreover, industrial, agricultural, and commercial interests control the law-making power, and hence reformatory legislation has somewhat of a bizarre character. It is not possible in the light of present knowledge to determine the extent or character of disease produced by food adulteration. In a few cases we have direct clinical evidence of the effect, as when poisonous elements are introduced into food articles by accident or carelessness. An instance of this was the series of **lead-poisonings** that occurred in Philadelphia from the use of lead chromate (chrome yellow) as a color-substitute for eggs. Another instance is the large number of cases of **arsenical neuritis** that lately occurred in England, in consequence of the use of an arsenical glucose in the making of beer. The latter incident illustrates very well the indirect and insidious manner in which food adulteration may cause injury to health. The so-called 'brewing-sugars' used as substitutes for malt were prepared by the action of sulphuric acid on starch or cane-sugar. By a change in the manner of making the acid, an appreciable amount of arsenic was introduced, which passed into the brewing-sugar and from this into the beer.

Leaving out these specific types, we may recognize the following injurious practices in general adulteration:

The **digestibility** or **nutritive value** of food is diminished in many ways: By **substitution,** as when cottonseed oil is put in place of olive oil, oleomargarin for butter, glucose for cane-sugar; by **dilution** with or without some concealing manipulation, as in watering or skimming milk, adding inert materials to flour; or by **addition of preservatives.** Food may be rendered harmful by direct addition of **poisonous colors or flavors,** but this source of danger is now less common than formerly. All data available seem to indicate that most of the synthetic (coal-tar) colors are of no sanitary significance in the quantities in which they are usually employed.

It seems probable that most harm is done by **unclean food,** using this term in a wide sense to include not only contamination with common dust and dirt, but with different living organisms ranging from bacteria to entozoa. Many of the dangers of this class are as yet not recognized with precision, some are wholly unsuspected, but a large number is now clearly known. No food article is more important from this point of view than **milk.** This, being taken, as a rule, raw, and principally by infants and invalids, becomes an active agent in the distribution of disease unless collected and transported under conditions of extreme care. For many years sanitary authorities have been concerning themselves almost entirely with the question of chemical analysis of milk and disputing about standards and limits of composition; but watering and skimming of milk are of trifling importance to the public health compared with the question of cleanliness.*

Milk may **convey disease** in several ways. **Specific** affections in the animal—for example, tuberculosis—may infect the milk; **contagious or infectious** diseases, as scarlatina or typhoid fever, among the persons on the farm may be carried by it. Typhoid epidemics from milk have been recorded in many places. In the warm season of the year milk improperly collected may become so rich in **putrefactive** microbes as to produce serious intestinal disturbance.

The only **protection** against these dangers is extreme cleanliness, and this condition can be maintained only by strict supervision. Experience has shown that neither the producers nor the purveyors of milk can be depended upon to exercise proper control. Even when they are willing to do so, they often do not have the necessary knowledge. Private enterprise has offered some successful examples

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*See also vol. VI, pp. 63 to 67.

FIG. 86.—COW STABLES.

of proper methods in milk production. The plan established by the Philadelphia Pediatric Society has been very satisfactory. This Society has made an agreement with certain milk producers to establish an expert inspection at regular intervals, and allows those who accept that inspection to use the Society's certificate.

The proper method of **milk production** is exemplified by the dairy at Thorndale, Pa. In this dairy constant supervision is maintained by veterinary surgeons, none but healthy cattle being allowed in the herd. The stables are so constructed as to be well lighted and easily ventilated. All milking is done in a special room not directly connected with the stable. Milk is passed into the cooling and bottling room through a filter; no direct personal communication between these two rooms is permitted. Farm hands are under supervision both as to personal habits, clothing, and home associations. The milking and bottling room can be sterilized with steam, if needed. All containers are regularly sterilized. A large pasteurizing apparatus is in use, by which a still more thorough protection is afforded. The annexed illustrations show these improved methods. (Figs. 86, 87, and 88.) The results of such reforms are notable. Clean milk keeps much better than unclean, and hence liability to the use of preservatives is avoided. It does not have the objectionable odor and taste of common milk. The wholesomeness, especially for infants' food, is far above that of the ordinary product. The possibility of distributing epidemic diseases is almost wholly avoided. The difference in quality between the two classes of milk is strikingly shown by the difference in bacteria present. The clean milk has usually less than 5000 microbe colonies to 1 cubic centimeter; common milk has usually over 500,000.

Ignorance in regard to the effects of many forms of adulteration has led to exaggeration of danger in some cases and undue minimization of it in other cases. As noted above, it is not probable, at least it is not proved, that the minute amounts of coal-tar colors commonly used are injurious. It is not yet established that all kinds of preservatives are hurtful. The elaborate researches of Tunnicliffe and Rosenheim, lately published, have failed to prove that any injury results, even to delicate children, from the use of food containing notable amounts of boric acid, borax, or formaldehyde. It is alleged, however, that fluorids are seriously harmful.

Among the common **adulterants** which are of uncertain effect, but likely in some cases to do harm, may be enumerated **glucose,**

Fig. 87.—Cooling and Bottling Room.

FIG. 88.—PASTEURIZING ROOM.

used largely as an adulterant for syrups, honey, and jams and jellies; **cottonseed oil, peanut oil,** and **sesame oil,** used as adulterants for olive oil; and **oleomargarin,** used as a substitute for butter and an adulterant for cheese. **Baking powders** are probably unwholesome, but it does not appear possible to decide which class of these is most objectionable.

The statements made above in regard to milk will apply to several other classes of food—namely, that **contamination** by filth or material from diseased animals will be more serious than changes in chemical composition by abstraction of some ingredient or addition of a make-weight or diluent. For example, as set forth in Part I of this volume, the distribution of typhoid fever by oysters grown in a sewage-laden estuary has been proved. A similar danger from many forms of **vegetables**—for example, salad and radishes—has been widely suspected. The numerous **parasites** which inhabit the tissues of our domestic animals are a constant menace. The liability to tapeworm and trichina has long been known; a less widely recognized danger is that due to the invasion of the digestive tract by the animal parasite, **Anchylostoma duodenale.** This is frequently introduced by ingestion of materials, especially water, that have been in contact with surface soil. In Porto Rico 1000 deaths in a month from this cause have been reported.

It will be noted that the foods which are most concerned in these effects are those that are eaten **raw and fresh** or very **slightly cooked. Thorough cooking** is a remedy against most infections. Long keeping or heavy salting has also a beneficial effect, but not nearly so marked as cooking. Brief exposure to low temperatures, even to that of liquid air, is of little advantage as a measure of disinfection.

WATER-SUPPLY

In modern municipal engineering **water-supply and sewerage** should be considered together. The difficulty of dealing with sewage is much increased by defective methods of water-supply. Unless careful supervision be exercised, water will be wasted, and sewage extensively diluted. For this reason the purveying of water by private companies will be often more satisfactory than when done by the municipality. This is well illustrated in the case of Philadelphia, which has become distinguished for its wastefulness, a result that has not inured to the advantage of the citizen in any way, but has prevented good sanitary control of the water and increased the expenses of sewer-construction. The statement sometimes made that water should be 'free' in order to encourage cleanliness is a mere piece of demagogery, mostly urged in defense of persons or corporations that wish to shirk their proper share of water-rents.

The tendency at the present day is to utilize **surface water** for city supply. In small communities common wells and springs or even rain-water may be sufficient; occasionally deep (artesian) wells will be available, but, as a rule, the abundance, uniform quality, and small proportion of mineral matter which are requisite for the best development of a mixed industrial community, will be found only in streams and fresh-water lakes. When a territory is unpopulated and undisturbed, it may be that surface water can be used without danger, but the practical issue is in reference to growing populations in civilized countries.

There are some erroneous views prevailing in regard to the nature of **water-pollution** and as to the condition under which it is removed. The chemical changes in surface waters are not very marked. These waters are liable to contain a miscellaneous assortment of **living structures,** representatives of many classes of animals and plants. It is customary to overlook the larger forms of life, but they should not be ignored in close sanitary study, for they may contribute injurious effects. It is very often said that water will purify itself as it flows, but this is a most indefinite action, and it will be entirely unsafe for the sanitarian to rely upon the published observations in this regard; for each river and each season will be a rule to itself. It may be considered that the processes to which surface water are subjected in its ordinary condition are not distinctly purifying agents in the more exact sense of the term. The proper method of purifying water is by **filtration through the soil;** this has been imitated very well by filtration through sand, but the natural filtration of the water of wells and springs is far more satisfactory than any purification during the flow of surface water. That this is the case seems to be proved, not only by analytic data, but by sanitary experience. It is well known to chemists that well-water in districts where there is evidently high soil pollution, and where the contaminating influences are almost alongside of the well, will show a complete transformation of all organic matter and a practical freedom from bacteria. It is further known that waters derived from such polluted sources may be used for long periods without seeming to cause disease. In fact, to meet this difficulty chemists have been in the habit of designating such waters as 'dangerous to public health,' and not as containing disease-producing agents.

In civilized countries there is very little territory that is entirely free from invasion by man or the domestic animals which serve his purposes. These animals have much in common with human beings, sharing many diseases with them. Man has in many cases differentiated them so that, like himself, they have departed from natural conditions, and, leading artificial lives, have become much more liable to disease. We must, therefore, consider that **domestic animals** may be sources of pollution of water, and not think only of occupation by human beings. If an enormous area could be pre-empted and maintained, we might hope to accomplish something, but such permanence is not to be looked for. Practically, such territory will be found to be more or less occupied at the time it is pre-empted, the engineering operations for its preparation will not be perfect on account of the cost, and there will be no certainty that it will be kept in perfect condition. Moreover, most municipalities are short-sighted, and an insufficient amount of territory will be taken; the result will be that in time additional supply is needed, and this will be taken from collections of water arising or existing in territory outside of the original bounds. This is the usual history of such operations.

Apart, however, from pollution from disease-producing agents introduced by **population,** we may distinguish certain liabilities to deterioration which arise from natural causes, practically out of human control. Various conditions disturbing the organic life in water are always existent; miscellaneous pollution with organic matter from surface washings is constantly taking place; and in this way we can at any time have aberrant or abnormal bacterial forms which may have a disease-producing character. We must also remember that surface water receives the rain and surface washings directly, and that even the atmosphere, particularly that in the neighborhood of large cities, may contain considerable polluting material.

Recently another probable danger from surface water has become apparent. It is now established that the **mosquito** is the intermediate host of several parasites, notably those causing malarial and yellow fevers. While in most cases the communication is by the bite of an insect which has become infected by previously biting an infected human being, yet it is not impossible that the individual disease-germs in the dying mosquito are carried by it to some nearby pool, and, the body of the insect there decomposing, the germs may be set free to infect those who drink the water. The germ may remain inactive for a long time and not perish; even the dead body of the insect blown into the water may infect the latter. It seems, therefore, that it is impossible to preserve surface water from contamination, and when we are dealing with the enormous areas that are required for supplying the water to American cities, with wasteful habits, we have a problem which will heavily tax engineering and administrative methods.

Filtration

The solution of the difficulty is reached by filtration. The subject has been so extensively studied that sufficient data have been obtained to show that even a very impure water can be rendered safe for use provided the impurities are those which arise from what may be called 'natural causes,' excluding contamination from mining and manufacturing establishments. In most cases even these forms are capable of treatment. The safest system of filtration is that which imitates the natural biologic purification; that is, the **slow percolation** of the water **through sand or earth,** by which the normal bacteria convert the organic matter into oxidized forms and destroy to a large extent the abnormal forms, and, indeed, largely destroy themselves by exhausting available food.

For filtration on a **small scale** many forms of **apparatus** have been devised. The older forms employing animal charcoal, coke, sand, or powdered quartz were of little value, simply straining out the coarser suspended matter. In the approved apparatus of the present day, more efficient straining materials are used, being either a natural or an artificial **porous stone** diaphragm. This may be in the form of a flat plate or hollow cylinder. The former method is used in a very popular house filter; the plate, constituting the bottom of a stone jar, is supported on another stone jar as a receptacle for the filtered water, the original water being placed in the upper jar. This filter can easily be cleansed.

Natural stone is liable to contain crevices through which water may pass without being thoroughly strained; artificial diaphragms are less liable to such defects, and hence are preferred by many sanitarians. Of the latter form, the Berkefeld and Pasteur filters are most common, and have been highly commended.

All these forms require **regular cleansing** to maintain them at the highest efficiency. The cleansing should be by scrubbing with a stiff brush (or the material furnished with the filter) the surface upon which the suspended matter collects. Sterilization of the diaphragm by heating in an oven to somewhat above the temperature of 100° C. (212° F.) is advisable. The diaphragms may also be sterilized by formaldehyde. Germicides containing mineral matters should not be used.

The most convenient arrangement for **house filtration** is the attachment of the filtering apparatus directly to the cold-water pipe so that filtered water may be drawn directly. Under no circumstances should the attachment be made to the hot-water spigot, nor should the water drawn from the latter source ever be used for cooking or for drinking either alone or as part of foods or beverages. There is always danger that the hot water will act on the lead pipes and dissolve some of this dangerous element.

In large houses a filtering apparatus is often attached to the **main supply.** In such cases the above-mentioned diaphragm filters are usually too expensive when installed in size sufficient to secure good flow. Mechanical filters using a **coagulant** (generally aluminum sulphate) and filtering through some powdered material are employed. Sand, powdered quartz, animal and wood charcoal, asbestos, spongy iron, iron oxid, and paper pulp are among the substances that have been used. Each of these has advantages and disadvantages, but it is not possible to decide positively among all of them; indeed, the degree of success obtained with any material is much influenced by the skill of the operator and by the attention to manipulating and cleansing. None of the forms delivers a sterile filtrate continuously, but all improve the character of a very bad water.

In large installations for **town supply** the approved form is the **sand filter bed,** which acts as a straining agent, and also as a soil for the development of nonpathogenic bacteria, which destroy the organic matter.

Boiling water for a brief term, one to two minutes, will destroy all important disease-producing bodies. Long boiling makes water flat and vapid, and many persons will not drink it. Heating under pressure is an efficient method, but is costly both in installation and operation. A method of boiling water conveniently and economically is by use of the **Forbes sterilizer** shown in the accompanying illustrations. The supply of water entering the bowl is maintained at the boiling-point and overflows into the cooling tube.

Figure 89 is a diagram of the construction of the portable form. The appearance of the apparatus is shown in figures 90 and 91, the latter being the permanently attached form. In the portable form the raw water is contained in the bottle 1 and runs from this into the cup 2; then through the pipe 3 into the compartment 4 of the heat exchange, fills this, and then runs into the heater 5, and rises

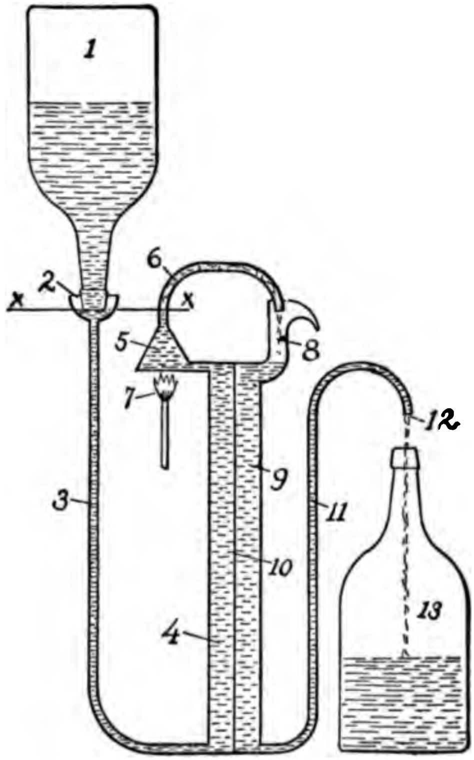

FIG. 89.—DIAGRAMMATIC SECTION OF FORBES PORTABLE STERILIZER.

in the pipe 6 to the level x. No more water will now run out of the bottle 1, because its mouth is sealed by the water in the cup 2 at the level x. Heat is applied, which causes the water to boil, rise in the pipe 6, and flow over into the cup 8. It is therefore impossible for any water to pass through the apparatus until it has boiled, for it is only by boiling that it can rise sufficiently in the pipe 6 to flow over into the cup 8. This boiling lasts for but the fraction of a second, and once the water has passed through the pipe 6, it is removed from where heat can reach it. When some water has boiled over, as above stated, the level of the water in the heater 5, and likewise the level of that in the cup 2, is lowered. This exposes the mouth of the bottle 1, so that a small quantity of air enters the bottle and allows a corresponding quantity of water to run out of the bottle and refill the cup

FIG. 90.—FORBES STERILIZER.

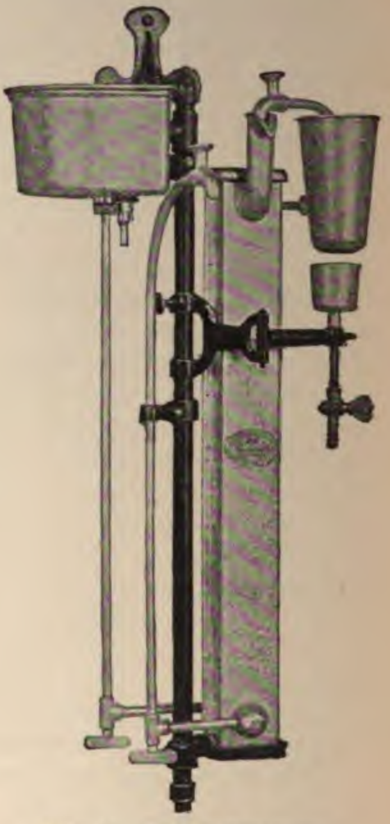

FIG. 91.—FORBES STERILIZER.

2 and heater 5 up to the level x again, when the mouth of the bottle is again sealed by the water, and no more water can run out of it until the level is again lowered by reason of more water boiling over through the pipe 6.

This action becomes continuous, for the flame 7 is constantly boiling the water in the heater 5 and causing it to flow over through the pipe 6. The water continues to boil over into the cup 8 and quickly fills compartment 9 of the heat exchange. When compartment 9 is filled, the water runs out of the pipe 11 at the opening 12 into the receiving bottle 13. While passing down through the compartment 9, the heat of the water is transferred through the thin metal partition or diaphragm 10 to the cold water passing up through compartment 4, so that the water which is boiled in the heater 5 passes out of the apparatus nearly as cold as that entering, while the cold water entering the apparatus becomes heated as it passes up through compartment 4, and reaches the heater 5 in a very hot condition and nearly at the boiling-point.

Therefore, the only heat which has to be supplied to keep the apparatus running continuously is that necessary to bring the already highly heated water entering the heater 5 to the boiling-point, and cause it to rise above the normal water level x and boil over through the pipe 6, and so pass on through the remainder of the apparatus to the discharge outlet 12.

It will be seen that very little of the water is converted into steam, most of it merely foaming over at the temperature of 100° C. (212° F.), which is sufficient for the destruction of ordinary pathogenic bacteria. The cooling tube is tortuous and its walls are in direct contact with the entering cold water. The effect is therefore to heat the incoming and cool the outgoing stream, thus securing rapid and economic heat-transfer. The effluent water will be but a few degrees hotter than the incoming stream. The apparatus has been indorsed by several competent observers, and is especially adapted to the treatment of water at military stations. It has, for example, been much used in the Philippines.

CHAPTER IV

DISPOSAL OF WASTE; DISPOSAL OF THE DEAD

House Refuse. Human Excreta. Plumbing. Disposal of Sewage. Purification of Sewage—Sewage Farms; Filtration; Septic Tank Process. Disposal of the Dead—Cremation; Burial.

DISPOSAL OF WASTE

Under this title will be considered all questions relating to the removal or destruction of **house refuse.** The disposal of the waste products of manufacturing and mining involves questions of chemistry that cannot be dealt with here.

When communities are small or houses are scattered over a large area, **earth-burial** affords a satisfactory means of disposal for all normal waste; *i. e.*, the excreta of human beings and domestic animals, offal, and garbage. The bacteriologic activity of ordinary soil is very great, and the waste material rapidly passes through the cycle of transformations by which the nitrogen is finally converted into nitrate, and the other elements oxidized into forms harmless to animals and nutritive to plants. This power of soil is, however, far from inexhaustible, and hence in crowded communities a saturation with effete matter occurs and offensive products of putrefaction collect in the soil, pollute the ground-water, or escape into the air.

High land-values in municipalities cause occupation of almost every portion of land and concentrate population unduly, so that the question of house-waste disposal becomes a most important one. In medieval times, and even down to the present period in many parts of the world, no system was followed other than individual impulse, and filth of all kinds accumulated in cellars, back yards, and even in the streets. In better-managed cities much attention has been given to the subject, and many plans devised. Most of these have not passed the experimental stage and need not be considered.

Sewerage Systems

For disposal of **human excreta** the **water-carriage** system is extensively applied in all parts of the world, but especially in American cities. The appliances need not be described in detail, but conditions necessary to prevent injury to health may be set forth briefly. The simple connection of a bowl with a pipe leading to a street sewer, with the provision for a flush with running water, which was the original form, was soon found to be highly objectionable, owing to the liability of sewer-air (misnamed sewer-gas) to enter the house. It is true that careful bacteriologic and chemical examinations of sewer-air, together with better information as to the etiology and pathology of disease, have shown that the air of sewers is not usually chargeable with the causation of specific diseases. It does not usually contain specific germs. Nevertheless, clinical experience has amply shown that it is unwholesome for respiration, and that when such air enters the house frequently, injury to health results. To avoid such danger, systems of traps and seals have been devised, often unnecessarily complicated.

The best **plumbing** practice at the present day may be summed up as follows: Free **ventilation** of the whole house system by an open upright pipe overtopping the roof by several feet; water seals for all bowls, tubs, or sinks, such seals being either provided with anti-siphon vents or with loose rubber-ball valves (the latter is commonly used on washstands and kitchen sinks); an inverted siphon on each main discharge pipe between the house system and sewer, to which latter is attached a ventilation shaft opening by a perforated plate at the pavement level—the latter being commonly known as the foot-vent. When in good order and of efficient construction, this system can be relied on to prevent ingress of sewer-air, but bad work and neglect will render it very unsafe. Many houses require for the water-supply for the upper floors a storage tank, which is kept full by means of an automatic valve. To provide against damage by overflow in case the valve fails to close when the tank is full, an escape pipe is provided. The outlet of this pipe is often carelessly inserted in the upright ventilating shaft or into the main discharge-pipe, by which means the exhalations from the drainage system may easily pass into the stored water. The outlet of the overflow-pipe should be free; that is, not inserted into any conduit which is part of the drainage system. The best arrangement is to let it open on an inclined part of the roof, some feet away from the rain-gutter. In one very well-arranged house in Philadelphia the overflow-pipe is carried down to the kitchen sink, terminating about a foot above it. By this means all contamination is avoided, and, moreover, a warning is given when the automatic control is out of order.

The rubber-ball valves of the common washstand trap act, as a rule, very well; but if the sink be unused for several months, especially in hot weather, the rubber ball may adhere so firmly to the metal that the water cannot flow freely. When unused, all water seals may dry out and thus give opportunity for free entry of sewer-air. This condition is occasionally the cause of illness in houses that have been left unoccupied for some time.

The **disposal of water-carried sewage** is a matter of much concern to sanitarians. In most cases a city simply drains into the nearest water-course or drainage area, with resulting serious pollution of the stream, but often legal or other interferences compel amendment.

The original method for the disposal of **town sewage** was to allow it to flow through surface or underground conduits to the nearest water-course and then to the outlet of such stream. Many cities still have surface drainage of this character. In ancient Rome an extensive system of underground sewerage obtained, and some of these sewers still perform an important function. Such a system of disposal is in favor with engineers because it is comparatively simple in construction and usually efficient. The pollution of the water-course is a most objectionable feature, and the legal principles under which such pollution may be forbidden are slowly developing in judicial and legislative quarters. From the sanitary point of view the system is highly objectionable, except perhaps where it is possible to introduce the sewage directly into the ocean, but even this method must be regarded as a sacrifice of the best hygienic principles to expediency or economy.

The **purification of sewage** by distributing it on open land, the so-called 'sewage-farm' system, is an excellent hygienic measure, since it enables the operation of the natural methods of oxidation. Unfortunately, defective engineering often leads to disappointment. The sewage farm is usually too small, and the land becomes water-soaked, resulting in inefficiency. This condition is especially seen with the dilute sewage of American cities, which are wasteful of water. The sanitarian cannot afford to overlook the danger from the use of foods grown on sewage-farms. The flooding of a large area with fresh house-sewage is by no means analogous to the action of rainfall or irrigation. Disease-producing organisms of all types, bacteria, amebæ, and entozoa, will be entangled in the growing plants and infect those who are fed with such products. This phase has been noted in connection with food-supply. In spite of this risk, it may be safely assumed that if a liberal allowance of land be set apart and restriction placed on the use of water by the community so as to prevent waste, the sewage-farm system can be applied with much satisfaction; but since these conditions are of the type most difficult to secure in municipal affairs, other methods have been sought.

Filtration through sand has given good results. This has been investigated extensively by the Massachusetts authorities, who have found that an intermittent filtration—that is, a supply of sewage alternating with the complete drainage and aëration of the filter—will give excellent results. More satisfactory still is a combination of the two methods—namely, filtration and disposal of the filtrate upon the surface of land.

For a long while many of the filtration methods were conducted upon an erroneous principle—namely, the use of metallic precipitants for the purpose of coagulating much of the organic and some of the mineral matter of the sewage, the precipitate or sludge being easily separated by subsidence or very rapid filtration, after which the fluid portion (filtrate) was subjected to further treatment or often thrown into a running stream. In many cases better results can be obtained by allowing natural fermentation and purification to go on in the sewage stored in tanks or reservoirs. Methods based on this principle have been of late applied on a practical scale in several places in England. The following summary of the process is condensed from a paper by William Easby.* The so-called septic tank method is the most novel form of treatment, and will be described briefly.

Septic Tank Process.—The septic tank, the prototype of which is the common cess-pool, is a long shallow reservoir of masonry. Free access of light and air is sometimes avoided, but this is not necessary. Sewage enters through pipes which are turned downward to within a few inches of the bottom of receiving chambers, called 'grit chambers,' which are walled off from the tank proper. In these much of the mineral matter in suspension, especially street detritus, is deposited, and the liquid overflows into the tank proper and passes very slowly to the opposite end, by which process the suspended organic matters are mostly deposited, and subsequently in large part liquefied, with formation of much gas. The effluent pipe, broad and flat, at the extreme end of the tank, leads the sewage into an aërating

* "Proceedings of The Engineers' Club of Philadelphia," 1900, p. 133.

trough, from which it overflows in a thin sheet, and passes through pipes leading to the filtering area, traversing shallow channels on the filtering bed, overflowing the borders of these, and filling the bed. The discharge from these beds is also through pipes, the operation being through the following cycle, the valves acting automatically: The supply-valve opens and fills the bed; it then closes, and the filled section remains undisturbed until another section has received a charge, when the former is emptied. There are four periods—filling, standing full, emptying, and aërating. Coke and clinker are used in the filters.

The biochemic changes in the septic tank are complex. The organic matter is hydrolyzed; that is, takes up one or more molecules of water under the influence of enzyms and breaks down into simpler forms, especially ammonium compounds. Gases, including methane and hydrogen, are evolved. Many enzyms are secreted by bacteria. The process is one of liquefaction, which is the principal function of the septic tank. A large proportion of the organic matter is transformed into methane, hydrogen, nitrogen and ammonium compounds. Methane and hydrogen are inflammable gases which can be drawn off and used for heating purposes. The accompanying plan of the Manchester installation will indicate the general arrangement of the tanks and filters (Figs. 92 and 93).

Among the further improvements in these methods may be mentioned the Adams automatic siphonic attachments, by which the personal supervision required is reduced to a minimum.

The most efficient and rapid method of dealing with the impure liquid which flows from the septic tank has been found to consist in treating it intermittently in coke-beds which have been primed with bacteria by being placed for some weeks frequently in contact with sewage. The complete cycle of treatment in the London beds consists in filling the coke-bed, emptying it after a couple of hours, and then leaving its coke contents in contact with the interstitial air for another period of two hours. It has been found possible to repeat this cycle four times in twenty-four hours. By this purification an effluent is obtained which is saturated with dissolved oxygen, which remains entirely inoffensive in smell for an indefinite period in an incubator at summer heat, and which, therefore, when discharged into a water-course would maintain the respiration of fish and would never render the water offensive.

The coke-bed reduces the readily oxidizable dissolved matter in the

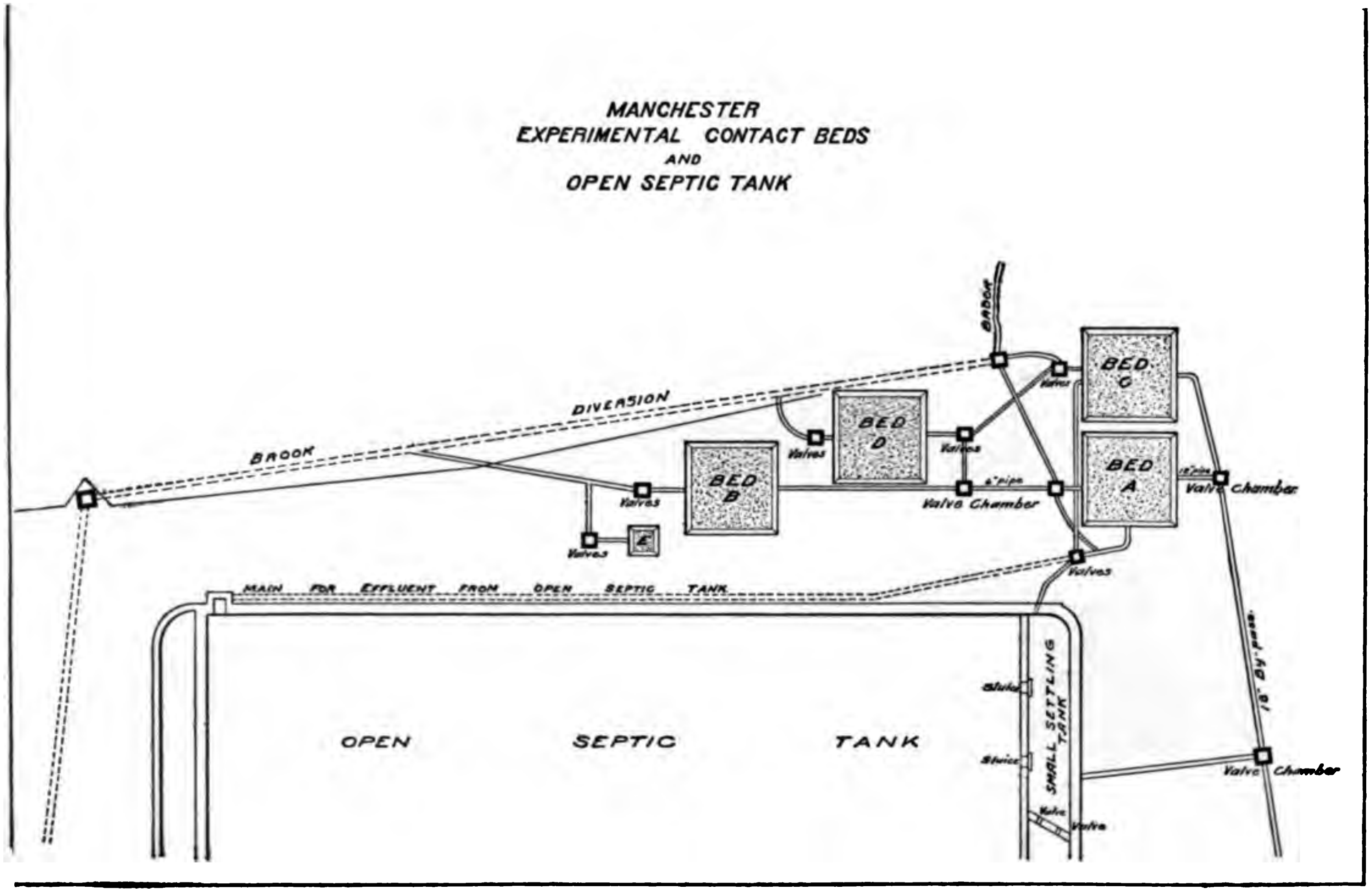

Fig. 92.—Plan of Contact Beds and Open Septic Tank.

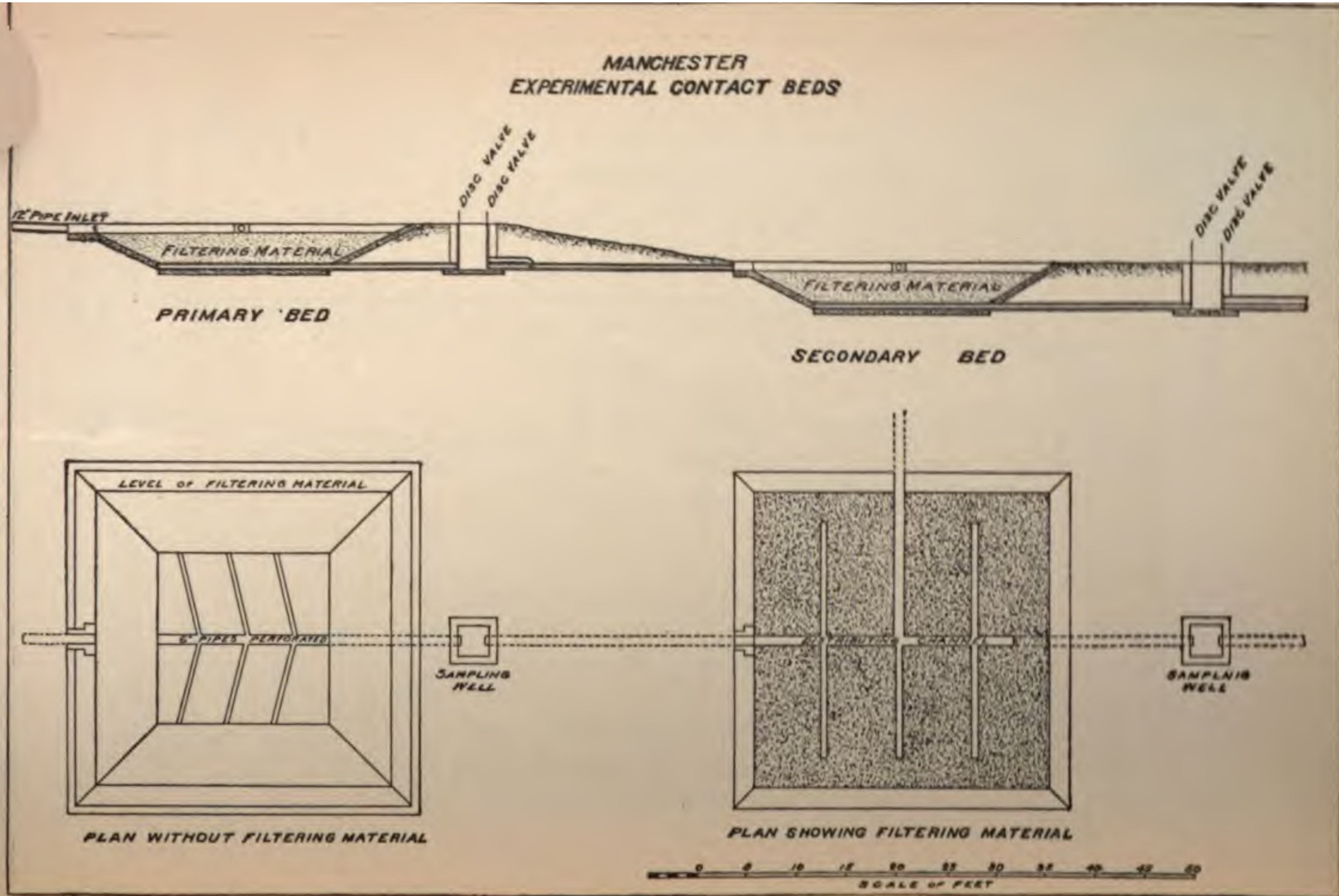

Fig. 93.—Manchester Contact Beds.

FIG. 94.—VIEW OF CONTACT BEDS A AND B; MANCHESTER.

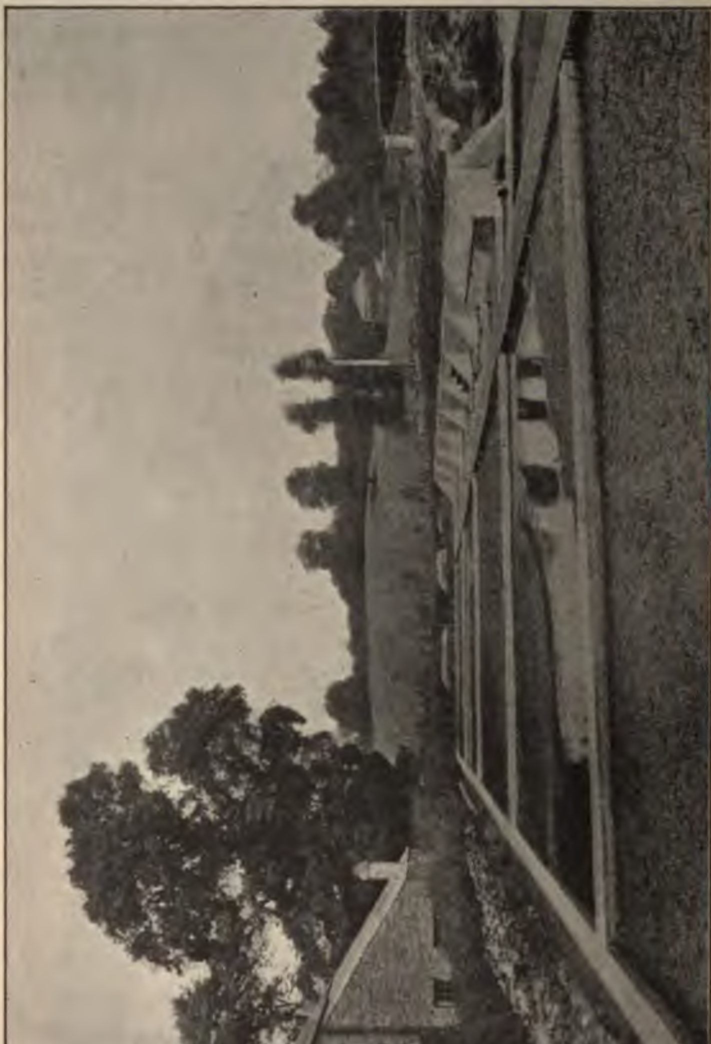

Fig. 95.—View of Filters; Exeter Septic Tank Installation.

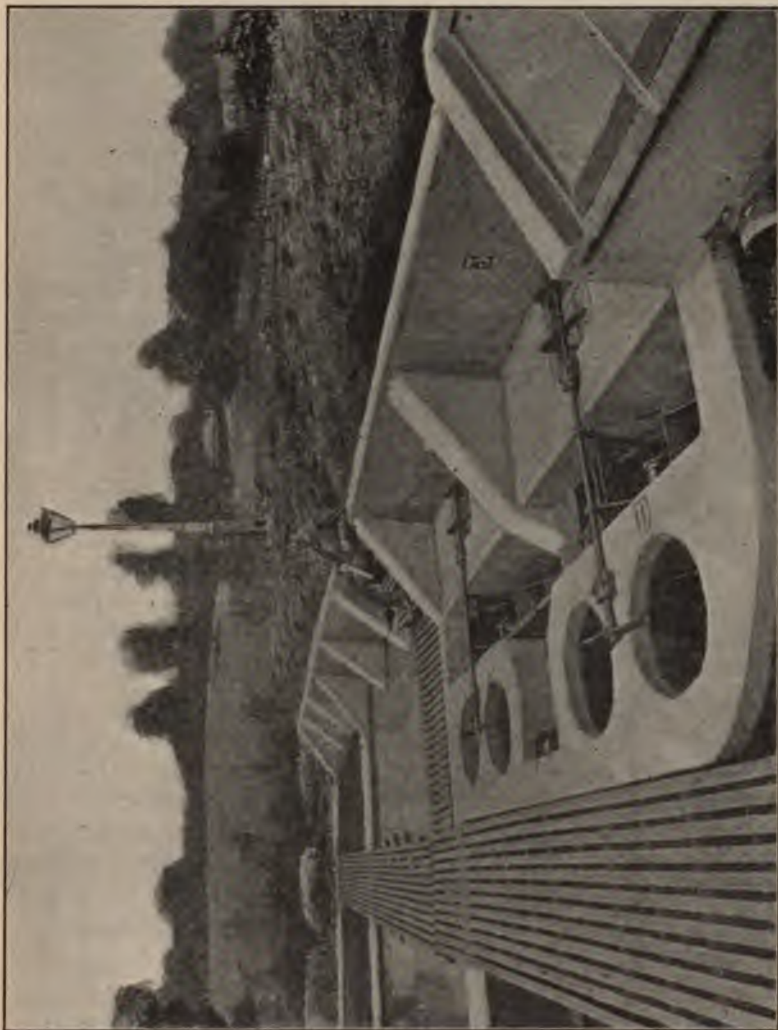

Fig. 96.—Automatic Supply System; Exeter Installation.

settled sewage by from 60 to 70 per cent., and the whole oxidizable matter in the unsettled raw sewage by more than 90 per cent.

The effluent contains large numbers of bacteria; but the presence of these bacteria is useful in effecting inoffensively the removal of organic substances as soon as the effluent mingles with well aërated river-water.

Garbage Disposal

The term 'garbage' will be limited here to the **solid refuse** from food. Ashes and waste paper should always be kept separated from garbage proper. The disposal of the latter is a difficult problem, especially in summer, when it is not only bulky from the waste from succulent vegetables, but soon decomposes and becomes offensive. Several methods of disposal are in vogue. **Burial** is not unsanitary when plenty of land is available, but in cities this necessary condition does not usually obtain. Destruction in the **kitchen** by **drying and burning** is satisfactory under good housekeeping supervision, but most households are not fortunate in this respect.

In large cities the collection and disposal of garbage is a matter of **municipal control.** Some operators burn the material at once; others treat it for extraction of the more valuable materials—*e. g.*, fatty matters—and reduce the residue to forms suitable for fertilizing purposes, for which, however, its value is usually low.

Under any collection system garbage is apt to cause some annoyance. The collecting carts do not usually make daily rounds, and housekeepers are, therefore, obliged to allow the material to accumulate, for which porous and leaky containers, boxes, barrels, and old tinware are often employed. These are, as a rule, not fully emptied by the collectors or cleansed by the housekeeper, and hence are always offensive. Fortunately ordinary garbage is not likely to cause or disseminate disease. Summer garbage contains a large proportion of water and much carbohydrates, especially cellulose; the fat, bones, and skin of food-animals are rarely infected with disease-germs, hence offensiveness is the principal nuisance these materials occasion.

A good system of garbage disposal would seem to be the **drying** of the materials by the **waste heat** of the house in special receptacles which are from time to time taken to the utilization establishment. If fresh garbage be collected, each householder should be obliged to keep it in an impervious, tightly covered receptacle, which should be emptied in the warmer season at least every second day.

Some large cities have adopted the practice of **carrying garbage** far out **to sea** and dumping it. In some cases it has been deposited on deserted islands. The first method is expensive, and unless constant and strict supervision is exercised, the laden scows will not be taken out to sea, but be dumped in the outer harbor and cause a nuisance as well as block the ship-channel. Depositing the garbage on land is a good method if a very large area be available and the material be well spread and mixed with soil, but ordinarily the garbage is piled in a deep layer carelessly, and it putrefies and becomes a serious nuisance.

DISPOSAL OF THE DEAD

Cremation is the most advisable method of disposing of the bodies of the dead, especially in cases of contagious disease; but the practice is little followed. As far as the liability to spread **infection** is concerned, the ceremonies of funerals, and the exposure of the corpse to the gaze of friends and relatives, are more objectionable than the mere fact of burial. Whatever may be the individual view on such questions, **earth burial** will be the practice for many years, and the attention of sanitary authorities should be directed to rendering this custom as innocuous as possible.

Burial.—Much has been written about the objectionable effects of **graveyards,** but a large portion is merely general statement. Intramural cemeteries are usually considered prejudicial to public health, but it is doubtful if mortality statistics of large cities would show evidence of such danger. Of all methods, other than cremation, of disposing of the dead body, especially when dead of contagious disease, earth-burial is the best, and is a strictly natural method, for it is by means of the action of soil microbes that the organic mass is converted into harmless materials. The real objection to intramural cemeteries is that they interfere with proper use of land. Of course, there must be a limit to burial in such places. Earth is a natural disinfectant, but it is not an inexhaustible one. A minimum must be fixed to the depth of covering, but with a few feet of earth over a body there is no reason to suppose that any dangerous emanation could arise.

Intramural cemeteries are often neglected, overgrown with weeds, and become a resort of stray animals. So long as the living relatives will not encourage or even allow the removal of the dead to extramural grounds, it is to be regretted that the conditions cannot be made more elegant, and the location of bodies marked by simple and artistic methods instead of the hideous tombstones so commonly seen.

These features are, however, of less moment in view of the tendency to establish cemeteries on the **outskirts** of large cities. Here a new question arises—namely, to what extent are such cemeteries likely to contaminate **water-supply?**

In civilized countries the body is shrouded, placed in a substantial coffin, and this often inclosed in a box. Graves are deep and well drained. Uniform temperature, deficient supply of air and moisture, and long protection from the direct action of the soil greatly retard decomposition, so that even several years elapse before the body begins to disintegrate. It follows, therefore, that, for contagion to spread from a body buried in the customary manner, it is necessary that materials reach to the surface of the soil and be washed by storm waters into the neighboring stream, or pass downward entering the subsoil currents, and then into streams or springs. The first of these methods is impossible; the surface washings of a cemetery are far less harmful than those of a farm or town. As has been noted above, a body buried a few feet below the surface of the soil cannot give off any exhalations or germs. As regards the possibility of disease germs passing downward, we have proof that even coarse particles of soil will act as a filter. Soil is almost sterile a few yards below the surface, notwithstanding the large numbers of microbes present in the upper layers and the constant downward movement of the water falling on the surface.

There is reason to believe that a few months after burial the disease-producing microbes are dead; that even if a body containing them were buried unwrapped in the soil, it would be unlikely that it would contaminate the subsoil water. In the sanitary aspect of the question indeed 'dead men tell no tales.' The distribution of disease by water arises from the contamination of the water by the excretions of living human beings and animals.

PART III

DOMESTIC AND PERSONAL HYGIENE; NURSING AND CARE OF THE SICK-ROOM

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PART III

DOMESTIC AND PERSONAL HYGIENE;* NURSING AND CARE OF THE SICK-ROOM

CHAPTER I

THE HYGIENE OF DWELLINGS

Site. Soil. Drainage of Soil. Construction and Arrangement of Buildings; Ventilation—Natural, Artificial; Heating; Cooling; Lighting. House Drainage—Plumbing, Fixtures. Water-supply.

In constructing habitations for human beings consideration must be given to: (1) The site and the character of the soil; (2) the arrangement and construction of houses; (3) the house drainage; (4) the water-supply.

The Site and the Character of the Soil

Chief attention should be directed to the **character of the soil** in relation to its moisture and its freedom from organic impurities. The **water** present in the soil may be mere moisture mixed with air, or ground water. The latter is supposed by some to have an important bearing on the dissemination of typhoid fever. The **air** in the pores of the soil, called ground air, is subject to movements, and is easily influenced by changes in the temperature and changes in the pressure of the atmosphere. Such factors are especially operative in winter when by the circulation of the heated air of dwellings the ground air is drawn up through the house.

* In the preparation of these chapters for the press, valuable assistance has been given by Dr. Myer Solis-Cohen, of Philadelphia.

Heavy rains displace the air from the interstices of the soil and cause it to enter houses. Contamination from the ground air may be prevented by providing impervious floors and walls to cellars and basements.

In respect to the site it is necessary to dry the ground if it be at all damp, and to remove all refuse from habitations. The former object is attained by drainage of the ground water, the latter by sewerage. Sewers should not be used as drains. Porous earthenware pipe is the best material for drains, although coarse gravel or broken stones may be employed. The drains should be placed not deeper than five meters (sixteen feet) and if possible not less than three meters (nine or ten feet) below the surface, and care must be observed that the outflow of the drain is unobstructed. It has been suggested that at least in some places the planting of trees and bushes may assist in draining the soil. Eucalyptus and sunflower are among those advised. Sewer-pipes must be air-tight and water-tight. Made ground should be drained efficiently, and is best when it has been laid down for several years before being occupied.

THE ARRANGEMENT AND CONSTRUCTION OF HOUSES

The ordinary building materials are brick, granite, marble, sandstone, and wood. The advantages of **brick** are: It allows ventilation through the walls; owing to its poor conducting qualities, it maintains a uniform temperature; it is durable; it is fireproof. **Wooden buildings** permit also of natural ventilation, and are especially desirable in hot climates, as they cool rapidly. Paint interferes with ventilation through the walls, while calcimining offers slight resistance to the passage of air. New dwellings should not be occupied until the walls have become thoroughly dry. When the dampness in walls is caused by capillary attraction from the soil, it can be prevented by interposing a layer of slate in the foundation wall. If due to rain, a couple of layers of good paint will prevent it. Blocked water-pipes and leaking roofs may also cause dampness of houses.

Interior Arrangement

This concerns itself with **construction and capacity of rooms, ventilation, heating, cooling, lighting,** and **plumbing.**

Construction and Capacity of Rooms

In the **designing** of rooms, coved ceilings and floor junctions, well puttied floor-joints or close-fitting hardwood floors, rounded corners, and in general such construction as permits ready cleansing and avoids accumulation of dust, are to be desired. For prevention of infection it is better to paint the walls than to paper them. Care should be taken to avoid arsenical paint or paper. Before repapering, walls should be thoroughly scraped and washed.

The **living-rooms** should be larger than the sleeping-rooms, and should possess a cubic space of at least twelve cubic meters (yards) for each occupant, though thirty cubic meters (yards) is preferable. The height should be not less than 3 meters (yards), and rarely over 4 meters (yards). For **sleeping-rooms** ten cubic meters (yards) is the minimum air space allowable for each adult, twenty-five cubic meters (yards) being more desirable. The height should be at least two and three-fourths meters (yards), rarely more than three meters (say, 10 feet), and the floor space at least three square meters (yards). Every room should have at least one window, extending nearly to the top of the room, equal in area to at least one-tenth of the floor space and opening half its size.

Furnishings should be simple; dust-collecting hangings should be avoided. Rugs that can be removed and well shaken or beaten out-of-doors are to be preferred to carpets. The **bedstead** should be of metal, two meters (6½ feet) in length, and just wide enough to accommodate one person. The **cleansing** of rooms and their contents should be systematic and careful.

Bath-rooms should have tiled or painted walls, and tiled or cement floors with impervious joints. There should be no sharp corners in room or moldings. Good ventilation must be provided; in addition to which, the window should be open whenever the room is not in use.

Ventilation

The **object** of ventilation is twofold: to remove the vitiated air of an apartment, and to supply pure air from without; these objects are accomplished simultaneously.

Impurities in the Air

These are **gaseous**—carbon dioxid and monoxid, marsh gas, hydrogen sulphid, and various organic substances, such as amins, ammonia, volatile fatty acids ; and **solid**—soot, dust, debris of vegetable and animal origin, and living micro-organisms.

Air of normal purity, that found out-of-doors, contains ordinarily about 0.03 to 0.04 per cent. (3 to 4 parts in 10,000) of **carbon dioxid.** To keep the atmosphere of the house equally pure about 1,000,000 cubic feet of fresh air would be required for each individual each hour, an impossibility under ordinary conditions in a cold climate. The working standard proposed by De Chaumont, and generally accepted, permits a vitiation of 2 parts in 10,000 (in all, 6 parts of CO_2 in 10,000). Air of this standard of purity may be obtained through a supply of 3000 cubic feet (say, 85 cubic meters) an hour for each adult, and can be breathed with impunity. A greater degree of contamination is unwholesome.

Carbon monoxid enters the air of dwellings as a product of the combustion of illuminating gas and of coal. It is more dangerous than carbon dioxid. **Sewer air** and **dust** are always unpleasant, and very often inimical to health. The air in inhabited rooms, when still, contains relatively few **micro-organisms;** but when the dust is set in motion, the number in the air increases greatly, many of them being mold spores.

Tests.—The air of an apartment should not offend by its odor a person entering from out-of-doors. The amount of **carbon dioxid** present is accepted as an index of the total impurities. The tests for it are based on its absorption by clear lime-water or baryta-water, with the formation of an insoluble carbonate and a decrease in the alkalinity and transparency of the solution. Pettenkofer's method is the most accurate, but is somewhat complicated. In Angus Smith's **minimetric method** six clean and dry flasks are required, having a capacity respectively of 150, 200, 250, 300, 350, and 400 c.c and provided with tight-fitting rubber stoppers. Fifteen c.c. of fresh lime-water or baryta-water being placed in each flask, and agitated for several minutes, the smallest flask showing turbidity indicates the proportion of carbon dioxid present, according to the following table:

Capacity of Flask		Parts of CO_2
150 c.c.	indicates	1.6 in 1000
200 c.c.	"	1.2 "
250 c.c.	"	1.0 "
300 c.c.	"	0.8 "
350 c.c.	"	0.7 "
450 c.c.	"	0.5 "

Approximate and fairly satisfactory results are also given by Fitz's air tester and by the two known as Professor Wolpert's.

Methods of Ventilation

The methods of ventilation vary with the space of the room or building to be ventilated, the number of individuals occupying this space, the character of the building, its exposure, the necessity for artificial heating, and similar factors. They are usually divided by writers into two classes, **natural** and **artificial.** The former term is applied when the construction of the house is such as to permit or to utilize intentionally the **diffusion of gases,** the action of **wind,** and the movements of air caused by **inequalities of temperature;** the latter term is applied when special apparatus is employed to displace vitiated air by fresh air, either through **heat** or **mechanical means,** as pumps, jets, fans, bellows, and the like. The line of division is not sharp in relation to means of ventilation by differentiation of temperature.

NATURAL VENTILATION

Diffusion of Gases.—Gases diffuse at a rate inversely proportional to the square root of their densities; that is to say, the greater the difference in density of two gases, the more rapidly do they intermingle; and the more alike their densities, the less is the tendency to mix. Consequently, when the air of a room is warmer than that outside, rapid diffusion occurs through any crevice or opening, and through porous materials, such as bricks, stone, mortar, and wood. Non-gaseous impurities held in suspension are, of course, not removed by this method of ventilation.

Wind.—Atmospheric currents act by **perflation** when passing freely into a room through windows, doors, and other openings, and by **aspiration** when blowing across the tops of chimneys and thus causing an uprush of air.

Temperature and Specific Gravity.—Heated air expanding and becoming lighter tends to **rise** and pass out of the room in a current through any available opening; while the cooler outside air entering to take its place will naturally tend to descend. Devices to secure an **upward direction** of the incoming current, or to admit it **near the ceiling,** are therefore necessary. Professor Willis L. Moore's

'Nevo,' or 'gravity cooler,' elsewhere described, takes advantage of the higher specific gravity of air artificially cooled.

Methods of Natural Ventilation

The simplest means of ventilation, open doors and windows, are available only in warm weather. **Perflation** is aided by having the windows on opposite sides of the room. In cool weather the current of fresh air not previously warmed should not impinge directly upon the occupants of a room. The inlets for cold fresh air should therefore be at least seven to eight feet above the floor and directed upward to the ceiling. The outlets should be at the top of the room, as heated air rises.

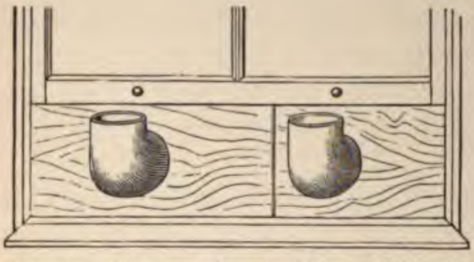

FIG. 97.—ELBOWED TUBES.—(*Starr's "Hygiene of the Nursery."*)

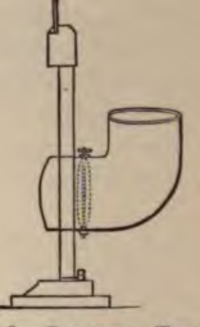

FIG. 98.—ELBOWED TUBE IN PROFILE, SHOWING DAMPER.—(*Starr's "Hygiene of the Nursery."*)

There are various simple **devices for windows** by which the incoming air is given an upward direction that it may rise toward the ceiling and mix with the warm air there. The most common plan is that suggested by Hinckes-Bird, of placing a **board** from four to six inches wide under the lower sash, thus permitting the air to enter between the sashes. Circular openings have been made in the board, through which **elbowed tubes,** directed upward, project into the room. A light **frame** of wood, metal, or glass may be made to fit in front of the lower ten or twelve inches of the window-frame, or a **piece of cloth** or **paper** may be tacked or pinned across it, covering the opening when the lower sash is raised; or the upper portion of the **upper sash** may be made movable, so that it may be tilted inward, like a transom. **Per-**

forations may be made in the lower part of the upper sash; **Currall's window ventilator** consists of a metal plate fixed in a direction parallel to the window-frame, over the inside of an opening made into the lower sash bar. In **double windows** the lower, outer sash is raised a few inches and the upper, inner one is correspondingly lowered. **Double panes** of glass may be so adjusted as to leave an open space at the bottom of the outer pane and at the top of the inner one. **Movable panes** may be sliding or may swing on a central or a lateral pivot; in the latter instance being provided with checks. These are often present in double windows. A pane may be **louvered,** that is, arranged in slats opening or closing by means of a lever, and slanting outward so as to direct upward the incoming air. Similar results are accomplished by the use of **Boyle's** or **Cooper's ventilator.** The latter is a perforated disc of glass

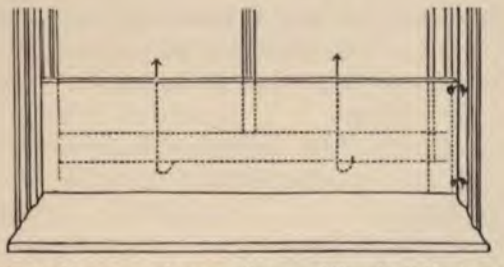

FIG. 99.—FRAME IN FRONT OF LOWER SASH.—(*Starr's "Hygiene of the Nursery."*)

attached by means of a pivot to a pane of glass similarly perforated. By rotating the disc the apertures in the pane can be partially or completely closed at will. The proper place for louvers or ventilators is the lowest pane of the upper sash.

Fresh air may be admitted and foul air let out through **apertures** made directly **in the walls** of a room, and communicating with the exterior through porous or perforated bricks, valved boxes, tubes, or shafts; often gratings and dampers are provided over the interior openings for regulation of the incoming current. Ventilators should so be made that all their parts are accessible for cleansing.

The best types of **air bricks** are those of Ellison and of Jennings. These bricks are pierced with a number of conical or trumpet-shaped openings narrowing toward the house. This arrangement, by distributing the air over a gradually increasing surface, lessens the velocity of the entering current and prevents a draft. The **Ellison bricks** are best placed just behind the skirting board. In the **Jennings air brick,** which is usually placed near the ceiling, the air first enters a 'dust trap' and then passes into the room through louvers or slats, directed upward.

Steven's drawer ventilator is like a movable box with the back out, fitting into a hole in the wall. The front of the drawer gives the entering air an upward direction.

The **Sheringham valve** is an iron box fitted into the wall; the air enters from without through a perforated brick or grating, and the face of the box within the room is hinged at the bottom so that it can be opened or closed at will. As the inner aspect of the ventilator is larger than the outer, the velocity of the current of air is lessened, while an upward direction is imparted by the valved opening.

Tobin's tube pierces the wall horizontally; its outer opening is covered by a perforated plate, and its inner opening communicates with a vertical shaft that carries the air up five feet or more to enter the room near the ceiling.

In both Sheringham's valve and Tobin's tube the air may be filtered through muslin or cotton-wool or be made to deposit dust particles in a water tray.

Mackinnel's ventilator consists of two tubes, one inside the other, extending through the ceiling of the room and the roof of the house. The inner tube projecting well beyond the outer, above and below, carries off the heated impure air. At its lower end a broad circular horizontal rim or flange deflects outward the fresh air passing down between the tubes. The top is protected by a cowl. A cruder arrangement is a **single tube** with or without Watson's partition or Mure's double partition.

Pott's ventilating cornice is a hollow, perforated, metallic cornice, divided by a horizontal plate. The lower channel communicates with the outside and brings fresh cold air into the room, while the upper channel opens into the chimney and carries off the foul air. In an analogous method, a **perforated inlet tube** is carried along the cornice of a room on three sides, and a similar outlet tube, on the fourth side.

Another system consists of a series of **transverse boxes or tubes** placed at regular intervals close to the ceiling, running across the room from wall to wall. The sides of the tubes are made of perforated zinc, while the ends communicate with the outer air through air-bricks. A partition in the center prevents the wind from blowing right through.

In the **Abrahamson system** a metallic box centrally divided into two chambers of sufficient caliber is placed at an elevation on the wall, the direction of the current out through one side and in through the other being attained by means of a simple device on the principle of a perforated valve.

Ventilation should be attained without a draft, hence open doors and windows while a room is occupied should not be regarded as scientific means of ventilation in cold or cool climates, though such may have to be adopted for want of better.

Outlets are of prime importance. They should be as near the top of the room as possible, or, if near the floor, be connected with the chimney or with an **aspirating shaft** of special construction. When a **window** is open 'top and bottom,' the upper opening serves as outlet.

A **natural outlet** for vitiated air is afforded by an open fireplace, or other aperture into a chimney-flue. When fresh air is entering a room from other sources, devices intended as inlets may act as outlets for the time being. Various **special outlets** have also been devised:

FIG. 100.—COWL.

Arnott's valve is placed in the wall near the ceiling and opens into the chimney when the draft is from the room, closing when the pressure is greater from the side of the chimney. **Boyle's valve** is similar to this, but has small talc plates instead of metal. A **shaft** is often constructed beside or surrounding the chimney-flue, with an inlet near the ceiling and an outlet at the chimney top.

Cowls attached to the tops of chimneys and ventilating shafts aid perflation when faced to the wind and aspiration when backed to the wind. This method is employed in the ventilation of ships and in **Sylvester's system** of house ventilation. A lobster-back revolving cowl may prevent back-draft.

METHODS OF ARTIFICIAL VENTILATION

Artificial ventilation is accomplished by the **vacuum method,** in which air is extracted from or aspirated into a building; by the **plenum** or **propulsion method,** in which air is forced into a building; or by a **combination** of both.

Vacuum Method

This is carried out by **heat** or by **mechanical** means (jets or fans).

Heat.—For purposes of ventilation, heat is best applied by means of the **open fireplace,** through which the expanded column of air ascends to make way for a colder column. Fireplaces may so be constructed as to aspirate fresh air into the room. In the **Galton grate** a metallic flue extends upward into the chimney, through which the hot air ascends. Around this flue is an air-chamber communicating with the atmosphere at or below the level of the fireplace, and opening into the room near the ceiling. Fresh air is drawn into the air-chamber and discharged in the room at a temperature of 80° or 90° F.

Boyd's hygiastic grate, as well as the **Manchester, Meissner,** and **Bohm stoves,** act upon the same principle.

Warmed pure air is also supplied by **ventilating stoves.** In **George's calorigen** and **Bond's euthermic stove** a tube passes through the wall of the house and then through the stove, at the top of which it opens into the room. The **jacketed ventilating stove** is surrounded by a cylindric jacket reaching to the floor, where it communicates with a fresh-air duct.

Hot-air furnaces are of great influence in ventilation. Through a cold-air box, fresh outside air is carried to a chamber surrounding the furnace, whence it passes through tubes to the various rooms. The cold-air box must be clean and protected against the entrance of vermin and of cellar air.

Steam and hot-water heating are likewise employed in artificial ventilation. In this system the lower part of a circuit of pipe filled with water or steam is heated in a furnace. The other portions of the circuit, used in heating the air, are inclosed in radiators placed in the room to be heated (direct radiation), or elsewhere (indirect radiation). **Direct radiation** is objectionable unless there is an independent ventilation system, or provision is made for the admission of fresh air through the register (**direct-indirect method**). In

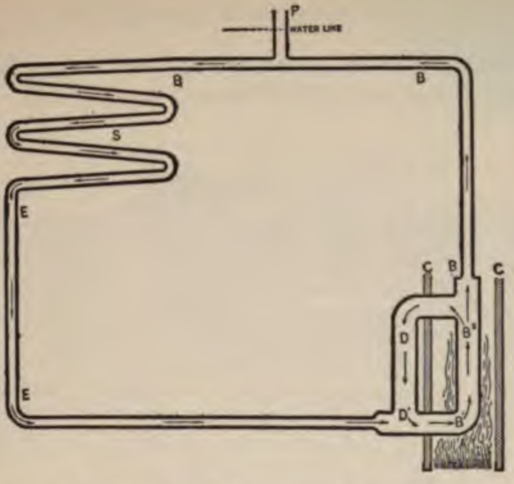

FIG. 101.—SYSTEM OF HOT-WATER HEATING.—(*Coplin and Bevan's "Hygiene."*)

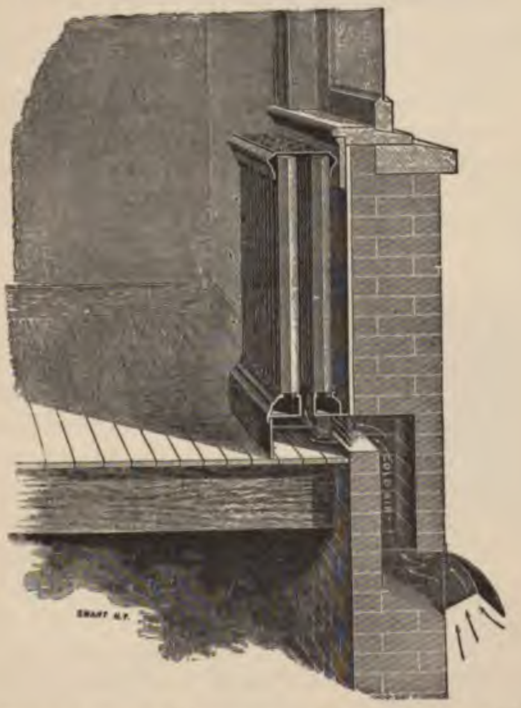

FIG. 102.—DIRECT-INDIRECT RADIATION.—(*Coplin and Bevan's "Hygiene."*)

indirect radiation the radiator may be placed in the cellar, where it is usually employed in conjunction with fans, the fresh outer air being

FIG. 103.—INDIRECT RADIATION.—(*Coplin and Bevan's "Hygiene."*)

conveyed by flues, as in a hot-air furnace; or it may be placed beneath the room to be heated in a galvanized iron chamber or box communicating above with the room, and below with a fresh-air passage.

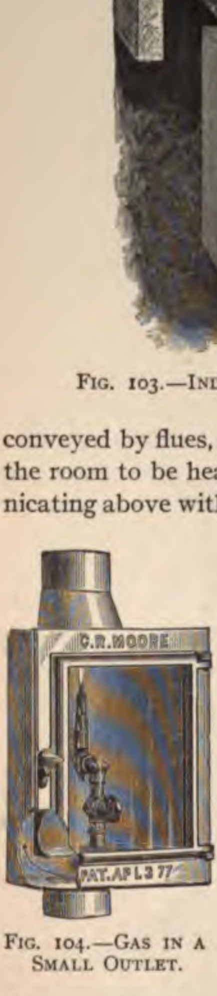

FIG. 104.—GAS IN A SMALL OUTLET.

Extraction of vitiated air may be accomplished by shafts running from the different rooms to the bottom of the chimney-flue just over the furnace or to an extraction shaft heated by steam or hot-water pipes or by gas. Whatever the source of heat, it should be placed at the bottom of the shaft. **Gas** may be used in the smaller outlets placed in rooms. An extraction shaft may even be placed over a gas-light or chandelier. In **ventilating gas-lights** a cover of bell glass collects the products of combustion and carries them off through a tube inclosed within a larger one. The space between the two tubes, being thus heated, acts as an extracting shaft for foul air. To prevent down-drafts the shaft or tube should be covered with a Sugg's cowl or a talc valve. This is the principle of the **Sunlight gas-burner** and of **Benham's ventilating globe-light,**

the latter admitting slightly warmed fresh air as well. Placing the inner tube of **Mackinnel's ventilator** over a chandelier increases its effectiveness.

Mechanical Aspiration and Propulsion

Jets of **steam, compressed air,** or **water** may be utilized to **extract air** by producing a strong upward current in a shaft into which tubes from different rooms open below the jet. This principle is also used for **propulsion.**

Fan ventilators, consisting of a wheel formed by a number of vanes or blades attached to an axle, are used both in **extraction** and in **propulsion.** Many types have been devised, some to be used in conjunction with heat.

The **direction** of the circulation of air in a room as well as the determination of the openings and outlets in a room and the strength and rapidity of the current may roughly be tested with a lighted match or some light material. The velocity may be measured by an anemometer or air meter; and the capacity of the inlets and outlets for admitting and removing the air computed by multiplying their areas by the velocity thus ascertained.

Essentials of Ventilation

In any scheme of ventilation, regard must be had to certain **practical points** stated by Parkes and Kenwood substantially as follow:

1. When air is heated, it expands and tends to rise; when air is cooled, it contracts and tends to fall.

2. Cold air tends to enter a room and to move about very much as water would; and this holds true so long as the temperature of the fresh air remains lower than that in the room.

3. The extent of inlet provision for fresh air is not quite of the same importance as that for the exit of foul air; for if foul air is extracted in sufficient quantities, fresh air will enter somehow to replace it, as by skirtings, crevices in doors and windows, or even through the brick-work of the walls.

4. While the inlet provision for fresh air should average 24 square inches for each individual, several small inlets not too near to each other are preferable to one large one; and the provision of inlet areas somewhat larger than those of exit tends to minimize drafts.

5. Inlets should be as low in the room as possible, *i. e.*, just above the floor (so as not to raise the dust) if the outside air is warm or

has been warmed prior to entry, but at a height of 5 feet or more if the outside air is cold; otherwise unpleasant drafts are experienced. As a further protection against unpleasant drafts when cold air is admitted, the incoming air should be directed upward; while hot air, since it tends to rise, should be directed downward.

6. Outlets should be as high * as possible, and preferably close to or in the ceiling; and they should have their extractive powers maintained by means of heat or of an exhaust fan, or they are liable to act as inlets.

7. If possible, outlets should so be placed that vitiated air is drawn toward them before mixing with the general air of the room.

8. The tendency for fresh air to take a direct course to the outlets must be overcome by judicious selection of the positions of inlets and outlets.

9. Methods of ventilation devised to ventilate *crowded* premises are generally inefficient, unless the incoming air can be warmed in winter to about 60° F.; for efficient ventilation by cold air cannot be tolerated, and there is a great tendency among workers to close all ventilating inlets.

10. With less than 250 cubic feet of space for each person, ventilation can never be satisfactory without the aid of mechanical force.

11. The source of the incoming air should be considered. It should not be borrowed from adjoining rooms, but taken directly from the outside. One great advantage of the more expensive mechanical system of ventilation is the fact that sufficient air can always be obtained from a source that is known and selected.

12. Ventilation dependent on the extraction of foul air is more convenient and satisfactory than that in which propulsion is mainly relied upon; but the purity of the air is not so easily provided for.

13. Warmed air forced into a room should be raised only to a temperature sufficient to prevent a feeling of cold (about 60° F.). More highly heated air is often felt to be overdry and unpleasant.

Heating

Heat is **transmitted** by **radiation**—traveling in straight lines from its source, as in the open fireplace; by **conduction**—passing

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* In many buildings in the United States air automatically maintained by means of a thermostat at the temperature desired, is made to enter through high inlets, the outlets being near the floor.

from one particle of matter directly to another, as in the steam radiator; and by **convection**—being carried by currents of heated air, as in the hot-air register.

The **sources** of heat commonly employed in dwellings are wood, coal, coke, gas, oil, and electricity.

The **means** of heating are open fires, stoves, hot-air furnaces, and pipes containing hot water or steam.

Open fireplaces and grates present a comfortable appearance, are excellent ventilators, and add no impurities to the air of the room. They are wasteful, however, permitting about 87 per cent. of the heat generated to pass up the chimney. The waste of heat may be diminished in a measure by the use of the rifle-back chimney, floor-fed flues, under-fed fires, draft-regulators, or water-backs with circulating apparatus attached. The old-fashioned **Franklin open-fire stove** which stands out in the room, being connected with the flue by a pipe, yields proportionately a large amount of heat.

Heating by open fireplace is not efficient when the external temperature is low, on account of the cold air constantly entering the room. The room, moreover, is unequally warmed, being too cold in one portion while unbearably hot in another, and cools very quickly after the fire has gone out. These objections may, however, be overcome in part by the use of ventilating fireplaces and grates.

Stoves are made of brick, tile, and cast- or wrought-iron. When made of a slow-conducting material such as **brick** or **tile** they retain their heat for a long time when once heated; but if quite cooled, take a long time to re-heat. **Iron** stoves are apt to dry the air too much and to become overheated, when they produce carbon monoxid and burn the organic matter in the air, causing a disagreeable odor. They are more efficient when the combustion is confined in a clay fire-box. Even better are the 'slow combustion' stoves, made internally of fire-brick and cased in sheet-iron, which retain the heat much longer than ordinary iron stoves. Moisture should be supplied by vessels of water placed on the stove or about the room.

Of **gas stoves** there are four common forms in general use:

The **reflector stove,**—consisting of a naked gas-flame, backed by a glass or metal reflector,—though bright, gives out little heat and, when unprovided with a flue, adds considerably to the vitiation of the air. In **condensing stoves,** which have small heating power, the water vapor is condensed and carries down with it other products of gas combustion, but not carbon dioxid, for which reason a flue is required. Gas stoves fitted with **coke, asbestos,** or **hollow-ball refractory fuel** and lighted by Bunsen or Argand burners, by rendering the fuel incandescent, resemble open grates. They are somewhat extravagant and require a flue. **Ventilating stoves** were described in discussing ventilation.

Oil stoves are very convenient, as they require no chimney or flue to carry off the products of combustion when a good quality of oil is used.

The **electric air heater,** in addition to possessing the same advantage, is cleanly and produces no noxious gases.

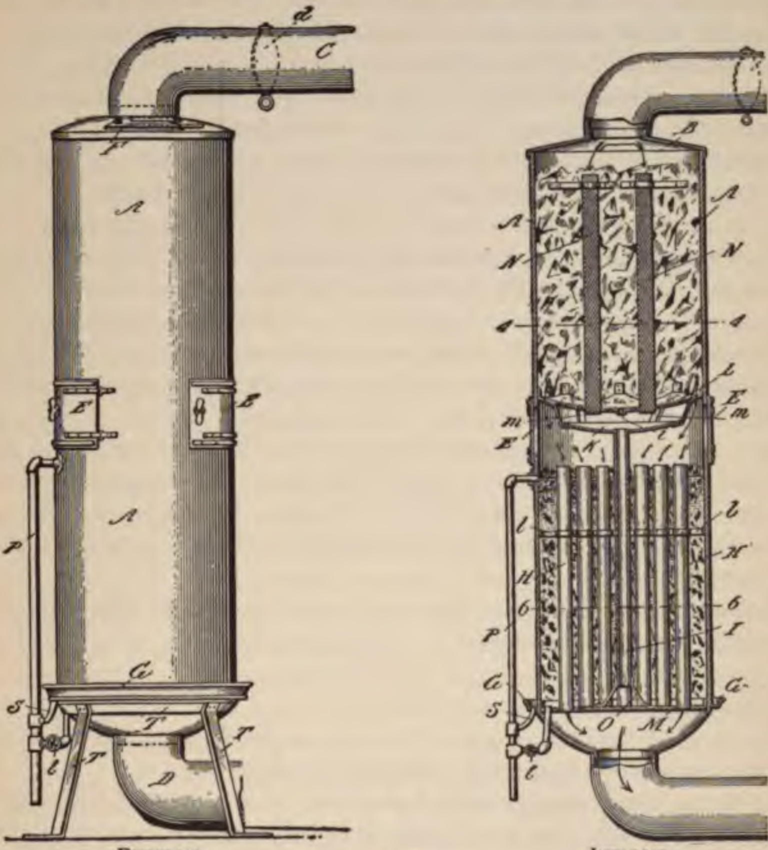
Hot-air furnaces are extensively used in the United States. The heaters should possess a large heating surface and should not require that the fire-pot be heated to redness.

Steam and **hot-water heating** were described under Ventilation. Indirect radiation is probably the best system now in use for heating an apartment. In all systems of heating, **moisture** should be introduced to maintain the relative humidity at 50 or 55 per cent. Moisture can be imparted to dry air by the addition of steam or by exposing pans of water to the heated current or by hanging wet gauze screens or cloths or sponges in front of the register. The 'humidifier' exposes to the air passing through the registers a surface of cotton wicking communicating with a reservoir of water. Every furnace should contain a water chamber and on all stoves pans of water should be placed. In the northern United States there is a general tendency to the overheating of houses in winter. The **temperature** of living-rooms should rarely exceed 65° F., and never be over 70° F. It can be regulated automatically by means of a thermostat. Bedrooms are best left unheated at night, but may be warmed in the morning if used for dressing rooms. This depends somewhat on the age and general vigor of the occupants.

Cooling

The usual method of cooling, which is expensive, is to convey into an apartment air that has been cooled by being propelled over surfaces of pipes through which is circulated brine maintained at a temperature of 40° F., or less, by previous contact in a tank with pipes containing ammonia liquid continuously circulating. The humidity of the supplied air may be lowered to any degree by previous heating. The same flues may be utilized that are used in supplying air heated in the basement by steam or hot water.

The air in an apartment may be cooled as well as dried and purified by means of a **gravity cooler.** The 'Nevo' (Fig. 105), devised by Professor Willis L. Moore, may be operated at about the same cost as



EXTERIOR. INTERIOR.

FIG. 105.—A NEVO.

A, Outer shell or casing; *G*, trough for precipitated moisture; *S*, discharge pipe; *P*, waste-pipe; *F*, door to admit ice to the upper half of cylinder; *EE*, doors through which ice and salt are admitted to the lower half of cylinder; *NN*, reticulated pipes to facilitate the flow of air through the broken ice and the diffusion of the air laterally through the ice; *HH*, thin copper pipes that receive the air after it passes the intermediary bottom; *M*, bottom of cylinder *A*, into which are fitted the lower end of pipes *HH* in such manner that the air that enters the tops of the pipes may be discharged into the large pipe *D*, which conducts the air to the room or apartment to be cooled.

the usual heating apparatus. It consists of a copper or galvanized iron cylinder divided horizontally. The upper compartment contains vertical reticulated pipes and is packed with pieces of ice weighing from two to four pounds each. The lower compartment incloses vertical, thin, water-tight, copper pipes which are surrounded by ice chopped into pieces the size of stove-coal, or even smaller, and thoroughly mixed with sodium chlorid or calcium chlorid in the proportion of one pound of salt to four pounds of ice. The warm outside air entering the top of the cylinder by means of a pipe comes into contact with the ice. Its temperature is thus rapidly lowered, and as a consequence its specific gravity increased, causing it to fall. At the same time, the greater part of its moisture is precipitated and the dust is extracted through the surface tension of the water on the melting ice. The reticulated pipes facilitate the flow of air and the diffusion of the air laterally through the broken ice. When the cooled and dried air enters the copper pipes, it is still further cooled by the freezing mixture surrounding them and consequently falls more rapidly, until by the action of gravity alone it is discharged from a tube at the bottom into the lower part of the room. The discharge of the air through the apparatus may be accelerated by the action of an extraction or propulsion fan and lessened or stopped by the partial or complete closure of a damper situated in the entrance pipe. By means of a pipe the water from the melting ice is carried into a bucket or into a branch waste-pipe.

Other methods of cooling rooms, which require no apparatus, will be described in the chapter on the Sick-room.

Lighting

Light is supplied to a room by the sun in **natural illumination,** and by some substitute in **artificial illumination.**

Natural lighting should be obtained when possible from reflected rays. For windows, **plate glass** is to be preferred when the light is reflected. **Ground glass** will soften direct sunlight. **Ribbed glass** and **prismatic glass** are extensively used. The latter is a combination of prisms for bending rays and diffusing them at an angle. The natural light of a room is derived directly from the sky, and, striking the floor within 10 or 20 feet of the window, is usually almost entirely lost. In the prismatic system, however, the rays of light are received upon a plate of prisms and turned back into the room, if the conditions are favorable, even to a distance of 200 feet. The prisms are relatively inexpensive and in every respect are hygienic.

There should be at least one window in every room. When rooms are lighted by a well, its walls should be polished and of a light color.

Artificial lighting is accomplished by means of candles, lamps, gas, and electric lights. **Candles** vitiate the air proportionately more than other illuminants. The odor of **kerosene** and the marked vitiation of the atmosphere it produces are especially objectionable. **Illuminating gas** having an excess of yellow rays is injurious to the eyes. Owing to the presence of carbon monoxid it is harmful when inhaled; so-called 'water-gas,' from its greater proportion of this substance, being more toxic than ordinary coal-gas. The 'natural gas' used in some localities, though less poisonous, is especially dangerous, since in the absence of odor, its escape is not recognized. Gas-lighting has been greatly improved by the use of the incandescent mantle. This light resembles daylight, and owing to the diminished consumption of gas, vitiates the atmosphere less. It is the cheapest and best of available artificial lights dependent wholly or partially upon combustion. Recently incandescent mantles have been introduced for use on hydrocarbon (gasoline) lamps, thus making incandescent lighting possible everywhere and at a cost in consumption of less than one-fifth of an ordinary kerosene lamp. The material used in these lamps is known in the trade as '74° stove gasoline.' With the mantle it gives an illuminating capacity of 100 candle-power to the burner, without odor or dirt. An ordinary kerosene lamp gives 25 candle-power. **Acetylene** has not yet been tried on a sufficiently large scale to determine all its qualities, but the light is whiter and more brilliant than that from the same amount of common gas or oil, and hence the proportional pollution is lower. Pure acetylene is not very poisonous or irritating, but, unfortunately, the commercial article, made from crude calcium carbid, is always contaminated with compounds of phosphorus and sulphur which are offensive and dangerous. The removal of these impurities involves considerable expense.

Of the illumination methods at present available, the **incandescent electric system** furnishes the maximum of light with the minimum of heat and polluting influences. The arc light, however, is objectionable, being too strong and producing nitric acid in injurious quantities.

When light depending on combustion processes is used, provision must be made for increased ventilation. For every lighted gas burner, 12 to 15 cubic meters (420 to 520 cubic feet) of air an hour is necessary to prevent undue contamination of the air of the room.

HOUSE DRAINAGE

Plumbing

All sewer wastes must be removed from dwellings through a system of plumbing that shall not permit the leakage of liquid or solid matters or of foul air or odors. This requires sound materials, absolutely tight joints, thorough ventilation, and a plentiful water-supply to insure efficient flushing. The pipes should be easily accessible and so far as possible are best placed in full view. Nearly every municipality has adopted regulations governing the construction of the drainage system. These regulations differ somewhat in detail, as do the recommendations of authors. With slight local modifications the system described in the following pages may be accepted.

The **house-drain** is the horizontal main pipe of the house carrying the waste and soil from the vertical soil-pipe into the street-sewer. It should be of extra heavy cast-iron. Earthenware should never be used for drain-pipes within the house, beneath the foundation, or near a well of drinking-water. The house-drain should have a uniform fall of at least one-fourth of an inch to the foot and should be carried along the cellar wall or suspended from the ceiling, unless fixtures in the cellar discharge into it, when it should be laid in a trench. Just inside or outside the foundation wall an **intercepting trap** is placed, sometimes called the siphon or running trap, or main trap. This trap should be of the same diameter as the drain and be pierced with **clean-out holes** provided with air-tight covers. Ventilation is obtained through the **fresh-air inlet,** a pipe about four inches in diameter entering the house-drain on the inner side of the main trap and extending to the external air at or near the curb. The termination should be at least fifteen feet from the nearest window or the cold-air box of a hot-air furnace.

The **soil-pipe** is a vertical pipe carrying the soil and waste from the branch soil-pipes and the waste-pipe to the main house-drain. Cast-iron has been the material generally used for it in the United States, being stronger, cheaper, and more durable than lead, which is preferred in England. Galvanized wrought-iron with malleable iron fittings makes the best soil-pipe, and is now coming into general use in the United States. The walls should be not less than one-eighth of an inch in thickness and the diameter ordinarily should not exceed four inches. Soil-pipes should run as nearly vertically and straight as practicable and all bends must be obtuse-angled. The junctions with the waste-pipe and branch soil-pipes must be by Y-branches, and with the main drain by a curved-elbow bend of large radius supported on a foot. The soil-pipe should be extended in full diameter above the roof for at least two feet, but far from air-shafts, windows, ventilators, and mouths of chimneys. The outlet should not be covered except with a wire basket. The pipe should be fastened securely along its course with wrought-iron hooks or straps and should be supported firmly at the bottom. Cast-iron pipes are made in lengths of five feet, exclusive of the socket or hub, which is an enlargement of one end into which the plain or spigot end of the next section fits. The socket end should point upward toward the commencement of the drain and the joints must be caulked with oakum and molten lead or with Spence's metal. An adjustable joint is made by the Sanitas flanged pipe, in which a lead washer or gasket is squeezed between the flanges of two adjoining pipes and crushed to half its original thickness. In connecting a lead pipe with an iron pipe a strong brass thimble or ferrule is joined to the former by means of a wiped, soldered joint, then received into the socket of the iron pipe and caulked with hemp and molten lead. With the flanged Sanitas pipe, the lead pipe is flanged out and bolted to the iron by means of cast-iron rings with ears and bolt-holes corresponding to those on the pipe. In England, in order to prevent rusting, iron pipes are often coated inside and outside with the magnetic oxid of iron (Barff's process), with coal-tar pitch, or with Angus Smith's solution. The coating is also used to render the inner surface perfectly smooth. In the United States the pipes are not painted for this purpose. **Branch soil-pipes** carry the contents of water-closets and urinals to the vertical soil-pipe. They should be as short as possi-

FIG. 106.—QUARTER-BEND.

FIG. 107.—Y-BRANCH.

ble, have a fall of at least one-fourth of an inch to the foot, and be trapped not more than two feet from the closet. In America they are usually made and joined like the vertical soil-pipe.

The **waste-pipe** is a vertical pipe that receives through the branch waste-pipes the waste water from sinks, wash-basins, bath-tubs, etc. It resembles in every way the soil-pipe, which it joins near the base. In England, however, the **waste-pipes from the fixtures** are usually taken through the external wall to discharge in the open air over a channel leading to a trapped gully at least eighteen inches distant. **Branch waste-pipes** have commonly been made of lead, which is easily run, especially in bends. In the United States they are now generally made of galvanized iron, where concealed, and of painted or nickeled brass with screw joints, where exposed. If improperly laid, lead pipes may sag, with the formation of air-locks. Lead pipes should always be joined to each other by wiped, soldered joints, made by opening out the upper end of the lower pipe, fitting into it the rasped lower end of the upper pipe, and over this joint pouring heated solder, which is so shaped as to give a bulbous form to the joint and is then wiped around with a hot moleskin cloth. An inferior joint is made by heating the ends of the pipes either with a copper-bit or blowpipe and pouring the solder between them. Iron and brass waste-pipes are joined by screw couplings. The rules governing branch soil-pipes also apply to branch waste-pipes, which, however, need be no larger than one and a half to two inches in diameter. Each waste-pipe must be provided with a trap placed as near as possible to the fixtures.

Rain-leaders are pipes collecting the rain-water from the roof and eaves-gutter, and discharging it into the house-drain, street gutter, or yard sink; the latter method being objectionable.

Traps.—Appliances used as barriers against the entrance of sewer-gas into the house are termed **traps.** In the best forms, they attain this object by the constant maintenance of a sufficient depth of water (**water-seal**) between the inlet and the outlet of the trap. The water should stand at least three-fourths of an inch above the openings. The trap should have no angles or projections, it should admit of ready inspection and cleansing, and should be self-cleansing so far as possible, being completely washed out with every flush of water through it. Instead of, or in addition to, the water-seal, some traps employ **mercury seals** or **mechanical devices** such as balls, flaps or valves, lips, etc. The **siphon** or **round-pipe trap**

consists of a bend in the pipe which remains full of water after water is discharged through it. There are a number of forms: running trap, S-trap, three-quarter-S, and double-S or hunchback, etc. The siphon is the best variety. Bedell's and Stewart's traps are provided with a metallic flap or valve and lip respectively. In the **bottle** or **pot trap** the water enters at the bottom and flows out at the top. This form is not self-cleansing and retains dirt. The **D-trap** is open to the same objection. In the **ball trap**, which is not very desirable, a ball acts as a valve by floating up against the entering pipe. The **mid-feather** or **Mason's trap** is a round or square box with the entry and exit tubes on opposite sides at the same height and separated by a partition reaching from the top to a point below the lower margins of the pipes. Not being self-cleansing, it is a bad form of trap. The **bell trap** has been used in kitchen sinks,

FIG. 108.—FORMS OF TRAPS.

FIG. 109.—BELL TRAP.

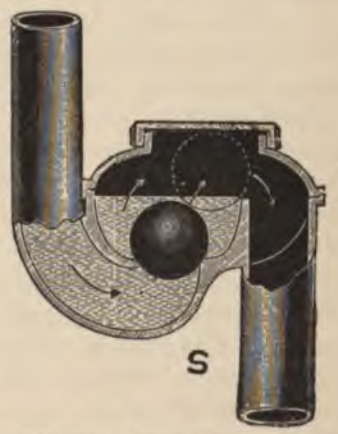


FIG. 110.—BALL TRAP.

but is objectionable. The inlet is a strainer attached to a conical pan which covers the projecting outlet pipes. **Grease traps** are also used in sinks, but unless frequently cleansed, become objectionable. They consist of a reservoir with the inlet at the top and the outlet at the bottom; the grease floats to the top and can be removed periodically. The same method is employed in trapping a **cess-pool.** The **gully trap** is a chamber or box having for the inlet a grating covering the top; the outlet tube being a short distance below. Gully traps are used in the drainage of yard and rain-water pipes and in the English system of disconnecting the waste-pipes from the drain. **Deans's trap** is fitted with a bucket provided with a handle so that all deposits can be removed.

Loss of Seal.—Traps may lose their seals by evaporation, momentum, back pressure, leakage, capillary attraction, or siphonage. **Evaporation** occurs with long disuse and may be prevented by frequent flushing or by pouring glycerin or oil into the fixture. By the force of its **momentum** a sudden flow of water may unseal a trap. This should not occur if the trap is of proper size and in a straight position. **Back-pressure** rarely occurs at the present day. **Leakage** requires no explanation. Water may be withdrawn from a trap by **capillary attraction** when paper, cotton, thread, hair, etc., accumulate in the trap and project in the lumen of the pipe. **Siphonage** may occur when a large volume of water completely fills and descends a vertical waste-pipe, producing by suction a vacuum in smaller branch waste-pipes, which aspirates the contents of the trap. When two siphon traps are placed in the course of the same pipe, without an air opening between, the action of one may empty the other. A trap may also be self-siphoned. Siphonage is **prevented** by several methods. The up-cast limb of the trap may be widened into a reservoir, which, however, acts as a cess-pool and may accumulate sediment. The creation of a vacuum may be prevented by connecting the trap with a ventilating pipe and by extending the vertical waste-pipe over the roof. Each trap at its upper portion is connected with a branch vent-pipe which joins the main vent-pipe at a point above the fixture. The main ventilating pipe is a straight pipe extending into the air. Mechanical or non-siphoning traps are also employed, such as the 'Sanitas' and the 'Hydric.'

Fixtures

Wash-basins are made of copper, enameled and galvanized iron, earthenware, porcelain, and marble. They usually are provided with an overflow horn communicating above with the basin through a number of perforations and below with the branch waste-pipe. Other forms are provided with a stand-pipe which acts both as a plug and an overflow. The overflow is liable to have soap and filth deposited along its inner surface.

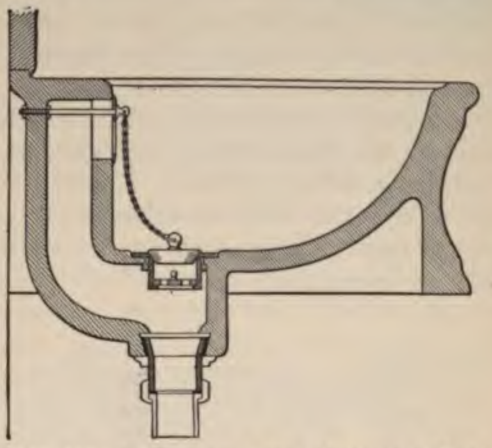


FIG. 111.—WASH-BASIN WITH OVERFLOW HORN.

Bath-tubs should not be placed in bed-rooms. There must be especially constructed bath-rooms, which should be fairly large, well lighted, and well ventilated. The tubs are made of porcelain, earthenware, enameled iron, and tinned and planished copper, the latter being incased in cabinet-work. They also are provided with overflows.

Sinks are made of cast-iron and enameled iron, steel, copper, soapstone, slate, earthenware, and porcelain. The outlet should be covered by a strainer. A grease trap is of advantage if cleansed frequently. A wood grating, if used, should be kept scrupulously clean and frequently aired. The sink should not be inclosed in woodwork.

FIG. 112.—STAND-PIPE.

Laundry tubs are best made of porcelain, and next best of soap-stone. Wood is the worst material and should be covered with zinc or some non-absorbent material.

Safe-trays, consisting of sheets of lead or zinc turned up several inches at the edges so as to catch all drippings and overflow from fixtures, under which they are placed, and connected with a drip- or waste-pipe, are to be condemned.

Water-closets.—Water-closets may be divided into those having, and those not having, movable internal mechanism. To the former belong the pan or container, the valve, and the plunger or plug closets. The latter includes the long hopper, the wash-out, the short hopper or wash-down, the siphon, and the siphon jet closets. The most objectionable form is the **pan closet,** consisting of a china basin, shaped like an inverted cone, with its outlet guarded by a movable metal pan that by the raising of a handle may be swung back into a large rounded cast-iron receptacle, in which it deposits the excreta and water, and from the bottom of which a short pipe leads to a D-trap. The **plunger** or **plug closet** is a trifle less objectionable. It is usually cast in one piece, the basin, which holds a large volume of water, being shut off from the vented trap below by a plug or plunger which acts also as an overflow. The best of the closets with movable apparatus, though by no means to be recommended, is the **valve closet.** This consists of a china or stoneware basin separated from a ventilated trap by a hinged, water-tight valve. The **long hopper closet,** a deep conical basin ending in a ventilated S-trap, is liable to become filthy and is difficult to flush. The **short hopper** or **wash-down closet** has a shorter cone with the back vertical, so that the excrement drops into the water of the trap and not upon the sides of the basin. In the **wash-out closet** the basin is so shaped that a small quantity of water remains in it to receive the excreta, which are flushed out over the retaining ridge into a siphon trap below. The best form is the **siphon closet,** which employs siphonage in addition to flushing. In one variety a weir-chamber with a constricted outlet is placed below the receiver. In the more common form a jet of water pushes over the contents of the basin and thus starts siphonage.

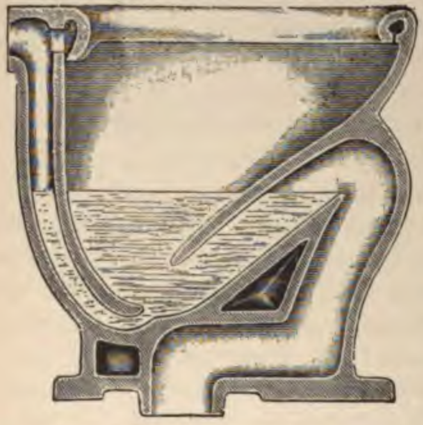


FIG. 113.—JET SIPHON CLOSET.

In every closet a **flushing apparatus** is required for the thorough removal of all matter from the sides of the bowl and its propulsion through and beyond the trap. It must discharge at least three to five gallons of water, which is spread by the flushing rim in small jets against the sides of the bowl. To insure a good force the water is usually delivered through a straight flush-pipe at least an inch and a fourth in diameter from a tank or cistern, which should be not less than four to six feet above the basin. It is usually recommended that the water should not come directly from the water-supply pipes lest the latter become contaminated. This is prevented, and water is economized, by the use of **water-waste preventing cisterns,** made, as a rule, of iron or of wood metal-lined. The tanks may be automatic or non-automatic. The **automatic flush tanks** are used in large establishments and are of two varieties. The 'tumbler' is

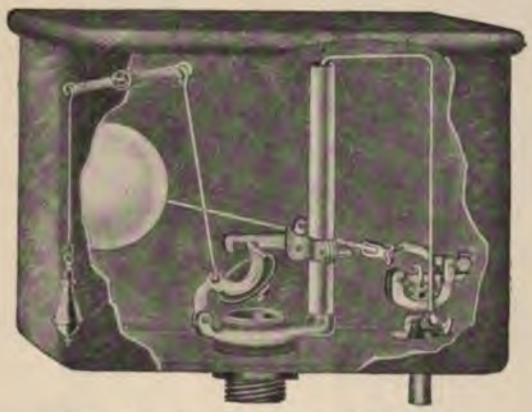


FIG. 114.—NON-AUTOMATIC FLUSH TANK.

a scuttle-shaped tank so balanced that when empty or filling it maintains an upright position, but when filled it tilts forward and discharges its contents. The **siphon** tank when full overflows into the long limb of a siphon and is thus emptied by siphonage. **Non-automatic** flush tanks are provided with a lever, to the long arm of which a chain is fastened, the short arm being attached to a valve closing the flushing pipe. When the chain is pulled down, the valve is raised. The flush may continue as long as the chain is held down, or for a certain length of time, or until the cistern is completely emptied, according to the mechanism employed. The chain may be attached to a handle or to the seat. Nearly all flushing tanks provide for an after-flush to refill the bowl of the closet. The inflow is controlled by a valve and float. In the United States, the flushing tank is now being supplanted by the **flushing valve,** which is a valve placed directly in the water-supply pipe above the closet, opened with a lever and closed by the pressure of the water. To conform with present regulations of the health authorities, a tank is sometimes placed near the top of the house from which the supply-pipe is extended to the flush valves.

Slop closets, which are flushed by the house waste-water, are used where the water-supply is limited. They are of two kinds,

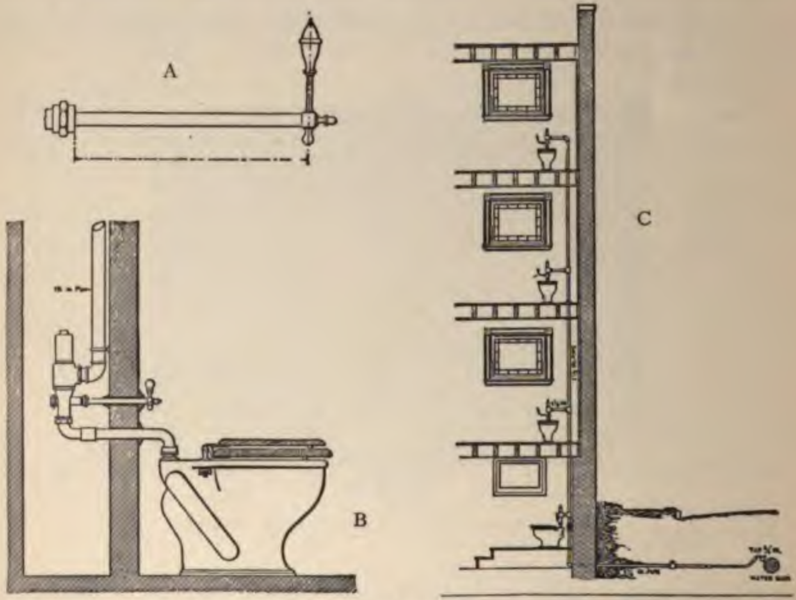


FIG. 115.—(A) FLUSHING VALVE (FLUSH VALVE, FLUSHOMETER, AQUAMETER, ETC.). (B) FLUSHING VALVE FITTED TO CLOSET. (C) SHOWING ATTACHMENT OF FLUSHING-VALVE TO SUPPLY-PIPE.

those in which the waste runs directly into the basin or is poured down by hand, and those in which it is collected in a siphon, cistern, or tipper and then discharged in a sudden flush. The latter variety may be made automatic. A tipper is preferable to the siphon or cistern.

Trough closets are used in public buildings, schools, factories, and groups of artisan's houses, etc. Beneath the closet seats of a series of compartments runs a long metal or stoneware open trough whose bottom is rounded, slightly inclining toward the outlet, and kept covered with water. The upper end of the trough should be connected with an automatic flush tank and the lower end with a siphon trap protected by a grid. In the use of all forms of water-closets, but especially of troughs, the strictest care is necessary to preserve **cleanliness,** not only by regular flushings, but also by the use of brushes and other mechanical cleansers at frequent intervals. A **disinfecting solution,** preferably chlorinated lime, should also be used with sufficient frequency.

Urinals.—Special urinals are necessary only in large buildings, and should have no place in a private house. They should be made of non-corrosive materials, such as china, slate, and stoneware, and should have a copious flush, acting automatically either constantly or at short intervals. A deodorizer is necessary, a simple one being a cake of charcoal saturated with sulphurous acid. Ice is sometimes used. In addition, mechanical cleansing with soap, and the use of chlorinated lime may be necessary.

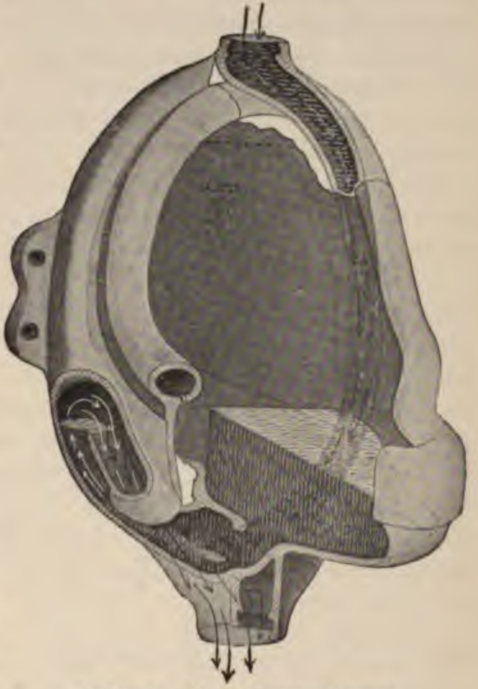


FIG. 116.—URINAL WITH FLUSH.

The Privy or Midden System

This method of disposing of excreta is practised in many rural districts and villages as well as in certain towns. The primitive form, a hole dug in the ground with a rough seat and improvised shed over it, is to be condemned, as it pollutes the soil around the house and the wells near it, besides giving rise to offensive odors. Any form, no matter how well constructed and supervised, is objectionable, yet by due care the risks can be reduced. The midden must be at least six feet from any dwelling and fifty feet from any well, spring, or stream. The capacity of the receptacle must not exceed eight cubic feet and the walls and floor must be of some impermeable material, as flag, asphalt, or cemented brick-work. The privy must be roofed and provided with ventilating apertures near the top. Its floor must be not less than three inches above the level of the adjoining ground, cemented, flagged, or tiled, and having an inclination toward the door of the privy of one-half inch to the foot. The seat should be hinged, so that the ashes, which should be provided, may readily be thrown in. The contents should be removed weekly and must not be carried through the house.

The **pail system** is used in many English towns. The excreta are received into movable receptacles, such as pails and tubs, having a capacity not greater than two cubic feet, and provided with close-fitting lids. They are made of tarred oak or galvanized iron, and should be both air-tight and water-tight. The pail must be removed, and a clean one put in its place, at least once a week. To delay decomposition and to prevent odors the contents of the pail are kept dry by the addition of some absorbent substance, such as dry earth, ashes, or charcoal, deposited either by hand or by a mechanical arrangement. Instead, the pail may be lined with sawdust or peat. The best form of pail closet is the **earth closet,** in using which each stool is immediately covered with one and a half pounds of dry, sifted earth and no slop-water is added to the pail contents.

Disposal of Domestic Dry Refuse

Every house collects dust, ashes, cinders, paper, etc., and scraps of waste food, known as garbage, swill, offal, and slop. In the country this is best burned and the ashes buried. In cities it should be deposited in galvanized iron pails or boxes with tight-fitting metallic covers, separate receptacles being provided for garbage and for ashes and other refuse. Ashes and dry refuse are usually collected once or twice a week, garbage daily during the summer, every other day during the remainder of the year. The removal carts should be of metal and should be provided with covers. It has been advised that garbage be burned in the kitchen stove or in a special arrangement attached to it.

WATER-SUPPLY

In rural districts, and in towns without provision for a general system of filtration, the prevention of the diseases conveyed by impure drinking-water devolves on the individual.

In the country, owing to want of official supervision, special care must be exercised in the **purification of water.** The country well is usually in proximity to the dwelling and draws contamination from a cone-shaped segment of the ground of which it is the center, and where slops and excreta are usually thrown. The same may be said of the spring and cistern. Purification of water may be attained by **boiling, distilling,** or **filtering.** The safest plan when pollution of the water is suspected is to boil it for several minutes. Forbes's apparatus, adapted to furnishing a continuous supply of **boiled water,** is described on page 353. Water long boiled is insipid, owing to the loss of gases. Filtration is a cheap and efficient method of purification. The Pasteur-Chamberland filter, although at first germ-proof, is not permanently so. It is, however, one of the best filters yet invented. It consists of one or more white candle-shaped tubes resembling unglazed porcelain and made of a clay found only in France. Pressure is required to force water from the outside to the hollow center. The filter should be cleansed frequently.

The purification of water on a small scale by **chemical means** is often convenient. Aluminum sulphate, either as such or in the form of alum, is generally applicable. When added to tainted water in the proportion of about 1 grain to the gallon (0.25 gram to the liter), the suspended matter, even when very fine, is collected and precipitated, conveying with it most of the bacteria and even some of the dissolved matter. Filtration may be much assisted by a preliminary treatment of the water with alum. The action depends on the presence of carbonates in the water, and fails therefore with rain-waters and some surface-waters containing but little mineral matter. Direct **disinfection of water by chemicals** has also been proposed. Schumburg and Pfuhl made elaborate investigations which seem to show that a small quantity of bromin added to water will kill pathogenic bacteria, and that the bromin can be neutralized by ammonia or soda, so that a clear, tasteless drinking-water will result. Schumburg recommended the following:

Potassium bromid,	20.00	gm.
Bromin,	21.91	gm.
Water, enough to make	100.00	c.c.

Neutralization tablets contained:

Sodium sulphite, ...	0.095 gm.
Sodium carbonate (dry), ...	0.040 gm.
Mannite, a sufficient quantity.	

Of the solution, 1 to 5 c.c. is sufficient for one liter and is neutralized by one tablet.

Huddleston's experiments served to verify those of Schumburg and Pfuhl. There were some failures which showed the limitations of the method, but it seems to be demonstrated that water infected with typhoid bacilli, but otherwise good, may be made potable. (See also pages 244 and 348 to 352.)

Water may be contaminated with **mineral poisons,** of which the most common is **lead.** Most natural waters do not apparently attack lead. Waters containing free acid or containing but little mineral matter cannot safely be conveyed in lead pipes or stored in lead-lined cisterns. Hot water from a kitchen boiler should not be used for drinking or cooking.

Care should be exercised in respect to **artificial carbonated waters.** If these be made from polluted water, the bacteria contained will survive and often proliferate; only distilled water, therefore, should be used in their manufacture. Also a word should be said regarding **ice**. Many micro-organisms survive freezing. To avoid danger, natural ice should be obtained from an approved source, or artificial ice made from distilled water be employed.

CHAPTER II

SCHOOL HYGIENE; HYGIENE OF TRAVEL

The School Building—Lighting; Furniture; Study Hours; Books; Medical Inspection. Care of Public Conveyances.

The same care must be exercised in the selection of a **site for a school-building** that is necessary for a dwelling; corridors and stairways should be large, straight, and well lighted. All doors should be wide and open outward, so that in case of fire ready egress is permitted. To secure the best environment, with ample light and sunshine and a playground, the school-house should occupy the center of a large lot. The **light** should enter the rooms directly, an oblong room receiving better lighting than a square one. The **windows** should be large and numerous and so placed as to permit the light to come from the left and rear of the desks in order that shadows may be avoided. Their combined area should equal from a tenth to a fourth of the total floor area. Sky-lighting is admirable, but can be utilized only on the top floor. Cross-lighting produces shadows. The windows should reach from a point at least four feet above the floor to one as near the ceiling as possible. There should be two shades for each window, arranged to permit the upper or lower half of the window, or both, to be shaded when necessary. Walls and ceilings should be of some light-reflecting color, preferably a light gray tint. If artificial light is used, there should be one burner for every four pupils. A school-room is well lighted when small print can be read in a remote corner even though the day is cloudy. A school-room should give 250 cubic feet of **air space** for each pupil. **Water-closets** should not be placed in basements, especially when the hot air for warming purposes is derived from such situations. The **cloak room** should be large enough to allow the clothes to hang without touching.

School Furniture

Desks should be at right angles to the windows, about one inch higher than the pupils' elbows, and at an inclination of about ten to fifteen degrees. Desks and seats should be adjustable and graded according to the sizes of the pupils, and not according to their scholarship. Many adjustable desks have been invented in which the seat or desk proper may be adjusted to the desired height by simply turning a crank. The **seat** should be of such a height that the foot rests firmly on the floor when the knee is bent at a right angle. The depth should be not less than eight inches. The distance of the eyes from the desk should be sixteen inches. Defective desks and seats are responsible for many deformities and eye defects.

Blackboards, charts, and **maps** should not be placed at a greater distance than 33 feet from the farthest pupil and should be opposite the source of light. The letters should be large enough to be easily read from any part of the room. The contrast in color between the board and the chalk should be as marked as possible. Copying from the blackboard should be avoided when possible on account of eye-strain due to the frequent change of focus. Bacteriologic investigations of pencils and slates show the danger of indiscriminate distribution of such articles among the pupils.

Regulation of Study

Children should not begin study before the seventh year. In the primary classes work should be confined strictly to the school. The daily session for very young children should not exceed three hours, and for older ones six hours daily should be the maximum. Physical exercises should be included in the curriculum. (See volume VII.) There should always be a sufficient intermission or 'recess,' during which the children should play in the open air. There should be several holidays during the year—advantage being taken of all legal holidays—and one or more short vacations, conveniently at Christmas and Easter, which should be devoted entirely to recreation. A long vacation is essential during the summer.

School-books should be printed on dull surface paper in type not smaller than long primer, with the spacing between the lines not less than $\frac{1}{16}$ of an inch. No line should extend over $4\frac{1}{2}$ inches, as long lines, by compelling extra rotation of the eye muscles, quickly tire the eye.

> These lines are printed in the smallest type, with the least spacing and the longest line permissible, according to the rules just laid down.

Daily **medical inspection of the public schools** is an established system in many of the leading cities of the United States. It is under the control of the Boards of Health with the co-operation of school committees.

THE HYGIENE OF TRAVEL

The general rules of personal cleanliness and avoidance of fatigue, excitement, and unwholesome food and drink, apply as well on journeys as at home. The rules governing invalids traveling for health are given in volume IV.

Care of Public Conveyances

Public conveyances expose the occupant to many sources of danger. These are perhaps greatest in **sleeping-cars,** but are present also in **vessels,** in **day-coaches,** and to some degree even in **street-cars, cabs,** etc. Strict cleanliness and routine disinfection are the obvious measures of **prevention.** Vehicles elegantly upholstered are more likely to retain infectious matters than are those fitted in leather, or with plain wooden seats, which can be cleansed more readily. Cushions, if used, should be detachable, and should be removed and beaten at the end of each trip. The American Public Health Association publishes the following recommendations:

"Passengers known to be contagiously ill should be isolated in a compartment appropriately equipped. Through trains should be provided with rooms for the sick, as well as staterooms, interchangeable in use. Coaches should be furnished with effective means for continuously supplying not less than one thousand cubic feet of warm air an hour for each single seat, and for distributing and removing the air without troublesome draft. The cleansing of cars should be frequent and thorough. Floors and sanitary and lavatory fixtures should be frequently treated with a disinfecting wash. All fabrics in cars should receive sterilizing treatment. Water and ice should be obtained from the purest available sources. The use of tongs in handling ice should be insisted upon. The water tank should frequently be cleansed and periodically sterilized with boiling water or otherwise. The public should be educated to use individual cups. The use of canned goods in buffet-car service makes careful inspection of such goods imperative. The filthy habit of spitting on car floors should be dealt with in a manner to cause its prompt discontinuance. Station premises should receive attention directed to general cleanliness, and should be plentifully supplied with approved disinfecting material."

CHAPTER III

PERSONAL HYGIENE

Clothing. Bathing. Food. Work. Recreation. Sleep. Stimulants and Narcotics. Special Hygiene—Care of Mouth, Teeth, Nose, Eyes, Ears, Skin, Hair, Nails.

CLOTHING

General Considerations

The essential **objects** of clothing are the protection of the body against wetting, injury, and variations in temperature. The **materials** for clothing are chiefly derived from the animal and vegetable kingdoms. To the former belong wool, furs, silk, and leather; to the latter, linen, cotton, and rubber. In choosing among the different materials we must take into account two things: their power of conducting heat and their capacity for absorbing moisture.

The power of **conducting heat** depends upon the nature of the material, its texture, its color, and the number of layers worn. **Colors** differ in their power to absorb and reflect the heat of the sun's rays. White absorbs the heat least and reflects it most; then in order come yellow, red, green, blue, and black. The looser the **texture,** the greater is the amount of air—a very poor heat conductor—in the meshes, and the warmer will be the garment. Similarly, when **many garments** are worn one over another, layers of air are confined between them, and the greater their **number,** the greater the protection against loss of animal heat. **Moisture** is held in two ways, being retained in the interstices between the fibers and absorbed directly into the substance of the fibers. When in the interstices it gives the sensation of dampness or wetness, and can be wrung out; but it may be present in the fiber in large amount without imparting a feeling of dampness or being expelled by pressure (hygroscopic moisture). The heat loss when the body is enveloped in wet clothing is considerable; according to Rumpel, three times as great as a nude person would lose under like temperature conditions through conduction and radiation.

Wool is a poor conductor of heat, a non-absorbent of odors, and a good absorbent of water, its power of hygroscopic absorption being double in proportion to its weight and quadruple in proportion to its surface. In washing, it shrinks and hardens. **Cotton** is a much better heat conductor than wool, is very absorbent of odors, and quite non-absorbent of water, either in or between the fibers. It is cheap, durable, and does not shrink. **Silk** is a poor heat conductor and a non-conductor of electricity, but is very hygroscopic. It does not shrink. **Linen** is a good conductor of heat and a bad absorbent of moisture, but is very durable. **Rubber** used in clothing is elastic and impermeable to water. **Leather,** though hygroscopic, is sufficiently waterproof for ordinary use. The so-called 'patent leather,' however, is made impermeable. **Furs** are impermeable to wind and of a very low heat conductivity.

Special Garments

Underwear should preferably be of flannel or wool, owing to their hygroscopic properties. Perspiration is absorbed by wool, from which it slowly evaporates, while it passes through the ordinary close-woven cotton and linen and evaporates from the external surface, causing the loss of heat to continue, and may produce chill by the sudden evaporation. Silk is excellent but expensive. It is especially to be recommended for gouty and rheumatic individuals, for those extremely subject to 'cold,' and for those whose skins are irritated by wool. Loosely woven cotton or cellular cloth or a mixture of cotton and wool or a loosely woven linen-mesh may be worn. Underclothing should be removed at night and allowed to air. Many parasitic skin diseases, especially in the tropics, are favored by the continuous wearing of damp underclothes. Even apart from esthetic considerations, frequent changes should be made to prevent injurious effects from the accumulation of excretory products in undergarments.

Outer garments for use in hot weather are best made of cotton and linen. Color is of importance, white being most suitable for hot climates and the warm season. Against cold, wool affords the best protection. Starching and ironing, by closing the pores in clothing, render it more impervious and tend to conserve the heat of the body. Thus starched clothing is more comfortable in cold weather, and unstarched, in hot weather. **India-rubber garments,** being impermeable, prevent evaporation, and should therefore be worn as little as possible.

Clothing should not be too heavy and should fit properly, in order not to embarrass the circulation or compress the viscera; there should be space afforded for circulation of air. The clothing of women should be suspended from the shoulders. It is well known that light, moderately loose garments are warmer than heavy close-fitting ones. Fur boas and other tight-fitting neck-coverings, and straps and belts about the waist, are to be avoided. Sealskin sacks and heavy wraps should be removed before, or immediately on, entering a warm apartment. They should not be worn for 'shopping' tours, and the like. It is well, sometimes, on entering a house from the street on a cold day, to wait a few moments in the vestibule, which is likely to be of an intermediate temperature; then to remove the outer wraps and go into the warmer room.

The prejudice that leads to the wearing of too heavy clothing is difficult to overcome. Many individuals are prone to asseverate that they invariably contract colds unless well swathed in over-warm garments. The fact is that they misconstrue a cough as the evidence of such exposure. The cough is not provoked by the inhalation of cold air, but is a reflex act initiated at the skin by the action of the cold air —a **skin cough.** I have tested a number of persons to determine whether particular regions on the surface of the body were sufficiently susceptible to an irritant to cause cough. In not a few instances I was able to mark out such regions, which I have denominated **tussogenic zones.** The irritant employed was a current of cold air from an air-pump. The zones were most frequently found on the anterior surface of the neck in the course of distribution of the vagi.

Robinson in discussing the climatology of **nudity** justly inveighs against the ever-increasing custom of over-covering the skin. He cites the story of the Indian who, apparently quite comfortable in inclement weather, although almost naked, was asked why he did not suffer, and replied: "White man's face no clothes, no sick. Indian all face." Excessive covering makes the peripheral nerves too sensitive to caloric changes and the capillary blood system too feeble to cope successfully with thermic, toxic, and traumatic impressions. The nude human skin can absorb all kinds of light waves. I have endeavored to show that ordinary sunlight falling upon the surface of the body penetrates the tissues to a variable depth, depending on the degree of cutaneous moisture, and Kime has recently demonstrated the power of the actinic rays of the sun to pass through the animal body, adducing in support of this observation scenes photographed through a human screen. Light is a powerful germicide, and the blood, while circulating through parts bathed in powerful light, is undoubtedly subjected to its chemical effects. We cannot possibly ignore its sanitary value. In ancient Greece and Rome sun and air were regarded as highly important for the health of man and animal. On the roof of nearly every dwelling in Rome there was a place called a solarium, and here the inmates exposed their nude and anointed bodies to the sun, not only for pleasure but for the preservation of health. When the skin of a man was not browned by the sun, he was ridiculed as an effeminate. Modern phototherapy makes efficient use of sunlight and electric light. (See volume IX of this series.)

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FIG. 117.—A WOMAN'S FOOT IN A POINTED-TOED STOCKING AND POINTED-TOED SHOE.—(*H. Augustus Wilson.*)
a–a, Meyer's line.

Footwear.—Protection of the feet against dampness is of the greatest hygienic importance. Whenever the feet become damp, the loss of heat becomes enormous. According to Pettenkofer, if the stockings contain an ounce and a half of moisture, the quantity of heat necessary to convert it into vapor is equal to that necessary to melt more than one-half pound of ice or to raise the temperature of half a pound of water from the freezing to the boiling-point.

Footwear should conform to the physiologic anatomy of the foot. Correct shoes can often only be made to order upon lasts made from a tracing of the foot. A proper shoe should be nearly straight on the inner side with a gentle curve on the outer side. The sole should be flat, not curved. A hygienic shoe should have a sole corresponding in shape to the impression of the normal foot. Corns, bunions, ingrown toe-nails, etc., owe their origin to badly constructed shoes. Heels should be broad and low. High heels weaken the arch of the foot through atrophy of the plantar ligaments. Shoes should be a little longer than the foot, but not so long as to permit friction of the shoe against the foot in walking. Patent leather shoes do not permit of sufficient circulation of air unless they contain a special ventilating device.

Many shoes sold as anatomically correct are anatomically incorrect. Meyer first called attention to the fact that in a normal human foot a line drawn from the center of the os calcis through the center of the metatarso-phalangeal joint of the great toe would pass through the center of the distal phalanx of that toe; and, further, that lines drawn through the center of each of the toes should converge at the same point. **Meyer's line** is of great value in the study of foot deformities superinduced by faulty shoes, and can be employed with or without the aid of the X-rays.

FIG. 118.—THE SAME FOOT AS IN FIG. 117, WITHOUT ANY COVERING.—(*H. Augustus Wilson.*)

a–a, Meyer's line.

Thomas S. Ellis and H. Augustus Wilson have both shown that much of the evil charged to shoes is produced by the ordinary median-pointed or even-sided sock. A separate stall for the great toe is desirable, but a sock with a straight inside line will suffice.

Garters.—Circular elastic garters, by interfering with the return of the venous circulation, conduce to the production of varicose veins. Stockings should be suspended from some part of the underclothing.

Corsets.—The corset, as ordinarily worn, is the most obnoxious constituent of woman's dress. The long list of maladies attributable to this article is not exaggerated. The pressure of the corset restrains the movements of the lower portion of the thorax, thereby interfering with the normal movements of respiration and circulation and dislocating the abdominal organs; backache, debility, nervousness, constipation, and hysteria may result from this artificial compression and dislocation of vital organs. It is largely responsible for gall-stones, hepatic torpor and displacement, displacement of the kidney, and displacement of the stomach and intestines (splanchnoptosis or Glénard's disease). It may be concerned in the reduction of local vitality, particularly in the evolution of mammary carcinoma. Even though the corset be worn loosely, the steels and stiffness render it an unfit article of dress. No one can possibly object to a **corset waist,** worn as a breast support only, but it should not be so constructed or worn as to be prejudicial to health in womanhood or childhood. Such waists should be loose enough to permit of free respiration and unrestrained motion. These requirements are attainable with the many hygienic waists now on the market, such as the Equipoise and Ferris waists, which combine all the attributes of grace and beauty. The Equipoise waist embodies the hygienic principle of support from the shoulders. Each part is carefully adjusted with relation to the others, so that the strains and pulls of all the attached garments are balanced. The Ferris waist has attachments for hose support and also adjustable shoulder-straps enabling a woman's shoulders to carry the weight of the skirts. **Straight front** abdominal corsets with low 'busts' and not pulled too tightly may be worn by stout women, and tend by their upward pressure to prevent descent of the stomach and kidneys.

Head-covering should be light and porous and should not constrict the scalp. The combination head-covering worn by women in mourning is particularly injurious.

Non-inflammable Clothing.—To reduce the inflammability of clothing, especially in those exposed to risk of fire in their daily occupations, Kedzie recommends immersing cotton and linen fabrics in starch solution containing a heaping teaspoonful of powdered borax to each half-pint. The fabric is not injured thereby, nor is any disagreeable odor imparted. There is no interference with the subsequent washing of the goods and the formation of a smooth and polished surface in the process of ironing is not prevented. The addition of 20 per cent. of sodium tungstate and 3 per cent. of sodium phosphate to the starch sizing is likewise effective.

Dyes.—Cheap anilin dyes used in underclothing and stockings are often the cause of obstinate cutaneous eruptions. The strange superstitions in favor of 'red flannel' and 'medicated underwear' seem hard to get rid of.

BATHING

The various methods of bathing and their effects on the nerves, the muscular tissues and the blood, as well as on circulation, metabolism, secretion and excretion, are described in volume IX, on 'Hydrotherapy.' Hygienically, bathing is employed for its **cleansing** and its **hardening** effects.

To secure **cleanliness** the pellicle formed by dead scales, sebaceous matter and dirt must be removed. **Warm** and **tepid baths** are best suited for this purpose, taken preferably in the afternoon or at bedtime, and followed by a cold sponge or shower and then by dry friction. **Soap** is required to dissolve the grease upon the skin, and should be made of pure and fresh fat or vegetable oil with only enough alkali to balance the fatty acids.

For **'hardening the body'** or producing immunity against 'catching cold' by accustoming the vessels of the skin to variations in temperature, cold water is employed. The full bath, the half-bath, with or without affusions, the shower-bath, and the sponge bath are available. The latter, though not quite so efficient as the others, is often more convenient. The best time for taking the cold bath is immediately upon rising. The duration should at first be short, and both this and the form of the bath are to be governed by the effect. It is necessary that complete **reaction** take place. This is aided by rubbing the body with a rough towel until it glows, before and after the bath. Persons not used to the cold bath may be accustomed to it by gradual reduction of the temperature of the water. Accurate thermometry is often necessary. Systematic cold bathing is best begun in the warmer months. For delicate persons it may be most advisable after preliminary cooling of the head, to sponge or immerse the body in hot water (95° to 100° F.) for a minute or two, and then to make a cold application—shower, sponge, douche, immersion—with gradual increase in duration and force and gradual decrease in temperature on successive days. A **shower-bath brush** has been devised with soft white bristles on one side and harsh black bristles on the other. It is attached by means of a rubber hose to a reservoir or faucet and water run through it.

The **soothing** effect of a warm bath is utilized after an unusual amount of physical exercise when the muscles are stiff and sore, and also, before going to bed, to promote sleep.

The **hot bath** should not be taken without therapeutic indication.

Turkish baths, Russian baths, and other forms of **sweat baths,** especially when conjoined with massage, have important hygienic uses, in promoting circulatory activity, metabolism, secretion, and elimination of waste, more particularly in the obese and those of gouty tendency and sedentary life. They are discussed at length in volume IX of this series.

No bath should be taken while digestion is going on; that is, for three hours after a meal.

Sea-bathing.—The contact of the waves and breakers upon the skin, the stimulation due to the saline constituents of the water, the pure air of the seashore, and the breezes free from micro-organisms, make sea-bathing one of the most invigorating forms of the cold bath. Reaction is promoted by the impact of the waves and by the exercise of swimming. It is a popular but erroneous belief that the salt of the sea is absorbed through the skin. The duration of the bath must be limited by the reaction, and chilling is to be avoided. One should avoid bathing when overheated, fatigued, or exhausted. The bath is taken best in the morning and never until at least two hours after a meal. One should not stand around after having been in the water, but should dry the body quickly and vigorously, if possible selecting a bathing room exposed to the solar rays, where the nude body may receive the invigorating impact of the energy of the sun. During menstruation and in the last months of pregnancy sea-bathing must be forbidden.

The average amount of salts in sea-water is about 3 per cent., and this may be regarded as the average percentage of sea salt for a bath taken at home; *i. e.*, about 9 pounds of salt to 30 gallons of water. When sea salt cannot be obtained, the following mixture of salts dissolved in about 30 gallons of water may be regarded as a good substitute for a sea-bath:

Sodium chlorid (common salt), ...	4 kilograms (8 lb. 13 oz.).
Sodium sulphate (Glauber's salt), ...	2 kilograms (4 lb. 7 oz.).
Calcium chlorid, ...	½ kilogram (1 lb. 2 oz.).
Magnesium chlorid, ...	1½ kilograms (3 lb. 5 oz.).

Bath Pruritus.—An annoying itching of variable duration frequently follows bathing, whether in salt or fresh water, especially if the bather suffer from a naturally irritable skin. Very often when the body is not thoroughly dried eczematous eruptions occur, especially in parts subject to friction, as the groins, perineum, inner surface of the thighs, armpits, etc. Friction of the skin with a coarse towel or flesh-brush may result in the production of skin lesions like psoriasis and erythema, especially in those predisposed. The use of impure and irritating soaps contributes to many of the cutaneous affections following frequent baths. The most expensive toilet soap is usually the best. Irritable skins should be dried without friction and then freely dusted with a powder of talcum or one composed of equal parts of zinc oxid and starch.

Care of the Complexion.—The use of warm or hot water upon the face is likely to produce chapping and roughening of the skin, especially in winter when the face is exposed to winds. Cold water to the face acts as a stimulant to the blood-vessels and elastic fibers of the skin and reduces its sensitiveness to the action of winds and cold air. The use of soap for cleansing the face is to be avoided, being only indicated, and then with moderation, in persons with oily skins, or in those exposed to an atmosphere laden with dirt. When the circulation of the skin is faulty, it may be remedied by kneading or vigorous pinching of the face by the fingers. When the skin is very dry, anointing the face at night with a little lanolin or almond oil is serviceable.

FOOD

The general principles of diet and the quantity and kinds of food needed in health are fully discussed in volume VI of this series, on "Dietotherapy and Food in Health." Certain other facts must be considered in the hygienic regulation of eating.

Hours for meals vary with country and occupation. In France but two substantial meals a day are eaten. A cup of hot coffee or chocolate, with bread or a roll, is taken on rising. In the late morning there is a substantial breakfast, and between six and seven o'clock in the afternoon, dinner is served. The German also takes his coffee and roll soon after rising, but dines early and takes a supper with meat between half-past seven and eight o'clock. The custom of German business men to interrupt work and give sufficient time to meals and cheerful social converse in the early afternoon, is conducive to health and longevity. The common custom in England among the more comfortable classes is to breakfast at eight or nine o'clock, lunch or dine between one and two, take a cup of tea at four or five, and dine or sup at seven or eight o'clock. Englishmen, as a rule, eat too much meat, although out-of-door life and devotion to sport, among the well-to-do, usually postpone gout and other ill consequences to late middle life, when activity is diminished. In the United States three substantial meals are eaten daily. In the rural districts and among many classes in the cities, including the great bulk of wage-earners, the heaviest meal is taken at noon. Breakfast is eaten immediately after rising and supper about six o'clock. Professional and business men who are not occupied in physical labor or outdoor pursuits usually dine after their work is over. Breakfast is taken at half-past seven to half-past eight, lunch between one and two, and dinner between half-past six and half-past seven. Most Americans, rich as well as poor, eat too hastily and partake too freely of animal food.

It is of great importance to allow **sufficient time** for meals; and when at least an hour cannot be taken in the middle of the day, it is usually better to be satisfied with a very light luncheon, or even a plate of soup or a glass of milk and a few crackers, than to gulp down a more substantial meal. Both before and after eating, from ten to thirty minutes should be given to rest or pleasant converse. The hurried midday lunch of shop-girls, and of professional and business men, is especially potent as a cause of indigestion. Injury also follows irregularity of meal-times as well as the habit of going without food from breakfast to a late dinner.

Conditions Affecting Digestion.—Beginning breakfast with fresh fruit, and dinner with soup, excites the secretion of gastric juice, so that it has attained its full strength and quantity by the time the principal food is taken.

Variety should be observed both in the food and in the methods of its preparation.

Cooking not only renders food more pleasing to the eye and to the palate, but makes it easier of mastication and digestion, at the same time killing any living organisms that may be present. It coagulates the proteid constituents of meat and forms gelatin from the connective tissue, while it also coagulates the albumins and globulins of vegetables and converts the insoluble starch into soluble starch or into the more digestible forms of dextrin and maltose.

The drinking of **ice-water** at meals not only retards digestion, but frequently leads to sore throat. Very hot or very cold food should be swallowed slowly.

Violent **exercise** immediately after eating retards digestion and may produce acute dyspeptic symptoms. No severe mental or physical labor should be undertaken directly after meals. Yet the day laborer begins work again almost immediately after dinner without experiencing evident ill effects. Exercise before meals is often beneficial, and horseback-riding is supposed to maintain the functional activity of the liver.

Rest should be taken after the ingestion of a heavy meal, if only while sipping hot coffee or smoking a cigar. Rest before dinner is also beneficial, and may be obtained while making a leisurely toilet. Digestion being retarded by sleep, it is unwise to retire for two or three hours after a heavy meal. On the other hand, as hunger produces wakefulness and restlessness, the taking of a glass of hot milk or a cup of chocolate before going to bed may prevent insomnia.

Strong **mental emotion** inhibits digestion, while pleasure and laughter affect it favorably.

Smoking after dinner promotes in many the secretion of gastric juice, while after breakfast in some it favors peristalsis. Before meals it may destroy the appetite and interfere with digestion.

WORK

The **occupation** may have an influence on health, as fully discussed in Part I of this volume (pages 64 to 70). In tailoring or dressmaking the workers are often confined in overcrowded, badly ventilated rooms. In other trades they are exposed to irritating and poisonous gases, fumes, and dusts, and to infective matter in dust. Some are exposed to extremes of heat, others to dampness or abnormal atmospheric pressure. Occupations involving constrained attitudes, or overexercise of parts of the body, lead to various deformities; while through lack of exercise and fresh air, a sedentary occupation often contributes to ill health. Occupations involving severe nervous and emotional strain may lead to brain fag and neurasthenia, or to forms of insanity; those of a monotonous character, to melancholia. The various statistics that have been compiled cannot be relied upon, it being impossible to eliminate outside influences that may have affected the health of the worker as much as or more than the trade itself. Attention to ventilation, to home influences, to the character, preparation, and eating of food, and participation in active outdoor exercise would reduce to a large extent the detrimental influences of occupation on health and length of life.

The **length of the working day** must often vary with the occupation. As a rule, however, under favorable conditions ten hours is considered the maximum for men, and eight hours for women and youths. Children under fourteen years of age should not work in mines, factories, or workshops. The tender age at which girls are often sent to work, and their long hours of monotonous labor, tend to impair the vitality of the race by physical deterioration of its mothers. This evil, however, belongs to economic rather than to medical problems, both as to cause and prevention. The greater the amount of mental or physical energy required, or the greater the danger from the occupation, the shorter must be the working day. Working overtime should be prohibited. A midday pause of at least one hour is required, and there should be a weekly rest of twenty-four hours. The Mosaic dispensation in commanding men to abstain from work on one day in every seven, gave religious sanction to a sanitary measure.

In the professions regular hours of work are often impossible. Some minds are systematic, others are not. One man can study better at night, another in the early morning. The physician, who sometimes works twenty hours a day, usually has to do his reading, writing, and thinking when he can snatch time. The clergyman is subject to the calls of various duties at any moment. Nevertheless the attempt should be made to shorten the hours of labor and increase those of mental relaxation and physical exercise. Regular hours and sufficient time for meals, are above all important.

The **business man** should train himself not only to leave his business cares at his office, but also to control his feelings, avoiding alike sudden paroxysms of passion and long-continued states of anxiety and ambition, for excessive emotion is more injurious to the brain than excessive work. A philosophy of complacency should be cultivated by all.

Mental overwork may be indicated by excessive nervousness, irritability, headache, a sense of weight on the top of the head, a feeling of constriction in the forehead, insomnia, numbness in one or more of the extremities, permanent slight loss of control over some groups of muscles, momentary loss of consciousness, failure of memory, and loss of the power of fixing the attention. These forewarnings of nervous breakdown should always be heeded. The worst breakdowns, however, often come on insidiously.

It sometimes becomes necessary to do a great deal of work in a short time. If the object to be gained is sufficiently important and a compensating rest is taken after the exertion, the slight risk may be justifiable, for the brain usually recovers from the acute exhaustion following a brief mental excess. **Stimulants** are to be avoided, however, during a period of hard brain-work. Tobacco and alcohol are dangerous in many ways; morphin and cocain lead to insanity; tea and coffee are safer. The taking of simple food at not too long intervals, especially a glass of hot milk at bedtime, is beneficial.

REST AND RECREATION

Habitual recreation is absolutely essential for the preservation of mental and physical health. It may be mental or physical or both. Monotony in any occupation is injurious. The human body is not constructed on the lines of a watch, to run continuously after a few hours of indifferent recreation and sleep. An ancient sage is said to have divided the twenty-four hours into three portions—eight hours for labor, eight hours for refreshment and recreation, and eight hours for sleep. The division may still be accepted.

The **kind of recreation** required varies with the vocation of the individual. At the end of a day's work the laborer requires physical rest and mental exercise, while the professional man needs exercise of body and relaxation of mind. Both need cheerful and sprightly surroundings. Laughter has a decided recuperative value. Hence the greater vogue of comic opera and farcical plays than of grand opera and tragedy in our too strenuous day and country.

Mental Recreation.—Healthful employment of the brain is as necessary as is its nutrition. No great intellectual work has been achieved with a brain that has not been systematically exercised. Mental overwork leads to mental decay. Fret, hurry, and worry, emotional disquietude, and the endeavor to accomplish some task in too short a time are some of the causes that conduce to brain exhaustion. Working in a single rut is another factor. While sleep restores wasted nerve force, yet we are constrained to seek rest for the jaded brain by so diverting its activity as to sustain and soothe it. The overworked mind thus finds rest in social **converse,** in cheerful and not too intricate **games,** or in the world of **art** and **letters,** as opened by books, museums, plays, operas, and the like.

Music as a therapeutic resource has occasionally, from very remote times, been experimented with by physicians. Its association with pleasing pictures has been tried by Dr. J. Leonard Corning, who reports very soothing results in certain disordered mental states. He finds music most effective while the patient is asleep or about to fall asleep, harmony more effective than melody, and some of Wagner's compositions particularly excellent. The patient dons a hood so fashioned as to form a reverberator and goes to bed. The pictures are thrown on a screen at the foot of the bed, and the music is supplied by a phonograph.

The cultivation of some **hobby,** like the collection of stamps, coins, paintings, rare books, old prints, old china, old furniture and the like, is not merely an agreeable diversion, but may be a veritable safety-valve for overwrought cerebration.

Recreation should not involve **mental labor,** especially of a kind similar to that of the working hours. Sunday-school teaching may be beneficial to the business man or to the society girl, but is injurious to the public-school teacher. Chess-playing, while to be condemned as a recreation for those whose life-work requires long-continued hard thinking, may be indulged in by those whose chief strain is emotional or whose day's work is a round of monotonous labor not involving the higher mental faculties. A good working rule suggested by Dr. H. C. Wood is that he who has labored upon dry intellectual subjects is better in the evening for an emotional stirring up; whilst he who has spent his hours in the turmoil and excitement of the stock or grain exchange needs rather some calm intellectual pastime which shall restore his mental equilibrium. The practical test, however, of the hygienic value of a recreation is its effect as shown by the individual's relative aptitude and desire for work after indulging in it.

Physical Recreation.—Exercise, in order to be productive of good, must be accompanied by relaxed mental tension and emotions, for unless it gives pleasure it is a strain and not a diversion. The physician on his vacation enjoys walks of miles, though he may find walking becoming irksome as a matter of duty at home. The various forms of physical exercise, their regulation, indications, and counterindications, are fully considered in volume VII, on "Mechanotherapy and Physical Education."

Vacation.—A periodic complete annual rest should be taken; by town dwellers, preferably in the summer. Its duration should be proportionate to the severity of the winter's strain, and not less than two weeks. This not only rests the weary brain, but restores as far as possible the health of the muscles and digestive organs. During vacation one should be free from anxiety and other depressing emotions. The relative isolation of an ocean voyage or of a hunting or fishing expedition is one of the chief factors in its usefulness. Camping out is to be specially commended to those of sedentary occupation; and for those who do not wish to destroy the life of animals, 'hunting with the camera' is a pleasing and beneficial sport. Spending one's days, however, in bed and one's nights in the ball-, bar-, or billiard-room at a fashionable resort may not be a means of improving the health. On the other hand, cheerful emotions are necessary. Travel invoked as a source of recreation may prove a hardship if its pursuit be made perfunctory, justifying the quotation:

"Cœlum non animam mutant, Qui trans mare currunt."	"They change their skies, but not themselves, That cross the seas."

Sleep is, without doubt, the natural restorative of a fagged brain. Its value depends more on its intensity than on its duration, eight hours of a sleep disturbed by dreams being of less value than a deep, dreamless sleep of but two hours. The amount of sleep necessary is commensurate with the mental and physical exercise of the waking hours. The average man requires seven or eight hours of sleep each day, yet it is impossible to lay down any rule that can apply indifferently to all persons under all circumstances. Children need more sleep, and aged persons less sleep, than do vigorous adults. Those who have to rise early during the week should lie abed longer on the day of rest.

STIMULANTS AND NARCOTICS

Alcohol is not a necessity in health; yet is often beneficial by being conducive to pleasure and good-fellowship. It should be avoided by the young, but may usually be taken without serious detriment by those who have reached middle life. To the aged, who have previously been abstemious, it is often a support. In the least excess, alcohol does harm. What may constitute harmful excess varies with the individual. One who inherits a tendency to dissipation, or one of weak will, should not taste an alcoholic beverage; total abstinence can do no harm to any. In quantities of one to one and a half fluidounce in twenty-four hours alcohol is said by certain authors not to be injurious to the average normal man. Women should take less. One ounce of alcohol is equivalent to two fluidounces of spirits (brandy, whisky, rum, etc.); or to five ounces of the stronger wines (port, sherry, and Madeira); or to ten ounces of the lighter wines (clarets, burgundies, Rhine wines, champagnes, etc.); or to twenty ounces of beer. The estimate quoted is therefore quite liberal, perhaps too generous. Those engaged in hard labor, or exposed to extremes of heat and cold, are better without alcohol. **Beer** and **light wines** are to be preferred to spirits, unless the individual be of gouty tendency. **Spirits** are least likely to be harmful if taken well diluted with carbonated water. **Liqueurs** contain many toxic substances and should be avoided altogether. The best time to drink an alcoholic beverage is with the principal meal of the day. Strong liquor taken in an undiluted form upon an empty stomach is always injurious. By provoking appetite and limiting tissue waste it is doubly dangerous to the man of sedentary habits, whose unused muscles require little food and waste too slowly. The morning ride after the hounds, following a night's tippling, renewed the old English squire's tissues, used up the surplus food, and stimulated the kidneys and skin to excrete the excess of alcohol that otherwise would have caused more serious injury. The wine or beer taken by the European laborer with his meal renders his coarse food more palatable.

Coffee and tea, taken in moderation, may have a beneficial influence, but when used to excess give rise to nervous disturbances and dyspeptic symptoms. They serve as a vehicle for sugar, milk, and cream, and are also a means of introducing water into the system. They should never be given to children.

Tobacco used in moderation is one of the least hurtful of luxuries, its effects being transitory and functional in character and due to the imbibed poisons (carbonic acid, ammonia, nicotin, a volatile empyreumatic substance and a bitter acid), which are readily eliminated. It soothes and probably conduces to clear and quiet thinking, when smoked leisurely after the midday meal or after the work of the day is over. Hurried smoking, smoking during work hours, and excessive smoking are harmful in different degree to different individuals. As in the case of alcohol, the question of excess is much modified by the individual equation. Three cigars of ordinary size daily are not demonstrably injurious to the average adult in good health. Those of erethic temperament are more easily affected by tobacco than are the phlegmatic, and the sedentary brain-worker cannot with impunity smoke so much as he who leads an active outdoor life. While the disturbances produced by tobacco are chiefly functional, yet undue repetition will induce structural lesions in the blood, the stomach, the heart, the organs of special sense, the brain, the nerves, and the buccal and bronchial mucous membranes. It is especially injurious to the young, arresting oxidation at those periods of life when that process is most active and most needed, and when the structures of the body are attaining their full development; thereby causing impairment of growth, premature manhood, and physical degradation. The poisons are absorbed by a clean clay pipe, which is consequently much safer than a short dirty pipe or a fine cigar. Sore throat is prevented by the use of a long-stemmed pipe, which renders the smoke cooler by the time it reaches the throat. Smoking half of a long cigar is next best, being much safer than smoking a short pipe or a cigarette, which in this respect is the most injurious of all. The habits of inhaling the smoke, of swallowing it, or of passing it out through the nose may lead to disease of the irritated parts. In habitual smokers, at the inside of the corners of the mouth and lips and in some other localities, there may appear opalescences known as the milky patches of smokers, and sometimes mistaken for syphilitic mucous patches. They usually subside with the abandonment of the practice. A large proportion of the cases of epithelioma of the tongue apparently occurs in those who smoke short-stem pipes.

Drug habits, as the abuse of morphin, chloral, cocain, sulphonal, trional, and the like, may sometimes be due to unwise prescription or thoughtless recommendation by medical advisers. While these and similar agents must be used when necessary, as a rule it is best that the name of the drug be not mentioned. The prescription must be definite in dose and directions, and only sufficient in quantity for the immediate occasion. Physicians should lose no opportunity to make their patients and the public in general aware of the insidiousness and danger of drug habits. Especially is this advice called for at the present day in connection with the 'headache powders,' 'neuralgia pills,' 'soothing' and 'sleeping potions,' and bromid compounds so widely advertised and so readily to be obtained even from reputable pharmacists. The untoward influence of these preparations of known or unknown composition may be manifested by immediate or remote effects; by sudden cardiac failure, or more frequently by the gradual development of myocardial degeneration, nephritis, anemia, or cerebrasthenia. A heart depressed by the habitual or occasional use of coal-tar derivatives may be unable to withstand the attack of the toxins of acute infections, as influenza, typhoid fever, and pneumonia, or even a sudden or unusual strain, as in muscular exertion or child-birth.

SPECIAL HYGIENE

Care of the Eyes

The eyes should never be exposed to the direct glare of the sun. For **reading** or any close work a sufficient light without glare should fall over the shoulder, slightly to one side, giving constant illumination, without flickering or shadow; and when the right hand is used as in writing or sewing, the light should come from the left. The book or work should be held about eighteen inches from the eyes and no print should be read continuously that does not appear perfectly sharp and distinct at this distance. Stooping forward or sitting in a careless or lounging way when reading should be discouraged, as it tends to bring the eyes too near the page. Reading in a moving car or carriage strains the accommodation, by necessitating a change of focus with every jar. Reading while lying on the back strains the external muscles of the eyeball, which, being accustomed to combine convergence with a downward movement of the eyes, are put to extraordinary effort in other associated movements and hence are easily fatigued. Looking at pictures hung high in a gallery causes a similar strain. The continuous gaze upon the page should be interrupted occasionally by looking into the distance, thus resting the eyes. One should not persist in reading or writing when sleepy, on account of the tendency to divergence and relaxation of accommodation, which can be counteracted only by a supreme effort of the will. The page read should be printed with ink of good quality and with type of good size and shape on a good quality of unglazed paper, and, if very wide, in a double column. When prolonged near use of the eyes produces headache or necessitates excessive straining to prevent blurring of the object, the eyes should be examined.

The Ear

The hygiene of this organ consists chiefly in letting it alone. The ear should be **cleansed** with a damp cloth, never with soap and water. The meatus should not be entered. Removal of collections of ear-wax should be intrusted only to the skilled hand. Dropping a quantity of oil or other fluid into the ear does not soften the wax, but instead causes it to swell. The method may be used, however, to smother and float out a living insect. A foreign body in the ear may be made to fall out if the head be inclined to the side and the canal straightened by pulling the auricle outward and backward. Cotton should not be worn in the ear except during swimming or diving, or for a special therapeutic purpose. Violently blowing the nose when it is stopped up or filled with a cleansing solution may drive the nasal discharge into the Eustachian tube, which, however, may be emptied again by aspiration, through compressing the nose and swallowing. Careless douching or spraying of the nose may carry infectious particles into the Eustachian tube; while the use of cold solutions may be harmful even in the absence of infection. A box or kiss on the ear may rupture the drum membrane. Pulling the ear is also dangerous. After frost-bite the ear must be thawed slowly. The wearing of ear-rings should be discouraged.

The Nose

Ordinarily no local care, other than the use of the handkerchief, is required after childhood. Prophylactic hygiene consists in attention to the rules laid down under bathing, clothing, heating, and ventilation, especially in keeping the air of the house moist.

The Teeth

Civilized man must give his teeth constant attention. Particles of food remaining after meals should be removed by the use of dental silk, a quill toothpick, or the brush. The teeth should be **cleansed** at least twice a day, particularly before going to bed, and at least once a day with a pure mild soap or a powder that will produce a slight polishing effect, without being coarse enough to harm the enamel. When the saliva is acid, the powder should be alkaline. **Brushes,** which should not be too broad, may be made of wood, badger's hair, felt, etc., but best of bristles, which should be long, moderately stiff, elastic, of uneven lengths, and not too close together. The brushing should be up and down and across, inside and outside and in between the teeth. The rinsing of the mouth with a mild antiseptic solution at bedtime or after each meal has been advocated. Care is necessary as to the composition of such washes. All acids—even boric acid, benzoic acid, carbolic acid, salicylic acid, and saccharin—may [illegible] the dentine; while eucalyptus and the coloring-matters used in commercial tooth-washes often stain the teeth. Rough usage such as cracking nuts is to be avoided.

The Throat

The prophylactic hygiene of the throat is similar to that of the nose. Sudden changes of temperature are to be avoided, as in coming from the cold street directly into a very warm room and standing by the fire. In using the voice for singing or for public speaking, breathing should be of the abdominal type, which requires little effort and utilizes the entire volume of air in the lungs upon vocal organs in a natural position. The forced clavicular type of respiration, on the other hand, requires considerable effort, and utilizes only the upper portion of the volume of air upon vocal organs in a constrained position.

The Skin, the Nails, and the Hair

The **skin** is preserved in a healthy condition by observance of the general hygienic principles discussed under the headings of Food, Exercise, Bathing, and Clothing; not the least important matter being its frequent exposure to light.

The **nails** are kept clean by scrubbing with a nail-brush, warm water and soap, or aromatic spirit of ammonia. Metallic and ivory nail-cleaners are commonly employed, but are usually needless; if one is used, it must be blunt. The best nail-cleaner is the nail of a finger of the other hand sheathed in a fold of handkerchief or towel. A penknife or other sharp instrument scratches the under surface of the nail, making a place for the lodgment of dirt. The skin overhanging the root of the nail should be pressed back once or twice a week to prevent it from encroaching too far and by becoming torn and ragged furnishing a portal for infection. The finger-nails may be cut in a curved direction; the toe-nails should always be cut straight across.

The **hair** should be brushed for several minutes morning and night, its growth being increased by the consequent stimulation of the circulation in the scalp and by the removal of dandruff. The loose hairs which may be removed are soon replaced by new and more vigorous ones. The brushing should produce in the scalp a feeling of warmth without soreness. The brush for adults should be stiff, with the little tufts of bristles widely separated; somewhat softer for children or those with very sensitive scalps. The teeth of the comb should be far apart, blunt, and smooth. The hair when being dressed should not be pulled upon tightly by twists or knots or curl-papers, and should not be wetted. **Shampooing** is necessary to cleanse and stimulate the scalp and keep it free from dandruff; the frequency varying from once a week to once a month, according to the rapidity with which dandruff and dirt accumulate. With warm water and any good toilet soap, or tincture of green soap, a lather is made, rubbed vigorously into the scalp with the finger-tips or a stiff nail-brush, and removed by a douche of warm water, followed by cold water. The hair is then dried with towels and often with the heat of the sun or of a fire. If the scalp, which always feels dry immediately after washing, does not soon become oily from the stimulation of the oil-glands, it may be rubbed with petrolatum, wool-fat, or olive oil. Daily **massage of the scalp** will improve its circulation and increase the growth of hair. The finger-tips are moved over all parts of the scalp and then the scalp itself is moved over the underlying skull.

The **beard** and **moustache** must be kept clean, and should be included in the frequent ablutions of the face during the day. Some modern surgeons advocate the clean-shaven face as a measure of asepsis.

Shaving is best done by the individual himself, or at least at home. The danger from a barber-shop is lessened, however, when separate cup, shaving-brush, razor, and towel are used for each customer and the barber washes his hands thoroughly after each operation.

CHAPTER IV

HYGIENE OF SPECIAL PERIODS

Infancy. Childhood. Puberty. Old Age. Hygiene of Women: Menstrual Period; Pregnancy; Puerperium; Menopause.

The general management described under Personal Hygiene is subject to slight variations at different periods of life.

INFANCY

The new-born child before receiving its first bath should be rubbed all over, gently but thoroughly, with olive oil or purified white vaselin or washed, unsalted lard or the white of an egg. For the **daily bath** the following are needed: a tub of tin, porcelain, agate, iron, or rubber; a bath stand; a china sponge-basin; a bath thermometer; a rubber cloth or an oil-cloth to be laid beneath the tub; a low chair with a broad seat; a rubber apron; a bath-apron consisting of two long and broad pieces of soft white flannel sewed or, better, buttoned to a waist-band; a piece of good soap, preferably imported castile or palm-oil; two wash-rags of soft flannel, of old diaper cloth, or of the Arnold cotton goods; a large, soft, fine sponge; two large warm and dry towels of fine, soft, and absorbent material; and a simple powder. The water should be soft, clear, and sufficient in quantity to cover the semi-reclining baby up to the neck. The temperature, at first 100° F., is lowered gradually as the infant grows; at six months of age, it is 90° to 95° F. for winter or 80° to 85° F. for summer; or, when hardening effects are desired, it is regulated as described in the volume on "Hydrotherapy," page 174. The bath must be given at a regular time, the best hour being at about ten in the morning, midway between two feedings. A warm part of the room must be selected, before a fire if possible, and sheltered from drafts, often by means of a screen placed around the chair and tub. The baby is undressed and wrapped in the bath apron. The face is then washed with a separate soft wash-rag and water, but without soap, the ears being avoided. The mouth is cleansed with a little moistened absorbent cotton wrapped about the little finger or about the end of a smooth stick and projecting well beyond it. The eyelids may be separated and a little warm water squeezed between them. The whole body, including the scalp, is then soaped with a second wash-rag, particular attention being paid to the armpits, the groins, and the region between the folds of the buttocks. With its head and back supported by the nurse's left arm and hand, the child is lowered gently into the tub and submerged up to its neck, its head never being allowed to dip under the water. During the time (one to five minutes) it remains in the tub the child is washed and douched with a sponge, after which it is lifted to the lap and enveloped in a towel or in the dry folds of the bathing apron, where it is patted thoroughly dry—not rubbed. The baby is then rubbed briskly with the palm of the hand, especially on each side of its spine, until its skin is slightly reddened. The folds of the skin may be powdered or not, and the child is quickly dressed. The hair is dressed with a camel's-hair brush, no comb being used. After the age of six months the scalp should not be soaped oftener than twice a week. An evening sponge is sometimes given. A child should not be bathed when cold or overheated or immediately after a meal.

As the **teeth** are cut, they should be rubbed with a moistened cloth and later with tooth-powder applied by means of a small soft brush or a small pine stick sharpened into a chisel-shaped edge.

After each bowel movement the lower parts of the body ought to be sponged with warm water without soap and carefully dried. Should erythema intertrigo develop, the parts should be gently cleansed with starch-water, dried with a soft cloth, and dusted with Anderson's powder.*

Clothing.—Long clothes are worn for the first six months and should be warm and loose. The **binder** or abdominal band of knitted wool or of fine, soft flannel, extending from the hips to the lower ribs, ought to be so loose that the hand will slip easily under it. It may be made with shoulder straps. The **diapers** or napkins are to be made of linen or cotton, not of canton flannel, and should never be covered with waterproof material. Whenever soiled, if

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* Powdered camphor, 90 grains; powdered zinc oxid, ½ ounce; powdered starch, 1 ounce.

only with urine, they must be changed, washed with pure soap without soda, and dried thoroughly. Crocheted or knitted **socks,** of silk thread or soft worsted yarn, should reach fully half-way to the knee and be held in position by a loosely tied ribbon, tape, or knitted cord, or by a narrowed band of stitches. The **shirt,** of flannel, merino, or soft worsted yarn, its weight varying with the season, should be loose, having a high neck and long sleeves, and reaching to below the hips, where it is pinned to the diaper. It may be fastened at the neck with tape or buttons, or it may be open the full length in front, being fastened by small flat buttons. The **petticoat,** of white flannel, should be made in Princess style with arm-holes, never reaching more than six to ten inches below the feet and fastening in the back with one or two small flat buttons or with a narrow ribbon to tie at the neck. The **dress** or slip, of cambric or nainsook, should be a little longer than the petticoat, have long sleeves, and fasten behind with buttons or a narrow ribbon. In the **Gertrude suit** the last-mentioned three garments are put on together; the shirt being sewn with the seams outside and having high neck and long sleeves, reaches to ten inches below the feet; the middle garment is larger and longer, but with scalloped neck and without sleeves; and the slip is still bigger, with high neck and long sleeves: all fastening behind with two or three small buttons. A different set of clothes must be worn **at night,** consisting of a binder, a diaper, a shirt, and a long and roomy nightslip, of muslin in summer and in winter of canton flannel with a drawing-string at the bottom. **Other garments** needed for the baby are a warm soft flannel shawl or shoulder-blanket, a cambric or silk cap, a knitted worsted sack, a flannel or wash-flannel wrapper, and in winter a long, warm, woolen cloak, a warm thick hood, a Shetland veil, and warm knitted mittens. **Short clothes** differ from long only in that the skirts end a short distance below the knees, which leaves the legs exposed and necessitates their being protected in one of two ways. The stockings should be long enough to reach the diaper, to which they are pinned, or both may be fastened to a waist or diaper-suspender; or the stockings may be attached to the petticoat by means of elastic bands. Another way of protecting the legs is by the use of drawers, of wool, merino, or canton flannel, made in two pieces which should fit rather closely, button or pin to the waist of the petticoat, and reach to the shoe-tops. The first **shoes** should be of soft kid with kid or thin leather soles, without heels, somewhat longer than the foot, and fully as wide, with wide and loose toe but closely fitting instep and heel, made into rights and lefts, and laced. **Bibs** and **creeping aprons** are now added to the baby's wardrobe.

Sleep.—For the first few months the baby usually sleeps eighteen or nineteen hours each day; at one year it requires fifteen or sixteen hours of sleep; and at two to three years, twelve or thirteen hours. The habit of **regularity** in sleeping is formed by putting the child to bed at definite hours and not taking it up again to soothe it, and not even sitting in the room. For the first three or four months the baby is put to bed at half-past five or six and roused but once or twice during the night. It should sleep undisturbed from 11 P. M. to 5 A. M. While the infant is allowed to sleep during the day as much as it will, after it is a month old it should be kept awake for about an hour before its bedtime. After the fourth month the child should go to bed at six or seven in the evening and sleep until six or seven in the morning. Until the sixth month it may be suckled at ten or eleven o'clock at night, but after that age should not be taken up. Between six months and a year, sleep by day will be limited to a nap of one and a half to two hours in the morning, the time depending largely on the hours for suckling, and, if necessary, an afternoon nap lasting not later than 4 P. M. Between one and two years the afternoon nap is omitted, the morning sleep being then of two hours' duration, beginning at eleven or twelve o'clock, the child being undressed for it and put to bed in a darkened room. The child preferably should sleep in the morning undisturbed until he wakens of his own accord,—although he may be roused gently and gradually at a fixed hour, never earlier than seven,—and when thoroughly awake should be taken up immediately, washed, dressed, and fed. If the child, however, awakens too early in the morning, his bedtime should be postponed; and if he seems tired when roused, he should be put to bed at an earlier hour.

The baby should sleep alone, thus escaping the dangers of being overlain, irregularly suckled, and, to a certain extent, of getting the covers over its head. For the early months many prefer the bassinet, which should stand high, be easily portable, and simply decorated. A cradle is not so serviceable. From eight or nine months to five years of age the child should sleep in a curtainless crib with high hinged or sliding sides and provided with springs or a woven-wire mattress. The **baby's bed** is made up by placing on a soft, thin, horsehair mattress, a rubber cloth covered by a double sheet. A small pad of nursery cloth may be placed directly under the body. The coverings consist of a muslin sheet, one or more soft blankets, and a light spread. The pillow should be small, thin, made of soft horsehair (except for very young infants, who may be allowed feathers), and covered with a fine linen pillow-slip. The head should never be covered. Tossing off the bedclothes may be prevented by fastening two short pieces of elastic to the covers by a clamp and tying them to the sides of the crib with pieces of ribbon or tape. The bed should be aired thoroughly in the morning and re-made at night when the sheets become soiled. The sheets may be warmed before the child is put to bed.

Food

The subjects of infant feeding, both natural and artificial, and of weaning, are fully considered in volume VI of this series, on "Dietotherapy." Yet it may not be amiss in this connection to add or emphasize by reiteration a few practical points.

Suckling.—The healthy child will instinctively suckle when applied to the breast. It should lie on its side on the arm of the mother, who, after convalescence, inclines her body forward so that the nipple drops into the child's mouth. By placing the nipple between her first two fingers, squeezing its base when the fluid runs too freely and pressing the breast when the supply is not free enough, the mother regulates the flow of milk, maintains the nipple in the correct position, and keeps the breast from pressing upon the baby's nose. Very often the child may be induced to suckle if the nipple is previously moistened with sugar and water or with milk squeezed from the breast. The infant is put to the breast after the mother has rested, which is usually within eight hours. Early suckling aids the uterine contractions. The colostrum is sufficient to appease the infant until the mother's milk is obtained, and it is unnecessary and often harmful to introduce sweetened water, gruel, or other indigestible substances into the infant's stomach. The **duration of each nursing** should not exceed fifteen minutes and the child should be kept awake until it has finished. The child should be suckled from each breast alternately. After each feeding, its mouth should be washed out with a soft rag dipped in a boric acid solution. The **nipples** should be cared for as directed under Lactation.

Weaning. — Under ordinary circumstances, infants should be weaned between the tenth and fifteenth months; the process should be gradual. Weaning in midsummer is to be avoided if possible. An immediate indication for weaning, or at least for taking the child from its mother's breast, would be the existence in the mother of an acute infectious disease, or of tuberculosis or any serious ailment. Menstruation may or may not impair the mother's milk.

The **temperature** of the breast-milk entering the child's mouth being always below 98° F., milk to be given to children should not be heated above this temperature. Just before feeding, the bottle may be placed in a vessel of hot water. A bottle should not be warmed over for a second feeding. A simple apparatus has been invented in Germany, known as the 'milk thermophor,' consisting of a cylinder with a compartment for receiving the nursing-bottle and an isolated covering which retards heat radiation. The other part of the apparatus consists essentially of a compartment hermetically inclosing a chemical that does not need replenishing. If the thermophor be placed in boiling water for eight or ten minutes, a bottle of milk introduced into the compartment of the cylinder will remain at the body-temperature for from seven to ten hours. If the child during the night requires the bottle, it is replaced by a second bottle of cold milk, which will become warm by the time it is to be used. The action of the apparatus is based on the principle that certain chemical compounds (usually sodium acetate with glycerin) are liquefied, when subjected to heat, binding up heat which is given off when the compound recrystallizes. The necessity for **absolute cleanliness** of bottles and nipples is obvious.

Growth.—The child should be **weighed** in a warm room and lying on a previously weighed piece of flannel, on an extremely sensitive scale. Successive weighings should be at the same interval before or after feeding. The weight is to be watched in order to determine whether the child's growth is progressing normally, especially when the sickness of the mother or other circumstance has made artificial feeding necessary. No fixed rule can be laid down, but in general babies lose weight for the first seven or eight days, and increase after that about one ounce daily during the first two months of extra-uterine life, and about three-fourths of an ounce daily during the next two or three months; after that about half an ounce daily. At five or six months the birth weight is doubled, and at one year it is trebled. The mean increase in **length** is about one inch a month from the second to the fourth month, and after that, up to one year, about half an inch monthly.

Exercise

Three or four days after birth the baby may be placed on its back upon a pillow and carried about the room for ten or fifteen minutes two or three times a day. At the age of two weeks it may be taken, properly protected, into another and somewhat cooler room. After the first month it may be carried in the arms, with its head and body well supported. At this age in summer-time it may be taken in the arms into the open air for ten or twenty minutes on the first occasion and longer on subsequent outings. When three or four months old the child may sit upright upon the nurse's arm with a hand supporting its head and shoulders, being carried alternately on each arm. From this time onward the baby should be placed several times a day upon a blanket or soft mattress or sofa or in a clothes-basket or large padded box, and permitted to kick. Later it may be placed in a creeping pen. In winter or bad weather or in the presence of catarrh of the head, chest, or bowels, the child should be kept off the floor. In winter, it may be taken out-of-doors for an hour in the morning and half an hour in the afternoon, when the sun is shining; or may be wrapped thoroughly and walked for half an hour or so in a room with the windows open. If the weather be very cold, the windows may be opened for an hour and closed before the baby is brought into the room. In summer, the greater part of the time may be spent in the open air.

The **baby carriage** should be well balanced and smoothly running, having a dark-colored, detachable sunshade, and a soft bed giving lateral support. When the child is eight months old, it no longer needs to have its head supported when it is carried, and if propped with extra pillows at the back and sides, can sit up in its coach on an adjustable seat. At the end of a year the child will make attempts at **standing,** and some months later will be able to **walk,** but he must be permitted unassisted to teach himself to walk. Much harm is done by premature urging. Age is not a safe guide. Some children begin to walk much later than others. When the child can walk pretty well, he may have a ten or fifteen minutes' outdoor stroll, the duration being increased gradually until at two and a half or three years of age he may walk half a mile. The coach may now be discarded for an express wagon or a go-cart, or a sled in winter.

Training.—Great stress is laid by Crozer Griffith on physical, mental, and moral training. To train the muscles controlling the **bladder** and **rectum** a receptacle should be placed under the child soon after a meal, when it is most likely to empty its bladder, and at the time of the expected movement of the bowel. Some sound may be made by the caretaker which the child will learn to associate with the act. Later the child is placed in the nursery chair at the proper time, and when at last it can be trusted, drawers may be substituted for the diaper. Taking the baby up after the last feeding may prevent its soiling the bed. A few simple **toys,** neatly cared for, are better than many costly ones. 'Baby-talk' should never be used. Children being great imitators, the force of example is important. Obedience should be implicit and unquestioning, not for a reward. Firmness and truthfulness should be exhibited by parents. The child should not be shown off or frightened or left entirely to the society of domestics. At a suitable age, he may be sent to a kindergarten or at home acquire knowledge by play. School life should not begin too early, however, or be too strenuous. When civilization arrives, the playtime of life will last longer, and in consequence activity endure till the end, which will be further postponed.

CHILDHOOD

Bathing.—After the third year three warm full baths a week, taken preferably in the evening, are required for cleanliness. Each morning a sponge bath is to be given at a temperature varying from 75° F. in summer and 85° F. in winter, to 65° F. or to that of the water as it flows from the faucet. After the skin is dried gently with a soft towel it should be rubbed with the open hand until it glows, the whole process lasting not longer than ten minutes. As the child gets older he washes himself, taking a cold sponge or plunge immediately after rising, and soaping himself thoroughly with his hands. In addition, it is sometimes necessary to take a warm full cleansing bath once a week, before going to bed. This bath should not occupy more than ten minutes, and is best followed by a cold douche or rapid cold sponge.

Sea-bathing.—Attention is frequently called by writers to the cruelty of carrying a small terrified child into the ocean. A child of three years of age, however, or even younger, dressed in a bathing suit and hat, may be allowed to play on the beach and splash in the pools of water. An older child may enter the surf after first wetting his head. The bath should be taken about three hours after breakfast, should last ten minutes if the weather be cool, twenty to twenty-five minutes if the weather be warm, but should cease at the first indication of chattering of the teeth or blueness of the lips. If followed by exhaustion or lassitude, the duration of baths must be shortened and their frequency lessened. The latter should not exceed once a day. The child should never enter the water when cold or perspiring.

Clothing.—A child's underclothing should be of woolen the year round, with high neck and long legs and sleeves, the thickness varying with the season, but the change from heavy to light not being made until the hot weather sets in permanently. The outer garments should be loose and warm. As the child begins to walk the shoes should be made heavier and decidedly thicker at the heel; an actual heel, however, is not to be worn before the sixth or eighth year. At night a light, high-necked, long-sleeved merino shirt may be worn—with night-drawers of canton flannel and having feet, in winter; of muslin and without feet, in summer. Later, girls may wear night-gowns and boys night-shirts, or, better, pyjamas. For going out-of-doors in winter the child will require a warm wrap or overcoat, a hood, cap or hat, mittens and leggings, which should be put on just before going out and taken off immediately upon coming in. If rubber coats, overshoes, or boots must be worn, they should be removed as soon as possible, the covered part undressed, and the skin rubbed to redness with a coarse towel.

Food.—The subject of diet for children is discussed in volume VI, on pages 164 to 166.

Sleep.—Children over four years of age will seldom sleep in the daytime, but should go to bed at eight o'clock or earlier and be allowed to sleep for ten hours or more. The hour for retiring may gradually be changed to nine o'clock by the time the age of ten or twelve is reached, and should not be made later until after the fourteenth or fifteenth year. Regularity must be preserved in the hour for going to bed, any postponement being injurious, especially if for a party. The child should not romp or become excited or eat during the hour preceding bedtime, and after getting into bed must not be disturbed by a bright light or conversation.

Physical and Mental Exercise.—Physical exercise must be proportioned to the strength and development of the child. The practice of mild calisthenics, as is now the custom in many schools, is to be commended, but probably the child derives greatest benefit from dancing indoors and its natural play out-of-doors. The modern system of **mental training,** however, is not to be praised unreservedly. The education of a child cannot be governed by general rules; but must be modified to conform with the general development, the progress, and chiefly the individuality of each pupil. The precocious child should not be stimulated by exhibition and applause, but is to be restrained. The backward child should not be punished or degraded, but should receive kindly encouragement. School hours should not be too long; school-rooms should not be crowded; teachers should not be so overworked that their tact and patience must fail. Examinations and their mechanical requirements, with concomitant physical and mental strain and excitement, are especially baneful. Two features of the contemporary school are, however, most excellent—the attention paid to nature-studies and the generally judicious selection of literature for reading exercises.

Special Precautions.—The infections of childhood probably find entrance chiefly through the pharynx and air-passages. Hence cleanliness of the **nose and throat** is all-important. The nasal passages should be cleansed daily, if necessary by spraying with a dilute alkaline solution. In addition to due care of the **teeth,** the **mouth and tonsils** should be wiped with a soft rag dipped in boric acid solution. Gargling daily will sometimes mechanically dislodge the contents of the tonsillar crypts, and thus aid in preventing infection. A **discharging ear** should always receive attention. If a child looks dull and stupid, especially if he be a **mouth-breather,** his nasopharynx should be examined for adenoid growths. Children should be taught to blow the nose and should never be allowed to snuffle water into it. Care is required to prevent them from inserting **foreign bodies** into the nose and ear.

PUBERTY

At this period it is especially important that the strictest attention be paid to all the matters discussed under Special Hygiene. In addition, the skin and all excretory organs must be kept in good condition and perfect metabolism promoted by judicious exercise. Nervous excitement must be avoided or soothed and the mental activity carefully but unobtrusively guided. Healthful amusement is important. Wise supervision must be exercised over books and companions. Outdoor life and interests, not alone sports, but also the observation of plant and animal life, of geologic formations and the like, are to be encouraged. It is well for the youth or maiden to go to bed wholesomely tired, so that sleep may be prompt and dreamless. Special care must be observed in the case of neurotic individuals. Instruction as to the hygienic rules to be followed and information concerning and warning against possible abuses should be frankly and fearlessly given at this time. Most of the misery caused by neglect or abuse is due to ignorance, and might be prevented by the establishment of confidential relations between parent and child.

MARRIAGE

The physician should be looked upon as the family's friend and adviser when son or daughter contemplates marriage. The family history and previous medical history of each party should be obtained. When there is on either side an undoubted pathologic heredity of a serious nature, as insanity, tuberculosis, or carcinoma, marriage should be discountenanced. To warrant this responsibility, however, there should be no doubt in the physician's mind as to the actuality of the supposed morbid inheritance.

It is the opinion of the best authorities that if a syphilitic has been thoroughly treated and two years have elapsed without any overt manifestation of disease, the patient may marry. We know from experience that the infectiousness of syphilis diminishes after a variable period, which is shorter in man than in woman. Some authorities are even more conservative, advising the postponement of marriage until at least four years after symptoms have ceased. With this interval it is most probable that the wife and progeny will be saved from infection. One evidence of the cure of syphilis is the reduction of the lymph-glands to their normal size that follows energetic mercurial treatment. After gonorrhea, marriage can be countenanced only if gonococci and shreds be absent not alone from the urine, but also from the discharge of an artificial urethritis excited by silver nitrate. Some of the States have enacted laws prohibiting and penalizing the marriage of a person suffering from syphilis or gleet. Excess or perversion in marital intercourse is to be avoided. Withdrawal and other unnatural practices are sometimes responsible for symptoms that the physician at first fails to understand.

OLD AGE

Food should be nutritious and easily digestible. Large quantities are not required; and as digestion is sluggish it is not well to increase the number of meals, unless in the presence of actual disease requiring small and frequent feedings. When the **teeth** decay or fall out, they should be filled or substituted with false teeth. Whenever these expedients fail, the solid food should be cut or ground into small pieces before being ingested. All food should be moved around by the tongue and mixed with the saliva before being swallowed. The aged are extremely sensitive to cold and require **artificial warmth** to maintain the body-heat. **Excretion** may have to be aided. Especially must constipation with its accompanying straining be avoided. Failure of **mental power** may often be postponed by change of occupation and scene. Some special interest is necessary to keep at due pitch the zest of life after it becomes necessary to diminish ordinary activities. It is as great a mistake, when mental and physical vigor are preserved, to 'rust out' in age, as it is to 'wear out' by excessive labor in earlier years. **Fresh air** is especially needed; walking and driving are good when possible. Sitting on a porch or in a garden, or by an open window, may be resorted to when no other airing can be obtained. For **bathing,** warm water is best, though a cool sponge may be taken afterward by those who react well. **Wine** in moderation is useful when no counterindication exists. Sudden or violent **exertion** or **emotional excitement** is to be avoided, especially when marked senile changes exist in the heart or vessels. **Sleep** at night in the aged is usually shortened, and there is a tendency to rise too early, which should be discouraged. On the other hand, afternoon naps are desired and are usually helpful. The special **diseases** and **disorders** of age are beyond the scope of this discussion.

THE HYGIENE OF WOMEN

Menstrual Period.—Rest and quiet should be enjoined at the menstrual period, especially during the earlier years, when mental and physical disturbances are apt to be manifested. When possible, rest in bed is indicated. If the latter restriction be impossible, then all mental and physical labor should be reduced to a minimum and heavy lifting, overfatigue in walking, too long standing, riding a horse or wheel, and dancing, etc., should be avoided. Care should be taken by means of warm clothing to prevent chilling. Cold-water baths, including the surf bath, are to be prohibited. The **menstrual discharge** is usually received in napkins, though the use of the menstrual pad is preferable. Much of the distress attending menstruation is due to the unhygienic dress of civilized women, and this should be corrected. When the flow is excessive without other sign of disease, hot vaginal injections may be given about the fifth day, and rest in bed maintained until the discharge ceases.

Pregnancy

Upon hygienic life during the period of gestation the health of mother and child in great measure depends. The **diet** should be simple and consist chiefly of milk,—plain, diluted with effervescing waters, or made into puddings, etc.,—fruits, and fresh vegetables. One to two quarts of water should be drunk during the day. Meat should be taken in small quantities and not oftener than once a day. Rich, indigestible food and alcohol should be avoided; the use of coffee and tea should be restricted. Morning sickness may sometimes be prevented by taking a hot drink in bed before getting up and while lying flat on the back, resting for half an hour afterward. It may be coffee, tea, cocoa, chocolate, broth, or milk, with or without toast. In severe cases of **hyperemesis,** nourishment should be restricted to nutritious liquids or easily digested substances like beef-juice, milk, pancreatized if necessary, tropon, somatose, plasmon, peptonoids, kumyss and the like. Rectal alimentation may be necessary. Lavage of the stomach with clinical saline solution at a temperature of 100° F. often affords relief, as does the application of the faradaic current to the epigastrium or to the vagi, before or after meals. In this condition mental therapy is of value. When more active measures are necessary, the condition passes beyond the province of the hygienist.

The **kidneys** demand constant supervision, especially if nephritis is known to exist. The urine should be examined frequently and the total excretion of solids, and especially of urea, carefully estimated. The development of albuminuria calls for a diet exclusively of milk. The action of the skin and bowels should be stimulated. Moderate **exercise,** such as walking or driving over a smooth road, or some passive exercise like massage, should be encouraged during the early months. Sea-voyages, horseback-riding, bicycling, dancing, lifting, straining, working the sewing-machine, and exercise of any kind sufficient to induce fatigue are always to be avoided.

When exercise is not well borne, provision should be made for an out-of-door existence. Care of the household duties may be regarded as safe exercise, but any work necessitating the use of the abdominal muscles, as reaching a shelf, must be avoided.

Rest after the mid-day meal, in bed if possible, is essential in the pregnant state, and an abundance of sleep is requisite. The excitements of social life should be suspended. Mental irritants, like sudden emotions of grief, fear, and anger, react on the hypersensitive pregnant woman and are not without influence on the child *in utero*. There is an element of truth in the popular belief that **maternal impressions** leave their imprint on the physical or mental structure of the child. It is therefore necessary to protect the pregnant woman from disagreeable objects and all unpleasant impressions and to place her in an environment conducive to cheerfulness and equanimity. The despondency, irritability, or other mental anomaly associated with gravidity of the uterus demands constant supervision, and relief should be sought through cheerful associations, pleasant diversions, and kind assurances. It is at this period of her life that the wife needs, above all, the most thoughtful consideration of her husband.

Sexual intercourse need not necessarily be prohibited to the pregnant woman, though it should be avoided during the early and late months; and if indulged in at any time during the period, moderation must be observed. The **clothing** should be light and warm, and suspended from the shoulders, its character being necessarily influenced by the condition of the weather. Heavy skirts, corsets, and tight bands should be avoided. Multiparæ often obtain great relief by wearing an abdominal belt or support.

Frequent warm tub-baths with an abundant use of soap promote excretion by the skin and are best taken at night. A moderate cool sponge-bath in the morning is beneficial, but very hot or very cold baths and foot-baths are dangerous, as is sea-bathing.

The **breasts** should not be pressed upon by the clothing, but should be supported if very heavy. Flat or retracted nipples should be drawn out daily by the thumb and index-finger or by the breast-pump, during the latter weeks of pregnancy, and they also may be covered with the nipple-protector. Washing the nipples with cold water and then applying equal parts of glycerole of tannin and water every morning and evening during the last month will diminish their sensitiveness and their liability to fissure.

Edema or a varicose condition of the legs may necessitate the wearing of an elastic stocking, or the application of a bandage of elastic or of flannel webbing.

The Puerperal or Lying-in Period

Absolute cleanliness of the patient, of every one who attends her and everything that comes in contact with her, is the best preventive of infection. A soap-and-water tepid sponge-bath should be given in the morning about an hour after breakfast, preferably with a wash-rag, and light rubbing with alcohol may be practised in the evening.

Rest.—For the first few days after labor a woman should have absolute physical and mental rest, undisturbed by loud noises or a glaring light. During the first week visitors should be excluded from the lying-in room, only the husband and mother being admitted for short and infrequent visits, after having been duly cautioned to avoid exciting subjects of conversation. After the first week the patient's relatives and nearest friends may see her for a few moments if they are known to be free from contagion and of cheerful disposition. Immediately after delivery the patient should lie flat on her back, for the first six hours without a pillow. Hirst keeps his patients on their backs for a week, but Davis believes that this posture, too long continued, favors retroversion. After the patient has reacted perfectly and is no longer in danger of hemorrhage or relaxation of the uterus she may be permitted to move about comfortably in bed, turn on either side, or even lie upon the abdomen. Several days after confinement the shoulders may be raised a little, and by gradually propping the patient higher in bed in a few days she can assume very nearly the sitting posture. The patient is to be kept in bed until the fundus of the uterus has sunk to the level of the symphysis pubis and blood is absent from the lochia—usually from ten to fourteen days. She may then rise to use the commode and may put on her flannel wrapper, stockings, and bedroom slippers and shift herself from the bed to a lounge rolled alongside, where she may pass the day, sitting up for gradually increasing periods without being permitted to become fatigued. During the fourth week she may walk about the room and at the end go downstairs. Careful vaginal examination should be made at about this time and repeated six weeks after delivery.

Diet.—For the first three days a very light diet is given, chiefly of milk and water with toast or crackers and gruel or mush, grits or boiled rice, and a little stewed fruit or baked apples. The dietary is then increased gradually by the addition of soft-boiled eggs, custard, junket, light puddings, broths, soups, jelly, sponge-cake, ice-cream, charlotte russe, and fresh fruits and vegetables. During the second week the white meat of fowls, sweetbread, lamb chops, fish, and oysters are added, and during the third week beef, bacon, and potatoes. Rich and indigestible food and alcoholic drinks must never be taken.

The Obstetric Binder.—An abdominal pad, usually consisting of one or two folded towels, is placed above the uterus until the latter disappears below the pubis. Over this is fastened the abdominal binder, made of unbleached muslin, about a yard and a quarter long and wide enough to reach from the trochanters to the floating ribs, gored at the sides above and below the hips, and pinned together from above downward. Sometimes it is provided with buttons in front and laces at the side. The binder may be worn after the pad has been discarded.

Lactation

After each nursing the **nipples** should be cleansed with cold or warm water and castile soap, or with a saturated solution of boric acid, and dried with a soft cloth. If disposed to crack after cleansing, they may be anointed with sterile cocoa-butter or sterile olive oil or with an antiseptic ointment. Should cracks or fissures develop, they should be cleansed antiseptically, as with a weak formalin solution, and painted with silver nitrate or other healing application. A nipple shield must be used in this condition, as also when the nipple is very tender or of such size and shape that the baby cannot obtain a satisfactory hold. The shield should be simple and must fit tightly; one of glass with a rubber nipple being most frequently employed. It should be cleansed by boiling, and when not in use be kept in a saturated boric acid solution. If the shield be refused by the child, it should be filled with warm milk and inverted over the nipple. When the nipple is merely depressed without being inverted, it may be drawn out by means of the breast-pump, in which suction is made by a rubber bulb, or, far better, by the mouth through a piece of rubber tubing. These articles also must be boiled and kept in boric acid solution. The chief use of the breast-pump is in emptying the breasts, which, however, may be accomplished and the nipple drawn out by filling a bottle with very hot water, emptying it rapidly, and quickly applying it inverted over the nipple.

The patient's comfort is increased and serious disturbances often prevented by the application of a **mammary binder,** which may be of many forms. The handkerchief bandage consists of a handkerchief folded as a triangle, tied obliquely over the chest with its base under the breast and fastened by safety-pins to a strip of muslin or bandage tied around the waist. One may be applied to each breast. A simple straight bandage of unbleached muslin, properly shaped by darts, with a compress under the outer portion of each breast, is useful. The Murphy binder is made from a straight piece of muslin with a notch for the neck and two deeper notches for the arms. It is applied over the breasts, the ends being pinned in front. The double Y-bandage is made with two or three toilet napkins, folded lengthwise so that each is 32 inches long by 3 inches wide. A V is formed by making a diagonal fold in the middle of one or by pinning two together. To the apex is fastened one end of the other napkin, which is passed across the back and fastened by pins to the free ends of the other napkin or napkins, which are carried across the chest, one above and the other below the breasts. It may be kept from slipping in either direction by adding shoulder-straps and by fastening it to the abdominal binder, and has the advantage of not requiring to be removed when the baby nurses.

These bandages are useful only while the patient is in bed, and when she gets up must be replaced by something less cumbersome, as the obstetrical breast-support with knitted bosoms.

To maintain a **good quality of milk** the mother should be careful in her diet and take regular exercise in the fresh air; avoiding late hours, fatigue, mental or physical, and all sources of worry, anxiety, or nervous excitement. **Insufficiency of milk** may be caused by neglect of any of these precautions or by lack of vigor or physical development. The supply of milk may be increased by the free use of milk and milk-foods, chocolate, gruel, animal broths and soups, and sometimes by the moderate employment of one of the thinner malt extracts. (See also vol. VI, p. 145.) Massaging the breast and encouraging the patient in the belief that she will have sufficient milk may be of benefit. When the **flow of milk is excessive,** liquids, starches, and sweets should be restricted and the child's sucking supplemented by the breast-pump. The breasts should be covered with sterile gauze to soak up the leakage and prevent it from soiling the clothing.

Distention of the breast caused by failure of the milk to escape (caked breast) is best treated by massage just before the child is nursed or the breast-pump applied. The breast is washed with soap and water and then, with warm sterile olive oil and aseptic hands, rubbed gently, for from ten to twenty minutes, from below upward and from the base toward the nipple. Hot fomentations may be applied for fifteen to twenty minutes before rubbing or before the child suckles. Cloths soaked in lead-water and laudanum may be applied, care being taken to cleanse the nipple before putting it into the baby's mouth. Should an **abscess** form, the child must immediately be taken from the breast, which is to be treated surgically.

If for any reason it becomes necessary **to check the lacteal secretion,** abstinence from liquids, the use of saline cathartics and, if necessary, of potassium iodid, with the local application of belladonna ointment or atropin oleate, may effect the object. The breasts should be compressed with a figure-of-eight bandage or a straight wide bandage, plain or with arm-holes, as in the Garrigues breast bandage.

Urination.—In view of the tendency to retention of urine and of the slight dependence to be placed upon the statements of the patient, or sometimes even of the nurse, concerning thorough evacuation of the bladder, the physician should examine this organ by abdominal palpation. Often no difficulty in micturition will be experienced, but should any exist, natural urination may be induced by one of the expedients described in the chapter on Care of the Patient. When the patient has not voided urine for twelve hours after labor, she should be catheterized, with full aseptic precautions, necessitating exposure of the parts. The water may subsequently be drawn three times a day if necessary.

Defecation.—If the bowels have not moved within the first forty-eight hours after labor, a laxative should be administered, followed, if necessary, by an enema.

THE MENOPAUSE

Hygienic management during the menopause involves the careful supervision of every function of the organism and includes massage, outdoor life, and gentle exercise. Frequent warm baths are indicated, the Turkish bath coupled with massage promoting the equal distribution of blood so essential in this epoch. Purgatives, especially the salines, are of especial benefit in relieving the condition of plethora almost invariably present. Better than purgation when decided plethora exists, is blood-letting. The existence of anemia, which like plethora can be determined only by an accurate blood examination, demands the free use of assimilable chalybeates. Attention to the nervous system is of paramount importance. Amusements and congenial occupation should be provided. The burdens of domestic care should be lightened and the woman relieved of worry and responsibility. The importance of mental and emotional calm during the menopause is shown by the fact that about four per cent. of the cases of insanity in women develop at this epoch. The diet should be simple and unstimulating. Alcohol in every form must be prohibited. When everything else fails, recourse must be had to the rest-cure, which is almost a specific for the relief of the erratic symptoms of the nervous system.

All disturbances occurring at this time must not, however, be ascribed to the climacteric. Often some grave pathologic condition is overlooked by the physician who rests content with a superficial observation. For example, it is at this particular period that malignant uterine tumors are prone to appear. Neumann made an analysis of the **complications of the menopause** in 500 women. In 183 cases the flow of blood returned a year or more after the menopause had become established. Of this number, more than one-half (54 per cent.) were found to be suffering from uterine cancer.

Pruritus, so common during the menopause, is best treated by a lukewarm bran-bath (88° F.) before retiring. Following the bath, the parts are dusted with a powder, which is also used several times during the day. The dusting-powder recommended by Kisch consists of 1 part of salicylic acid, with 50 parts each of starch and talcum. Ovarian extract and mammary extract are said by some observers to inhibit or mitigate many of the annoyances of the menopause. Picrotoxin also has been employed with some success.

CHAPTER V

HYGIENE OF THE DIATHESES

Scrofulous or Tuberculous Diathesis. Rachitis; Infantile Scurvy. Gouty Diathesis. Rheumatism. Apoplectic Habitus. Neurotic Temperament.

In addition to the general measures of hygiene detailed in previous pages, and which apply here also, there should be emphasized certain special features of hygienic prophylaxis relating to those as yet ill understood conditions of metabolic perversion and structural anomaly that we term **diatheses, temperaments,** and the like.

The Scrofulous or Tuberculous Diathesis

Pathologists in general regard scrofula as an expression of infection with the tubercle bacillus, but clinicians, as a rule, adhere to the older idea, and recognize a diathesis or morbid predisposition that renders the individual specially liable to tuberculous infection. Jaccoud, followed by the editor of this series, uses the term 'hypotrophy' to express this fundamental condition, believing it to be one of lowered vital or trophic activity. Robin and Binet hold that there is an augmented excretion of carbon dioxid, indicating hyperoxidation, and therefore excess of energy. In 1793, Beddoes showed that 'excessive oxygenation' characterizes 'florid consumption'; in the editor's view it evidences a stage far beyond predisposition. Experience shows that those measures ordinarily termed 'tonic and invigorating' are most useful in prophylaxis. In the case of children believed to be specially liable to tuberculosis, the reconstructive régime should be instituted at birth. An ailing mother, more especially if she be actually tuberculous, should **not suckle** her infant. A healthy wet-nurse should be obtained if possible; failing which, the milk of asses or of goats is preferable to that of cows, and the latter, if due care be exercised as to purity in collection and preparation, is superior to commercial foods as the basis of artificial nourishment. The child should be **weighed** at definite intervals to obtain an index of nutrition. The rules of life laid down under Hygiene of Infancy should be followed scrupulously. The

environment of the infant must be one of absolute cleanliness, and special attention in this respect should be given to the floor, the dust of which is a prolific source of infection.

As the child grows up, provision must be made for **open-air life,** preferably in the country, with free exposure to **sunlight.** If city residence is unavoidable, parks, rivers, country excursions, are to be utilized as freely as possible. Ample provision must be made for the inhalation of air free from dust, gases, and other irritating substances. The sleeping-room should be well ventilated and provided with an abundance of light. **Sun-baths** are of great importance. If the room be small and crowded, as among the poor, the necessity for cleanliness and good ventilation becomes even greater. Healthful **exercise,** both indoors and out-of-doors, must be encouraged, especially such as favors the development of the lungs and muscular system. Passive movements, like those of the Sylvester method of artificial respiration, combined with stimulation of the skin and muscles over the chest by massage, are of great service. Slow raising and lowering of the arms may be combined with forced slow inspirations of fresh air, long held, and followed by slow expirations; the breathing being performed through a small oral aperture, or through a tube around which the lips are closed. For regulated respiratory exercise, S. Solis Cohen's 'resistance valves' may be used. Skipping backward with the jumping-rope is a means of throwing the shoulders well back. In judicious degrees, and with due regard to age and strength, as well as to climate and season, skating, swimming, rowing, tennis, golf, running, riding, driving, cycling, walking, climbing, are specially useful forms of exercise. The majority of writers favor a highly nitrogenous **dietary,** with abundant fatty food. A general mixed diet with a plentiful supply of pure milk is, in my experience, the best. I can see no advantage in the employment of cod-liver oil as a prophylactic, for its only positive action is to nullify the appetite and disorder the digestion. If cod-liver oil have any value, it is because of the easy assimilation of its fatty constituents. As the latter are contained in equally assimilable form in milk and butter, there is no need to disorder the stomach for the sake of obeying a tradition.

School should be postponed to as late a period as possible, and care must be exercised in providing a hygienic environment. Confinement to the school-room must be limited, and the school-hours broken with intervals for recreation in the open air. Sufficient protection against 'catching cold' will be afforded by the daily systematic use of cold water, to which, if desired, salt may be added. The child must be watched carefully. Pallor, dyspeptic disturbances, enfeeblement and the like, call for immediate medical attention. Very often it may be necessary to suspend school instruction and remove the child to the country, seashore, or mountains. **Vacations** are to be spent, if possible, in the mountains or at the seashore; the latter being preferable in many cases, because of the bathing. Throughout life, wise choice must be exercised as to matter and time of study, business, and amusement. **Occupations** that can be carried on in the open air are to be preferred for the poor or for the rich.

Special functional deficiencies may call for attention. **Nasal breathing** must be unobstructed. Partial occlusion of the nares in the growing person is a patent factor in the production of chest deformities, notably the so-called 'narrow chest.' In the adult, hindered nasal respiration is associated with catarrhal affections of the respiratory tract. In infants, nasal obstruction interferes with suckling and therefore impairs nutrition. **Enlarged cervical glands** may be tuberculous, but sometimes are due to infection from the mouth, teeth, nose, or tonsils; the hygiene and treatment of these parts must therefore have due attention. **Anemia** must promptly be corrected, not merely by the administration of chalybeates, but by hydrotherapeutic measures and open-air exercises specially directed to improve the function and development of the lungs. **Digestive disorders** are to be remedied by dietetic, hydrotherapeutic, and other means. The **circulation,** both central and peripheral, and the **secretions** and **excretions** must be kept normally active, hydrotherapy and massage offering the best choice of remedies for any deficiency. **Chronic affections of the respiratory tract,** even of non-tuberculous origin, are sources of danger. Especially is this the case if unresolved bronchopneumonia, lobar pneumonia, or pleurisy be secondary to an acute infection, as measles, pertussis, influenza, or typhoid fever. More frequently than is recognized, recurrent bronchopneumonia of children is of tuberculous origin, as has been pointed out by the editor of this series. Even in previously healthy persons, **pleurisy** is often followed by tuberculous lung disease. It may be a primary manifestation of tuberculosis, the lungs becoming infected secondarily; or the pleurisy may be secondary to disease already present in the lungs. It is wise to regard any individual who has suffered from an attack of pleuritis as predisposed to pulmonary tuberculosis, and to institute appropriate prophylactic measures.

These conditions, in addition to the best general nutrition, and the use of iodin internally and externally, demand pulmonary gymnastics, open-air life, and in some instances residence at an altitude or the use of compressed and rarefied air. (See vol. x, "Pneumotherapy.") In the case of very feeble or erethic persons needing protection, warm and sheltered **climates** may have to be sought; but it is better, as a rule, to attempt, at least by degrees, to stimulate the vital energy by means of cold and elevation, and to induce progressive resistance to the effects of wind and weather. **Marriage** should not be entered upon unless health appears to be perfect. Especially does this warning apply to women,—for their own sake as well as for that of their possible offspring,—pregnancy and lactation often having an ill effect upon those predisposed to tuberculosis.

Rachitis

Much can be accomplished by way of prophylaxis against rickets. Faulty diet is in a great measure responsible for the disorder, even should infection prove to play a part. The physician must carefully regulate the frequency of feeding and the quantity and quality of food taken. Frequent changes of the decubitus of the child may prevent deformities. Warm clothing, frequent bathing, and life in the open air and sunshine are important factors in the management. A rickety child should not be permitted to walk, and the application of splints extending beyond the feet may aid in this restriction. In rachitic children deformities are most frequent in the lower extremities, owing to the fact they bear the body-weight, but the vertebral column and the thorax are not exempt. The employment of supporting apparatus for the trunk and extremities must be condemned, inasmuch as the deformities are the result of general skeletal disease and the fixation of the apparatus on other parts will lead to malformation of the latter. An excellent method to prevent deformities in children is to compel them to lie in a stretched posture on an unyielding mattress. In summer the child may be wheeled in the open air in the same position. Carrying the child in the arms often leads to **vertebral deformities.** The latter, however, develop most frequently during the school years, and in girls more than in boys, insomuch as the former are more prone to work and play in the sitting posture. They may be prevented by strict observance of hygienic methods during the developmental years. There must be sufficient rest and forced nutrition. Sleep should be encouraged. Abnormal postures, especially those adopted during the school-hours, must be corrected; indoor occupations must not be too prolonged. Gymnastic exercises and bathing are useful as corrective and nutrient measures.

Scurvy-rickets (infantile scurvy), an affection limited to the first four or five years of life, is encountered in infants fed exclusively on artificial food or on sterilized milk. The prophylaxis is suggested by the etiology; the use of orange-juice is especially beneficial.

The Gouty Diathesis

Gout is essentially a disease of heredity. It is characterized by a definite metabolic perversion, and may be associated with high arterial tension, arterial degeneration, and cardiac hypertrophy. The early precipitation of an attack is favored by overindulgence in eating, especially of meats, the excessive use of alcohol, and insufficiency of exercise. Physical and mental excesses, and exposure to cold and damp or to sea-air, may also be exciting factors. The primary attack may be delayed and recurrences prevented by prophylactic management. Individuals predisposed to gout must avoid occupations involving contact with lead. Diet is of prime importance. (See vol. VI.) Aliments which contain much nuclein, such as the glands and viscera, increase the alloxuric constituents in the blood and must be prohibited. Sweets are injurious. Starches and fats may be taken in moderation. A good rule is to diminish the amount of food, especially of meat, eating the latter but once a day, and always to rise from the table feeling a little hungry. Malt liquors and sweet wines must be avoided absolutely. Water should be drunk freely, as it favors elimination. Alkaline and sulphurous mineral waters are often useful. (See vol. IX.) The skin should be kept active by regular ablutions, frictions, some form of exercise sufficient to produce free perspiration, and an occasional Turkish bath. The action of the bowels should be free; and occasional mercurial purgation is useful. An open-air life should be encouraged, with exercise such as walking, cycling, and horseback-riding in moderation; that is to say, not beyond the point of gentle fatigue.

The Rheumatic Diathesis

Acute articular rheumatism is doubtless an infection; yet it profoundly modifies metabolism, and thus may be said to originate a diathesis. There are also certain hereditary tendencies that, for want of a better term, we now call rheumatic. Likewise certain chronic metabolic perversions of unknown origin—probably akin to those of gout, and similarly misnamed 'uric acid diathesis,'—are at present included in this diagnostic scrap-bag. During an attack of acute rheumatism, cardiac complications are less likely to develop when the patient sleeps between blankets instead of sheets. The latter become wet with the acid perspiration and conduce to relapses through chilling of the skin. Those liable to attacks of acute rheumatism, or who suffer with the chronic variety—muscular or arthritic—must be cautious in diet; but, except as to sugars, which are to be cut down to a minimum, avoiding excess rather than foregoing any special class of food. The skin and the eliminative organs in general should be kept in active function by muscular exercise in the open air, and by the free use of water internally and externally. Massage and occasional Turkish baths or other diaphoretic measures are useful. Sometimes a course of mineral waters is of benefit. Chilling and wetting are to be avoided, but it is better to 'harden' one's self against cold by judicious hydrotherapeutic measures, than to become 'soft' from overcoddling. Sometimes, however, climatic change is not only advisable but necessary in order to permit open-air life. Clothing should be light and porous, but warm; woolen or silk being worn next the skin throughout the year.

The Neurotic Constitution

Heredity is an important factor in the etiology of nervous diseases. In some instances the neuropathic liability consists in the inheritance of some constitutional anomaly; in others, in the inheritance of a vulnerable nervous system. It is important to recognize early in life the morphologic and functional stigmata of the neurotic constitution. Nevertheless too much importance must not be attached to innate tendencies to the neglect of personal responsibility; nor is it to be taken for granted that these tendencies cannot be overcome. On the contrary, a wise **prophylactic régime** is often highly successful.

The **nutrition** of the child is to be supervised carefully according to the general principles laid down elsewhere. Abundance of light and air; the daily systematic use of cold water by sponging or immersion; due regard to the character of the clothing, with particular care as to the coverings about the genitalia; activity in the open air; and rest at the proper time—all contribute toward the healthful development of the nervous system. Excessive activity and forms of exercise that may in any way produce injuries should, however, be interdicted. Any injury, however insignificant, should be followed by absolute rest in bed until the shock to the nervous system has subsided.

Mental development should be permitted to take care of itself and the child be withheld from school as long as possible. The **morals** of the child should be closely watched and any obliquity in this direction corrected, not by punishment but by appeals to reason. To inculcate fear in an obstreperous child is not conducive to healthy development, but voluntary abstention may develop into a habit of inhibition. During the years at school, great care should be exercised to avoid excessive mental activity. Rest and recreation should alternate with study or confinement in the class-room. It is often impossible to obtain the necessary mental relaxation in public schools, and under such circumstances private tuition may become necessary. While mental relaxation is to be encouraged, indolence should not be permitted, for discipline is above all essential; nothing contributes more to the production of nervous diseases than an unoccupied mind. The choice of a suitable **occupation** for a neuropath is of prime importance. Pursuits that contribute to the development of occupation neuroses (see pages 64 and 79) must be avoided. Those who work in lead, mercury, arsenic, and the like, are liable to suffer from neuritis and mental disturbances. Neurasthenics are largely recruited from those indulging in excessive mental activity, while the unoccupied are likely to be introspective, hysterical, and hypochondriacal. Those engaged out-of-doors suffer less than those occupied indoors. Occupations that entail irregularity in hours are harmful. Railroad employees and laborers in factories frequently suffer from traumatic neuroses, as a result not only of concussion of the nervous system, but also of unhygienic environment. In women especially another factor, in addition to constant unrest of body and mind, is emotional excitement. In recent years **traumatism** has been recognized as an important factor in the production of functional nervous disorders. This may be so in the absence of any external manifestation of injury. Hysteria and neurasthenia are often thus caused. Accordingly, it is our duty to limit so far as possible the frequency of traumatism and to treat it thoroughly when it occurs. The virus of **syphilis** depresses the nervous system and hastens its final dissolution through exciting causes like alcoholism, excessive venery, brain-strain, and excitement. Syphilitics should, therefore, submit to thorough and continuous treatment for purposes of prophylaxis. They should lead a life free from undue strain, and, above all, abstain from the use of alcohol.

The hygiene of the **sexual apparatus** is too often disregarded by the physician. Masturbation is usually begun in early life. It may give rise to profound disturbances in mental and physical equilibrium, but as the habit is usually discontinued when years of discretion are reached, serious consequences but rarely follow; mental suffering is aroused, however, and the ever-ready quack with sensational advertisements finds numerous victims. Physicians can do much for these unfortunates by sympathetic assurance of recovery. The prophylaxis is educational. Influences that appeal to the erotic faculty should be avoided; prurient literature should be eschewed; lascivious statuary and pictures should not be viewed; and suggestive exhibitions should not be attended. Illicit sexual indulgence, as also excess and perversion in marital relations, are to be interdicted.

Alcohol is one of the most potent poisons for the nervous system; even when consumed in the smallest amounts by persons of a nervous temperament, it is likely to induce changes in the nerve-tissues resembling those seen in old age. The habitual use of alcohol ranks next to heredity as an independent cause of insanity. The psychic degeneration due to alcohol is characteristic, and consists in gradual impairment of memory and will, in sluggishness of perception and of judgment, in loss of the moral and esthetic sense, with paroxysms of anger, depression, and irritability. Moderate indulgence in light alcoholic beverages at meal-time need not be harmful to persons active in mind and body, but to those of neurotic heredity even moderate drinking is always injurious. **Tobacco,** like alcohol, is a drug. Used in moderation by normal adults who have gradually become habituated to its effects, it may be harmless, or even beneficial, but those of neurotic temperament are usually injured by the indulgence. **Coffee, tea,** and **cocoa,** like other luxuries, may through overindulgence injure the nervous system. Many of its affections are wholly attributable to these substances, and it is good practice to interdict them absolutely in regulating the life of a neuropathic individual.

The value of a correct **diet** for one liable to nervous disorders is attested by the remarkable results achieved through forced feeding in the rest-cure. A neurotic should, so far as possible, conform throughout life to the principles of a partial rest-treatment. He should take easily assimilable food at short intervals and enjoy an extra amount of repose. He should sleep in a well-ventilated room, kept cool, dark, and quiet, and upon a comfortable bed with a moderate amount of covering. Sleep is a habit that should be cultivated by going to bed and awakening at definite hours. It may be apposite to recall the words of Courtney: "Affections of the brain and nervous system are in a greater measure preventable than those of other parts: consequently the mental and nervous salvation of the individual is, practically speaking, to a very marked extent, within his own hands, and it may be worked out by him through rigid attention to the guidance of hygienic laws."

The Apoplectic Habitus

The prophylactic management is influenced by the etiology. There are certain prodromes of cerebral hemorrhage, such as vertigo, headache, numbness of one side, and fullness in the head, correction of which might prevent an attack. Apart from certain congenital, and perhaps hereditary tendencies, the **etiologic factors** of cerebral hemorrhage are, as a rule, syphilis, chronic alcoholism, renal lesions, and overindulgence in food, which demand respectively an energetic mercurial treatment, abstinence from alcohol, and dietetic precautions. Abnormal blood-conditions, which act by impairing the nutrition of the blood-vessels or increasing the vascular tension, must be corrected. An impending attack may be averted by a hot foot-bath, with cooling of the head, rest in bed, the sedative application of heat or cold to the precordia, and, if necessary, cupping or blood-letting. Emotional disturbances, such as fright, grief, and anger, as as well as worry and fatigue, should be avoided. The sexual act, coughing, straining at stool, muscular effort, and cerebral activity, in fact any condition tending to increase the blood-pressure, should be prohibited. Baths may be helpful, but they must be neither hot nor cold, and douches to the head are especially counterindicated. Cold foot-baths with friction are often useful revulsives (see vol. IX). Regularity of bowel-movement should be maintained, and occasional saline purgation is of service. Plethora or any tendency thereto is best combated by limiting the quantity of food and liquids ingested. Meat free from fat, fish, green vegetables, fruit, raw and cooked, milk, and eggs may be allowed in moderation, whereas starchy foods should be limited and alcoholic drinks interdicted.

CHAPTER VI

THE SICK-ROOM*

Position; Size; Preparation; Ventilation; Heating; Cooling; Lighting.

In the **selection** of a sick-room a number of factors must be considered.

Position

In cases of contagious disease the room should be near the top of the house, as thus the best isolation and greatest protection against diffusion of infection are maintained. For non-contagious cases, however, the lower stories are often more convenient. The **situation** should be such that the patient is not disturbed by the noise of a busy street or of children romping in a nursery and is, moreover, not annoyed by the smell of cooking or by other odors.

Sunlight being necessary, the **aspect** of the room is important. If the windows be on opposite sides, it is desirable that they should face northwest and southeast, as they would thus receive the morning and afternoon sun and be struck obliquely by the hot mid-day sun. If only on one side of the house, however, they should face south or southwest. If the light is too bright, a dark screen may be put before the window, without excluding the air, or the patient may lie with his back to the window.

The room should be **spacious** and the ceiling high. It should contain a good-sized window, opening top and bottom, and working smoothly and easily. In summer, **screens** should be placed in the windows, or mosquito netting be tacked across, to keep out flies, mosquitos, and other insects, which not only annoy the patient but also act as carriers of infection. A fireplace and chimney, if present, should be in good condition. A stationary basin should be covered

* The directions in this chapter are to be observed when a special room is set apart as an infirmary, but of course cannot always be carried out in their entirety in an improvised sick-room.

with paper or a board or be kept filled with water, frequently changed, to prevent impure air coming up through an imperfectly trapped waste-pipe. The **floor** should preferably be uncarpeted, though strips of old carpet, which should subsequently be burned, may be laid across it. If the carpet cannot be removed, it may be covered with linen. It is desirable that the flooring be of some impervious material, such as beeswaxed oak or varnished deal, and as free from crevices as possible. Old floors, when time permits, should have their cracks and fissures filled in, and then should be stained and varnished. The **walls,** if of plaster, should be scraped and limewashed or painted with pigment that does not contain lead. Wall-paper may be varnished; the walls must be dry. The **ceiling** should be limewashed frequently, or, better, made impervious by cement or paint.

Pictures on the wall should not be hung too high for dusting. It is much better to remove hangings, pictures, ornaments, and all other unnecessary objects.

Ventilation

The **air** of the sick-room must be kept pure and is best **tested** roughly by the sense of smell; a person coming into the room directly from the pure atmosphere outside should notice no difference as regards freshness and should detect no disagreeable odor. Other tests are described under Hygiene of Dwellings (see page 374).

Windows are the best avenues for ventilation. "Windows are made to open," wrote Miss Nightingale,* "doors are made to shut." The best method is to open windows on opposite sides of the room, the window always being opened from the top, that the entering air may become somewhat warmed as it descends and that any draft that is created may pass too high up to harm the patient. The bed, of course, should not be directly under an open window. Still in windy or cold weather, a draft may be caused which can be prevented by guiding the entering current of air in such a direction that it will not strike the occupants of the room. In addition to the methods described under Hygiene of Dwellings (pages 376 and 377), this may be accomplished by drawing a blind down all the way in front of the opening and holding it away from the window by tying it to a chair or some other object. Wire or common gauze

* "Notes on Nursing."

or flannel may be arranged over the space so as to divide the current of air or deflect it upward. A board placed so as to slant inward and upward from the top window-sash, or a Venetian blind pulled down, or an inside shutter closed in front of the opening with the slats slanting outward and downward, will give the entering air an upward direction. A pane of glass may be removed and its place taken by a tube or by a perforated piece of sheet metal or by a piece of tin or zinc or pasteboard so fixed as to slant inward and upward.

The simplest plan, of course, is Hinckes-Bird's, of placing a board from four to six inches wide under the lower sash. Instead of a board, a frame covered with a piece of flannel may be used, or, when that cannot be obtained, carpets, sacks, or anything procurable may be substituted. Covering the board with green baize or some other suitable material will better prevent the entrance of air at the lower part of the window. The same result is attained by covering with a piece of paper or cloth the space made by moving either sash, or, if the window-sill be deep, by raising the sash until its edge is even with the top of the sill.

By paring the lower rail of the upper sash and the upper rail of the lower sash a slit is cut between them that will admit air even when the window is closed. Boring holes in the same rails in a perpendicular direction will give similar results.

The air of the room is **extracted** best by a good fireplace and chimney, being thus renewed four or five times hourly. In summer a burning lamp or candle should be kept standing in the fireplace to warm the air and produce an upward current. It is, of course, necessary to see that the chimney is not choked up.

An imperfect expedient, when other methods are not available, is to **open the windows in an adjoining room** and the door between.

In addition to the continuous ventilation, especially if poor, the room should be thoroughly **aired** two or three times a day. For this the bed may be rolled into an adjoining room or the patient may be covered up, head and all, or be covered by a blanket thrown over the head-board of the bed, or he may hold an open umbrella in front of him or above him with a shawl or blanket thrown over it, or he may be protected by a screen placed before the bed. All the windows are then opened wide, top and bottom, for a few minutes.

Heating

The temperature of the sick-room, as a rule, should be at about 60° F. when the patient is in bed and 65° F. when he is up all day. The **newly born** and the **old** require about 65° F. to 70° F. In **pulmonary affections** and **acute rheumatism** the temperature should be kept at about 70°. In **acute nephritis** and sometimes in **croup,** a temperature of 80° F. may be necessary. The degree of warmth should be tested not by one's feelings but by the thermometer, which should be suspended on the wall near the bed and at about the level of the latter. It should not hang near the fire or over the fireplace, or near the window or near a lighted gas-fixture. An even temperature should be maintained, necessitating hourly observations of the thermometer.

The sick-room may be **heated** by any of the methods recommended under Hygiene of Dwellings; but never at the expense of ventilation by shutting all the doors and windows.

Cooling the sick-room is often necessary in summer. The **sun** may be kept out of the room by green curtains or blinds or inside shutters, best by Venetian blinds—especially those like the Marquise, which can be pushed outward and kept in position by rods. An outside blind can also be improvised by attaching two loops to the lower corners of an inside blind, which is carried outside the window and fastened by means of the loops and some tape to the ends of two sticks about three feet long, the latter being pushed out at the bottom of the window as far as possible and secured to the window-sill or side of the window.

The room may be cooled by placing a large block of ice in the middle of the room in a shallow tub, or, better, on a strainer over a basin. Several of these may be placed about the room or near the window. Branches of trees may be placed in the tub or in a vessel of water. Large wet sheets hung before open windows help to cool the air. Spraying water or eau de Cologne about the room often proves refreshing. A 'Nevo' (see page 387), however, is the best and surest cooling apparatus.

Artificial lighting is usually necessary at night. Flames use up the oxygen of the air and produce carbonic acid and other impurities. Of these, gas is the least suited for a sick-room and oil the best. A good oil lamp, therefore, with a suitable shade, may be used, or a night-light, such as Clarke's night-light. 'German floating lights' or 'night-candles' are also employed. The **incandescent electric**

light is infinitely superior to all other modes of artificial lighting, as it neither uses oxygen nor produces carbonic acid. There are now to be obtained **portable electric lights** operated with dry batteries. These will burn continuously for six to eight hours or will give several hundred brief illuminations before new batteries are required.

Humidity

The air may be **kept moist** by boiling water in a croup- or bronchitis-kettle or in an ordinary kettle with or without a steam-pipe, by dropping very hot bricks into water, by suspending wet blankets or sheets in the room, or, best of all, by means of a steam atomizer. If the latter is not available, moisture may be diffused by means of a common hand atomizer.

It may often be found necessary to **reduce the moisture** in the air of the sick-room. To render the atmosphere of a room anhydrous, vessels containing calcium chlorid may be placed at various points in it.

CHOICE AND ARRANGEMENT OF CONTENTS

It is always advisable not to have too much or too elaborate furniture in the sick-room. The most suitable chairs are of wood with cane bottoms and without rockers.

The Bed.—The simplest and at the same time the most desirable bed is that made of brass or iron with chain springs or with a woven-wire spring mattress. In the selection of a bed, height, weight, durability, and simplicity of construction must be taken into consideration. The sick-bed should be higher than the conventional bed, thus facilitating examinations by the physician and relieving very materially the attendant's constant stooping. A single bed is better than a double one for obvious reasons. The weight should be only sufficient to insure durability, as assistance would be required in changing the position of a heavy bed. All sick-beds should be mounted on casters, though the bed is steadier when only the two legs at the head are thus fitted permanently. Extreme simplicity is always possible in metallic bedsteads. Corners and crevices must be avoided in their construction, so that cleanliness may easily be maintained. A bed painted or enameled white is pleasing to the eye of the patient—a psychic effect not to be disregarded. A desirable size for the bed is 6 feet 6 inches in length, about 37 inches in width, and 25 inches in height. The position of the bed is important. It should be accessible from all sides. Though it must not directly face the window, it should so be placed, if possible, that the patient lying quietly in bed may obtain a view of the outer world.

Invalid Beds.—In long-continued sickness or in cases of fracture it is often necessary to employ a special bed. A simple means of converting a double bed into two beds is the adjustable bed guard, consisting of a cushioned partition or rail extending from the head to the foot of the bed either upon or above the mattress. It is fitted

FIG. 119.—GORHAM INVALID BED.

with patent catches, so that it may easily be adjusted or removed in a few seconds, and, when in place, will separate the occupants of the bed and guard them against the unconscious movements of each other. It is particularly adapted for use when two children occupy the same bed or a child sleeps with parent, nurse, or other older person.

Convenient invalid beds, known as the 'Gorham' and 'Crosby' beds, consist essentially of two distinct parts; the first, in effect, a cot with adjustable transverse bands (instead of the ordinary canvas bottom) so arranged as to admit of the removal of one or more of them, if desirable, without disturbing the patient; the second, a trundle-bed. There is a mechanism by which when needed, and without moving the patient, he may be lifted from his bearing upon the bands of the cot and later be replaced. The facility it affords in treating bed-sores, or preventing their occurrence; the ease with which parts of the body in contact with the bed can be ventilated and bathed, or dressings applied to wounds in those situations without moving the patient; the readiness with which defecation can be accomplished with the aid of a single attendant; and the general cleanliness and freedom from fetor insured, are points of excellence in favor of these beds.

Mattresses may be of straw, horsehair, wire, etc., the most comfortable for the patient being a mattress stuffed with horsehair and the most hygienic being the wire mattress. No bedding should be used which cannot easily be washed and sterilized, and whatever the character of the stuffing, it must be so disposed that the center of the mattress will be thicker than the sides. If thus properly constructed it will present a slightly convex surface and hollowing will be avoided. A special mattress known as a 'fracture mattress,' consisting of three pieces, is very convenient, as by removal of the middle piece it allows of the introduction and withdrawal of the bed-pan with the least possible movement on the part of the patient.

Hot-water beds and **air-beds** made of rubber and filled respectively with warm water at a temperature of about 100° F. by means of a funnel and pitcher, or with air by means of bellows or an air-pump, are employed in long-continued illness and as a prophylactic measure in decubitus. The water-bed is placed on the springs with rubber sheeting, paper, or other suitable material intervening to prevent rusting, and is then filled. The bed-coverings are made up in the usual way. **Hebra's water-bed,** otherwise known as the continuous bath, is described in volume IX.

The **sheets** should be of white bleached cotton, two and three-quarter yards in length, and of sufficient width to be tucked under the edges. Linen is not so warm and is therefore more comfortable in summer.

The **blankets** should be of light weight and white or light yellow in color that dirt may be detected readily.

The **outer covering** should be light, a white dimity or a light-weight honeycomb spread. A clean white sheet will answer the purpose. Scarlet blankets are sometimes used. The heavy cotton counterpane or down-quilt should never be used, as it interferes with the ventilation of the bed.

There should be two **pillows,** of horsehair, moderately firm, as wide as the bed, about fifteen inches deep and eight inches thick, and properly covered.

Bed-making.—The under sheet is put on first, and must be drawn quite tightly over the mattress and well tucked in, first at the top and bottom, and then at the sides; or it may be fastened to the mattress by safety-pins. Whenever the bed is liable to become soiled, two **draw-sheets** are required to protect the mattress. The under draw-sheet is usually made of mackintosh or rubber, but ordinary table oil-cloth, enameled cloth, and oiled muslin have been employed. When these cannot be procured, the best substitute is paper, either two folds of heavy brown wrapping-paper or newspapers. An old blanket or a comforter should not be used unless nothing else can be obtained. The best draw-sheet consists of a piece of rubber cloth thirty-two inches long and forty-five inches wide. It is placed across the bed over the lower sheet so as to reach from the middle of the back to the knees. It may be provided with eyelets to lace across under the bed or with tapes which are tied to the sides of the bed; or the four corners may be pinned to the mattress to prevent wrinkling. A cotton draw-sheet, two and a quarter yards long and two yards wide, is doubled and placed over the rubber sheet so as to cover it completely, being tucked in at the sides and fastened with safety-pins to the under part of the mattress at the four corners. The two hemmed ends should be near the foot of the bed to avoid irritating the patient's back. The best way, however, to obtain smooth tension is to fold the draw-sheet across the bed so that the crease is in its long axis. The two ends are then sewed together like a round roller towel. The sheet is laid upon the bed and wooden rods are slipped in through the two sides so that they lie along the sides of the bed with their ends projecting beyond the sheet. A strong girth or strap is passed under the bed and around the upper ends of the two staves, and another strap similarly around their lower ends. By drawing these straps tight and buckling them the formation of creases in the draw-sheet will be prevented. The upper sheet comes next, then the blanket, and lastly the spread. These covers should be tucked in at the sides and at the bottom, but must not be drawn too tightly over the patient's toes. The upper end of the sheet is to be folded over the blanket and coverlet. These latter are not to be turned back above, but if too long may be folded over at the lower end.

These directions are for the ordinary sick-bed. Bed-making for special cases will be described under Nursing in Special Diseases.

APPLIANCES FOR THE SICK-ROOM

Various appliances may be required in the sick-room for different indications. The patient often must be **propped up** in bed. For this a **bed-rest** is needed, the best consisting of an adjustable wooden or metal frame with back of canvas, cane, carpet, webbing, or a spring, and with arms. In its absence, the patient may be slung up in netting or canvas which is passed around his back with the ends tied to the foot of the bed. A straight-back chair may be turned upside down so that it rests on the front edge of its seat and the top of its back, or a broad board or the leaf of a table may be rested in a slanting position on the bed and on the head-board. These latter may be placed beneath the mattress. In propping with pillows, the method least to be recommended, the first pillow is pressed well down under the back and the others added successively, one behind the other.

The patient is prevented from **slipping down** in bed by having placed under his knees a roller pillow, made of stout ticking with rounded ends, twenty-one inches long and from four to eight inches thick, stuffed firmly with horsehair and covered with a cotton slip; or a bolster, blanket, or comforter placed in a bolster-case, the ends of the pillow being attached to pieces of strong tape or broad bandage or to strips of stout webbing which are fastened to the head of the bed. For a tolerably strong patient there may be laid at the foot of the bed a block of wood nearly the width of the bed and beveled on the side near the feet, or a footstool with the upper surface toward the feet, or a small drawer, against which he may push.

To assist the patient in **moving himself in bed** various devices are used. The best **bed-crane** is an arched iron curve fixed to the head of the bed by its long upright part and having suspended from its end an adjustable leather strap with a handle. Suspending the strap or a cord from a ring in the ceiling or fastening the crane to the wall above the bed is not so practical, as it prevents the bed from being moved. The strap may be attached to a divisible wooden cross-beam which is set up transversely over the patient.

A **bed-trace** may be used, consisting of a girth, strap, rope, or towel tied in a loop reaching about to the middle of the body and fastened to the foot of the bed.

To keep the weight of the **bedclothes off the body** or off parts of it, **bed-cradles** are employed. The former object may also be accomplished by tying to the sides of the bed the ends of three half barrel-hoops or the hind legs of two chairs with the backs uppermost; or by running a cord under the covers diagonally from the head to the foot of the bed; or by passing corkscrews through the bed-clothes, guarding their points with corks, and attaching to the handles strings which are fastened to a nail in the wall. A **bed-frame for a limb** may be improvised by inverting over the limb a wooden box with the ends knocked out, or a bandbox with the sides cut out; or by placing over it a three- or four-legged stool.

To **prevent bed-sores,** the parts of the body exposed to prolonged pressure must be protected; **water-cushions** are the most serviceable appliances. They are made of rubber, square or oblong or shaped like a horseshoe, or circular with an open round or oval center. Billroth used a large water-pillow, almost bed-width square, placed flat upon the middle of the bed and filled slowly with water at about 95° F. (35° C.), repeatedly testing the tension—which must be such that when both hands and arms are used, effort is necessary to press the sides of the cushion together; a sheet should be spread over it and pillows placed above and below it. The patient is then carefully laid upon the cushion, so that about a hand's-breadth of its lower end extends beyond the pelvis. **Rubber air-cushions** are made in similar shapes, but must not be too full and should be smoothly covered by material that is sewed, not pinned. Japanese **paper rings** to be inflated with air last a reasonable time and may be obtained quite cheaply. A soft **horsehair pillow** may be used; or a ring made of horsehair covered with soft leather, rubber cloth, or with a double layer of oiled muslin, may be placed so that the opening comes beneath the sensitive part. For **protecting small surfaces,** such as the heel, circular pads can be made by filling narrow bags with horsehair, wool, wadding, oakum, jute, cotton batting, blanket, straw, compress, or even with a sheet, and sewing the ends together to form a ring; or by forming out of one of those materials a circular pad with a hole in the center, covering it with a compress and winding a bandage around it to keep it in place.

For making local applications of **dry heat,** hot-water coils, bottles, bags, and cans are used. Bottles and bags, and the like, must be tightly stoppered and have an undisplaceable covering of flannel, an undershirt or large stocking serving the purpose. Bags should have the air expelled and be about half filled. Bottles should not be more than two-thirds full and should be placed with the corked end away from the patient. Also thin bags made of flannel or of old muslin or of gauze, filled with salt, bran, crushed oats, sand, ashes, hops, or chamomile flowers, and heated in an oven, or in a farina-boiler, are used. They may be covered with a pad of cotton-wool and oiled muslin, and may be made half-moon shape when intended to be applied over the ear. Heated bricks, tiles, plates, irons, or marble slabs may be wrapped in flannel and applied, or heated flannels may be employed alone. Electric heating pads, chemical thermophors, and Japanese hand-stoves are employed likewise. (See volume IX.)

Dry cold is applied locally by means of an ice-water coil or an ice-bag. The latter is half filled with pieces of ice broken the size of small walnuts by pounding with a hammer the ice wrapped in a coarse clean cloth or placed in a stout canvas bag; or, without noise, by splintering it with a strong pin, darning needle, bodkin, awl, or hat-pin. Mixing the ice with one-third sawdust will make it last longer, while the admixture of a little salt will intensify the cold. The bag is pressed firmly around the ice to expel the air, fastened securely by tying the mouth on a cork or wooden bung, and is covered with lint, linen, gauze, or cotton. It may be kept in place by a bandage or it may be suspended from a curved rod. It may be applied to **the head** in the form of an ice-cap—a rubber cap on which there is a bag for ice. An ordinary ice-bag may be put in a bag stitched upon a woman's night-cap, which is then drawn together like a tobacco-pouch; or it may be suspended by tying about its neck a bandage the ends of which are pinned to the pillow; or it may be folded in a napkin, which is pinned to the pillow. When no ice-cap is available, a smooth piece of ice, two or three inches long and one and a half inches broad, may be placed in a cup of soft sponge which is squeezed out whenever saturated. Ice-bags must always be refilled before the ice has melted, and when placed beneath a part, should be drained by means of a catheter fastened into the bag and attached to a rubber tube conducted into a vessel underneath the bed. In emergencies, glass bottles, tin boxes, an ordinary bladder, or a waterproof sponge-bag may be used, or gutta-percha tissue may be cut into suitable shape and the edges fastened together with chloroform.

Portable bed-tables or **bed-trays,** standing on legs high enough to keep the tray off the body, are very useful, some being provided with a flap that can be raised up at a slope for the purpose of reading or writing. In their absence a firm wooden board, twenty inches wide and as long as the width of the bed, may be fitted at the ends with supports sixteen inches high. A **bedside table** consists of a stand, mounted on rollers, with an adjustable wooden top that can be moved across the bed, raised or lowered, or tilted at any angle.

A **screen** is necessary to protect the patient from drafts or glare of the sun. One may be improvised by covering a clothes-horse with a blanket, sheet, spread, or shawl.

Bed-pans are usually made of earthenware or agate-ware and are round, oblong, or slipper-shaped. Before being used, they should be warmed by having warm water poured into them or by being held over a register; or they may be covered with flannel. They sometimes are provided with a rubber air-cushion, and they may be made of rubber with inflatable sides. The round pan, used mostly for men, is passed under from the side; the slipper pan, more suitable for women, is introduced from the front. The patient, if able, should raise himself a little; and his back should be lifted and protected by a hand as the pan is slipped into place. If too sick to raise himself, or too heavy, the assistance of a third person will be required. A soup-plate, or a dust-pan with flannel on the edge and the handle held well down, makes an extemporary bed-pan. **Chamber utensils** should be made of glazed white earthenware and with properly fitting lids. **Commodes** are useful for convalescents. **Urinals** are best made of glass and with wide necks, but may be improvised from old jam-pots or pickle-jars. All such receptacles should be covered immediately after use, carried straight to the closet, emptied, cleansed, and partially filled with a solution of chlorinated lime. They are not to be brought into the room again until needed.

Nourishment may be administered to invalids in the recumbent position by means of the **feeding-cup.** This is made preferably of glass, but may be improvised with a tea-pot. Liquids may be sucked through a bent glass tube or through a clean rubber tube, which must be lifted from the liquid before it is removed from the patient's mouth.

Medicine-glasses should be provided for measuring the doses of liquids given and should be thoroughly cleansed and dried immediately after use. Spoons differ greatly in size and the drops of different preparations also vary in size. An ordinary teaspoon, however, may be said to hold about a fluidram, a dessertspoon two fluidrams, a tablespoon half a fluidounce, an ordinary wine-glass two fluidounces, a small teacup four fluidounces, and a tumbler about half a pint. A minim corresponds with a drop of a watery solution or fluid extract and with two drops of a tincture.

Medicine-droppers, dressings, trays and pus basins of various shapes and materials, a silent clock, an invalid chair, leg-rests, a washstand, pitchers, basins, a towel-rack, a bath-thermometer and a

A *B*

FIG. 120.—KNOPF'S POCKET SPUTUM-FLASK.
A, Closed. *B*, Taken apart for cleansing.

room-thermometer, are also among the necessary appurtenances of a sick-room.

Sputum should always be received in a suitable vessel. Nonmetallic cuspidors may be used, inclosed, if desired, in an ornamental frame. Sputum-cups should be made of glazed earthenware and without corners, or of pasteboard and supported, or not, in a metal rim. Pocket-flasks are sometimes employed. When nothing better is at hand, a jam-pot, into which a newspaper has been folded all around, may be used. The receptacle should contain a disinfectant solution (carbolic acid or chlorinated lime—mercuric chlorid being unsuitable), should be covered to exclude insects, and should be emptied frequently. Spittoons may be cleansed with boiling water or with a disinfectant solution; earthenware **sputum-cups** should be boiled or placed in a sterilizer; paper or pasteboard cups or linings are to be destroyed by fire. When a patient is prohibited from lifting his head, he may expectorate into cloths or Japanese paper handkerchiefs, which must promptly be burned—never into handkerchiefs or towels which are to be washed. When used, the cloths may be placed in a muslin or paper bag, which is to be burned with them.

A **bath-tub** is frequently required, preferably on wheels, though in its absence a wash-tub will answer. **Portable bath-tubs** or **fever cots** have been devised for administering the bath in bed. (See volume IX, pp. 518 *seq.*) A **substitute** may be improvised by spreading a mackintosh beneath the patient and holding up its sides, the head of the bed having been raised and a tub placed at the foot.

Stretchers are sometimes needed, and may be improvised by rolling two long broom handles or poles tightly in each side of a stout sheet placed beneath the patient, who may then be carried by two persons, one at either end; or, better, by four, each clasping with one hand the end, and with the other the middle, of the pole around which the sheet is wrapped.

Less serviceable is an improvised **hammock** made by each of four persons lifting a corner of the undersheet. **Carrying-chairs** are also used.

Fresh flowers, whose perfume is not too strong, may be allowed in the sick-room during the day if agreeable to the patient, but must be removed at night, and thrown away when faded, the water being renewed daily.

CLEANSING THE SICK-ROOM AND ITS CONTENTS

Every day the floor should be cleansed from dust. **Sweeping** on a hard floor should be done with a soft-hair broom or floor-brush used with long slow strokes and kept near the floor, the dust being taken up frequently. Moistened tea-leaves or sawdust may first be sprinkled over the floor, or a dampened hand-brush may be used, or flannel may be fastened over the floor-brush. Carpet on the floor should be cleansed by means of a cloth wrung out of hot water and wrapped around a broom, and rinsed out when dirty. Strips of carpet and rugs should be removed and cleansed in the open air. A hardwood floor is much more easily cleansed if it has been varnished with shellac and then polished. In **dusting,** a dry cloth or a feather duster should never be used. With a damp cloth wrung out of a weak solution of carbolic acid the dust should carefully be wiped from the furniture and woodwork into the cloth.

A thorough weekly cleansing of the room is also necessary. Scrubbing the floor is generally considered objectionable, vigorous rubbing with a cloth or carriage-sponge, wrung out nearly dry, being preferred. The doors, window-sills, and other woodwork, however, should be washed thoroughly with hot water, soap, and a scrubbing-brush. All **waste matter,** including water used for washing, should be carried immediately out of the room and suitably disposed of. All **utensils,** such as basins, bed-pans, and the like, in addition to their daily care, should be washed out once a week with soap and water and left in boiling water for an hour.

In the case of infectious diseases, provision must be made for **disinfecting** the clothing, bed-linen, sputum, urine, feces, and the like, and the vessels containing them. The person handling the discharges, utensils, or fomites must thoroughly disinfect whatever part comes in contact with them, and must be especially careful before eating to wash the hands in an antiseptic solution. **Soiled** or **infected linen** or **soiled clothing** or **dressings** should not be left about the room in uncovered receptacles. **Fresh blood-stains** may be removed from blankets or ticking by the application of a paste of fine starch or wheat flour which is allowed to dry, and from rubber by a chlorinated soda solution. Bed-clothing, stained underclothing, and all articles stained with discharges from wounds should be placed at once in a vessel containing a mixture of carbolic acid and soap.* The vessel, which should be brought to the bedside, is then immediately covered. At the end of a half-hour or an hour the clothes are removed and thoroughly rinsed in cold soapsuds until all traces of the stains have disappeared, when they can be sent to the laundry. Another method is to put the soiled articles into cold water for two hours and then boil them. Soiled dressings and similar articles are to be thrown into a special covered receptacle and, as soon as possible, removed from the room and burned.

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*Carbolic acid, 3 parts; common soft soap, 1½ to 2 parts; cold water, 100 parts. The soap is dissolved in the water, the acid added, and the mixture thoroughly stirred.

VISITORS

Visits must not be permitted to interfere with the patient's meals or periods of rest and sleep. The number of visitors admitted should be small, and depends upon the condition of the patient and how he is affected by the visit, especially by its influence upon his night. No visitor should be received in the evening. Visitors are to be admitted preferably one at a time, and should not be permitted to remain too long. They should lay aside their outer clothing, enter promptly and quietly, and sit down near the patient and facing him. They should speak quietly, firmly, distinctly, and in brief sentences. Conversation tending to excite the patient must not be permitted. When patients are not seriously ill, or toward convalescence, or in cases of chronic illness, lively and entertaining chats may be helpful. It is often necessary to watch visitors carefully to see that they give nothing to the patient. This is especially important in the management of those addicted to drugs and during convalescence from typhoid fever.

CHAPTER VII

CARE OF THE PATIENT

Toilet; Attire; Positions; Movement; Food; Amusement. Changing the Bed-clothes. Quiet and Avoidance of Disturbances. Qualities of a Good Nurse.

Toilet

The face, neck, and hands of a patient should be washed night and morning and a warm general bath given every day. If the latter is impossible for any reason, the patient should be bathed daily at least as far as the waist. The armpits and the feet and legs should receive special attention. The back and shoulders should be bathed night and morning, rubbed with alcohol, and dusted with an absorbent powder. For bathing a patient in bed, a basin of warm water, soap, a soft wash-rag, or a piece of soft flannel, a soft sponge, and a soft towel are brought to the bedside. The bedding is protected by a thick towel or a piece of waterproof sheeting, or by a mackintosh turned up at the edges to form a trough that extends over the foot of the bed, where a receptacle is placed; or the sheets may be removed and substituted by two blankets kept for the purpose. The patient is then washed, one part at a time; one arm being dried and again covered before the second is washed. Tender or painful spots are bathed gently in one direction with a soft sponge and then mopped or patted dry with a soft towel. Parts exposed to pressure, like the back, heels, ankles, and elbows, may be bathed frequently with a one-half per cent. solution of formalin, or with a mixture of alum and salt in dilute alcohol, cologne, or vinegar, or with alcohol and quinin, to harden the skin. Care must be taken after washing to dry the parts thoroughly with a smooth warmed towel or warm sterile absorbent cotton. Unnecessary friction must be avoided; an unappreciable wound occasioned by careless rubbing of the skin may cause the development of a bed-sore.

Dusting-powders, such as zinc oxid and starch, zinc stearate and benzoic acid, acetanilid and boric acid, bismuth subnitrate, borax, talcum, and the like, must be used generously to prevent attrition of the parts. If the skin shows any inclination to give way, the affected part should be protected from contact with the air by means of flexible collodion, to which may be added iodoform in small quantity, or by a dressing with zinc oxid ointment or salve of wool-fat and corrosive sublimate (1:2000).

The **mouth** should be cleansed by swabbing or rinsing at least three times a day; in some cases, every hour. Oleo-balsamic mixture, well diluted, boric acid solution, a few drops of tincture of myrrh in pure water, are among the useful preparations. For washing out the mouth a very soft toothbrush may be used, or small squares of gauze or old linen may be wrapped about the index-finger; or a bit of lint, of clean soft sponge, or of cotton may be fastened to a wire or wooden applicator, even a penholder, a matchstick, or a toothpick. The sponge or its substitute is dipped in the wash and inserted into the mouth, going over it thoroughly, passing along the gums behind the wisdom-teeth, then over the roof of the mouth along the inner margin of the teeth and under the tongue. If necessary the tongue should be scraped. Lemon peel or soda-water will remove sordes or crusts from the lips or teeth. The teeth should be brushed when possible and bits of food removed from between them with floss-silk. Before and after the taking of food the buccal cavity should be cleansed. Careful toilet of the mouth will sometimes overcome the patient's repugnance to food and may prevent many unpleasant complications, such as aphthous ulcer, thrush, parotitis, and even lobar pneumonia.

The mouth is kept **moist** and **thirst assuaged** by frequent rinsing with some aromatic solution and by moistening the lips with rose-water or cold cream. Glycerin, being hygroscopic, is not suitable for this purpose. Mucilaginous drinks, by providing a fine moist covering for the fauces, materially assist in diminishing thirst. Carbonated drinks containing some fruit juice are agreeable, assisted perhaps by some diluted acid which acts as a ptyalagog. Small pieces of ice allowed to melt in the mouth are often more comforting than the drinking of water. Tablets of sodium bicarbonate, especially if mildly effervescent, allowed to dissolve on the tongue, may allay thirst when liquids are to be restricted. Thirst can sometimes be controlled psychically. Opium, by reducing the irritability of the thirst center, is the ideal medicament, but for obvious reasons should not be used except in cases of necessity.

The **nails** should be kept clean and trimmed. The **hair** should receive attention at least once in twenty-four hours. The long hair of women should be arranged in two loose plaits, drawn well over to the side and braided low down just behind the ear; the first two or three turns being looser than the subsequent ones and the ends being tied. These may be laid upon the pillow or in front upon the chest or may be fastened on the top of the head. The hair must be dressed before the body-linen or bed-clothes are changed and before any dressings or bandages are applied; the pillow being protected by a towel. Instead of combing and brushing all the hair at once it is better to dress portions at different times in the day. The hair should be grasped between the head and the comb or brush. The latter is used in an upward direction, gently but firmly, without jerking or pulling, beginning first at the ends and taking a little of the hair at a time. The brush may be sprinkled with toilet vinegar or cologne water. The hair should be washed occasionally, the pillow and the patient's shoulders being protected with a rubber sheet on which the hair is spread out until dry. If the hair contain parasites, it should be cut close or even shaved off, especially in a man. Instead, the head may be bound up for two or three days in a cloth kept moist with a solution of carbolic acid (1 : 20 or 1 : 40) or of mercuric chlorid (1 : 500) or a decoction or alcoholic solution of larkspur. Over this is to be placed a cap of oiled muslin, or the pillow may be protected by a rubber cloth. It is sometimes less troublesome to rub the parasiticide solution into the hair, which is then wrapped in a dry towel or cloth. In either case, after the hair is dry, alcohol is rubbed about the roots.

ATTIRE

Clothing in bed need consist merely of a night-gown for a woman and pyjamas or a night-shirt for a man, although woolen under-garments may be worn if desirable. The same clothes should not be worn day and night. Two sets, therefore, are required, which must be aired, dried, and warmed outside of the sick-room before being put on. A patient who sits up in bed should wear a flannel vest under the night-gown or a flannel jacket or dressing-sack over it. The 'Nightingale' wrap is very convenient and is easily made out of two yards of a double thickness of outing flannel of ordinary width. A straight slit six inches deep is cut in the middle of one side, the points thus formed being turned back to form the collar, and the corners of the opposite side are turned back to form cuffs. The edges are bound or pinked, and buttons and buttonholes are added to the side on which the slit was made. A bald-headed person should wear a night-cap, especially if accustomed to a wig.

To **remove clothing in bed** the patient is raised a little and the garments drawn upward well under the arms. The neckband and wristbands having been unfastened, the sleeves are gently drawn off, and the garment then slipped over the head. If one side be injured, the sleeve is first pulled off the arm of the well side, which is drawn back, the shirt stripped over the head, and then slowly and carefully drawn over the injured arm. Sometimes the garment is first removed over the head and then from the arms, being taken off the sound side first. If an arm be bandaged, the sleeve may be unstitched and allowed to remain on, or the sleeve can be opened from wrist to neck, placed under the arm, and fastened by means of buttons or of tapes four to six inches apart stitched on either side of the slit. If the patient cannot be raised, the garment may be ripped up the middle in front and provided with tapes. In removing a patient's clothes preparatory to putting him to bed great care must be used, especially if he be unconscious or injured. Ripping is always preferable to cutting. Suspenders should be unfastened behind as well as in front. The clothing can then be removed under a sheet, coat, vest and shirt, and trousers and drawers being pulled off together. **In dressing** an injured person the sleeve is drawn over the affected arm, the shirt then passed over the head, and the well arm introduced into its sleeve. Under ordinary circumstances the arms are put into the clean sleeves as soon as they are taken out of the soiled garment, which is then slipped over the head, while the clean garment is slipped on with almost the same motion and drawn down smoothly in the back. Another plan is to pass the fresh shirt over the head after the arms have been removed from the old one, which is pulled off over the feet as the clean garment is brought down. When the nightshirt has been slit in front, one sleeve is slipped on as the soiled one is removed, both garments are then carried under the shoulders and the arms taken out of the other sleeve and slipped into the fresh one. When several garments are worn, they are put on together, one inside the other. If an arm be bandaged to the chest, the free arm is first put in its sleeve and the shirt then slipped over the head, drawn down and fastened, the empty sleeve being fixed in front.

MOVING AND LIFTING

When moved for any purpose, the patient must always be supported. If **raised** to have pillows readjusted, his head is to be lifted carefully and allowed to rest on the shoulder while his back is supported with the hand. The other hand having arranged the pillows, the supporting arm easily and gently lays the patient back. To **lift** a patient **upward** in bed, one hand is passed well under his back, the upper part of the arm and shoulder supporting the heavy part of his shoulders, and the other hand is placed below his hips. The patient assists if possible by putting his arms around the nurse's neck. This is necessary in the less desirable method of passing the hands under his arms and clasping them behind his shoulders or of simply grasping him under the arms. In another method, of sliding the arms under his pelvis, the patient may assist by pressing with his hands and heels against the bed. Pulling the undersheet upward on the mattress with the patient on it will accomplish the same purpose. When two helpers are available, they should stand on the same side of the bed. The first places one arm under the patient's neck so that his head rests upon it, the hand being passed under his arm on the other side, and the other hand and arm under the middle of his back. The second passes one arm under the lower part of the patient's back and the other under his knees. Then they both lift the patient toward the head of the bed, a third person supporting a limb if injured. A patient is **placed** in a **sitting position** in bed by being taken hold of below or by the pelvis and with a quick, lifting movement pushed upward in the bed, so that by stooping forward a little he actually sits with the pelvis upright and hips bent. In **moving** a patient **from one side** of the bed **to the other,** one hand and arm are carried obliquely well down under his back, so that the attendant's shoulder supports his shoulder, while the other hand is put over and slipped well under his other shoulder, the upper half of his body then being gently and evenly lifted over. The first hand is then slipped under the lower part of the back, the other just below the hips, and the other half of the body is moved. Instead, the undersheet with the patient on it may be pulled over, or it may be secured to the mattress with safety-pins whilst the draw-sheet is loosened and with the patient on it pulled across the bed. In **transferring** a patient **from one bed to another** the beds are brought close together and the under-sheet loosened and drawn with the patient on it over to the fresh bed. A stout rubber cloth may first be passed beneath the under-sheet of the bed on which the patient lies and secured with safety-pins, extending over to the fresh bed and covering the intervening crevice; or the mattress with the patient on it may first be pulled a little way over the second bed. If the heads and feet of the beds are low, one person may grasp the sheet above and another below and the patient may be lifted steadily over, and slowly and gently lowered in the fresh bed; the sheet then being slipped out. This may be done even if the beds cannot be placed side by side. If the patient be very heavy, or if a broken limb must be supported, more assistance is required. When the patient is to be moved from one bed to another by one person, the distance should be made as short as possible. This may be accomplished by putting the beds with the head of one at the foot of the other, or by placing them parallel with the head of one opposite the foot of the other; so that the patient can be laid on the side of the new bed he occupied in the old. After removing the covers and drawing the shirt well down, the attendant stands on the side of the patient opposite the painful parts, bending his knees, and brings his lower arm as far as possible under the upper part of the patient's thighs, passing his other arm under the middle of the patient's back to the other side. The patient having placed his arms around the bearer's neck and allowed his legs to hang limp, the bearer straightens his own bent knees and rises, bending his own spine backward until his chest supports the body of the patient. An injured member or the head of an unconscious patient must be supported by a second helper. It is advisable to have a second helper stand on the opposite side of the fresh bed and by laying his own hands under the patient assist in laying him down gently. Should a patient be very heavy, he may need two to carry him. If the bed is narrow, the two helpers may stand on opposite sides of it, pass their arms under the shoulders and upper part of the thighs, grasping each other's hands, and at a given signal lift the patient slowly and carefully. A third may support the head or an injured limb. As a rule, and always when the bed is broad, the two bearers stand on the same side of the patient, one placing his arms under the back of the patient, who clasps him around the neck, the other and stronger placing his arms under the pelvis and thighs. At the word of command they lift the patient, carrying him upon their chests, and lay him down with simultaneous movements. A third may carry the head, and if necessary a fourth the legs, all on the same side. Three persons may carry a patient, by the first passing one arm beneath the neck and the other under the shoulder-blades, the second passing one arm above and the other below the buttocks, the third passing both arms under the lower limbs, and all moving by small, quiet side-steps. In **lifting** a patient **off the floor,** one or two persons kneel down on one side of the patient and slide their arms under him as in the methods described. Their wrists are then grasped by persons on the other side of the patient who render them support as they slowly rise. In **transferring a patient to a lounge** or invalid chair, he is carried in one of the ways described, the lounge or chair being brought near and placed preferably with the head of the lounge or the back of the chair toward the foot of the bed. In **lifting** or moving a **broken limb** the hands are placed underneath the limb, grasping it firmly, one above and the other below the seat of fracture.

FEEDING THE SICK

This subject is fully considered in volume VI of this series, but certain considerations may here be emphasized.

Observation should be made of the patient's appetite, likes and dislikes, whims and fancies, digestive ability, the times when he is most faint, and the quantity he can generally eat. Lack of desire for food, due to defective cooking or wrong time of serving or to dislike of the particular food offered, should not be mistaken for lack of appetite.

The Food.—Diluting liquid food too much may so increase its bulk that the patient tires of swallowing before enough nourishment has been taken. It is usually better to surprise a patient than to ask him what he would like to eat. Twice-cooked food should not be served; it is better to cook but a little at a time. Food when served should neither be, nor look, greasy; broths should always be skimmed; everything should be fresh and properly cooked and seasoned. Food should not be kept in the sick-room. When milk disagrees or is distasteful, it may be diluted with effervescent water, made alkaline by the addition of lime-water or of sodium bicarbonate (ten grains to the pint), or be diluted and pancreatized, or be substituted by kumyss, whey, buttermilk, and the like.

Preparations for Feeding.—The food should be prepared outside

In feeding helpless patients, the nurse passes her hand beneath the pillow and slowly and gently raises the head, keeping it straight (as a slight inclination to the side may cause the food to run out of the mouth) and not bending it so far forward as to make swallowing difficult. The clothes should be protected by a napkin placed under the chin. The patient should not be allowed to swallow during inspiration and should have disposed of one mouthful before the next is given. He may be fed with an ordinary cup or tumbler, not more than one-half full, with a glass feeding-cup, or, especially when his head cannot be raised, with a tablespoon or teaspoon, a medicine dropper, a baby's feeding bottle, or a tube of glass or rubber.

Unconscious patients can be given only fluid nourishment. When fed with a spoon, not more than a teaspoonful and not less than half a dram should be given at once. The spoon should be passed far back into the mouth, emptied slowly, the lips and nostrils being then closed. The patient must be seen to swallow before the process is repeated. If the jaw is set, a medicine dropper may be used. In feeding children or infants, fluids may be poured with a spoon into the nostril. **Artificial feeding** is often required, a stomach-tube being passed through the mouth or nose into the esophagus or stomach. **Nasal feeding** is probably the best method when the patient is unconscious, and may also be employed for young infants, in cases of diphtheria, stomatitis, or of other painful throat affection, and often for the insane. A soft catheter is coated lightly with olive oil, vaselin, glycerin, butter, white of egg, or milk, and passed gently through the nostril down to the esophagus or into the stomach. After making certain that it has not entered the larynx, a funnel is attached to the free end and the fluid is poured in.

Rectal feeding is sometimes necessary. It is described fully in volume VI of this series, pages 176 to 178.

Feeding by **inunction,** as in rubbing olive oil, cod-liver oil, and cocoa-butter into the skin of the abdomen and thighs, has sometimes proved useful in cases of extreme emaciation.

Intravascular feeding has almost entirely given way to infusion with clinical saline solution.

Hypodermic feeding has been attempted, but has not proved of much avail. More extended trial should be made of the **nutrient infusion** method of Southgate Leigh, who dissolves the white of one egg in 10 or 12 ounces of clinical saline solution, filters through sterile cotton, and administers by hypodermoclysis. The solution may be kept on ice for 36 hours. Before injection it should be warmed by immersing the bottle in water at about 105° F.

Care after Feeding.—When the patient has finished eating, the tray and its contents should be removed from the room at once. Untasted food, half-emptied cups or glasses, or soiled dishes, should never be allowed to stand about the sick-room. After eating, the patient's mouth should be rinsed or swabbed out with pure water or a mouth-wash and the lips thoroughly dried with a fresh, clean napkin. The bed should be kept free of bread-crumbs. No one except the patient should eat in the sick-room.

A certain **latitude** might well be given to orders concerning food to enable the nurse to vary them according to circumstances. Often when a patient cannot take six ounces of nourishment every three hours he can be persuaded to take an ounce every hour or a dram every fifteen minutes. Faintness may at times be prevented by the giving of food outside of the regular hours.

Care of Food.—Food must always be kept fresh and water must be filtered and boiled. In the absence of a refrigerator a small basin may be turned upside down in a large dish-pan and a large cake of ice wrapped in flannel placed upon it. The food may be arranged about the ice and the whole covered with a fresh napkin and kept near an open window. Ice will be kept longer in a glass if suspended in a piece of flannel in which one or two holes are made, and in a pitcher if a newspaper be wrapped around the pitcher. Any of the filters mentioned in previous chapters of this volume may be used. Mrs. Dacre Craven, who in her "Guide to District Nurses" tells how to improvise nearly every article needed in the sick-room, says that a good extemporary filter can be made out of a common flower-pot by placing a piece of sponge in the hole at the bottom, laying over this two inches of charcoal and then two inches of sand, the flower-pot then being placed over a vessel. She also removes the unpleasant and 'flat' taste of boiled water by pouring it when cold from one jug to another a few times.

Care of Bed Patients

The **comfort** of a patient confined to bed may be increased greatly by frequently drawing the under-sheet tight and smoothing out the creases. If the patient can raise himself, it can be done by one person, first on one side and then on the other. Otherwise two must draw the sheet tight from opposite sides and ends. The shirt also must often be drawn smooth. Pillows should be changed and shaken up. If not counterindicated, the patient may occasionally be turned carefully over on his side and kept so for a little while. The back should frequently be examined to detect the earliest sign of a bed-sore.

Urination must be watched. When suspended, it may often be re-excited by hot applications over the kidneys, bladder, external genitals, or by the placing of a hot sponge beneath the thighs, or of hot water in a bed-pan beneath the hips, or by the sound of running water. Should catheterization be necessary, it should be regarded as a surgical procedure and performed in full view with strict asepsis.

The **bowels** must be kept open. In giving a **purgative enema,** the bed is to be protected by a rubber sheet and a folded sheet or towel. The patient should lie near the edge of the bed on his left side with his hips and knees flexed. The nozle of the syringe should be oiled and inserted very gently into the rectum in a direction upward and slightly backward and to the left. No force must be used; perforation of the rectum with almost instant death has followed the incautious insertion of a hard rubber nozle. Impacted feces may be removed, if necessary, with a finger, the nail being trimmed very short; no instrument should be used for this purpose. The injection should be given very slowly, with temporary suspension when it causes pain. After the nozle is gently removed and a folded towel is pressed against the anus, the fluid should be retained for ten or fifteen minutes. For a **high enema** a rectal tube or a soft-rubber catheter or a piece of moderately thick rubber tubing is best, but the thin tubing of a fountain syringe may be used. The patient's head should be lowered and his hips raised by the placing of a pillow under them, or the Sims or the knee-chest position may be assumed. The foot of the bed may be raised on bricks, blocks, chairs, or on a table.

Changing the Bed-clothes.—A patient confined to his bed should be supplied with two beds if possible, each with its own set of covers, so that he may pass the day in one and the night in the other. The clothes of the unoccupied bed should be aired outside of the sick-room. A double bed may be utilized by having the patient sleep in one side at a time or by placing on it two single mattresses and making up two separate beds. In a single bed two mattresses, if not too heavy, may be used. In changing them, the mattress on which the patient lies is drawn half-way off the bed and the other put on close to this; then by means of the under-sheet the patient is drawn upon the fresh mattress, which is pulled into position. When but one bed and one mattress are available, if the patient is able to be moved he should be carefully wrapped up and placed on a lounge or couch or in an invalid chair or armchair while his bed is being re-made. It will often be necessary, however, to change the bed-clothes while the patient is in bed, as fresh sheets should be supplied at least once a day. In doing this the patient is moved to one side of the bed and the bed-clothes are loosened, all pins being carefully removed. The upper bedcovers on the opposite side of the bed from the patient are pushed well over against his back and the undercovers rolled lengthwise, or, better, folded alternately backward and forward (as in accordion plaiting), right up to the patient, thus laying bare at least half the mattress. The warmed clean undercovers are then rolled and folded lengthwise in a similar manner for half their width, and placed along-side the soiled ones, the unrolled half being spread across the mattress and securely tucked in at the top, bottom, and sides. The upper clothing is then spread out again over the clean sheet. The patient is now moved to the clean side of the bed or is lifted while both rolls are pushed under him. If strong enough, he may raise himself by means of a bed-crane. Or he may be turned on his side while the folded sheets are tucked close up to his back, then rolled gently over them, and turned on his other side while they are drawn through. The soiled undercovers are then removed and the remaining half of the clean ones stretched out, smoothed, and tucked in. The fresh upper-covers are next spread over the soiled ones, which are slipped off while the clean covers are being arranged and tucked in. The bed may be changed from the top instead of from the side; the upper sheet may be put on beneath the soiled one; or the clean upper sheet may be drawn down over the patient as the soiled sheet is removed.

QUIET AND THE AVOIDANCE OF DISTURBANCES

The sick-room should be kept quiet and all unnecessary noise avoided. Doors should not creak, windows should not rattle, or blinds or curtains flap. A fire should be raked with a stick of wood, coal put on one piece at a time, each wrapped in paper or laid on with a gloved hand, and ashes should be removed with a wooden shovel. Rocking-chairs are best out of the sick-room. Rustling dresses, squeaking shoes, jingling keys, and the like should not be worn. Heavy and clumsy movements and stumbling are to be avoided. Doors must be opened and closed softly but promptly. No one should lean against, sit upon, or unnecesarily shake or even touch the patient's bed. Affectation of all kinds, such as whispering or walking on tip-toe, should be avoided. Whispering in the sick-room is particularly tormenting. Reading aloud slowly, with clear enunciation and intelligent expression, may be permitted, if agreeable. Care is necessary in selection of reading-matter, and the time must not be prolonged. Nothing should be done in the patient's room after he has been settled for the night.

THE NURSE

The personal qualities a nurse should possess are: honesty, accuracy, obedience, loyalty, fidelity, punctuality, readiness, decision, adaptability, tact, discretion, dignity, kindliness, patience, sympathy, gentleness, hopefulness, courage, firmness, truthfulness, courtesy, self-control, power of observation, memory, resourcefulness, quietness, skill, neatness, modesty, cleanliness, and common sense. Knowledge, training, system, and experience are additional requisites, as are health, strength, and endurance. It is of the utmost importance that the nurse maintain her own health, not only to prevent a breakdown, but to preserve her vigor, efficiency, watchfulness, and keenness, as well as her interest in and zeal for her work. She should have wholesome, nourishing food, at regular intervals, about seven hours of undisturbed sleep, and not less than one or two hours a day of outdoor exercise. It is to the patient's interest for the physician to see that the nurse is properly cared for. She should take a cold bath every morning, and a warm bath with soap every night if possible, once a week at the very least. The hands should be washed frequently, sterilized before beginning a dressing, and disinfected after attending to the patient. The nails should be cut short and even and kept scrupulously clean. The hands must be kept smooth and soft, for which the application of equal parts of glycerin, alcohol, and rose-water will be found useful. The teeth should be cleansed and the mouth rinsed out on rising and after each meal. Frequent gargling with a mild disinfectant solution is advisable. The nurse's toilet should of course be performed outside of the sick-room. Any cut or abrasion should receive immediate attention. The dress should be clean, simple, neat, pleasing, and made of a washable material. Shoes should fit perfectly and should conform to the rules laid down under Personal Hygiene. Caps, aprons, bibs, handkerchiefs, collars, cuffs, and sleeves should be white and spotless. Chatelaines should never be worn.

In her intercourse with her patient the nurse, although sympathetic and soothing, should be reticent, often non-committal, and should avoid gossip and too great intimacy. Her relations with the physician, however, should be most frank, honest, and straightforward. She should in her daily report to him give the briefest possible, but complete, written summary of what has happened during the preceding twenty-four hours. Numerous charts and forms have been devised for recording temperatures, pulse, respiration, bowel movements, and the like. In addition to the graphic record of temperature, there should be some such form of report as that shown on page 485, which any intelligent person can rule extemporaneously, allowing sufficient width for legible entries in the respective columns. One table can be made for the twenty-four hours, but it is usually better to keep separate sheets for the day (hours between 7 A. M. and 6 P. M., inclusive) and for the night (hours between 7 P. M. and 6 A. M., inclusive); adding the night totals to the day totals for the complete summary.

Some physicians prefer, in place of tabulated data, a running report supplemented with a summary of the various totals for twenty-four hours.

When it is impossible to obtain the constant services of a trained nurse, the visiting of a district nurse once or twice a day will often be preferable to unskilled family nursing. Affection cannot take the place of knowledge or training, while discipline is often indispensable to successful management.

NURSE'S RECORD

Mr. ....

Dr. .... Date ....

DAY REPORT (OR NIGHT REPORT).

Hour	Temperature	Pulse	Respiration	Nourishment		Water	Stimulants	Special Application	Medicine	Urine	Stools	Sleep	Remarks
				Solid	Liq.								
7 A. M. (or P. M.)													
8 A. M. (or P. M.)													
9 A. M. (or P. M.)													
Etc.													
6 P. M. (or A. M.)													
Highest													
Lowest													
Totals													
Totals of night report													
24 hour totals													

CHAPTER VIII

SPECIAL NURSING

Fevers. Convalescence. Diseases of the Respiratory Tract. Diseases of the Digestive System. Nervous and Mental Diseases. Diseases of the Circulatory Apparatus. Surgical and Gynecologic Nursing. Obstetric Nursing. Nursing of Children. Nursing in Contagious Diseases.

FEVER NURSING

Especially in fevers should the recommendations given in the foregoing chapters be carried out strictly. The patient must be kept clean and his mouth be washed out frequently. The nurse, without waiting for the patient to ask, must regularly offer him **cold** (boiled or filtered) **water** to drink, giving at least a quart in the twenty-four hours. The methods of giving **baths** and other hydrotherapeutic applications are fully described in volume IX of this series. The position of an unconscious patient should be changed frequently and the sheets drawn taut. Unless specially indicated, patients should not be wakened—certainly not at night—for nourishment or treatment or to have the temperature taken. A **delirious** patient should not be left alone for a moment, and if violent or difficult to restrain, there should be two persons in the room. A nurse with experience and judgment is required. Patients should be kept **quiet,** at absolute rest. Physical and mental exertion, including useless talking, are to be avoided; evacuations must be made in bed. When photophobia exists, **light** should be excluded, and in cases of smallpox and measles it may be well to color the windows red, as with translucent paper. The directions given under Prophylaxis of the Special Infections in Section IV of Part I of this volume must be followed strictly. Visitors should be excluded from the sick-room.

CONVALESCENCE

The vigilance of the nurse should not relax during convalescence, which in a number of diseases (for example, scarlet fever) is the most contagious stage, and in all is a period of debility, necessitating rest, upbuilding, and careful management to insure restoration of vigor and to protect from relapses and dangerous sequels. During the first stage of convalescence the patient is allowed to sit up in bed supported by pillows or a head-rest. During the next stage he may get out of bed for a few minutes each day, prolonging the time according to his reaction. It is difficult to generalize in this matter, the strength of the patient being the chief index. Careful observation of the pulse, respirations, and temperature must be made. When the patient is sitting up, it is usual to envelop him in a comfortable gown. A blanket may be placed in an easy-chair reaching to the floor and folded up over the feet. If the patient is allowed to go out in the open air, gray blankets may be used for warmth. One evil to be avoided is excitement, which is readily brought about by seeing too many relatives and friends. Ample provision must be made for **sleep** and **rest** during stated hours of the day, and the convalescent should retire early after taking a bath and some slight nourishment. The **dietary** during the early period of convalescence should be limited to soft foods, while later on, more solid articles may be ingested. Convalescents should not be allowed to overexert themselves, as they become exhausted very easily. A change of climate is often necessary.

In volume IV (on "Climatology") and in volume VI (on "Dietotherapy") there are many useful directions concerning this period of various diseases. In addition, certain other precautions may be emphasized.

Restrictions as to diet and motion should not be removed too soon after the subsidence of **typhoid fever.** Liquid diet should be continued for at least one week, better for ten days, after the evening temperature has remained below 99° F., and semi-liquid diet, with rest in bed, maintained for ten days or two weeks longer. The feces and urine must still be disinfected, and it is often well to administer an appropriate urinary disinfectant at this time, if it has not been given during the period of active disease. Constipation is to be controlled by the use of enemas, preferably hot oil, followed by saline solution; for the use of cathartics is attended with much risk. Cardiac inadequacy, anemia, and the like call for appropriate dietetic and hydrotherapeutic management, remedial exercise, and sometimes tonic and ferruginous medication. In rare cases fever is prolonged without continuing lesion and toxemia, and will not disappear until the patient is allowed to get up and move around gently. It calls for nice discrimination in diagnosis to recognize instances of this kind. Typhoid fever often induces anemia and reduces the resistance to tuberculous infection; appropriate tonic measures, ferruginous medication, and inhalation exercises, with free exposure to fresh air and sunlight—best in the country or at the seashore—are indicated. Return to study or work too early after typhoid fever may lead to nervous or cardiac disturbances.

Following **scarlet fever,** on account of the danger of cardiac complications and of nephritis, rest is to be continued for a sufficient time. The return to solid food, especially to meat, must be gradual, and only easily digested foods should be allowed, so that excrementitious products may be reduced to a minimum. Cutaneous activity is to be stimulated by frequent bathing in warm or even hot water. Residence in a warm climate is often indicated as a further safeguard against serious renal disease.

During convalescence from **measles** care must be exercised to prevent respiratory complications. An equable temperature is desirable, and until desquamation has ceased, confinement in a warm room is imperative. The best nutrition and general hygiene possible are necessary in order to counteract the special liability to tuberculosis that often develops.

Recovery from **influenza** is often protracted, and the greatest firmness must be exercised in resisting the patient's entreaties to be allowed to go out too early or to resume work too soon. Nervous sequels, pulmonary disease, cardiac impairment, too often result from want of such care. Owing to the subnormal temperature usual during convalescence and the extreme weakness of the patient provision must be made for supplying warmth. Exposure to sudden thermal changes is often followed by evil consequences. The profuse perspiration which persists so long should not be interfered with except by general tonic treatment, but an alcohol-quinin rub may be given after a prolonged or severe sweat.

After an attack of **diphtheria,** even though the patient be in perfect health, active bacilli may still be resident in the throat in secluded areas like the crypts of the tonsils; hence during convalescence isolation and the use of disinfectant gargles must be continued. It is especially necessary to guard against sudden cardiac failure from premature exertion, or even from assumption of the upright posture.

In convalescence from **acute articular rheumatism** it is necessary to guard against cardiac sequels and against relapses. The patient should remain in bed for at least one week after the temperature has reached the normal. The temperature of the sick-room should be a little higher when the patient is up—about 70° F. Even after the patient is permitted to return to his usual activities, exposure to wet must be avoided and the clothing must be unusually warm; the underclothing should be of silk preferably, or of wool. The skin must be kept active by warm baths and friction. The diet should be simple and easily digested.

In convalescence from **pneumonia** and **pleurisy,** hydrotherapy, massage of the chest, and inhalation exercises should be utilized to avert chronicity, and to prevent the persistence of a *locus minoris resistentiæ,* inviting tuberculous infection. After **bronchopneumonia** especially, repeated light blistering may be necessary in addition.

DISEASES OF THE RESPIRATORY TRACT

The first requisite is to provide a pure atmosphere free from dust. Articles that attract dust, as books and carpet, should be removed from the room. The floors and walls of the sick-room should be cleansed with a damp cloth and the use of the broom or duster must be forbidden. The room should have a sunny exposure; its temperature should be maintained at a definite point night and day. The illuminant should be that which vitiates the atmosphere least.

In **laryngitis, bronchitis,** and **pneumonia** the air should be kept moist, and in **asthma,** as a rule, kept dry, by any of the methods described in the chapter on the Sick-room. A good hygrometer is a relatively sensitive apparatus with which to test the moisture in order to determine the sleeping apartment best adapted for an asthmatic; it being a recognized fact that mere transference from one room to another in the same dwelling may prevent or even inhibit a paroxysm of asthma. In California, paroxysms of bronchial asthma are coincident with increased humidity of the atmosphere.

Observations demonstrate that in **phthisiotherapy** air of relatively low humidity is of the greatest importance. The converse is likewise true—that catarrhal affections of the respiratory mucosa are more frequent in a dry than in a humid climate. A patient with pulmonary tuberculosis should live out-of-doors as much as possible, if convenient in a tent; or if not, he should sleep alone in a large, high-ceiled room containing several windows, on the sunny side of the house. He should be in the sun as much as possible. Superalimentation being necessary, he should eat largely of nitrogenous food, drink milk between meals and at bedtime, and consume half-a-dozen raw eggs daily. Regular exercise should be taken in the open air, without passing the point of gentle and pleasant fatigue. When fever is present, absolute rest in bed is required, and always after the midday meal there should be a partial or complete rest of from an hour and a half to three hours.

In **pulmonary hemorrhage** absolute rest is the primary indication. As soon as possible the patient should be placed in bed or on his back on a lounge or easy chair, with his head and shoulders slightly elevated to prevent immediate regurgitation of the blood that rises in his throat. During the paroxysms of bleeding the head should be turned to the side and the chin slightly elevated to favor the exit of blood. No attempt should be made by the patient to check the flow of blood, though he should try to avoid useless coughing. Bits of ice may be kept in the mouth or swallowed. Food should be cold, and given in small quantities at intervals of about two hours. The temperature of the room should be low. An ice-bag or cold coil should be applied to the chest over the area of suspected hemorrhage; or a piece of coarse linen may be wrung out in very cold water and folded in the shape of a triangle, the apex of the triangle being placed in the epigastrium and the base at the neck, with the ends pressed into the supraclavicular regions. The bowels should be emptied by enema to avoid straining. The patient must not be allowed to talk, but may, when necessary, say a few words in a labial whisper, without effort. Above all, the frightened patient must be quieted with assurances that the hemorrhage is of little significance. Wolff tells all his phthisical patients, although they have never suffered from hemoptysis, of the possibility of this occurrence and finds that the warning has a decidedly prophylactic effect in controlling excitement. In severe shock following hemoptysis, nothing equals a rectal injection of a hot saline solution, or about 4 to 6 fluidounces of clinical saline solution with addition of calcium chlorid (15 grains to 4 fluidounces) may be administered subcutaneously by the slow method (see volume IX). If the hemorrhage is to be controlled by physical means, one may encircle the arms or legs near the trunk with a handkerchief or bandage. The pressure must not be great enough to stop the arterial pulse, but should be just sufficient to prevent the return of the venous blood; or foot-baths may be employed as a revulsive measure. Knopf warmly advocates deep, quiet respirations after the acute attack of hemorrhage has subsided, for the purpose of hastening the complete cessation of the bloody expectorations which show a tendency to become chronic. Strapping the chest on the affected side may be necessary to control severe and repeated bleeding. S. S. Cohen advises the use of calcium chlorid, which may be given with essence of pepsin, in doses of fifteen grains every two hours for not longer than four days. Injections of gelatin (2 per cent. in saline solution) have been advocated. Administration of adrenal preparations is without benefit. Reports as to the utility of ergot are contradictory. Nitroglycerin in very small doses may be useful, as is also morphin or codein—but we shall not go further into drug-treatment. Cloths containing blood and sputum and other infectious material must be destroyed, and sputum cups cared for as described under Special Prophylaxis.

NERVOUS AND MENTAL DISEASES

The nursing of acute infections involving the nervous system is the same as that described under Fevers. In chronic organic nervous diseases, as a rule, constant nursing is required only after the onset of paralysis. **Bed-sores** are common in cases in which the spinal cord is involved. In addition to the precautions set forth in preceding chapters, it is important to move the patient frequently into a different position in bed, to another bed, and, when possible, to an arm-chair. The use of a water-bed is helpful, especially when the patient cannot be moved much. One of the many methods of healing a bed-sore is to lay upon it a piece of fine silver plate cut to fit, and united by a wire to a piece of zinc of similar size, laid a little above the sore, both being fastened by adhesive strips. When the sphincter muscles are paralyzed, **incontinence** of urine and feces increases the liability to bed-sores. A certain quantity of urine can usually be retained in the bladder, however, and if the patient be catheterized every three hours, he may sometimes be kept tolerably dry. If this expedient fails, or cannot be carried out, a suitable urinal must be attached. For the cystitis that, despite aseptic precautions, usually follows prolonged catheterization in these cases, the bladder will have to be washed out. When the feces are hard, retention usually occurs, instead of incontinence, and may require active measures for its relief. In applying **local heat** or **cold** extreme caution is necessary when anesthesia of the parts exists. A patient addicted to a **drug-**

habit (opium, alcohol, or the like) must be closely watched to be prevented from obtaining the drug surreptitiously. The management of **unconsciousness** depends upon its cause. When due to **cerebral anemia** (fainting), the patient should be laid on his back with the head low. His clothing should be loosened and his face sprinkled with water. Ammonia water may be held to the nose and cold water, vinegar, or brandy applied on the temples. If the patient can swallow, he may be given wine, coffee, or ten to fifteen drops of Hoffmann's anodyne. In cases of **cerebral congestion** the head should be high, and cold should be applied to it; a hot foot-bath being given at the same time and mustard poultices applied to the calves of the legs. If **cerebral hemorrhage** (apoplexy) have occurred, the treatment is much the same, it being of the greatest importance that the patient be not disturbed at first, although later his clothes may be gently removed, if necessary with the knife. If mucus accumulate in the throat, the patient may be turned partially on the side and supported in this position. Warmth may be applied to the extremities. Venesection is often helpful, but this belongs to treatment, rather than nursing. The management of an **epileptic** seizure consists in watching the patient after loosening the clothing and placing a pillow or some substitute under his head. A cork, a roll of stiff paper, a piece of india-rubber, a wedge,—with a string attached and fastened securely about the auricle, to prevent loss into the patient's throat,—a bandage, a towel, or a folded handkerchief may be inserted between the teeth, the lower jaw being depressed and the tongue, if caught, pushed in, unless this requires great effort. Otherwise the patient should be let alone. If the fit be preceded by an aura, the patient should be put quickly into a place of safety and made to lie down; and if the aura begin in an extremity, the attack may sometimes be stopped by holding the limb tightly or tying a ligature around it above the point where the aura begins. An epileptic should not be exposed to danger from fire or machinery. **Abnormal mental states** preceding, following, or taking the place of an epileptic seizure should be guarded against. When **delirium** exists from any cause, the room should be kept quiet and usually to some extent darkened as well. The patient should be carefully watched, not harshly contradicted, but humored, soothed, and comforted, and persuaded to do what is required by skilful management, often by use of his own ideas. Only rarely is physical restraint necessary, and then the greatest care must be exercised. Measures must be taken to prevent the patient injuring himself or others, and there should always be at least one person in the room. Mental rest and fresh air are indicated in **neurasthenia, chorea, hysteria,** and **hypochondriasis** and many other nervous diseases. Often physical rest is required as well. The management of such cases includes electrotherapy (see vols. I and II of this series), dietotherapy (see vol. VI), mechanotherapy (see vol. VII), hydrotherapy (see vol. IX), and rest and mental therapeutics (see vol. VIII). The **nurse** for cases of functional nervous disorders must have a strong body and a fortunate balance of moral and intellectual faculties. The qualities particularly required are tact, decision, firmness combined with gentleness, and a good temper. Especially must the nurse be intelligent, educated, modest, neat, and refined.

Alienation.—Whether an insane patient should be treated at home or in a hospital or asylum depends upon the form of the alienation and the facilities for taking care of the patient, including the provision of efficient nurses or attendants. Cases of **senile** and **secondary dementia, idiocy,** and **imbecility** can usually be cared for at home without requiring the services of a trained nurse or attendant. Mild **melancholia,** common **acute mania,** when not too severe, and some forms of **hysterical insanity** can be treated in a private house with ultimate chances of recovery. A patient who is **dangerous** to himself or others should never be treated at home if he cannot be constantly watched by skilled attendants. When two or more attendants are in charge, one should be put in chief authority and made responsible for the case. Certain general principles must be observed in dealing with the insane. Lying and deceit must be avoided whenever possible, and no promise made that cannot be fulfilled. A certain reticence and caution in speech, however, should be exercised, and irritating influences, whether books, letters, or visitors, kept away from the patient. It should be remembered that **delusions** and **hallucinations** cannot be dispelled by argument, but instead become more fixed, as a result of the excitation of the patient. The sufferer, therefore, should not be contradicted or ridiculed because of his delusions, nor, on the other hand, should he be encouraged in them. He should apparently be regarded and treated as if in his right mind, and should receive the social respect due to his position. Unrelaxing care is necessary to **prevent** a patient **from injuring himself.** All instruments with which he can inflict a hurt and all medicines must be kept out of his way, and never must the patient be allowed out of sight. If the patient exhibit mutilating, suicidal, or homicidal tendencies, the number of attendants should be increased and the clothing and bed should be searched frequently. **Cleanliness** of both patient and nurse is important. The nurse may have to wash and dress the patient. Cases of idiocy and dementia usually are particularly dirty. The temperature of the water must always be tested before a bath is given. **Occupation, amusement,** and **educational training** are now recognized as important therapeutic resources. In addition to being encouraged or compelled to take care of his person, the patient should be stimulated to engage in his favorite work with the nurse's supervision and assistance; care to avoid overwork being necessary. When the mental condition is the result of overwork, however, absolute rest, or at least a new method of employment, is often indicated. **Exercise,** properly regulated, should be provided for, out-of-doors whenever possible. **Constipation** must be guarded against. **Involuntary evacuations** during the night may often be prevented by a warm water enema at bedtime.

Feeding the Insane.—Insane patients should be carefully **watched when eating,** as they often bolt the food with great rapidity and in enormous quantity, upsetting their digestive apparatus or sometimes choking themselves. **Forcible feeding** may be necessary. A somewhat dangerous expedient is to compel the mouth to be opened by force or by **holding the nostrils** closed, and then to pour in the food quickly. Much better is the use of an esophageal or nasal tube (see also volume VI). Previous partial or complete introduction of the esophageal tube will often prevent a patient from forcing the nasal tube into the mouth. C. K. Mills advises that in forcible feeding at least three persons be employed, so that a violent struggle may be prevented. Great care should be taken in **handling** insane persons, many of whom (especially paretics) are predisposed to fracture and blood extravasation. When it is absolutely necessary to take hold of a violent patient and two attendants are available, one may attract the patient's attention in front while the other from behind throws the arms around him or seizes his arms above the elbows. **Mechanical restraint** is little used at the present day, but occasionally is necessary to prevent the patients from injuring themselves or others. The **straight-jacket** was abolished by law in Great Britain fifty years ago, but is used in America and on the continent of Europe. **Muffs** are employed sometimes in those rare cases in which a patient ordinarily quiet is known to be liable to seizures in which he will suddenly attack those near him. Apparatus for **strapping a pa-**

tient in bed without exercise of cruelty can be obtained of any instrument-maker. Bandages or ribbons may be used for tying the patient's hands to the sides of the bed. Most commonly, patients are restrained by **sheets.** The restraining sheet, which may be used in the case of delirious patients, is securely fastened to the sides of the bed for its whole length. Two sheets may be rolled into cords; the middle of one is placed behind the patient's neck, and the ends are brought forward in front of the shoulders, passed back under the armpits, and then secured to the upper part of the bed. The middle of the second sheet is laid over the patient's ankles, which are approximated; each end is then made to encircle the limb nearest to it, and, being brought down over the transverse portion between the feet, is fastened to the foot of the bed. Another way of confining the legs is to pass a folded sheet across the legs and ankles and fasten it to the sides of the bed. The patient may be wrapped in a sheet or sewed in a blanket or sheet, the bag thus formed being pinned together at the shoulder with safety-pins. This method is often employed when administering food or medicine to a refractory patient, especially in the case of children. The best method of restraint, however, is firm holding by the hands of skilled attendants. Instead of restraining a patient, many confine him in a padded cell or in a small room, with a mattress laid on the floor, but otherwise devoid of furniture and movable objects; the windows being securely screened, barred, or protected with mattresses, cushions, or boards, that may be taken from bedsteads or from the backs of wardrobes. The patient is watched through a small hole bored in an angle of the panel of the door. An illustration of the advances made in the care of violent patients is afforded by the acute wards of the Insane Department of the Philadelphia Hospital under the management of Dr. Daniel E. Hughes. A number of small cells, originally intended for the system just described, but whose doors are now never closed, open on a corridor. The cells are used only for patients whose condition of excitement demands isolation. At one end of the corridor in a large room, evidently designed for a living-room, beds are arranged in rows, where the patients lie. Absolutely no restraining mechanism is used, and only on rare occasions are the patients restrained by sheets. Attendants, who are nurses rather than keepers, are on duty in this ward in sufficient number. When a patient becomes at all excited, he is sent immediately to the acute ward, put to bed, and given dietetic, eliminative, and sedative treatment.

DISEASES OF THE CIRCULATORY APPARATUS

Absolute rest in bed affords some of the supreme triumphs of **cardiac** therapeutics. By this method alone the symptoms of failing compensation may ofttimes be relieved, and but two or three weeks of rest usually suffice to attain the object. The maintenance of secretion and excretion in such cases is of the highest importance, and these functions must be watched carefully by the nurse. In **acute rheumatism,** and other infections with tendency to cardiac complications, rest may avert the danger. In **pericarditis** rest in the horizontal posture diminishes the attrition of the inflamed surfaces against each other and cardiac activity is lessened by some 17,280 beats in the twenty-four hours; the tendency to effusion is thus much diminished and resolution is encouraged.

The most rational and effective treatment in early cases of **aneurysm of the aorta** is the method suggested by Tufnell, the essentials being rest and a restricted diet. The patient must be placed in a light and well-ventilated room on a prepared bed, where he must be content to remain for eight or ten weeks in the horizontal position and not even for a moment assume the erect posture. In the horizontal position the normal heart beats twelve times less in a minute than when the erect position is maintained; in disease, this difference amounts to twenty or more beats. It is this decided reduction in cardiac pulsation that determines the great advantage of the treatment. Mental quiet should be enjoined, for all emotions directly influence the heart. The epigram of Peter is worth repetition: "The physical heart is the counterpart of a moral heart."

In cases of **hemorrhage** of various origin it is often of great importance to **restrict** the ingestion of **fluids.** In such instances, small pieces of ice melting in the mouth allay thirst, and a half-ounce or an ounce of water or liquid food every hour or two while the patient is awake, supplies the minimum of fluid necessary to life.

SURGICAL AND GYNECOLOGIC NURSING; OPERATIONS; DRESSINGS

In surgical affections rest, temperature, fresh air, sunlight, and appropriate food are recognized factors in modifying the process of repair. Thus, in cold weather, when doors and windows are closed, the healing of wounds is retarded.

Preparations for Operation

The Room.—A well-equipped hospital should be provided with at least three operating rooms, one for general work, one for abdominal sections, and one for operations upon septic cases. The **walls, ceiling,** and **floor** should be hard and smooth, without corners or projections, and of materials that will endure frequent cleansing with **antiseptics.** The room should have wide **windows,** on the north side only, extending upward as high as possible, and should be provided with both **gas** and **electric light.** A skylight may be an additional advantage. In addition to the fixed light, there should be a movable light, preferably electric. The **ventilation** of the operating room should be independent of that of the rest of the building. It may be **heated** by direct radiation from steam or hot-water pipes, not from a hot-air register; an open fireplace is desirable. The **temperature** should be from 70° to 80° F., depending upon the nature of the operation. **Drainage** should be perfect.

An **improvised operation room in a private house** must be the best permitted by the circumstances. It should be as large, clean, airy, and light as possible, and should not communicate with a bathroom or closet, though it may conveniently be on the same floor. All pictures, carpet, curtains, and superfluous furniture should be removed. When the carpet cannot be taken up, oilcloth or newspapers covered with a sheet may be pinned over it. The window-panes should be painted with whiting, or across the lower portion of the window a curtain or newspaper should be fastened so that no view within is obtained from the outside. The room should be made as **aseptic** as possible. On the day preceding the operation it should be thoroughly disinfected, after remaining undisturbed for at least ten hours to allow the dust to settle. The walls and ceilings must be rubbed down thoroughly with bread-crumbs, which are eventually destroyed by fire. If possible, whitewashed walls are given a new coat. All the furniture in the room, the floor and woodwork, and the walls, if not papered, are scrubbed with warm water and soap and then with a disinfectant solution. More thorough sterilization of an improvised operating room may be attained by means of fumigation with formaldehyde gas. On the morning of the operation the room should again be gone over with a damp cloth wrung out of a disinfectant solution.

The **operating-table** preferably should be of glass or iron, capable of easily being arranged for the Trendelenburg posture. If possible, the table should be about 37 inches high and 25 inches wide. An operation table may be **improvised** with a plain narrow wooden table, or two placed end to end, or one placed across the head of the other; or three chairs with two planks, a leaf from an extension table, or an ironing-board, laid across them, may be made to serve. The **Trendelenburg position** may be obtained by raising the lower end of the table by means of chairs or boxes, or by fastening on the table a chair inverted so that it rests upon the front of its seat and the top of its back, the latter being nearer the head of the table. The table is covered with a clean, thick, folded **blanket,** over which is placed a piece of **rubber cloth,** mackintosh, oilcloth, or even paper, and over this a clean **sheet.** A pillow is laid at the head of the table and a folded blanket and sheet at the foot. The table is placed where the best light—natural or artificial—will fall on the site of operation. An **operating-pad** is often placed so as to lie under the part to be operated on, and, when a Kelly pad cannot be had, may be improvised out of a twisted sheet pinned to the covering of the table in the shape of and representing the raised edges of the Kelly pad. A piece of rubber cloth is then laid over this and tucked in under the outer side of the twisted sheet and hung over the edge of the table to represent the apron of the pad, its end resting over a slop-jar or waste-bucket. When a large quantity of fluid is to be drawn off, a large foot-tub should be placed beneath the table. **Portable stands**—at least three—are required, made of glass or steel or improvised out of small tables. If varnished, the tables cannot be scrubbed, but instead, should be covered with linen or cheese-cloth wrung out of a disinfectant solution. One of these should be placed a little to the right and just back of the operator to support a bowl of water for rinsing his hands. **Basins** are needed. They are made usually of agate or enameled ware, occasionally of copper or block tin, although china and earthenware may be used. **Instrument trays** should be of thick glass, porcelainware, or agateware, but a china plate, a basin, a tin dish, or a flat bake-pan may have to be used instead. Several **pitchers** should be at hand, preferably quart-size and of agateware; in the absence of many pitchers, **sterile water** may be stored in new, clean butter-crocks, pails, or buckets. Wide, though not very high, **glass jars** with screw-tops are the best receptacles for **sterile dressings,** but in their absence crocks can be used. **Foot-stools** are sometimes needed, but may be improvised out of wooden boxes. A tall **stool** is required for the anesthetizer. A **washstand** is a necessity,—

a fixed washstand with a supply of hot and cold water and operated by a treadle being most convenient in a hospital,—but should not be connected with a sewer. **Soap** and **sterile nail-brushes** should be provided. Agateware slop-buckets are the best, but earthenware, or even ordinary wooden buckets, will often answer.

In hospitals there is usually a special **apparatus for supplying sterile water** in large quantities, but in a private house a new wash-boiler or a large new kettle may be used. Immediately preceding any operation a large quantity of water must be boiled and placed in covered pitchers or other covered receptacles to cool. An **oxygen apparatus,** an **electric** (faradaic) **battery,** and a reliable **clock** may prove of service. A light **screen** may be placed across the door of the room to prevent drafts, and, when the sick-room is utilized as an operation room, should be placed before the bed so that the patient is not permitted to observe the preparations for the operation. A **hypodermic syringe** and a supply of camphorated oil, brandy, nitroglycerin, and tablets of strychnin, morphin, atropin, etc., **sand-bags** or extra **horsehair pillows,** and means for supplying **artificial heat** should be in readiness.

The patient's **bed** must be prepared before the operation is begun. It is made as described in the chapter on the Sick-room, with the addition of a single blanket placed beneath the upper sheet, and to be removed after the patient has reacted. The pillows are removed and a towel pinned in their place. On one side the covers are folded back to the edge of the mattress and not tucked in. Hot-water cans are placed in the bed, to be removed just before the patient is put in. What is known as the **divided bed** is often prepared for abdominal cases, two sheets and two single blankets being doubled and so placed over the patient that they meet in the center, the sheets first and then the blankets. Over the upper clothing, divided into two distinct halves by this arrangement, the spread is put on as usual. In cases of fracture or spinal disease, to render the bed firm and prevent sagging, a wide board, a table-leaf, slats, or an ironing-board may be placed across the middle of the bed under the mattress.

Instruments, Ligatures, and Sutures.—Instruments designed for aseptic work should be of metal, simple in construction and with smooth surfaces. The various methods of sterilization have been described in chapter XII of Part I. Instruments exposed to steam invariably rust. Baking in a hot-air oven injures the temper of the steel, dulls the edges of cutting instruments, and is inferior to boiling. Immersion of instruments in an antiseptic solution is not to be depended on. In emergency cases when time is a consideration, instruments may be sterilized quickly by placing them in a pan and pouring over them a small quantity of alcohol, which is then ignited. The alcohol is allowed to burn for not longer than half a minute, otherwise there is danger of affecting the temper of the instruments. The **immersion of instruments in boiling water** for fifteen or thirty minutes is an effective method of sterilization. To prevent the steel from rusting and to keep the instruments bright, a teaspoonful of sodium carbonate should be added to a quart of the water. There are many convenient forms of apparatus for the sterilization of instruments, but a tin pail or kettle will serve, in which event removal of the instruments is facilitated, if before immersion in the water they are wrapped in a towel or introduced into a bag. After removal from the boiling water the instruments are transferred without handling to trays containing sterile water or a 1 per cent. carbolic acid or sterile soda solution. Knives are boiled for only three to five minutes or are placed in a solution of carbolic acid, the blades always being wrapped in cotton.

After use, instruments should be washed with soap and hot water, brushed with a nail-brush or jeweler's brush, and, after a septic operation, must again be boiled before being placed in the instrument case.

Hard-rubber goods cannot be boiled, but are washed in soap and warm water and then kept in a disinfectant solution until ready for use. Hardened rubber goods may be restored to their ordinary elasticity by soaking them in a mixture of 1 part of ammonia to 2 or 3 parts of water from ten to thirty minutes. Soft-rubber articles can be boiled in a saturated solution of ammonium sulphate or sodium chlorid without undergoing deterioration.

For **ligatures and sutures** catgut is the best material, but owing to the difficulty in its sterilization its use has been dispensed with by many surgeons. Put up in hermetically sealed tubes by reliable makers it is usually to be depended on. The tube is sterilized, broken in an aseptic towel, and the catgut dropped into a dish of sterile water. Catgut must be kept in alcohol or other disinfectant solution. Silk and silkworm-gut may be sterilized in boiling water, creolin, lysol, or mercuric chlorid solution (1 : 1000). Or they may be introduced into test-tubes plugged with cotton, or filled with alcohol and tightly corked, and steamed in the sterilizer. Horsehair makes a good suture. The hair is washed in warm water with soap, then rinsed in alcohol and sterilized by steam. Silver wire is prepared by scrubbing in soap and hot water and boiling in a 1 per cent. sodium carbonate solution for thirty minutes. Some prefer before using the wire to heat it in an alcohol flame, which anneals it and makes it less friable. All suture materials can usually be purchased already sterilized.

Dressings.—Materials employed for dressings, such as absorbent cotton and antiseptic gauze, may be obtained from some trustworthy manufacturer already cut and sterilized. Dressings may be made from **gauze** or ordinary cheese-cloth which has been boiled in a 1 per cent. soda solution, rinsed, dried, and laid upon a sterile towel. The nurse, wearing a sterile gown, and with sterile hands, using a sterile pair of scissors, then cuts it into strips six to eight inches long and four inches wide for dressing wounds; and into strips cut bias one yard long and one inch wide for cleansing a glass drainage-tube; and from half-an-inch to six inches in width and one yard to three yards or more in length for packing a cavity. Bichlorid gauze is made by immersing plain gauze for thirty-six hours in a 1 : 500 bichlorid solution; and iodoform gauze by saturating the gauze wrung out of bichlorid with a mixture of alcohol (2 ounces), glycerin (2 ounces), and iodoform (8 drams). **Pads** are made by cutting gauze into pieces four inches square, which are rolled loosely in the form of balls, the free ends being twisted and tucked in, or into oblong pieces, the edge on one side being turned over for about two inches, the two adjoining sides folded over this, and the edge of the remaining side slipped into the fold opposite it, thus completing the square. **Cotton mops** are made by taking a piece of gauze 6 inches square, placing in the center a piece of absorbent cotton rolled in a ball two inches in diameter, and tying the gauze like a sack around the cotton by means of a string. For **abdominal operations,** pads six to twelve inches square are made of eight thicknesses of gauze with the edges turned in and hemmed and a piece of tape or knitting cotton eighteen inches long attached to one corner. These are made up into packages each containing a definite number, and are counted several times before being wrapped up, after being taken out, and again before the abdominal wound is closed. Larger pads similarly made are used for protecting the intestines. Gauze fails to absorb as readily as **marine sponges.** When these are employed, new ones should be used at each operation. They should first be pounded in a stout cloth and thoroughly rinsed, then soaked in a solution of hydrochloric acid (1 : 64) for twelve hours, washed in frequently changed warm water, and soaked in a saturated solution of potassium permanganate for fifteen minutes. They are then immersed in a warm saturated solution of oxalic acid until the color of the permanganate is removed, rinsed in sterile water, and immersed in a solution of mercury bichlorid (1 : 1000) for twenty-four hours. They are preserved in sterile jars containing carbolic acid solution (1 : 20), and at the time of the operation are removed from the latter solution, squeezed out, and introduced into a sterile solution of sodium chlorid (1 dram to the pint). When saturated with blood, they are cleansed in another sterile salt solution and used again. Gauze **bandages** may be made of any width. A many-tailed bandage is made out of a piece of well-shrunken new opera flannel, $\frac{3}{4}$ of a yard wide and $1\frac{1}{4}$ to $1\frac{1}{2}$ yards long, torn from the sides to the center into five strips of equal width. Canton flannel or thick muslin has also been used. A piece of **rubber-dam** 16 inches square is needed when a drainage-tube is used. **Adhesive strips,** some with tapes attached to the ends, are frequently required. **Retractors** are made by splitting the end of a wide bandage into two or three tails.

Steam sterilization is usually employed for dressings; hospitals having special apparatus for the purpose. In the absence of a sterilizer an ordinary wash-boiler may be used, water being poured in to the depth of about six inches and sticks or bricks placed crosswise built up above the level of the water, upon which the dressings are laid. The water must be kept boiling for at least an hour. Cotton, sheets, towels, bandages, blankets, caps, and gowns may be sterilized in the same way. It is often more convenient to introduce the towels and other linen used in the operation into a cotton bag or to wrap them in a sheet, so that after boiling, the entire mass can be lifted out at once. After removal from the boiler, each towel may be taken, when needed, with gloved hands or aseptic forceps. If sterilization by steam be not practical, dressings and linen may be sterilized, upon being wrapped in a towel or introduced into a bag, by boiling for fifteen minutes in a 1 per cent. solution of ordinary washing soda. After removal from the boiler they may be dried by baking in an oven. Absorbent cotton may be sterilized without previous boiling by baking in an ordinary oven. For carrying sterile and iodoform gauze, etc., sterilizing cylinders have been designed, $10\frac{3}{4}$ inches long by 3 inches in diameter, the mouths being plugged with cotton. In an emergency old linen may be torn into convenient sizes and boiled. When the time is too short to prepare towels properly, it is better to use cheese-cloth, soaked in a 1 per cent. soda solution, boiled for an hour, rinsed, and dried.

Operator, Assistants, and Nurses.—Before an operation, the surgeon and his assistants must remove their outside wearing apparel in a room other than that in which the operation is to be performed and don **gowns** of linen previously sterilized. The nurse puts on her gown over a clean dress. To prevent wetting the shoes and underclothing, rubber shoes may be worn and a rubber apron put on beneath the gown. The hair and beard should receive special attention relative to cleanliness; on the head a sterilized linen cap is usually worn. Huebener by holding Petri dishes containing agar a short distance under the beard while the latter was lightly stirred with a sterile instrument found that 42.3 per cent. of 26 beards thus examined contained pyogenic organisms. This experiment is a cogent plea for facial nudity in the surgeon. The **hands** of every one in the operating room, and especially of the surgeon, demand the utmost care. It has been truly said that "the modern surgeon is, or should be, the cleanest man that walks the earth." It is also true that the hands represent the weakest link in the chain of asepsis and antisepsis. The ever-recurrent question, 'Can the hands be sterilized?' is answered both in the affirmative and negative by many competent authorities, but all are unanimous in the opinion that such sterilization is difficult of attainment. Even though it is possible to attain surface sterilization, the deeper layers of the epidermis still harbor numerous bacteria. If the micro-organisms were distributed freely on the surface of the skin, asepsis would be easy of attainment; but unfortunately they lurk in inaccessible situations, like the hair follicles, and in the openings of the sweat-glands. Many surgeons now use sterilized rubber gloves. Cotton gloves have been suggested, but while they are capable of sterilization, they are pervious to fluids and soon become contaminated by exudation from the skin. Even coating the hands with different substances has been suggested, but found faulty. Whatever method be adopted, it is essential first to cleanse the hands and arms thoroughly by means of some alkaline soap, hot water, and sterilized brushes. The latter may be made aseptic by boiling for five minutes in a 1 per cent. solution of sodium carbonate, and are then to be immersed in a sterilized fluid until ready for use. Rings should be removed; the nails should be neatly trimmed and cleansed. Whatever the sterilizing process, it must respond to the following requirements: (1) It must not injure the skin while at the same time effecting satisfactory disinfection. (2) The entire process must be completed in one continuous and uniform act. (3) The materials themselves used in disinfection must be germ-free. In every method the hands and forearms are first scrubbed with soft soap and hot water for at least three minutes, special attention being paid to the nails. In the Fürbringer process they are next immersed in 95 per cent. alcohol for one minute, the nails and fingers at the same time being thoroughly rubbed and scrubbed to remove the fats and debris and thus allow direct penetration of the 1 : 1000 mercuric chlorid solution in which the hands are then rinsed, the fluid being well rubbed into the skin. The objections to this process are that bichlorid solutions discolor the hands and cause eczema and cracked skin, which favor bacterial development. In commenting on this method, one writer observes that "faith in bichlorid, the magic water, has been the source of more unexplained contamination in the employment of antiseptic methods than any one thing." In the Howard Kelley process the hands and forearms are soaked in a saturated solution of potassium permanganate at a temperature of 110° F. until the skin assumes a very dark brown color, then immersed in a saturated solution of oxalic acid at a temperature of 110° F. until the skin is decolorized, and then washed thoroughly in sterilized salt solution. They are again washed in mercury bichlorid solution (1 : 1000) for one minute, and finally in sterilized salt solution. Nicholas Senn advises thorough bathing and scrubbing with spirit of turpentine and alcohol and immersion and bathing in salt solution. In the Rauschenberg process a tablespoonful of chlorinated lime is moistened with sufficient water to make a thick paste, which is thoroughly applied to the hands and arms and carefully rubbed in about the nails, a piece of sodium carbonate (1 inch square and ½ inch thick) being rubbed into the paste until the latter becomes smooth. A sensation of coolness followed by heat will be experienced owing to the liberation of chlorin, the odor of which is removed by rinsing the hands in sterile water and washing them in water containing aromatic spirit of ammonia to 1 or 2 per cent. According to the tests of the bacteriologist, any one of the foregoing methods will insure surface sterility in the majority of instances. If **rubber gloves** are used in preference or in addition to the methods described, they must first be washed with soap and water to which ammonia-water has been added, and then boiled in a 1 per cent. soda solution for fifteen minutes. From the latter solution they are removed with sterile forceps and placed in the center of a sterilized towel, which is folded over them. To facilitate the putting on of the gloves, the hands may previously be moistened with sterile glycerin or any other lubricant not containing oil. If carefully used, gloves will still be serviceable after four weeks even though employed daily. After the hands are sterilized they should not touch anything not aseptic, except through the medium of sterile or antiseptic gauze. It is better to have in the operating room one or more nurses, and perhaps an orderly, with clean but unsterile hands.

The Patient.—Successful operations, especially in women, are followed not infrequently by neurasthenia and occasionally by mental disturbances. It would appear to be a most judicious practice to subject individuals before and after an operation to a **rest cure** as a legitimate means of shortening convalescence, hastening recovery of health, and restoring the nervous system from the shock that is always manifest in greater or less degree after operative procedures.

Preliminary treatment consists in attention to the digestion, bowels, skin, kidneys, and heart. A thorough physical examination is of course made and the urine and blood studied. A daily warm soap-and-water bath is of advantage, and before gynecologic operations a daily antiseptic vaginal douche. The diet should be unirritating and one leaving little residue. On the evening or day preceding the operation the patient should receive a bath, and, if there be no counterindication, a purgative supplemented by an enema. At least seven hours before an operation the patient should be given no food of any kind. Bouillon, coffee, or clear soup may be taken by weak or exhausted individuals at least two hours before anesthetization, or, what is still better, a stimulant may be given by the rectum. Morphin ($\frac{1}{12}$ to $\frac{1}{8}$ of a grain) given hypodermatically just before the operation, often controls the nervous system, assists anesthesia, and inhibits pain following the discontinuance of the anesthetic. Combined with atropin it is still better, as the latter diminishes the irritability of the stomach caused by the anesthetic and checks the secretions from the throat and mouth, which are very annoying factors in anesthesia. Morphin and atropin may be a means of misleading the anesthetizer, however, by their interference with the pupillary reaction.

On **the day before operation** the tissues about the seat of operation are prepared. By an attendant in sterile gown and with disinfected hands, the field of operation must first be shaved and then thoroughly scrubbed with soap and hot water by means of a sterilized brush or pledgets of gauze or cotton, especial attention being given to the umbilicus, pubes, and folds of the groin. After rinsing in warm boiled water the surface is cleansed with alcohol or ether to remove all fat and then washed with a warm solution of corrosive sublimate (1 : 1000). A pad made up of sterile or antiseptic gauze or absorbent cotton, moist or dry, or a towel wrung out of the solution, is then applied over the field of operation and kept in place by a bandage until the operation is commenced. When the skin is thick and oily, a soap poultice is often used on the field of operation at least six hours before the preliminary cleansing. It is made by taking several thicknesses of gauze and soaking them in soft soapsuds of moderate consistency, then squeezing out the water and applying the poultice to the skin. Just before the operation the protective dressing is removed and the operative field is again scrubbed with green soap and hot water and successively treated with hot water, alcohol or sulphuric ether, mercuric chlorid (1 : 1000), and hot sterile water. Care must be taken to prevent the hands of the patient from coming in contact with the operative field; in fact, the patient's hands may be rendered sterile when any operation is contemplated.

Certain **regions of the body** require special methods of sterilization. The **mouth** is prepared by the removal of dental plates or loose teeth, the repair of carious teeth, the removal of tartar, and repeated cleansing by means of some antiseptic dentifrice. For gargling and rinsing the mouth, a diluted solution of hydrogen dioxid water (1: 6) may be used. The **nose and nasopharynx** may be douched with an alkaline solution and subsequently sprayed with hydrogen dioxid solution. In operations on the **eye,** the eyelids should be sterilized after the conventional manner and the conjunctiva washed with sterile salt solution or a warm weak solution of boric acid. Operations on the **cranium** must be preceded by shaving of the entire scalp. Operations upon the **stomach** or **intestine** must be preceded by careful gastric lavage. In operations upon the **bladder** and **urethra,** irrigation with sterile salt solution is indicated. The **vagina** is prepared by scrubbing with pledgets of cotton and tincture of green soap, followed by copious douching with hot water and then with a disinfectant solution, and finally covering with a protective dressing.

After the sterilization on the morning of the operation, the patient is dressed in a light woolen undershirt and a short night-gown, the lower limbs being encased in canton-flannel leggings reaching to just below the groin. The patient should be made ready in a room other than that in which the operation is to be performed or a screen should be placed about the bed to hide the preparations that are being made. Before anesthetization the urine should be analyzed, the chest of the patient examined, the nasopharyngeal passages inspected and cleansed, and the mouth examined and freed from false teeth, gum, and other foreign substances. A safe rule is to wash out the stomach before giving an anesthetic. The bladder should be emptied by means of a catheter. All articles of clothing must be loose. Smearing the face with oil, glycerin, vaselin, or cold cream may prevent dermatitis. Covering the eyes with a towel will lessen conjunctival irritation. During anesthesia the temperature of the body must be maintained. The anesthetizer should have within reach a mouth-gag, tongue-forceps, gauze squares, and sponge-holders, towels, a basin, and a hypodermic syringe with medicaments that may be needed. After anesthetization—which should be accomplished outside the operating room—the patient is placed on the table, which has previously been covered with a sterilized blanket. The clothes are then removed from the part to be operated upon, sterile blankets laid over the rest of the body, and the edges tucked in. The protective dressing is removed, a sterile sheet with an opening in the center laid over the field of operation, and sterile towels arranged around the opening. Before the operation is begun, the operators, assistants, and nurses must see that everything that will be needed is at hand.

The Operation

The discipline of the operating room should be perfect. The duties of each assistant and nurse should be definite and recognized. In abdominal operations one nurse should give her sole attention to the pads or sponges and should repeatedly count them, accounting for them all before the abdominal wound is closed. The sponges must not be cut or thrown away without noting. Whenever a pad is placed within the abdomen, hemostats should be attached to its string or tape. When a sponge or pad is to be used again, it is thrown into a basin of cold water to be cleansed of the blood and is then rinsed in hot water. Nurses should be on the alert to supply clean towels as needed, change the solutions as they become soiled, and wipe the moisture from the faces of those engaged in the operation. Those with sterile hands should frequently rinse them in a disinfectant solution, and of course should touch nothing unsterile. On the other hand, those who come in contact with what is not aseptic should touch nothing sterile. Just before the wound is closed the soiled linen is removed and fresh put in its place. No one should assist who has not been accustomed to seeing operations and no spectator should be admitted without necessity.

After the Operation

After the dressing has been applied the patient is cleansed and dried, the bandage adjusted, the covers of the bed turned back, the hot-water bottles removed, and the patient placed in bed. If there is much **shock,** the patient may lie between blankets with well-protected hot-water bottles about the feet or surrounding the body, the foot of the bed being elevated. The extremities may be rubbed with alcohol. Rest in a warm bed for several hours before operation, avoidance of prolonged exposure and maintenance of the body-heat during operation, and the administration by rectum of hot clinical saline solution just before the patient is taken off the table, will often avert shock and prevent acute nephritis. An enema of hot coffee and whisky may also prevent shock.

The patient should be watched closely, and for at least thirty-six hours after the operation should not be left alone for a moment. The pulse and temperature should be taken at regular intervals and the dressing frequently inspected. To prevent **vomiting,** as soon as the anesthetic is withdrawn, gauze saturated with vinegar is placed over the patient's nostrils and mouth. Camphor, ammonia, and oxygen have also been given by inhalation for the same purpose, and sips of hot water or black coffee by the mouth. The administration of bits of ice or teaspoonful-doses of iced champagne, brandy, or soda water is less useful. Iced compresses may be applied to the head or throat and a mustard plaster or paste to the epigastrium, or the face may be bathed with cold water. Cocain in small doses is often effectual. Sipping hot water containing table salt may cause vomiting, but will often relieve the retching, which is far worse. The patient's face should be turned to one side. During retching or vomiting, the patient's forehead should be supported by the nurse with one hand and the shoulders slightly raised with the other, and, after a celiotomy, the abdomen should be gently supported by a hand on each side of the wound. **Backache** is often relieved by the placing of a small flat pillow or air-cushion under the small of the back and of a large firm roll or pillow beneath the knees. If the patient be permitted to turn on the side, the back should be supported by a pillow or by a blanket rolled lengthwise. **Restlessness** may be alleviated to some extent by gentle kneading and rubbing of the patient's lower limbs and by mental and moral influence. For **thirst,** hot water in sips, or cracked ice, is given; or the lips and mouth may be moistened gently with a piece of ice wrapped in gauze, with cold water, or with a mixture of glycerin, lemon-juice, and water; or wet cloths may be placed on the lips, and the hands and face may be bathed frequently with tepid water or with alcohol and water. Enteroclysis sometimes averts thirst. **Abdominal distention** may be relieved by the passage of a rectal tube or by the administration of a mild purgative or of an enema containing turpentine or asafetida. The **bowels** should be emptied thoroughly within forty-eight or seventy-two hours after an operation. Calomel may be given in minute, frequently repeated doses or in several comparatively large doses; or saturated solution of magnesium sulphate or of sodium and potassium tartrate may be given in hourly teaspoonful doses; and an enema may follow. Sometimes the addition of $\frac{1}{32}$ grain of morphin and the use of essence of pepsin as a vehicle prevents griping or nausea from the salt. The **bladder** should be emptied spontaneously when possible; if not, by catheterization at intervals of six to eight hours. Failure to secrete sufficient urine calls for enteroclysis, hypodermoclysis, or the freer use of water by the mouth, perhaps for mild diuretic medication. Physicians differ in their methods of administering **food and stimulants,** which often have to be modified to suit the individual case. After ordinary operations no change in the diet is made, unless indicated. After a celiotomy food may be withheld for the first twenty-four hours and then gradually given by the mouth; or a liquid diet may be given by mouth from the first, or by enema for the first three days. The first food is usually predigested, and given in small quantities at frequent intervals, the subsequent feedings depending on how well the food is retained. After the bowels have moved freely the diet is gradually increased. Stimulants may be given by mouth, rectum, or skin if believed to be necessary.

Hemorrhage is detected by its local and general manifestations. The bright red color, rapidly spreading over the dressing, that characterizes the stain of fresh blood must be recognized and distinguished from the thin dull color with the still fainter margin caused by the oozing of blood-stained discharges. In concealed hemorrhage only the general symptoms are present; sighing, panting, irregular costal breathing; thirst, dimness of vision, restlessness, anxious expression, dilated pupils, syncope, pallor, cold and clammy skin, weak, rapid and easily compressible pulse, and subnormal temperature. Treatment consists first in altering the position of the patient by elevating the part which bleeds, lowering the head of the patient, and raising the foot of the bed upon a table or chairs. A bleeding wound should be plugged with gauze, and the main artery supplying the part compressed until the arrival of the surgeon. In the mean time artificial heat should be applied to the body and preparations made for reopening the wound. A sterile salt solution should be in readiness for the surgeon, and the irrigator and its needle thoroughly sterilized. The extremities may be bandaged as in pulmonary hemorrhage. Usually the wound is reopened and the bleeding vessels sought and tied, but occasionally in abdominal cases the patient is merely kept at absolute rest to favor the gradual formation of a large clot.

Vaginal Work

A special **table,** with stirrups or foot-rests to support the feet, may be used, or, in its absence, a clean kitchen-table covered with a blanket, shawl, rug, or comfortable. When a bed is utilized, a wide board, a sewing- or ironing-board, or the leaf of a dining-table, inserted between the mattress and sheet will give a hard surface. A sofa or a bed without a board is a rather awkward substitute. There should be pillows for the head, single sheets for covering the table and the patient, and a pad. A chair should be provided for the physician. The patient's bladder and rectum should be emptied and, as a rule, the external genitals cleansed. The patient's clothing should be loosened around the waist and the corset removed. In a private house a night-gown, a wrapper, leggings, or stockings and slippers may be worn. A sheet is thrown around the patient, who steps upon a chair, stool, or foot-board, raises her clothing above the waist, sits, and then lies upon the table, in the position desired, the sheet being properly arranged. For a digital examination in bed the patient is moved to the side of the bed and placed in position.

Tampons are made by bringing together the edges of a sheet of wool (or cotton) several inches square and half an inch thick and twisting them into a stem about which soft white twine is wound tightly several times and tied, the ends being left at least six inches long. In making a 'butterfly' tampon a strip of wool is cut in the length of the lap about eight inches long, four inches wide, and half an inch thick, and doubled; the ends are rounded off, and the whole tied in the middle, where folded, with six inches of thread left hanging. The 'kite-tail' tampon is a series of tampons tied on one string at intervals of two or three inches.

Mounted sponges to be used in vaginal operations are made by cutting natural sponges about the size of walnuts, or by taking small gauze pads, and clamping them in sponge-holders or forceps.

A sterile or antiseptic **perineal pad** is applied after operations on the vagina. This is usually made of gauze and held in place by a **T-bandage.**

The Garrigues occlusion dressing consists of one or more pieces of antiseptic lint, placed over the vagina so as to make a dressing three by eight inches, covered by a piece of moist antiseptic gutta-percha tissue, four by nine inches, and kept in place by a napkin of antiseptic cheese-cloth eighteen inches square, folded diagonally so as to inclose a pad of oakum.

Irrigation of the vagina, uterus, bladder, and bowel is discussed in the appendix to volume IX. When stitches are present, pressure on them should be avoided in inserting the tube.

In **preparing** a patient **for an operation** on the vagina the latter should be sterilized.

Care after a vaginal operation includes everything mentioned under operations in general. After a plastic operation the knees are generally tied together for the first few days to prevent strain upon the stitches. The external genitalia may be washed by means of a stream from a sponge or syringe, or by gentle sponging. In withdrawing a catheter no urine should be allowed to drop upon the wound, which may be protected by a piece of cotton separating it from the catheter. After micturition or catheterization the parts must be thoroughly cleansed and dried. When the bowels are moved, great care should be taken lest stitches be subjected to undue strain. The nurse should always be present and, when the sphincter has been repaired, she may have to support the perineum with her hand as the feces pass the stitches. Means should be taken to secure a soft or liquid evacuation. If the patient lie on her side during defecation, she will be less apt to strain. The rectum should be irrigated and the parts cleansed and dried after each movement.

Dressings

A wound may be cleansed by directing into it a stream from a syringe or sponge or washing gently toward it. Before a dressing is changed everything must be in readiness. A protective is put under the part, the soiled dressing removed, and the wound surrounded by sterile towels or a sterile sheet. Dressings should be removed gently; if they stick, they may be irrigated with a warm solution until they come off easily. In handling a soiled dressing, forceps should be used whenever possible. Soiled dressings should be destroyed. It is well to use nothing a second time.

Description of the various dressings is beyond the province of this work.

OBSTETRIC NURSING

Preparations for Labor.—The room should be selected and prepared with due regard to the considerations given in the chapter on the Sick-room, and should be thoroughly disinfected if at any time it has been exposed to a contagious disease. The **bed** preferably should be narrow and high, with a firm mattress, and should be made up with draw-sheets of rubber and cotton placed across the middle of the bed over the under-sheet. This is known as the 'permanent bed.' Over this a second rubber draw-sheet and a second cotton draw-sheet are placed, constituting the 'temporary bed,' which is removed immediately after delivery. When a double bed is used, the temporary bed is arranged at the lower part of one side. Sometimes instead of the second draw-sheets, usually in addition to them, use is made of absorbent pads, two to three feet square and two to four inches thick, which are afterward to be burned. They are made by loosely quilting absorbent cotton, wood-wool, jute, bran, or sawdust into a linen or muslin cover, and are sterilized by steaming or baking. A Kelly pad, or one improvised, or sterile towels or napkins, may be used instead. It is well to have temporary coverings during labor and not to put the permanent covers on the bed until after delivery. A piece of **floor oilcloth** may be spread at the side of the bed, extending a foot or two under it.

The best **occlusive bandage,** which is rather expensive, is made up of carbolized gauze and salicylated cotton. A cheaper dressing consists of two thicknesses of rolled absorbent cotton or wood-wool, seven or eight inches long and four or five inches wide, inclosed in one-fourth of a yard of washed cheese-cloth so folded as to make a pad sixteen or eighteen inches long and four or five inches wide, the edges being stitched. Three or four dozen will be required. They should be put into a clean pillow-case or wrapped in a sheet and thus steamed or baked, being kept covered until used. They may be rendered antiseptic by previous immersion in an antiseptic solution. The Garrigues occlusion dressing, described on page 511, or sterile napkins of diaper linen or sterilized or antiseptic cloths of old linen or muslin may be used instead. The abdominal binder and breast bandage have been described. (See pages 442 and 443.)

The first step in the management of **the first stage** of labor is the evacuation of the rectum by means of an **enema.** The bladder also should be emptied at frequent intervals—if necessary, with the catheter. When gonorrhea is suspected, the vagina is usually sterilized; otherwise a vaginal douche is unnecessary. If time permits, the patient should take a warm tub-bath, washing herself thoroughly with soap and water; if not, a warm sponge bath should be given. Particular attention must be paid to the external genitalia, which may be cleansed with a disinfectant solution. The hair is usually brushed and arranged in two braids. The patient is clothed in a clean night-gown, a wrapper, and easy slippers, with the addition, in cold weather, of a thin woolen undershirt and woolen stockings. In the day-time the patient should be up and about, lying down during a pain or sitting with the body inclined forward and the hands grasping a chair in front. Liquid nourishment, milk, broths, and the like, with a very small quantity of bread, toast, or crackers, should be given at frequent intervals. Large quantities of water should be taken and a moderate amount of tea and coffee may be allowed. At night sleep should be encouraged or promoted. Sometimes when the os is the size of a silver dollar, often not until it is fully dilated, the patient is put to bed on her side or back. During delivery on the side, the upper limb should be supported by the nurse or by a pillow placed between the knees. The sheet may be draped over the side of the bed or it may be pinned around the waist, left open on the side next the obstetrician, the long end being often fastened beneath the arm. As **the second stage** approaches, a large sponge must be in readiness to catch the liquor amnii. During this stage the patient may be allowed to pull on a sheet or on a roller towel tied to the foot of the bed. The description of the management of the labor is not within the scope of this work.

So soon as the **head is delivered** the child's eyes are wiped with a piece of soft linen soaked in a solution of boric acid, and when the child is born it is held by its thighs and legs with the head downward while the mouth is similarly cleansed. At the close of **the third stage** the abdominal pad and binder are adjusted and the patient is cleansed and examined for lacerations; the occlusive dressing then being applied. After delivery, a solution of boric acid or a 5 per cent. solution of protargol or, in suspicious cases, a 2 per cent. solution of silver nitrate should be instilled in **the child's eyes,** a resulting inflammation receiving appropriate treatment. The **cord** should be dressed with salicylated cotton daily after the morning bath.

A premature child should be placed in an **incubator.** In the absence of approved special apparatus, a good-sized clothes-basket, bath-tub, or wooden box may be taken, lined first with heavy wrapping-paper and then with a padding of heated blankets or cotton, or both, and filled for half its depth with a non-conducting material like cotton-wool. Hot-water cans or bottles should be placed about, so arranged that any one of them can easily be removed for refilling without exposing or disturbing the infant. With the exception of its face and perineum the child should be wholly covered with lambs' wool, cotton-wool, or cotton batting, held in place by gauze bandages. A piece of absorbent cotton or wool should be placed over the perineum. The basket should be covered with a shawl or blanket, a space at the end corresponding to the child's head being left open, and may then be placed upon a table three or four feet above the floor. The temperature of the incubator should be maintained between 85° and 95° F. and may be regulated by means of a long thermometer placed beside the child. The child should not be removed from the incubator unnecessarily, and should be fed by means of a medicine-dropper or by gavage, a dram at hourly intervals being the usual quantity given at first. A daily rub with warm oil, later a warm sponge, takes the place of the morning bath.

NURSING OF CHILDREN

In managing sick children, gentleness, firmness, truthfulness, sympathy, and tact are necessary qualities. The child's confidence must be won. In **administering medicine** persuasion should be tried, and even honest bribery may be permitted. If these means do not overcome a child's obstinacy in a reasonable time, they should be desisted from. The child should then be taken up, wrapped in a shawl or sheet so as to confine the arms, the nose held, and, when the mouth is opened, a spoon inserted as far as possible, emptied gently, and slowly withdrawn. Occasionally the exhaustion occasioned by the fight overbalances the good derived from the medicine. A child with **cleft palate** sometimes may be fed from a bottle if a bit of thin india-rubber, cut the size and shape of the roof of the mouth, be stitched to an ordinary nipple so as to cover the gap.

NURSING IN CONTAGIOUS DISEASES

Notification, isolation, quarantine, and disinfection are the best means of preventing the spread of a contagious disease. The directions given in the chapters on Prophylaxis in the Special Infections should be followed rigorously. A sheet continuously wet with a volatile disinfectant solution may be hung outside the door of the sick-room. The lower end may dip into a reservoir (a tub is handy) whence the solution is drawn by capillarity, or the sheet may be sprayed, sprinkled, or immersed from time to time. Formaldehyde (1 per cent.), carbolic acid (5 per cent.), and the solution advised by J. L. Smith, consisting of eucalyptol (one part), carbolic acid (one part), and oil of turpentine (6 parts), are suitable for this purpose. They may also be sprayed about the room from time to time. Smith's solution may be evaporated from the surface of steaming water in a broad shallow dish, or formaldehyde be continuously generated from paraform—two pastils being placed in the cup, and the flame kept at the lowest point. Menthol or eucalyptol in small quantity may be added for fragrance. The patient and nurse should be isolated in the sick-room and should not come in contact with any one else in the house. Food should be placed outside the door, and is to be taken into the room by the nurse, who destroys what is uneaten. Before entering the sick-room, the physician should don a cap and put on a long gown, or a sheet, over his outer garments. Before leaving the house, he should wash his face, hair, and hands in a disinfectant solution, and may then submit to spraying with a solution of formalin, carbolic acid, or chlorin water, or to fumigation by means of formaldehyde or of chlorin. The latter may be generated by placing a dram of chlorinated lime or of powdered potassium chlorate in a saucer, together with a small quantity of hydrochloric acid. As an additional precaution, he should walk briskly, or ride or drive in the open air, before visiting the next patient. The nurse should likewise disinfect herself before leaving the room, and should change her dress and shoes. While in the room she may wear a gown and cap. When passing through the house to take outdoor exercise, she should go straight out without stopping. When in attendance on a case of diphtheria, both physician and nurse should spray their throats and noses frequently with an antiseptic solution, and they may take immunizing doses of antitoxin.

Disinfection has been fully discussed in Part I, chapter XII.

INDEX

A.

B.

C.

D.

E.

F.

G.

H.

J.

K.

L.

M.

N.

O.

T.

U.

V.

W.

X.

Y.

Z.

NAME	DATE DUE