ALIMENTARY ENZYMES

BENGER

Alimentary Enzymes

In Theory & Application

With Special Reference to
Their Use *in* Treatment
and Dietetics

Benger's Food Ltd.

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PREFACE.

During recent years the study of the various mechanical, chemical, and vital processes concerned in digestion has resulted in discoveries many of which are of great interest to the general medical practitioner. Unfortunately, these fresh additions to our knowledge appear in diverse journals and in various languages, and it is only occasionally that they are collected and embodied in a treatise or article dealing with the whole subject. The medical practitioner, frequently, has neither the time nor opportunity to study these articles as they appear, and at present there is no popular text-book which is quite up-to-date.

For this reason it is hoped that the brief résumé which has been prepared on the "Physiology of Digestion," and which forms the first chapter of this work, will be found worthy of perusal, if not of careful study. The question of "food," especially for invalids and infants, is undoubtedly increasing in importance, as it is now generally recognised that a physician should as carefully prescribe diet as medicine. In this connection, therefore, it is believed that the chapters dealing with "Digestion in Infancy," "Predigested Food," "Milk," &c., &c., will be found useful.

Digestion is a far more complex problem than it was at one time regarded, and in a sense it appears to commence before the food actually reaches the mouth, and the processes continue until the residue reaches the rectum. For example, starch, which may not be acted upon by the saliva in the mouth and stomach, may be digested by the amylopsin from the pancreas, and, still later, by the amylase of the succus entericus.

Our knowledge of the various enzymes, and of their mode of action, has been thoroughly studied, and where nature fails to produce them in the requisite quantity or quality, science steps in and can supply the deficiency. In the preparation of such products there is no doubt the late Mr. F. Baden Benger, F.I.C., F.C.S., Pharmaceutical Chemist, was one of the first and most successful.

Benger's Preparations of digestive enzymes and their food products were the practical outcome of the pioneer work done by the late Sir William Roberts, M.D., F.R.S., formerly Physician to the Manchester Royal Infirmary, and Professor of Medicine at the Victoria University, Manchester. These researches formed the subject of his addresses on Dietetic Preparations and Digestive Ferments, delivered before the Royal College of Physicians in 1880 (as Lumleian Lecturer) and various scientific societies, as well as of papers which appeared in the Proceedings of the Royal Society in 1881, and other scientific and medical publications.

The late Mr. Benger assisted Sir William Roberts in the practical work connected with his researches.

Since the origination of the "Benger" products it has been the rule of the firm to acquaint medical men with their composition and properties, so that they, the proper authority, might know with what they were dealing. It has been customary also to receive from medical men correspondence and enquiries for particular information relating to digestive ferments, their preparation and properties, and for detailed information respecting the "Benger" products. As far as possible this is gladly supplied, and such enquiries are welcome. The present work is based largely on questions put to the firm from time to time, and is an attempt to present the information in a connected form, in the hope that it may prove interesting and useful to medical men generally, and in order that they may have available, detailed and authentic information whenever such is required.

October, 1912.

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The plates at the end of this work have been selected and reproduced from the "Benger" Series of original, untouched photographs. They show the effect of an artificial gastric juice (containing Rennin and HCL 0·2 per cent.) on milk, etc., at 98° Fahr., in glass, under identical conditions.

PHOTOGRAPH I.—Curd from Cows' Milk (Fig. 4), and from the same milk after treatment with

(1) Benger's Food (6¼ %) for fifteen minutes. Fig. 4B
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PHOTOGRAPH II.—Cows' Milk sets in a solid curd, and has to be broken with a glass rod. This photograph shows the broken curd. (Compare with Plate III. *Photograph* III.)

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PHOTOGRAPH X.—Effect of excess of iodine on the same. (Compare with *Photographs* VIII. and IX.)

PART I.

CHAPTER I.

THE PHYSIOLOGY OF DIGESTION.

Under the term digestion is included all those processes to which the food is subjected in the alimentary canal and which have for their object the conversion of solid, insoluble, indiffusible food substances into soluble, diffusible bodies, which are capable of being absorbed by passing through the wall of the alimentary canal into the blood or lymph.

Broadly speaking these processes are either mechanical or chemical in nature, the mechanical factors in digestion being essentially due to muscular action, and having for their objects :—

(1) The breaking up of the solid or semi-solid particles of food.
(2) The incorporation of the food with the digestive juices.
(3) The propulsion of the digesting food along the alimentary tract.

The motor mechanisms include such actions as mastication, insalivation, deglutition, and peristalsis, &c., and are in some cases under the control of the will, in others involuntary and reflex. Roughly one may say that the food at the commencement and end of its journey through the alimentary canal is more or less under the control of the will, while during the middle part of its course it is quite beyond all voluntary control. Furthermore, one has to remember that even this voluntary control of certain of these "mechanical" actions is only partial, and the result of education.

The chemical changes involved in digestion result from the action of the digestive juices formed by the epithelium of the alimentary canal and by its glands.

The different digestive juices act in virtue of ferments (enzymes) which they contain, some of the juices containing several enzymes and so being capable of acting on several different classes of food substances. The enzymes set up hydrolysis, *i.e.*, split up the substance on which they act into two or more simpler bodies with the assumption of the elements of water, the whole object of the chemical factors in digestion being to convert insoluble, indiffusible bodies, such as proteins, starches, or fats, into soluble, diffusible, absorbable bodies such as peptones, sugars, and fatty acids.

The enzymes themselves are preformed by the gland cells as zymogens, inert precursors, which may be seen in the cells of "resting" glands as small granules which stain readily by certain specific methods. These zymogens become converted into the active enzymes either during the actual process of discharge from the cell, or after discharge, the inert zymogen in such cases being activated by admixture with some other digestive juice secreted at a lower level in the alimentary canal and containing some specific activating principle. In the case of some glands, the zymogens themselves have a precursor—a pro-zymogen, also an inactive body (*e.g.*, pancreas). Acids also have the power of liberating enzymes from zymogens. The exact chemical nature of enzymes is unknown, they probably contain nitrogen and may be allied to the proteins; they have the power of accelerating, to a very great extent, specific chemical reactions, which reactions occur best at body temperature (the optimum) and are retarded by cold, stopped indefinitely at 0° C., and stopped permanently at 100° C.

Many, if not all, the digestive enzymes, exhibit a reversing action, that is, having converted a good deal of the primary substances on which they act into the usual "end product," they react on the "end product" and convert it back into the original primary substance, so that a state of chemical equilibrium may be established. The enzymes are usually classified, according to the substance on which they act, into (1) Proteolytic—those which act on protein; (2) Amylolytic—those which act on starch; (3) Steaptytic—fat splitting, &c.

A detailed account of the individual ferments will be given under the different digestive juices.

Salivary Digestion.

In the mouth the food is subjected to both mechanical and chemical agencies. In the process of mastication the food is broken up into smaller particles. This, a voluntary action, is regulated by tactile and muscle sense, while its duration is chiefly determined by the physical condition of the bolus, such as its consistence, dryness, taste, temperature, &c., as well as by the state of the teeth and general habits of the individual. It is all important in early life to cultivate proper habits of mastication. This is at first an entirely voluntary act, but later can be performed without the direct intervention of the will; in other words, it becomes more allied to a reflex action. Much of the present decay of the teeth is bound up with this question of imperfect mastication. During mastication the food is thoroughly incorporated with the saliva—insalivation—a process whereby the particles of food are made into a coherent mass, which is lubricated, moistened, and so rendered fit for swallowing. Moreover it is during this period that sapid (tasty) substances are dissolved out, while the ptyalin (enzyme) is brought into intimate contact with starchy substances which are, as a result, partly, at any rate, converted into sugar (maltose). The saliva is thus the first digestive juice with which the food comes in contact, and its action not only takes place in the mouth but is continued for some considerable time (about two hours) in the stomach, hence salivary digestion is said to exhibit both a buccal and a gastric phase.

Ordinary "mixed" saliva is a somewhat thick, viscid, alkaline fluid, with a specific gravity of 1002-1006, which gives a faint proteolytic reaction and rapidly converts starch, glycogen, and other polyoses into maltose. The saliva is secreted by the submaxillary, parotid, sublingual, and buccal glands, the latter being a series of small mucous glands which occur scattered throughout the lining of the mouth. The secretion of the different glands varies considerably in physical and chemical properties. The secretion of the submaxillary and the sublingual glands is practically identical, and is a somewhat thick, viscid secretion, the function of which is not only digestive, but also that of a lubricant. Parotid saliva, on the other hand, is thin and watery, and is used chiefly for "flushing-out" purposes. The salivary glands do not secrete togcther as a whole, but react individually to different stimuli for specific purposes.

The approximate composition of mixed saliva is as follows:—

Water ......99·5 per cent.

Solids .... ·5 per cent. {Ptyalin. Mucin. Protein. Potassium Sulphocyanide. Salivary corpuscles. Epithelial scales.}

The composition of saliva is continually varied according to the purpose for which it is intended—not only the amount of water, but the amount of ptyalin, mucin, protein, and inorganic salts varying vcry considerably in specimens secreted for different objects, *e.g.*, should the food be dry, then watery saliva is secreted by the parotid, while should it not be specially dry but require lubricating for deglutition purposes, a thick, viscid, submaxillary saliva is poured out. Besides this the mouth is really the "sorting chamber" of the alimentary canal, and many substances introduced into it are useless, noxious, and even injurious to the animal. In such cases the saliva acts as a flushing-out, diluting, or neutralising agent.

The chief chemical use of saliva is to convert insoluble, indiffusible starches into diffusible sugars, intermediate bodies being soluble starch, achroo- and erythro-dextrin, maltose being the end product. This conversion, like all enzymic action, is very rapid, but takes place chiefly in the stomach.

The secretion of saliva commences before the actual introduction of food into the mouth, being initiated by a psychic stimulus, the thought or anticipation of food, this primary secretion being re-inforced by the sight, smell and finally the taste of food, so that a copious flow of saliva is ensured.

This "anticipation juice" varies in character just as does juice secreted as the result of stimulating the buccal lining locally.

The secretion of saliva depends upon a nervous, not upon a chemical, mechanism, as in the case of the pancreas, and if all the nerves are cut no secretion of saliva is possible. The afferent nerves are the sensory nerves of the mouth and adjacent parts, and are the same in the case of all the glands. The efferent channels vary in the individual cases; in the case of the submaxillary and the sublingual the chorda tympani and cervical sympathetic being the efferent paths, while in the case of the parotid the glossopharyngeal and sympathetic are the main channels. These nerves have nuclei or stations in their courses, and direct stimulation of the nerves themselves with stimuli of various strengths produces a secretion of saliva which not only varies in amount, but also in actual chemical composition, as regards amount of organic or inorganic solids, &c.

Deglutition.

The food having been masticated and insalivated, is swallowed, *i.e.*, passed through the pharynx and œsophagus into the stomach. The process of deglutition is now regarded as a purely involuntary reflex action brought about by stimulation of a definite area of the buccal mucous membrane by the bolus, recent investigations having shown that in all higher animals there is a special region in the mouth or pharynx, stimulation of which invariably produces the act of swallowing. The exact position of this chief deglutition-signal surface varies in different animals, but is in all animals situated somewhere along the main normal path of the bolus. In addition to this "chief" area, other necessary areas are also present in more lateral positions, the object of these being to ensure the swallowing of particles of food which have "strayed" from the main mass.

Two stages are described in connection with deglutition—the first a rapid pharyngeal stage, the second a relatively slow œsophageal, peristaltic stage. In the pharyngeal stage the bolus is rapidly shot through the pharynx by the contraction of the mylohyoid and hyoglossus muscles assisted by the rapid rotation of the tongue round the hyoid and by the contraction of the palatine arch upon the bolus. At the same time the bolus is prevented going up into the nose by the elevation of the soft palate, or going down into the larynx by the retraction of the root of the tongue and the drawing upwards and forwards of the larynx under cover of the retracted tongue. Simultaneously the laryngeal orifice is narrowed and the epiglottis pressed down. This drawing upwards and forwards of the larynx plays another important part in the mechanism of deglutition in that it pulls forward the hyoid and so opens the œsophagus, and thus prepares the way for the passage of the bolus. Finally during the first stage the food is prevented coming back into the mouth by the muscles of the palatine arch, which contract first upon and then behind, the advancing mass. The passage of the bolus down the œsophagus is much slower than its passage through the pharynx. Furthermore, it appears frequently, if not always, to be delayed just before its entry into the stomach—some authorities stating that of the time taken by the second stage, half is spent by the bolus travelling down the tube, and half in passing through into the stomach.

As regards the actual distance the bolus is projected during the first stage, this differs in different animals with the fluidity of the bolus and the position of the animal during the act; but, roughly speaking, in the case of a fluid bolus, one may say that it is projected to a level with the heart, while solids and semi-solids are only projected to the upper end of the œsophagus, their passage down this tube being associated with a peristaltic wave. The exact relationship of the bolus is a matter of some difference of opinion, some authorities considering that it forces the bolus down the tube, others that it follows on the bolus, its main object being to sweep along detached particles. This wave is peculiar in that it is conducted by the nerve, and not the muscle, and may be transmitted from the upper to the lower end of a divided œsophagus, after division of all the muscle, if the nerve is left intact.

Recently Cannon has described three kinds of peristalsis in the œsophagus, one depending on the integrity of the tube as a whole, one on the integrity of the nerve, and the other on the integrity of the muscle-coat. These differ in their reaction to anæsthetics, temperature, &c.

Gastric Digestion.

The gastric juice is a clear, limpid, acid liquid with a sour smell and taste, and a specific gravity of 1002. Its actual composition, like that of saliva, varies considerably with the object for which it is secreted.

Its approximate composition is, however, as follows:—

Water 99·5 Solids ·5

Solids ..	Organic	Pepsin. Rennin. Gastric Lipase.
	Inorganic	Chlorides, phosphates. H.Cl. 0·2 per cent.

The uses of gastric juice may be summarised as follows: (1) Digestive, (2) Antiseptic, (3) Activating or Hormonic. As regards its digestive action one may say in general terms that directly or indirectly it acts on all classes of food stuffs. Proteins are converted into proteoses and peptones by the pepsin-hydrochloric acid; the prolonged action of this substance may also lead to the formation of amino-acids, but this does not occur normally in the stomach. This action, as previously pointed out, is essentially one of hydrolysis. The various phases through which the protein passes may be summarised as follows: (1) Acid meta-protein

(2) Propeptone $\left\{\begin{array}{l}(a) \text{ Protoproteose} \\ (b) \text{ Heteroproteose} \\ (c) \text{ Deuteroproteose}\end{array}\right\}$ and (3) Peptone

As regards these substances, the acid metaprotein is a body which is insoluble in water, soluble in acid, precipitated by neutralisation and by neutral salts, *e.g.*, ammonium sulphate, and is not coagulated by heat. The propeptones or proteoses include: Albumoses, globuloses, gelatoses, elastoses, &c., and are a class of bodies precipitated by alcohol and nitric acid, and not coagulated by heat, but which give a rose-pink colour with copper sulphate and caustic potash. They are slightly diffusible. The primary bodies (proto- and hetero-proteose) are precipitated by saturation with magnesium sulphate. The secondary body, deutero-proteose is not precipitated by magnesium sulphate, but is precipitated by ammonium sulphate. The primary proteoses, moreover, are soluble and the secondary insoluble in water.

The final products, the peptones, are a class of substances which are soluble in water, precipitated by alcohol, tannin, picric acid, &c., &c., not coagulated by heat nor precipitated by nitric acid. They are diffusible, give a Biuret reaction, and are easily split up into groups of amino-acids or polypeptides.

In the digestion of fats, gastric juice plays a most important part. The pepsin-hydrochloric acid digests away the connective tissue, which binds the fat lobules and cells together, thus liberating the cells, the protein envelope of which is then digested in a similar manner, so that the fat is liberated and brought into intimate contact with the gastric juice, containing a lipase which splits the fat into glycerine and fatty acid.

The gastric juice of young animals is rich in lipase, but in adults it is doubtful if much is present. Recent researches have shown that in the later stages of gastric digestion there is a certain amount of regurgitation of food and pancreatic juice from the duodenum, so that possibly some of the fat splitting that occurs in the later stages of stomach digestion is really due to the pancreatic lipase.

Carbohydrates.—Gastric juice has no specific ferment which acts on carbohydrates, but the hydrochloric acid may act hydrolytically, converting cane sugar into dextrose and levulose, lactose into galactose and dextrose, and maltose into dextrose to a slight extent.

Milk.—Gastric juice exerts a considerable action on milk. The acid curdles the milk, *i.e.*, precipitates the caseinogen, while the rennin, which may or may not be a separate ferment, converts it (caseinogen) into casein, the casein being subsequently digested by the pepsin-hydrochloric acid and converted into caseose and casein-peptone. The other proteins of milk are digested by pepsin in the usual manner, while lactose is partially converted into dextrose and galactose.

Milk Digestion in Infancy.

It is probable that during infancy milk is digested in a slightly different way, but the ultimate effect is the same. The caseinogen from the milk of one animal may be readily digested in the stomach of another animal of the same species, but may be difficult to digest in that of an animal of another species. For example, cow's milk is readily digested by the calf, but in the stomach of an infant the curds produced are so large and dense that their solution is difficult, and at times impossible. A study of the process of coagulation, as illustrated by the diagrams at the end of this book, shows that when cow's milk, mixed with a little starchy matter, has been previously treated with a suitable digestive ferment, the caseinogen flakes (the curd) are no longer large and dense, but finely divided and comparable with those produced from human milk.

As the child grows older its stomach becomes able to digest cow's milk, hence there must have been some change, some modification of the mechanical, physiological, and chemical processes occurring in the stomach. In adult invalids, however, the conditions may revert to those of early infancy, and cow's milk becomes practically indigestible unless previously treated in the manner suggested. This partial pre-digestion appears to effect a change which the stomach, temporarily, is unable to effect, and which is absolutely necessary if the further processes of digestion are to proceed uninterruptedly.

Gastric juice is a powerful antiseptic, arresting putrefaction, and destroying many forms of micro-organisms taken in as food.

The Activating or Hormonic Action of Gastric Juice.

The gastric juice is responsible for those secretions which are poured into the lower parts of the alimentary canal. The acid content of the stomach is periodically discharged into the duodenum, where its acid converts prosecretin, a substance formed by the duodenal mucous membrane, into secretin, a substance which belongs to the group of bodies known as Hormones. This passes into the blood and stimulates the pancreas, liver, and intestinal mucous membrane, so that pancreatic juice, bile, and succus entericus are all poured into the intestine.

The Secretion of Gastric Juice.

This commences before the actual introduction of food into the mouth, and is initiated by the thought or anticipation of food, being subsequently re-inforced by the smell, sight, and lastly the taste of food. The juice thus secreted is known as appetite or inciting juice ; it is only secreted for a few minutes, and stops at once should the animal realise that it is not going to have the food. Such a secretion is known as a psychic secretion. When food reaches the stomach the products of salivary digestion (especially dextrin) act as chemical excitors to the gastric flow, a further chemical stimulus being supplied subsequently by the products of gastric digestion (peptones) as well as by certain substances, such as extract of meat, &c., which may be introduced with the food itself. The value of the psychic factor in digestion cannot be well overstated, as Pawlow has shown by direct experiment that in a given time, with appetite, an animal can digest five times as much food as without it.

As regards the relative value of the different components (visual, olfactory, or gustatory) of the psychic factor, one may briefly state that in some animals, *e.g.*, cats, the visual component is probably the most important (a cat when playing with a mouse is probably simply ensuring a flow of gastric juice to digest it). In dogs smell is the most potent element, while in man the gustatory factor is probably the chief one concerned.

Practical appreciation of the above facts in the treatment of diseases of the stomach and other allied conditions is shown in the frequent feeding of invalids, whose gastric digestion is impaired, with small amounts of food, so that a maximum psychic secretion may be obtained and digestion ensured.

Again, the administration of soup, or extract of meat (specific gastric excitors), as precursors to an ordinary meal or to forced feeding, ensures an efficient secretion of gastric juice. Finally, one might point out in this connection that the whole modern menu, though founded on instinct to a large extent, is so constructed as to stimulate the different components of appetite and thus ensure a maximum secretion. The psychic secretion only occurs when the vagi are intact; the specific excitors, however, act when the nerves have been divided, liberating a chemical substance (gastrin), which passes into the blood, and stimulates the cells to secrete. Hence we may summarise the matter and say that the gastric flow is started by a nervous, but sustained by a chemical, mechanism.

The Mechanics of Gastric Digestion.

The food on being swallowed is detained or delayed for a short time at the cardiac orifice, this being particularly the case if the substance swallowed is cold, or of a corrosive or irritant character. Usually the cardiac sphincter opens with each act of swallowing, but if several weak swallowing actions follow one another rapidly it may only open every third or fourth time. On the other hand, should the swallowing efforts be very strong and follow one another in rapid succession, the sphincter may remain open some considerable time. After the food has entered the stomach it travels along the greater curvature to the pylorus, and is then reflected towards the fundus. The different classes of food do not mix much in the stomach, but form successive layers (stratification). The bulk of the food ultimately forms a mass round which the fundus contracts tonically. Salivary digestion continues in the centre of this mass for at least two hours while the outer portions are gradually dissolved away by the gastric juice, the softened outer portions of the mass being squeezed off, and propelled towards the pylorus by a series of wave-like contractions which gradually travel towards the pyloric sphincter. When the food in the pyloric canal is liquid, the pylorus opens periodically to allow it to pass into the duodenum ; as soon as the content of the duodenum is acid the pylorus closes again, and remains closed until such time as the duodenal contents become alkaline and the pyloric canal is filled with acid liquid food. The impact of solid food against the pylorus causes the sphincter to close instantly and to remain closed for some considerable time, as has been demonstrated by means of a dry starch and bismuth pill, and a fluorescent screen. In one observation when the pylorus was opening several times per minute, after being struck by the pill it did not open again for 42 minutes.

From the above it will be seen that the stomach consists of (1) a cardiac sphincter or inlet which opens to pressure, but closes tightly to cold or injurious substances (corrosive irritants) ; (2) a fundus which contracts tonically round the food, in which salivary digestion continues, and whose main function is "to feed"; (3) the pyloric canal ; this contains acid liquid food which it squirts periodically through (4) the pyloric sphincter or outlet to the stomach. This is opened by an acid, liquid pyloric content associated with an alkaline reaction in the duodenum, and closed by an acid duodenal content, or by solid particles in the pylorus.

In starvation, the stomach exhibits periodic movements. The movements alternate with periods of rest, the latter lasting for 1½ to 2 hours ; the movements are easily inhibited psychically, always cease just prior to taking food, and can be stopped instantly by the introduction of food into the stomach, or duodenum.

The different food-stuffs escape from the stomach at different rates, carbohydrates being the first, and proteins the last, to leave, and upon reaching the intestines further changes are effected.

Pancreatic Digestion.

In the small intestine the acid food is brought into contact with the secretions of (1) liver, (2) pancreas, (3) intestinal mucous membrane—the succus entericus—in the order given.

The pancreatic juice is an alkaline, colourless fluid, which rapidly undergoes decomposition on exposure to air ; it has a powerful digestive action on all classes of food stuffs.

Composition of pancreatic juice :—

- Water. 97·5—98·5 %
- Solids .. 1·5—2·5%
  - Organic ....
    - Ferments: Trypsin, Amylopsin, Steapsin, Rennin
    - Traces: Leucin, Tyrosine ...., Protein
  - Inorganic ..
    - Chlorides.
    - Phosphates.
    - Carbonates.

Action on Proteins.

The pancreatic fluid, the proteolytic enzyme of which is Trypsin, converts proteins into alkali-albumin, secondary albumin, peptone, polypeptides, and amino-acids, and acts, not only on ordinary native proteins, but also on the more insoluble substances such as collagen, elastin, &c.

Trypsin is a substance which differs from pepsin in that (1) it acts in alkaline instead of acid medium, (2) it acts more powerfully and rapidly, (3) it corrodes away protein while pepsin swells it up and bursts it, (4) it acts on more insoluble proteins, *e.g.*, collagen, elastin, &c., (5) it carries the action further than pepsin, amino-acids being the end products instead of peptones.

Action on Carbohydrates.

Pancreatic juice contains a ferment—Amylopsin—which acts on starch and products of the action of ptyalin on starch, converting them into maltose and isomaltose. The continual action of pancreatic juice may occasionally produce a small amount of dextrose as well.

Amylopsin, like ptyalin, acts in an alkaline medium, but is more powerful, and is said to act on unboiled, as well as boiled, starch. It forms the same intermediate products—soluble starch, erythro- and achroo-dextrin, and maltose.

Action on Fats.

Pancreatic juice contains a fat-splitting ferment or lipase, known as Steapsin. This splits up fat into its component glycerine and fatty acid, the latter being either emulsified or dissolved in the bile, or combines with an alkali to form a soap. The great bulk of fat digestion is due to this pancreatic lipase.

ACTION ON MILK.

Pancreatic rennin converts the caseinogen of milk into casein, which, together with the lactalbumin and lactoglobulin, is subsequently converted into soluble peptone by the trypsin.

THE SECRETION OF PANCREATIC JUICE.

It is highly probable that secretion of the pancreatic juice, like that of saliva and gastric juice, is initiated by a psychic stimulus and commences before the actual taking of food. The psychic effect is reinforced by a chemical stimulus arising in the duodenal mucous membrane and passing direct to the pancreatic cells by the blood. The hydrochloric acid of the gastric juice comes in contact in the duodenum with a substance called prosecretin, and converts it into secretin ; this passes into the blood, is carried to the pancreas, and acts as a specific excitor to the pancreatic cells, which secrete pancreatic juice, which is poured into the duodenum. The juice at this stage, however, has little digestive activity, but becomes active after admixture with the succus entericus and bile.

Finally the secretion of pancreatic juice is maintained by specific excitors taken in with the food. Of these direct specific excitors the most important is probably fat, but starch is also probably a specific augmentor of the ferments.

BILE.

Bile is a reddish-green, viscid, alkaline, bitter substance with a somewhat musty smell. It readily undergoes putrefaction when exposed to air. Its specific gravity varies from 1020–1030 according to the method by which it is obtained. Bile may be the pure secretion of the liver itself or may be mixed with the secretion of the gall-bladder, mucin, &c. Gall-bladder bile is thick, and viscid, has a high specific gravity, and is rich in bile salts, whereas bile taken directly from the liver is thin, has a low specific gravity, and contains very little bile salt indeed.

The approximate composition of Bile is as follows:—

Water 85 - 98 per cent.			
Solids 2 - 15 per cent.	Organic ..	Bilirubin	Bile pigments
		Biliverdin	
		Sodium Glycocholate	Bile salts.
		Sodium Taurocholate	
		Cholesterin.	
	Inorganic	Phosphates.	
		Carbonates.	
		Chlorides.	

The Uses of Bile.

As regards the uses of bile, it may be stated in general terms that it probably has little direct digestive action, although it does contain a weak amylolytic ferment, and in carnivora and man a proteolytic ferment as well. The chief use of the bile, however, is to act as a lubricant and to activate the pancreatic juice, the fat-splitting ferment of which has its activity increased at least three-fold by the addition of bile.

This activating action is not due to a ferment, but to the presence of bile salts, substances which also play an important part in the solution of the oleic acid, in dissolving out cholesterin, in moistening the intestinal mucous membrane and rendering it more permeable to fatty substances.

The bile salts, also, preserve the integrity of the epithelium and stimulate peristalsis, thus acting as a natural purgative; they, moreover, exert a mild antiseptic action on the contents of the bowel. Bile, moreover, inhibits gastric digestion, firstly, by neutralising the acid chyme, and, secondly, by the bile salts combining with the proteoses and unaltered native protein, to form insoluble bodies.

The relation of the bile to fat is thus particularly interesting, for, not only does it assist its digestion by increasing the activity of the pancreatic lipase and by inhibiting the gastric juice, but it also dissolves out oleic acid (which is supposed to form a loose, easily dissociable compound with the amino group of the bile acids), and then, subsequently, becomes a solvent for stearic and palmitic acids as well. Recent experiments seem to show that as much as 50 per cent. of the fat of a meal may be dissolved by the bile. Finally, by lowering surface tension and increasing the permeability of the intestinal wall it further aids absorption.

The Secretion of Bile.

The secretion of bile is peculiar in that it is continuous and not intermittent, and that its constituents are drawn from the portal blood, where the pressure is very low. In the intervals of digestion, bile is stored in the gall bladder from which it is discharged periodically into the bowel. This discharge differs with different kinds of food, and is regulated by the same laws as those which govern the flow of the other digestive juices. When fasting, no bile passes into the bowel, but after taking food a flow begins after a definite time.

This discharge into the gut may be represented graphically by means of a curve which is found to be characteristic for each variety of food. After a meal of milk, for example, the curve shows three rises. The first commences after an interval of 15 minutes, reaches its maximum in 30 minutes, and is completed in 60 minutes. The rise is due to the passage of unchanged milk through the pylorus, the fat acting as a stimulant to bile secretion, and the fall is due to the absence of the fat stimulus. The second curve is the largest, occupies the second and third hours, and is at a maximum at the end of the second hour. It corresponds to the coagulation of the milk in the stomach, and its separation into whey and clot. The rise is due to the stimulating effects of the products of digestion. The third rise occurs during the fourth and fifth hours, corresponding to the digestion of the casein, and is due to the stimulus provided by the residue of gastric digestion escaping from the stomach. The curve for flesh is more prolonged, the latent period being about 41 minutes, while the maximum is reached half an hour after the beginning of the flow. Then there is a slow gradual decline broken by oscillations lasting about six hours, and a terminal abrupt fall. The curve as a whole is more uniform than that for milk, because flesh is composed chiefly of one kind of food (protein). For bread, the outflow is even longer than for flesh; the latent period is about the same, but the curve exhibits sharp oscillations, which last over seven hours. The rate of discharge is slower, but the total bile ejected is greater than for flesh. The sharp elevations are due to the mode of passage of the food along the bowel.

The presence of food in the duodenum and its reaction are not the only factors which determine the ejection of bile, for acids introduced into the stomach in the intervals of digestion and allowed to pass into the duodenum do not produce a flow. Foods such as raw white of egg or boiled starch do not cause a flow of bile on direct introduction into the gut, but fat, or the products of gastric digestion, do cause a flow.

Hence we may say that bile, like the other digestive juices, has its own specific excitors.

The secretion of bile by the liver is stimulated by secretin, as in the case of the pancreas.

Intestinal Digestion.

The succus entericus is a thin, watery, alkaline fluid secreted by the glands of Lieberkühn of the small and large intestines.

Its approximate composition is as follows:—

Water, about 98·5 %		
Solids .... about 1·5%	Organic	Lactase.
		Amylase.
		Maltase.
		Invertase.
		Erepsin.
		Arginase.
		Enterokinase.
	Inorganic ..	Salts, chiefly phosphates.

This secretion, unlike the other digestive juices, is not secreted to any extent before the entry of food into the gut, but is a local secretion only occurring in that segment of gut which actually contains the food or is just about to receive it. Pancreatic juice or ferments in the bowel also cause a copious secretion of succus entericus rich in kinase and in ferments.

The functions of SUCCUS ENTERICUS may be divided into digestive and mechanical.

(1) DIGESTIVE.—Succus entericus has a direct digestive action in virtue of the ferments which it contains. (*a*) On carbohydrates : Its maltase converts maltose into dextrose ; its lactase (found only in the jejunum) converts lactose into dextrose and galactose ; the amylase found in the duodenum converts starch into maltose ; while cane sugar is converted into dextrose and lævulose by invertase. (*b*) On fats : Succus entericus contains a lipase, which has the power of acting on emulsified fat such as occurs in milk. It has been calculated that in the absence of pancreatic juice about 50 per cent. of ingested fat can be absorbed in virtue of the intestinal lipase. (*c*) On proteins : Succus entericus acts on protein directly in virtue of its proteolytic ferment, and indirectly by activating the proteolytic ferment of the pancreas, converting the zymogen trypsinogen into the enzyme trypsin. The erepsin acts on proteoses and peptones, breaking them down into crystalline biuret-free substances. Erepsin has no action on native proteins except on casein. As regards the activating action of succus entericus on trypsinogen we know that ordinary pancreatic juice obtained by secretin has little action on proteins, only dissolving fibrin after from four to six hours, and not attacking coagulated egg-white even after ten hours; if, however, a little succus entericus is added, the fibrin is dissolved in from three to seven minutes, while coagulated white of egg is digested within ten minutes. It is believed that trypsin is preformed in the pancreatic cells as a prozymogen, that this prozymogen becomes the zymogen (trypsinogen) as it is discharged

from the cells into the pancreatic duct, and that finally the trypsinogen is converted into the enzyme (trypsin) by the enterokinase of the succus entericus. Finally, in this connection, one might point out that the weaker the proteolytic action of succus entericus itself, the stronger is its activating action on the pancreatic secretion.

(2) The Mechanical Action of Succus Entericus.—Irritants introduced into the bowel result in the secretion of an excessive amount of watery succus entericus, the object of which is to flush out the bowel and thus remove mechanically the source of irritation.

The Movements of the Small Intestine.

The small intestine exhibits three distinct kinds of movement :—

(*a*) A pendulum, or swaying, movement.

(*b*) A wave-like, peristaltic, propulsive movement.

(*c*) A swift, vermicular or roll movement.

Of these three movements the first two are normal, while the third only occurs under abnormal conditions.

The pendulum movement is a gentle swaying movement, made up of narrowing and lengthening, alternating with shortening and widening of the bowel. These movements are repeated rhythmically in the same segment of gut over and over again. Pendulum movements occur in all parts of the small intestine, and are most obvious when the bowel is distended with food, *i.e.*, three to four hours after ingestion. The movements are most energetic in the upper, and least energetic in the lower, parts of the bowel. They affect successive segments of gut, gradually working from above downwards. The contractions occur at the rate of about ten to twelve per minute and involve both the circular and longitudinal muscle coats.

They progress at the rate of from one to two inches a second, complete contraction and relaxation occupying from five to six seconds. The object of the pendulum movement is to segment or break up the food, small particles fusing together, large particles swaying backwards and forwards for half an hour, and it is calculated that each mass is divided and redivided about 1,000 times at the same level in the gut. In addition to this primary purpose for the pendulum movement there is a secondary use in pumping blood through the mesenteric vessels, and chyle through the lacteals. The peristaltic wave may be described as a localised dilatation immediately followed by a constriction which travels in a wave-like manner down the bowel, taking from two to three hours to travel the whole gut. The rate of progress is slower during fasting than during digesting. Peristalsis may be regarded as a local reflex which is stopped by the application of nicotine or cocaine to the circular muscle coat. Cannon describes two kinds of peristalsis:—

(1) A slow advance with halts and segmentations.

(2) A rapid sweep through several turns of gut without a halt. This variety is frequently seen through the duodenum and follows complete segmentation of the food.

The roll or vermicular movement is essentially protective in function and only occurs under pathological conditions. It is a very rapid movement which, starting at the pylorus, traverses the whole gut in the course of a minute. It may be produced by irritants in the bowel, by the products of putrefaction—sulphuretted hydrogen, skatol, and various toxines such as occur in summer-diarrhœa. It is also produced in asphyxia by the action of carbon dioxide, and frequently occurs immediately after death.

In abdominal operations the intestinal movements are markedly affected. The administration of ether is followed by a very slow discharge of food from the stomach and a very slow passage of food down the small intestine. If the bowel is allowed to cool the passage of the food through the small bowel is very rapid. If the bowel is handled all movements cease for at least three hours, while if the bowel is divided and then sutured, if the operation is performed on the upper part of the small gut, nothing at all is allowed to escape from the stomach for at least six hours, while, if the operation is done lower down, there is no food escapes from the stomach for two hours, but it is delayed in the upper part of the small intestine for many hours. In other words, the time during which the movements are inhibited is sufficient for the parts to heal, not firmly, but sufficiently well for the passage of food. The emotions profoundly influence the intestinal movements, and observations on man by the *x*-ray method show that mental worry results in stagnation and retention of food in the stomach.

Movements of the Large Intestine.

When the remains of the food have reached the large intestine the digestive processes have practically been completed. No digestive juices are secreted in the large intestine, and its function is almost entirely receptive and mechanical.

The large intestine is generally divided into proximal, mesial, and distal segments. In man the proximal segment is said to consist of the cæcum, the ascending colon, and half the transverse colon. The mesial segment is made up of half the transverse colon, and part of the descending colon, while the distal segment includes the remainder of the descending colon and rectum. In general terms one may state that the content of the proximal segment is fluid, while the movement exhibited is an anti-peristalsis (*i.e.*, from transverse colon to cæcum). The content of the mesial segment is consistent and nodular, and its movement is a true propulsive peristalsis. As regards the last of the segments its upper part is frequently empty, while the content of its lower part is nodular and consistent and under the control of the pelvic nerves. The movements of the proximal segment are relatively feeble and alternated with periods of rest. Periods of activity last from two to three minutes, quiescent periods last from twenty to thirty minutes. The movements are feeble but can be evoked by rectal injections of gruel made of starch paste or pea flour and water. If bismuth is mixed with these substances the movements may be observed on a fluorescent screen. After the anti-peristaltic movement has gone on for some time so that the food is thoroughly incorporated with the digestive juices, the cæcum contracts periodically and propels the liquid food along the proximal colon. Food accumulates in the proximal segment till it extends to the end of the region of anti-peristalsis. The contents become more consistent owing to the absorption of water, anti-peristalsis disappears, while a circular constriction appears at the end of the anti-peristaltic region and cuts off a portion of the mass which is squeezed off into the mesial segment, being subsequently driven forwards by true peristalsis and hurried on until it reaches the distal segment, where it remains until evacuation. The onward movement through the colon is less active at night than during the day time. Normally, the ileo-cæcal valve only permits the passage of food from the small to the large intestine. It may, however, occasionally permit a passage in the reverse direction. It is supplied by the splanchnic nerves which have a cell station in the solar plexus. Breakfast reaches the cæcum in about four and a half hours, the hepatic flexure in six and a half hours, the splenic flexure in nine hours, the iliac colon in eleven hours, while the whole journey should be completed in eighteen hours.

Absorption of Food Products.

At this point it may be useful to briefly summarise our knowledge with reference to the absorption of the products formed during the various processes of digestion.

The stomach can absorb alcohol but not water. It can also absorb certain substances slowly from dilute alcoholic solution. Peptones can only be absorbed to a very slight extent from the stomach.

In the intestines salts and water are absorbed unchanged.

Carbohydrates are carried to the tissue mainly as dextrose or levulose which are the final sugars formed by the action of the ferments of the intestinal glands, and are the only sugars which are directly assimilable when injected into the blood stream. They pass into the blood, not into the lymph.

In the small intestine the peptones, which are the results of protein digestion, are further split up by the trypsin into amino-acids (leucin, tyrosin). As such they are taken up and reconstructed by the cells of the mucous membrane of the intestines, where they are finally transformed into tissue-proteins of the nature of the particular tissue of which they are destined to become an integral part. If proteins are given in an amount more than is required for the repair of the body tissues, or if with the protein an insufficient quantity of "Protein-sparers," such as carbohydrate and fat, be taken, then a portion of the protein undergoes what has been termed "denitrification." By this process the nitrogen-containing part of the molecule is split off, leaving the carbonaceous moiety to be utilised as a source of heat and energy, which is a metabolic state to be avoided on account of the excessive work the digestion of proteins entails. It is in this way as "protein-sparers," and not as foods, that many beef extracts, on account of the albuminoids they contain, may be of service.

The fat which has been saponified by the pancreatic juice is taken up as soap by the cells of the mucous membrane of the intestines and passed into the lymphatic channels, to be conveyed by the thoracic duct into the general blood stream and then to the tissues of the body. The process is the same whatever fat is given ; there is no attempt by the intestinal epithelium to reconstruct the fat into a substance of uniform composition, with the result that, unlike what happens in the case of proteins, the chemical characters of the fat taken influence the variety of fat stored in the body. Fat itself can be also absorbed at a slow rate.

The absorptive power of the large intestine for peptone, glucose, alcohol, salts, and water is good, whereas albuminoids are probably not absorbed at all, and fats but imperfectly. Certain foodstuffs when introduced into the large intestine are taken up and are capable of supporting the body for a limited period without any appreciable loss of weight. The addition of a pinch of salt to a nutrient enema promotes its absorption by facilitating its diffusion and possibly by exciting peristalsis.

Rectal Feeding.

The precise mechanism by which *food administered by the bowel* is absorbed is not definitely established, for, so far as is known, the colon secretes no digestive ferments. Some writers are of opinion that reverse peristalsis is set up, thus forcing the food through the ileo-cæcal valve to be digested by the juices of the small intestine, whilst others believe that the true explanation lies in some exceptional peculiarity of absorption. Rectal alimentation is, at the best, but an ineffectual and temporary substitute for mouth feeding.

Micro-organisms in the Alimentary Canal.

In addition to the changes produced in the food by the digestive enzymes, certain changes are also produced by the micro-organisms present in the alimentary canal, and introduced *via* the mouth. These organisms act chiefly in the lower end of the small, and in the large, intestine.

Organisms taken in with the food are first attacked by the leucocytes formed by the lymphoid tissue of the tonsils and pharyngeal tonsils. Those that escape enter the stomach, and there, in the presence of warmth, and moisture, proliferate and act on any sugars present, splitting them up into lactic and acetic acids, &c. Very soon, however, the acidity of the gastric juice increases and stops their action. The acid chyme is periodically squirted into the duodenum where it is rapidly neutralised by the bile and pancreatic juice. As soon as the intestinal contents become alkaline, acid-forming organisms grow again and split up sugar into acids (lactic, acetic, &c.), so that the reaction of the gut again becomes acid towards the lower end of the small, and the upper end of the large, intestine.

The fluids secreted by the mucous membrane once more render the contents alkaline, and in this alkaline medium organisms grow rapidly, attacking any unaltered protein present, and breaking it down into substances such as indol, skatol, phenol, sulphuretted hydrogen, &c. Many of these are poisonous bodies which pass into the blood and combine with inorganic sulphates in the liver to form harmless bodies, such as indoxyl or skatoxyl, sulphate of potassium or sodium, which are excreted in the urine. Cellulose, and indigestible carbohydrates, are split up into methane, carbon di-oxide, and water, while lecithin is digested as glycero-phosphoric acid and choline, the latter being a poisonous alkaloidal body which is broken up by bacteria into harmless substances —methane, carbon di-oxide, and water.

The presence of carbohydrates in any portion of the alimentary canal is believed to exert a restraining influence upon the multiplication of the bacteria which most rapidly decompose protein substances. The whole subject, though full of interest, and of greater importance than is usually supposed, is too complex for discussion here, but the relation of bacteria to infantile diarrhœa may be briefly referred to.

Bacteria and infantile diarrhœa.

This subject has received a large amount of attention, especially by medical officers of health, and statistics conclusively prove that diarrhœal disease is far less prevalent amongst breast-fed infants than amongst the bottle-fed. The general opinion now held is that the disease is usually, if not exclusively, caused by the specific infection of the infant's food, but the specific organism has not been definitely identified. It is probably a bacillus allied to the bacillus enteritidis of Gaertner, which, outside the human body, may be found in excremental matter. Opinions differ as to whether the specific bacteria get into milk during the act of milking or whether they get in during the time the milk is kept in uncovered vessels in uncleanly houses. Pasteurising or boiling milk undoubtedly kills the bacteria, and infants' food prepared with such previously heated milk is much less likely to cause autumnal diarrhœa than milk which has not been so treated. Attention to this detail and to the thorough scalding and cleansing of all vessels in which infants' food is prepared or stored will do much to reduce the mortality from diarrhœal diseases.

CHAPTER II.

ON MILK AND CREAM FOR USE IN INFANT AND INVALID FEEDING.

THE great value of a satisfactory milk supply is universally recognised by medical men, but it is unfortunately the case that, especially in our large towns, there is considerable room for improvement, and, whilst a clean milk of good average composition is desirable for all, it is of the utmost importance to the young, the weak and the ailing, where the natural powers of digestion, assimilation, and resistance to noxious germs, &c., are deficient.

Care should therefore be taken that the milk used is of good quality, clean, free from preservatives and colouring matter, and of the characteristic odour and nutty flavour of milk from healthy, well-fed cattle.

PRESERVATIVES IN MILK.

It is important, for obvious reasons, that the milk should be free from preservatives, the most usual of which are Boric Acid, Borax (often a mixture of these), and Formic Aldehyde.

The following table shows the action of these on the activity of the respective digestive enzymes.

	Ptyalin.	Pepsin.	Trypsin.	Pancreatic Diastase.
Boric Acid.	Retards.	Retards.	Retards.	Retards.
Borax.	,,	,,	{ up to 2% accelerates activity }	,,
Formic Aldehyde 1 in 50,000.	,,	,,	Retards.	,,

"The Public Health (Milk and Cream) Regulations, 1912," made recently by the Local Government Board came into effect as from October 1st, 1912.

The addition of any preservative substance to milk intended for human consumption and the sale or exposure for sale of preserved milk is prohibited.

Restrictions are placed on the use of preservatives in cream, it not being permissible, where cream is intended for sale for human consumption, for anyone to add :—

(*a*) any thickening substance to cream or preserved cream ;
(*b*) any preservative substance to cream containing less than 35 per cent. by weight of milk-fat ;
(*c*) to cream containing 35 per cent. or more by weight of milk-fat any preservative substance other than (i) boric acid, borax, or a mixture of those preservative substances ; or (ii) hydrogen peroxide.

The addition of preservatives must be declared.

Up to 1 per cent. boric acid has only a slight retarding action.

Borax.—The retarding action of borax on ptyalin, pepsin, and amylopsin is directly proportionate to the amount present. The increased activity shown by trypsin is probably due to the alkalinity of the borax.

Formic Aldehyde in higher percentage will destroy the action of the ferments entirely.

Preservatives therefore hinder the peptonising or predigestion of milk, and consequently interfere with the ferments in Benger's Food.

Flavours of Milk.

Milk is liable to vary in flavour from various causes, and the whole subject has been admirably dealt with by Mr. James Long, in an article entitled "The Flavours of Cows' Milk,"* and to this article we are indebted for the following information upon this little understood but important subject.

Invalids are particularly prone to detect any unusual flavour in a milk food, and this may render it unappetizing or even nauseating. It follows, therefore, that any milk which shows the slightest departure from the normal, either in odour or taste, should not be given to invalids or used for preparing invalids' food. The same applies to the food of infants.

The flavours communicable to milk are chiefly due to one or other of the following causes :—

(1) The breed of cattle and to different strains of the breed.

(2) To dry rations, or rations of dry cakes, meal, hay, and straw, to which certain succulent foods are added.

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* Copies of the complete article may be obtained, free of charge, on application to Benger's Food, Ltd., Manchester.

(3) To herbage in which certain plants are mixed with the grasses and clovers.

(4) To uncleanliness.

(5) Substances added as preservatives.

Flavour may be imparted by unhealthy cows which should be excluded from the herd under all conditions. There is reason to believe that the richest milk is best, imparting more of the flavour of the hazel nut to the palate. The fact can be readily demonstrated by comparing the flavour of the milk from a Jersey cow with that from an average cow.

There are many foods which play a conspicuous part in imparting flavour to meat and milk.

Linseed cake, which is rich in oil, is used by many farmers for the reason that it maintains condition and is a useful laxative, but it is well known that it detracts from the flavour of the milk, for the production of which it is employed. The fat of milk—which consists to the extent of 80 per cent. of olein, palmitin, and myristin—also contains certain fatty acids such as capric, caproic, and butyric. When fat decomposes—and we know this fact too well in the case of rancid butter—it is split up into fatty acids, which play an important role and probably give rise in some circumstances to bad flavour in milk. There is an organism which its discoverer, Freidenreich, has named *Clostridium foetidum lactis*, which develops a somewhat disgusting odour, and is recognised in a variety of cheese known as Limburg. Indeed, there are many species of bacteria which are responsible for similar results, and it is of the highest importance that perfect cleanliness should be observed in all that relates to milk production and distribution.

There is, again, a cause for ill flavour in milk in the fact that the teat of the udder is not always emptied, and that, in consequence, it is infected with bacteria. It was found by Schulz that in the fore milk, *i.e.*, the first drawn, 80,000 bacteria were found in a cubic centimetre, whereas the last drawn was almost sterile. The first milk should never be passed into the pail; nor should the cow stand where manure can easily reach the teats, and so through the hand of the milker the milk itself. There is no greater source of contamination than the coat of the cow. Some milk reformers recommend that every cow should be daily groomed, but though the proposal is excellent it cannot prevent contamination. Those parts of the coat which are touched by the milker should be sponged with the cleanest water before milking, so that no particle of dirt and no living germ upon it may fall into the pail.

It is a well-recognised fact that cows which have been milking for a long period of time produce cream (where the cream is skimmed), which is difficult to churn and which is *bitter* on the palate. This is now known to be owing to the fact that the milk contains bacteria of various species which have been separately found by a number of bacteriologists, including Conn, Weigmann, and Freidenreich. The bacillus of Weigmann has been obtained from sweet milk, and according to Swithinbank and Newman, it has produced a bitter taste in sterilised milk in twenty-four hours. While it produces butyric acid, it fails to digest casein. In the opinion of Weigmann the bitter taste was owing to the decomposition of the casein and albumen. In the bacilli known as the Hay group the majority appear to possess the power of producing bitter flavour, both in the milk and its products. This flavour may be entirely destroyed by cleanly habits throughout the processes of which dairy work consists, in spite of the fact that it may have been going on for years. Milk occasionally has a soapy flavour, which is most disagreeable, it may be dealt with similarly with the best results.

Finally, we may sum up the question in a few words by remarking that the two chief causes of the introduction of flavour which is disagreeable are unfriendly bacteria, obtaining an entrance into the milk through uncleanliness of the animals, workers, utensils, or water, and plants eaten by cows which possess the property of flavouring milk in a disagreeable way. Among these we may notice especially Camomile, Tansy, Spurge, Stinking Hellebore, Wood Anemone, Wild Radish, Hemlock, Marsh Pennywort, Garlic, Mustard, Corn Mint, Butterwort, Crow Garlic, Broad-leaved Garlic, and Horse-tail. The neck of the Swede, sour grains, sour ensilage, are also untrustworthy foods where it is essential to produce an article of the purest type, and these are amongst the most flagrant causes of flavour, especially the ensilage.

Where milk is scalded, or Pasteurised, a change in the flavour is perceived when it reaches 175° to 180° Fah. If, however, milk is heated in a closed vessel placed in a water bath, the change in flavour is deferred. In scalding milk to prevent an unpleasant flavour, the water in the jacket should be cold, then brought to boiling point for a few minutes. The milk when heated to the required temperature should be removed, and quickly cooled by placing the vessel holding it in cold water, but the lid should not be removed during any portion of the process. When cooled the milk may be aerated by stirring it well.

There are some causes which affect the nutrient materials in milk which may have some weight in relation to its flavour. The milk of the evening, *e.g.*, 4 p.m., contains much more fat than the milk of the morning, 5 a.m., while the milk produced between April and August contains less fat than at other times.

Composition of Milk.

The composition of milk varies within limits, and most often in the amount of fat. In milk, as delivered to the consumer, we find that the fat may vary from 3·1 to 4 per cent., but the average of a considerable number of estimations, made in our laboratory, of milk from a variety of sources is 3·5 per cent.

AVERAGE COMPOSITION IN PARTS PER 100 OF

	Human Milk	Average Cow's Milk	One-third Cow's Milk Two-thirds Water	Half Cow's Milk, Half Water
Casein, Lact-albumin } Proteins	1 to 2	3·40	1·13	1·70
Fat	3 to 4	3·50	1·17	1·75
Sugars	6 to 7	4·75	1·58	2·38
Ash	0·1 to 0·2	0·70	·23	·35
Water	90 to 87	87·65	95·89	93·82
Totals	100·1 to 100·2	100·00	100·00	100·00
Calories per 100 grammes	56·6 to 74·1	66	22	33
Calories per ounce ..	16 to 21	18·70	6·25	9·35

The protein of Cow's and Human Milk is composed mainly of caseinogen and lactalbumin. In Cow's Milk the lactalbumin forms about one-sixth of the total protein. Authorities vary widely with regard to the proportion in Human Milk; but one-third of the total protein may be taken as about the proportion of lactalbumin present; some say one-third of the total protein is lactalbumin, others two-thirds.

Cream.

When milk is centrifugalised, or allowed to stand for a few hours, the fat globules, being of less specific gravity than the fluid in which they float, tend to rise, and can be separated from the milk below.

If separated by means of a centrifugal machine, it is usually bottled and sold as "dairy cream," whilst the ordinary home-made cream is spoken of as "gravity cream."

Cream represents milk with the normal amount of fat increased, mainly at the expense of the water removed in the process of obtaining it. There is no official standard for cream. Cream as sold in the shops and obtained by means of a centrifugal machine, would have a distinct advantage if it could always be obtained fresh and free from preservatives, since it can be separated so quickly from new milk that bacteria have no time to multiply and cause any change in the milk.

The amount of proteins and sugar present in cream is very much the same as in cow's milk, but the fat varies.

In our laboratory we have found that representative specimens of market cream, in bottles, from different sources, and described as Cream, Special Cream, and Double Cream, contained from 41 to 50 per cent. of fat, the average being about 45 per cent. They generally contained preservatives, and there was no possibility of ascertaining how long they had been kept.

Where it is desired to use "market" or "shop" cream in the formulæ given in the schedule following page 69, it must be added in smaller amount or diluted so as to contain approximately 20 per cent. of fat, which is the average found in "gravity" cream, but its use is not recommended.

To obtain " gravity " cream, set aside in a cool place (55° Fah.) fresh cows' milk in a shallow vessel covered with a piece of clean, washed muslin or linen.

Allow to stand undisturbed for six hours, then remove the upper one-tenth, either by skimming or, if a Gourmet separator is used, by pouring off the lower nine-tenths.

If a pint of milk has been set aside, it should yield two fluid ounces (four tablespoonfuls) of good cream, if the milk is of average quality.

The following table shows the average percentage of fat, found in a series of estimations, in the upper one-tenth of ordinary cows' milk set aside for four, six, eight hours, and overnight.

Percentage of Fat in Original Milk, 3·5.

	4 hours.	6 hours.	8 hours.	Overnight.
	Per cent.	Per cent.	Per cent.	Per cent.
Upper 1/10ths	15·30	19·70	20·84	23·71
Lower 9/10ths	2·21	1·74	1·58	1·28

The portion removed should be well stirred and care taken to keep it in good condition until required.

In many cases, however, instead of using mixtures of cream and diluted milk it is preferred to use what may be called " upper " or " top " milk.

If milk is set aside undisturbed, the fat gradually rises, and the " upper " portion will be richer in fat than the " lower." By removing varying portions of this " upper " milk at the end of a definite length of time, milk of any required degree of richness in fat can be obtained.

The use of " upper " milk in infant feeding has found favour with some medical men, more especially in the United States of America where it appears to be used extensively.

Average percentage of Fat in different portions of average Cows' milk (3·5 % fat) after standing undisturbed the length of time indicated.

	Average percentage of fat found in four hours.	Average percentage of fat found in six hours.	Average percentage of fat found in eight hours.	Average percentage of fat found after standing overnight.
	per cent.	per cent.	per cent.	per cent.
Upper two-thirds	4·42	4·54	4·62	4·8
Lower one-third . .	1·70	1·51	1·29	0·96
Upper half	5·08	5·48	5·6	5·88
Lower half	1·90	1·57	1·4	1·15
Upper one-third . .	6·42	6·93	7·28	7·70
Lower two-thirds	2·02	1·75	1·62	1·37
Upper quarter	7·90	9·03	9·49	10·18
Lower three-quarters	2·00	1·68	1·56	1·30

The table on page 36, which is based on some 500 estimations of fat in various portions of a large number of samples of milk, after standing varying lengths of time, shows the percentage of fat which may be taken to be present in the portions mentioned, after standing the length of time indicated. Milk, as is well known, is very liable to change, and for this reason it is preferable to use upper milks which have stood the shorter periods. This is especially the case in warm weather where there is no refrigerator available. The figures show that there is practically no advantage gained by allowing the milk to stand more than four hours, unless a very rich milk is required.

HOW TO OBTAIN "UPPER" MILK.

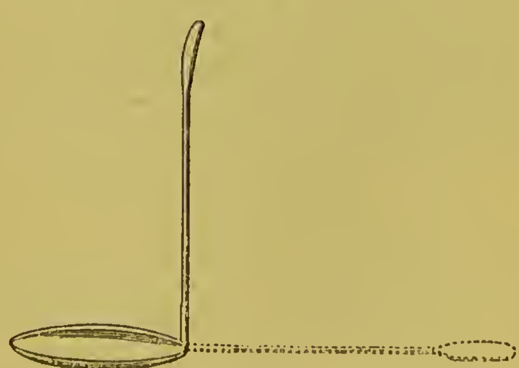
SET aside, undisturbed, in a cool place, fresh cows' milk at a temperature of from 50° to 60° Fah.—preferably at 55° Fah.—in a *clean* vessel covered with a piece of washed muslin or linen. At the end of the desired length of time, any portion of the milk may be obtained in several ways :—

(1) By syphoning off the remaining lower portion.

(2) By the use of an earthenware separator which allows the lower portion of the milk to be poured off, leaving the "upper" in the vessel, *e.g.*, the Gourmet separator, which can be obtained from furnishers of household utensils.

FIG. 1

FIG. 2.



(3) By taking off the portion required with a dipper. The one illustrated (Fig. 1) was devised by Dr. Chapin, of New York, and holds one fluid ounce. We have found a cheap tablespoon, with the handle bent at a right angle, answer very well (Fig. 2).

The upper milk to be used should be well stirred, and, if not for immediate use, should be kept in a cold place.

WHEY.

This is a milk product frequently found useful as a food for invalids and infants, or for preparing such foods. It is really milk from which most of the fat and protein matter have been removed.

It is the slightly turbid fluid which separates when warm milk curded by the addition of the rennet enzyme is allowed to stand or is broken up.

Experiments carried out by Schloss, at the Research Laboratory of the Board of Health, New York, reported in the "Archives of Pedriatics," 1909, page 438, show that from 70 to 80 per cent. of the bacteria in milk are removed by the clot formed by rennet in the production of whey.

By the action of Rennet the caseinogen of the milk is split up into insoluble protein (casein), whey protein, produced from the decomposition of the caseinogen, and the lactalbumin remaining in solution. If the curd is simply broken and the whey strained off the greater portion of the fat of the milk remains in the curd, and such a whey would contain approximately :—

Protein	0·8
Fat	0·2
Sugar	4·70
Salts........................	0·65
Water	93·65

If, however, the curd is thoroughly broken up with a fork and the whey strained through a piece of clean muslin, and the curds teased out in the muslin by screwing it round, there is a little increase in protein, and the fat is increased to from 1 to 2 per cent., the average found by estimation being 1·5 per cent.

Benger's Essence of Rennet, or Curdling Fluid, was specially prepared to meet the wish of the late Henry Ashby, M.D., F.R.C.P., Physician to the Children's Hospital, Manchester, for a curdling fluid to be used for the production of whey for use in infant feeding.

The process consists simply in warming one pint of milk to 104° F., then adding one teaspoonful of Benger's Essence of Rennet. Set aside for five minutes, then beat up the curd thoroughly with a fork and strain through muslin. If the whey is to be mixed with milk or cream, it will be necessary to destroy the still active ferment in the whey by warming it to 155° F., and keeping it at that temperature for ten minutes. If a higher temperature is used, the lactalbumin is coagulated.

The following quotation is from Dr. Ashby's article "On the Value of Milk Whey in Infant Feeding" which appeared in the "Edinburgh Medical Journal" for April, 1899:—

"Whey prepared in this way, with or without an addition of 2 or 3 drachms of milk sugar to the pint, makes a useful food for newly-born infants who have to be artificially fed, or for infants who suffer from chronic vomiting, or have liquid, green, and curdy stools. They will gain weight and be more comfortable than when taking diluted milk. A weak 'humanised' milk may be made by adding 10 oz. of fresh milk and ½ oz. of milk sugar to 20 oz. of sterilised whey. To make a 'humanised' milk more rich in fat, use 'top milk' in the same proportion. Let a quart of fresh milk stand in a covered glass jar in a cold place for four or five hours, remove the upper 10 oz. by skimming, add this to 20 oz. of sterilised whey with ½ oz. milk sugar.

"If these mixtures are carefully made according to directions, perfectly fresh milk of a good average quality being used, the analysis will work out something like the following, but exactness cannot be expected, inasmuch as milk varies in the amount of fat it contains and the time it takes to cream.

	Proteids.	Fat.	Lactose.	Salts.
Human milk, average	1·75	3·5	6	·3
Whey	·8	2	4·5	·6
Milk, 10 oz. / Whey, 20 oz. / Lactose, ½ oz.	1·75	2·5	6	·6
Cream (8 per cent. fat) 10. oz. / Whey, 20 oz. .... / Lactose, ½ oz.	1·75	4	6	·6

"It is always well to add a grain or two of bicarbonate of soda to render the mixtures neutral or slightly alkaline.

"It is often convenient to give dyspeptic infants whey at first or even to dilute the whey with a solution of maltose or barley water, as such infants cannot always digest as much as 2 per cent. of fat in their food. As they improve, add milk to the whey, or 'top milk,' as their digestive powers gain strength.

"It may be asked, What advantage has whey over a solution of lactose as a diluent? It certainly contains 'antiscorbutic' properties which a solution of milk sugar does not, and, moreover, it contains soluble proteids and a certain amount of fat. I have frequently found infants improve and gain weight after whey has been substituted for sugar water or barley water as a diluent for milk, and my experience is strongly in its favour. But more than the average intelligence is wanted in the nursery to carry out details."

CHAPTER III.

DIGESTION OF CEREAL MATERIALS.

Cereal food-substances consist mainly of Starch, together with a smaller percentage of protein bodies, fat, fibrous matter, and inorganic salts. A consideration of the digestion of cereal food materials resolves itself into an investigation of the action of digestive enzymes, viz.: the diastase of malt, ptyalin of saliva, and amylopsin of the pancreatic juice, which are very similar in their action, on the starch; and the proteolytic enzymes of the gastric and pancreatic secretions on the proteins.

The importance of starch as an article of diet is well known, and it is interesting to note that some two-thirds of the food we consume is composed of this carbohydrate, the chief sources of which are wheat, barley, potatoes, maize, rice, lentils, peas and beans.

Under the microscope the unbroken starch grains from each of these foods present definite, easily recognisable forms, which are composed of an outer protecting wall, described as starch-cellulose, containing within numerous fine particles known as granulose or starch proper, which is readily converted into sugars when treated with diastatic enzymes. Both starch-cellulose and granulose have the same chemical composition, which is of a complex character and is believed to be some multiple of $C_6H_{10}O_5$. Granulose is readily recognised by the action of a dilute solution of iodine and potassium iodide, which yields, in the cold, a characteristic blue colour.

The action of digestive enzymes on unbroken starch grains is very slow, owing to the resistance of the cellulose walls. Amylopsin and diastase of malt, it is stated, can dissolve the cellulose, but this is very slowly done. Starch, however, is not consumed in the raw state, but usually undergoes some preparation or partial cooking, and once the grains are burst the conversion of the contents is rapid. This breaking down of the grain may be accomplished by mechanical means, viz., by attrition with sand, and during the grinding and dressing processes in the milling of grain in the production of flour a considerable quantity of the starch grains is broken.

Dry heat also breaks down the starch grains, and at a temperature of 300° to 350° F. gradually changes the carbohydrate material into soluble dextrines. In the presence of water and under the influence of heat, starch grains first swell and then gelatinize, yielding, with from one to two per cent. of starch, an opalescent thickened fluid, or, if the mixture is concentrated, the usual well-known starch paste or jelly is obtained.

Starches from different plants are found to vary in the temperature at which they gelatinize, but almost all are burst at a temperature of 180° F. in presence of moisture. Wheaten starch breaks up at 150° to 160° F.

Starch or granulose under the influence of either ptyalin, amylopsin, or diastase (but especially under the two latter, which are more powerful than ptyalin), in the presence of water and at suitable temperatures, is readily converted into soluble sugars. If the process is followed by testing from time to time with dilute iodine solution, it will be seen that the conversion proceeds by stages (see illustrations, photographs VIII., IX., and X.), which may be stated as follows :—

(1) Starch. With iodine yields a characteristic blue.

(2) Soluble starch or amidulin. With iodine yields a blue tinged with purple.

(3) Erythro-dextrine. With iodine yields a yellowish brown or red.

(4) Achroo-dextrine yields no coloration with iodine.

(5) Maltose, which is the chief product obtained in artificial digestion of starches, yields no colour with iodine.

(6) Some small amount of dextrose may also be formed.

The whole of the starch is not changed into maltose, as part remains as dextrine.

These changes may be illustrated by the following formulæ :—

(1) $10\ C_{12}H_{20}O_{10} + 8\ H_2O = 8\ C_{12}H_{22}O_{11} + 2\ C_{12}H_{20}O_{10}$
Starch — Maltose. — Dextrines.

(2) $C_{12}H_{20}O_{10} + H_2O = C_{12}H_{22}O_{11}$
Dextrines. — Maltose.

In the preparation of starchy foods such as gruels or barley water the value of the action of heat is recognised. It is also necessary, when it is desired to pre-digest these, to have the temperature suitable for the action of the enzymes it is intended to use. The period of greatest activity in the conversion of starch by amylopsin is from 30° C. (86° Fah.) to 45° C. (113° Fah.). Above this the change becomes slower, until at 70° C. (158° Fah.) it is suspended, to be resumed on cooling provided the temperature of 70° C. has not been maintained for any length of time. At higher temperatures it is permanently destroyed.

In the digestion of gruels which have undergone previous boiling, the temperature should therefore be raised or cooled, as the case may be, to blood heat, and the digestive preparation added at that temperature.

The products formed consist of a mixture of soluble starch, dextrines, and maltose, varying in their relative proportions according to the activity of the ferments and the length of time allowed for digestion.

In the first chapter it was seen that the digestion of starch commences when it is admixed with saliva, continues for a time in the stomach, also that any portion which thus escapes digestion is afterwards acted upon by the pancreatic juice, and if any succeeds in escaping unaltered it is at a later stage attacked by the succus entericus, and the sugars produced by this action whether in the stomach or bowels, are quickly absorbed.

BARLEY WATER.

Barley Water is largely used as a diluent of cow's milk, and if present in sufficient amount and strength has the effect of making the curd of the latter much finer. (See illustration No. V.)

The following is a common method of preparation: Half an ounce of barley flour is well stirred with a little cold water to a pasty condition to remove lumps, then further water is added to make two-thirds of a pint (13·3 fluid ounces) in all. The whole is then gently simmered with constant stirring for 15 minutes, water being added from time to time to make up for the loss by evaporation. When cold the product is strained through fine muslin to remove any lumps.

A careful analysis of barley water prepared as above yielded the following result :—

Loss at 100° C.	97·09	per cent.	
Total Solids	2·91	,,	
Of the total Solids	0·81	,,	was soluble.
,, ,, ,, ...	2·10	,,	was insoluble.

The total Carbohydrates found equalled	2·43	per cent. and of this
the amount of soluble and insoluble were—		
Soluble Carbohydrates ..	0·45	„
Insoluble „ (starch)	1·98	„

This confirms the amount of starch found in barley water given in the quotation on page 56.

CHAPTER IV.

DIGESTION IN EARLIEST INFANCY.

Certain differences observed in the digestive processes during infancy require special reference. An infant cannot masticate food, and its natural food, mother's milk, and all suitable artificial foods require no mastication. As it is the act of mastication chiefly which causes the activity of the salivary glands, it follows that these glands remain inactive, or practically so, during the first few months of life. When the mouth of the infant is applied to the mother's breast, the reflexes causing suction and swallowing are set in action. The physiological and chemical processes which go on in the stomach vary somewhat in different animals and at different periods. Cow's milk is the natural food of the calf, and it requires no artificial preparation for the use of that animal; but it is not the natural food of an infant, and if not specially prepared, when introduced into the stomach of an infant, the curd produced is hard and indigestible. If specially prepared the curd formed may be as finely divided and as digestible as that formed from mother's milk. (Vide plates at end of book.) The addition of a little starch, as with Benger's Food, or in barley water, to the cow's milk has an extraordinary effect upon the character of the precipitated casein, and the experience of generations has shown that the use of small quantities of starchy material for this purpose is, in the main, entirely beneficial to the infant. An excessive amount of starch is undoubtedly injurious during the first few months of life, and because an excess has been found to be harmful, and it is now realised that the salivary glands yield little or no diastatic ferment during the first few weeks of life, there are many who think that all starchy substances are injurious in early infancy. However, all are agreed that at the age of six months the infant's digestive functions have so developed that starchy food can, usually, be readily digested.

Milk being the natural food of infants there will certainly be, in normal cases, digestive ferments present from birth which can deal with proteins, fat and milk-sugar, and make them assimilable. The most interesting and important question is the time at which the salivary and pancreatic diastatic ferments (ptyalin and amylopsin) develop in practical amount in the infant economy. The action of saliva, which has some little diastatic power from the first four weeks of life, if not from birth, can only play a very small part in digestion, as the food of an infant remains such a short time in the mouth, where the ptyalin exerts a great portion of its activity. The food, once in the stomach, meets the acid gastric secretion, which gradually puts an end to the activity of this ferment. The pancreatic secretion is the most important for starch digestion, and recent observations show that there is a definite amount of diastatic ferment secreted at birth, the contents of the intestines of newly-born infants possessing some amylolytic power. This ferment increases in amount with age and probably also with any demand for it which may be created by the presence of starch in the infant dietary.

In human milk nature provides a starch-free food. But whilst this is so there is not only no indication that small amounts of cooked starches cannot be dealt with by the intestinal secretions, and transformed by them into the ultimate end-products of digestion suitable for absorption, but there is actual experience to show that many children from earliest infancy undoubtedly thrive on such foods and take no harm from the amount of starch which is universally administered in the homely diluent, barley water, in which there is from one-half to two per cent. of starch according to the dilution and the method of preparation.

Modern observations even show that apart from the effect that a diluent, like barley water, possesses as a maker of flocculent curd, the starch thercin contained may even have a beneficial effect on gastro-intestinal changes in infants. As has already been remarked, the presence of a carbohydrate exerts a restraining action on the growth of proteolytic bacteria which give rise to putrifactive changes in the intestines, the products of which are the cause of some intestinal troubles.

If unconverted starch acts in this beneficent way, it is obvious that its administration in suitable amount in infant feeding is not only not contra-indicated, but may be, in some cases, even beneficial.

All artificial food prepared from cow's milk requires the addition of some sugar to supply this carbohydrate in proper amount, and cxperience shows that it is not necessary to add milk sugar, but that cane sugar, maltose, and dextrines (converted starches) will supply quite satisfactorily the deficiency in sugar.

Whilst there are many infants quite able to assimilate a diet of cow's milk, barley water, and cane sugar, there are also many that require the further help of the partial predigestion of the proteins of the milk, and this can only be managed by the addition of some tryptic ferment to the food. It is in this latter class of infants that a pancreatised cereal food for use with fresh cow's milk is of so much value, providing, as it does, a partially predigested carbohydrate and protein (the casein of the milk).

It was with the object of preparing such a food that the late F. Baden Benger continued the observations with pancreatic ferments which he was carrying out for the late Sir William Roberts, and which resulted in the preparation now known as Benger's Food.

The very great value of the treatment of milk with Benger's Food is, that, without converting the curd to any great extent, it acts on it sufficiently to overcome the great objection peculiar to cow's milk, viz., the clotting in large masses in the presence of the gastric fluid. *It is important to note that there is not sufficient of the tryptic ferment present in Benger's Food to thoroughly predigest the casein,* and whilst, within a limited range, more or less complete predigestion is obtained by a longer or shorter treatment, its obvious value is in adapting a food to individual cases; if a completely predigested food is wanted, then more ferment in the form of Benger's Liquor Pancreaticus or Benger's Peptonising Powders must be added.

This is very important when considering the question of atrophy, or the fear of gradual loss of function from unused digestive powers. Whilst therefore Benger's Food does carry predigestion a stage or two forward, it is important to remember, that, if prepared according to the directions for use, there is always something further for the digestive functions to do for themselves.

Analyses made of the prepared Benger's Food shew that a portion of the casein is converted into proteoses, and that little if any peptone is formed. The fat is not affected.

CHAPTER V.

PREDIGESTED FOODS IN TREATMENT AND THEIR ORIGIN.

WHILST S. Darby was probably the first to carry into actual practice the idea of preparing an artificially digested food, viz., "Darby's Peptonised Fluid Meat," the great and valuable uses to which such foods are now put in the treatment of disease, date from Sir William Roberts' classical and widely known Lumleian lectures on "The Preparation and Use of Artificially Digested Food," delivered before the Royal College of Physicians in 1880. Before Roberts took an interest in the subject, difficulties were encountered in the production of an artificially digested or peptonised food suitable for invalids, mainly owing to the use of the gastric method of its preparation. When milk, bread, egg, or meat is artificially digested with pepsin and hydrochloric acid, the results, both in appearance and taste, are very unappetising, not on account of the actual taste of the digested food itself, but because of the by-products of various kinds which accumulate as digestion proceeds. One of these by-products of protein digestion is a very bitter substance which Roberts thought gave the bitter taste to eructations met with in dyspepsia. He, therefore, tried to improve matters and used the pancreatic juice in his experiments. This promised one definite advantage over gastric digestion inasmuch as the pancreas can digest starches as well as proteins. Dr. Roberts sought the assistance of Mr. Benger in the practical work connected with his investigations, with the result that the well-known Liquor Pancreaticus was prepared, which, in Roberts' own words, "is an almost faultless pharmaceutical preparation" possessing the diastatic and proteolytic properties of the pancreas in a highly concentrated degree. It is a nearly colourless solution with very little taste or smell beyond that of the spirit used to preserve it. When this extract was added to milk it was found that digestion took place "with comparatively little disturbance of its taste and appearance."

Curiously enough, however, when ordinary milk was heated with the pancreatic extract it curdled, and although, in the further stages of digestion, this gradually redissolved, a portion of it proved to be very resistant and remained undissolved for many hours; but when the milk was diluted beforehand with one-third or one-fourth of its bulk of water, no curdling took place, the digestion or peptonisation proceeding with the milk in a fluid condition and with only a slight change of colour and appearance. During these changes the milk gradually lost its proper flavour and developed a slightly bitter taste, which is to many palates not disagreeable. No really unpleasant flavour was produced unless the process was allowed to go on to incipient decomposition. Such, briefly, were Roberts' laboratory experiments which formed such an important epoch in the preparation of food for invalids.

Predigestion of food, then, by pancreatic extract, has a double advantage over predigestion by pepsin and hydrochloric acid because starches and proteins are affected, and no unpleasant appearance or smell of the digested food need result.

Uses of Partially Digested Foods in Treatment.

It is not for us to instruct the medical man as to the special diseases in which it is desirable to help the alimentary system to carry out the functions of supplying food in an assimilable form to the body. We need only suggest the broad indications for the administration of partially or wholly predigested food, namely, illnesses in which it is necessary to help digestive functions which are impaired or arrested by disease, or in which it is desirable to supply the organs with a food which leaves very little unabsorbable or irritant residue. Frequent reference to the use of Benger's preparations in many diseases will be found in many classical works of medicine and current medical literature. A few of these will be found on pages 102 to 108.

As to how far it is advisable that predigestion should be carried in actual practice, the following extract from page 212 of Roberts' Diet and Digestion, in the chapter on "Deductions from Experiments" will be of interest :—

"Except in extreme cases, when the digestive power is wholly lost, or in complete abeyance, it is more advantageous to use a food which has been subjected to partial artificial digestion than food in which the process has been carried out to completion. If the patient possesses any digestive power at all, it is better that that power should be kept in exercise than that it should be permitted to deteriorate still further from total disuse. This is in agreement with the rule we apply in other cases of enfeebled functions, according to which we endeavour to combine partial rest with moderate exercise."

Nutritive Value or Energy-Quotient.

The far-reaching effect of Roberts' work will perhaps be better appreciated, if we consider for a moment the standard by which a foodstuff is to be judged. The physical test of any article of diet is based upon the potential energy it is capable of yielding when oxidised in the body. This energy is measured in Calories, a Calorie being the amount of heat required to raise 1 litre of water 1° C., or 1 pound of water 4° Fahr.

1 gramme of protein taken as food yields	4·1	Calories.
1 gramme of carbohydrates taken as food yields	4·1	,,
1 gramme of fat taken as food yields..	9·3	,,

To obtain, therefore, the total Calories yielded by 100 grammes of any foodstuff, one has merely to multiply the percentage of protein and carbohydrates by 4·1 and the percentage of fat by 9·3. An average man doing moderate work requires about 3,000 Calories per day. But to be satisfactory, a diet must, in addition to furnishing the requisite number of Calories, not only contain the proper percentage of each nutritive constituent, but also present them in a form capable of being digested and absorbed. It is with this latter, or physiological test, that predigestion is particularly concerned, since it makes possible the reception of foods, known to be highly nutritious, by stomachs which, on account of some impairment of function, could not, unaided, have dealt with such nutritious food.

In comparing the relative nutrient values of any food preparation, the comparison should be made of the latter in the form in which it will be consumed, *i.e.*, cooked and made ready for consumption, and regard should be had not only to the total Caloric value, but especially to what portion of that total value is in a condition likely to be utilised by the body. Cellulose and cooked starch have much the same chemical composition and Caloric value outside the body, but there is no comparison in their availability from a human food-value point of view.

CHAPTER VI.

STARCH DIGESTION IN INFANCY.

Amongst physicians who have made a special study of infant feeding, there are great differences of opinion as to the age at which starchy food should be used. Unfortunately, the opinions are not always based upon actual observations of the effect of farinaceous foods on children, but sometimes upon test-tube experiments and deductions from the observations of physiologists as relating to the periods at which certain glands become active or begin to secrete particular ferments. Others, noting that a large proportion of starchy food is dangerous during the first few months of life, argue that even the smallest proportion is contra-indicated. Others, again, from their experience with one form of starch, or farinaceous food, condemn all such foods, irrespective of whether the farinaceous constituent is predigested or not. Obviously there is the greatest possible difference between a mere aqueous solution of starch, and the same solution after it has been acted upon by a ferment which has converted by far the larger proportion into dextrines and sugars. There are many also who take up the illogical position of condemning starchy foods in early infancy, and of recommending the use of mixtures of cow's milk with barley water. Now, barley water is nothing more than a solution of starch, and, as usually made, contains from 1·8 to 2·3 per cent. of starch. A mixture of equal parts of milk and barley water will contain about 1 per cent. of starch, which is more than is contained in a food for young infants prepared from the formulæ prescribing Benger's Food. This concentrated preparation as sold in Tins contains a large proportion of starch, but when diluted and properly prepared only a trace of this starch is left, the remainder having been converted into soluble dextrines and sugars which are easily assimilable at the earliest age.

Anyone who cares to compare carefully the almost diametrically opposed opinions set out below will notice this divergence of opinion, and will almost certainly conclude that, whilst in early infancy an exclusively farinaceous diet, or a diet containing more than a certain quantity of starch, is likely to be injurious, yet that the administration of the very small quantity of starch necessary to prevent the formation of large and dense flocculæ of casein in cow's milk, is not only not injurious but positively beneficial. Of course, there are exceptions to all rules, but because on occasions an infant does not thrive on cow's milk, we do not argue that cow's milk is deleterious to all infants, and if an occasional infant does not thrive on a food containing a proper amount of starchy matter, it does not follow that starch is always deleterious. Referring to some of these idiosyncracies, Dr. Hutchison* says :—

> If a child is unable to digest much cow's milk, it is often worth while to try the effect of adding a little starchy food to the diet, even at an early age, for inability to digest milk appears to be sometimes accompanied by an unusual capacity for conversion of starch.

In a recent article contributed by Dr. Cautley† to the "Lancet," the question of starch digestion in babies is fully discussed, and at the conclusion of the paper he summarises the results of his observations in the following words :—

> The general conclusions from the above observations afford physiological and chemical support of the empirical use of starch in infant

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* Lecture on "Infant Feeding," *Lancet*, Sept. 19th, 1903.
† "Starch Digestion in Babies," *Lancet*, Nov. 6th, 1909.

feeding and may be summed up shortly as follows: (1) A diastatic ferment is secreted by the salivary glands and pancreas of new-born infants and even before birth. (2) Its amount and activity are slight in the first few weeks of life, and after that rapidly increase. (3) The glands, notably the pancreas, can be trained by means of a starchy diet to the secretion of an increased amount of the amylolytic ferment. There is no inherent reason why this training should not be begun shortly after birth in the case of the bottle-fed infants instead of waiting until the child has attained the age of six months, as so commonly advised on purely theoretical grounds. (4) Practical experience has shown that the usual barley water contains about 2 per cent. of starch. If mixed with an equal quantity of milk there will only be 1 per cent. of starch in the mixture. Such an amount is non-injurious and almost certainly is beneficial, for it encourages the growth of lactic acid bacilli and the formation of lactic acid. These organisms are of undoubted advantage in the prevention of the growth of proteolytic bacteria. (5) If a starchy food is used in the first few weeks of life it is advisable to begin with a milk mixture which will not contain more than 0·5 per cent. of starch and to gradually increase the amount as the child gets older. Indeed, at any age when a starchy food is first given it should be in very weak solution and slowly strengthened up to as much as 3 to 5 per cent. If the stools become very acid, or if they give a distinct starch reaction, the percentage of starch in the diet must be reduced. (6) Special care must be paid to these considerations in the first two months of life, because of the deficiency of salivary secretion. Further investigations may possibly show that this is a point of little importance as the pancreatic secretion may be sufficient in quantity and activity. (7) The evil effects of starch in early life are due to (*a*) excess; (*b*) its administration in the form of a more or less insoluble emulsion instead of as soluble starch; and (*c*) the substitution of starch for the necessary protein, fat, and salts. In other words, the mischief results from deficiency of necessary proximate principles of diet rather than from the presence of starch.

To discuss the subject fully would take up far too much space, and would not be of sufficient general interest. Still, in an article of studied fairness, all views should be represented, and in parallel columns are given the opinions of a few eminent men in the profession who have studied the question, and those who wish to further study the subject will find the Bibliography at the end particularly useful.

G. F. Still, M.D., F.R.C.P., Professor of Diseases of Children, King's College, London. COMMON DISORDERS AND DISEASES OF CHILDHOOD, 1909, *page* 62.

My own experience leads me to think that even such a small amount of starch (1 to 2 per cent.) as is present in barley-water is often harmful, and that all foods containing any starch whatever should be avoided until the infant is eight or nine months old, and even then starch-containing foods should only gradually be introduced, so that by the end of the tenth month an infant may be having two meals of starch-containing food in the day.

F. Smith, M.D., F.R.C.P., Physician to the London Hospital. INDIGESTION. *Practitioner, Oct.,* 1909.

I wish to protest against the view that babies cannot digest a small proportion of carbohydrate material, ... scientific baby-feeders have to recommend the addition of barley water to cow's milk, and this contains much more, and worse prepared starch than do some of the best proprietary foods.

Extract from DISEASES OF INFANCY AND CHILDHOOD (1908) *by L. Emmett Holt, M.D., Sc.,D.LL.D. New York, page* 206.

The use of the various cereal decoctions as an addition to the milk for young infants is a subject much discussed, and the question cannot be regarded as settled. I am quite convinced that this is a useful measure for some infants, but not that it is desirable for all. Surely no point in infant-feeding is better established than that the early use of much farinaceous food often results in serious harm. The addition to milk of farinaceous food in any considerable quantity should, I think, in the feeding of young infants be limited to those in whom some special conditions are present, particularly those who have more difficulty than usual in digesting the milk proteids. This subject will be considered more fully

Charles G. Kerley, M.D., New York, CARBOHYDRATE INCAPACITY IN INFANTS AND YOUNG CHILDREN.—*Archives of Pediatrics, March,* 1908, *page* 203.

Starch.—Some infants have a low fat capacity, some a low sugar capacity, some a low proteid capacity, and others a low starch capacity. That the youngest infant can digest starch was proven in the New York Infant Asylum observations a few years ago, which were made under my directions and which have been published.

Our observation was that if starch was not digested it did little harm. The removal of the starch from the food in children with distended abdomens produces little or no effect on the tympanites in most cases, the distention being due to other causes. The chief harm which we found arising from starch feeding was under the discussion of "Difficult Cases of Feeding."

the constipation which sometimes followed its use. This may be prevented by the use of some dextrinizing agent to convert the starch into the laxative maltose. It is rarely wise to use it in stronger mixtures than 3 per cent. in children under one year of age.

As relates to the starch digestive capacity of young infants it had been demonstrated conclusively, both from the experimental and clinical standpoint, that the youngest child may digest starch.

Cautley: "Starch Digestion in Babies,"—*Lancet*, Nov. 6th, 1909.

Pritchard: "The Physiological Feeding of Infants." 1909. Chapter on "Intestinal Digestion of Carbohydrates."

Jacobi: "The Role of Pure Cows' Milk in Infant Feeding."—*Maryland Medical Journal*, June, 1906.

Meara: "Problems of Nutrition in Early Life."—*Archives of Pediatrics*, vol. xxvii.

Chapin: "Theory and Practice of Infant Feeding." 1904.

Cautley: "Use and Abuse of Proprietary Food in Infants' Feeding."—*The Practitioner*, May, 1909.

Rotch: "Modern Laboratory Feeding."—*Archives of Pediatrics*, vol. xxv.

Holt: "Diseases of Infancy and Childhood." 1908. New York.

Fordyce: "Hygiene of Infancy and Childhood." 1910.

Corlette: "A Review of the Subject of Starch Digestion in Infants."—*Australian Medical Gazette*, Jan. 20th, 1905.

Kerley: "Carbohydrate Incapacity in Infants."—*Archives of Pediatrics.* 1908. Page 203.

Cameron: Pfaundler and Schlossman's *Encyclopædia of Diseases of Children.* 1908.

Ferriera: "Starchy Diet in Gastro-enteritis."—*Arch. des Infants*, May, 1908.

Finklestein: "Diseases of Nurslings." 1911.

Poynton: Cheadle's "Artificial Feeding and Food Disorders of Infants." 1906.

Sutherland: "A System of Diet and Dietetics." 1908.

Brockbank: "Children—Their Care and Management." 1912. Page 51.

CHAPTER VII.

BENGER'S FOOD FOR INFANTS UNDER SIX MONTHS.

The rule followed since the introduction of Benger's Food, has been to supply medical men with information on its composition, preparation, and properties and, of course, leave to them the decision as to its suitability in any particular case.

The Food is prescribed when conditions are considered to indicate its use, and when no longer required it should, naturally, be discarded.

Benger's Food is not put forward as a facsimile mother's milk, but as a useful adjuvant to milk or a milk mixture, on the casein of which it acts so as to render it much more easy of digestion, and clinical experience has amply confirmed its value in many cases of difficulty in the feeding of young infants. A reference to the formulæ, given in the table following p. 69, will show that it can be prepared so as to approximate the composition of human milk, and a further reference to the photographs will show how it is likely to curd in the presence of the acid gastric juice. It will also be noticed that there is always a certain amount of the wheaten starch in the Benger's Food unconverted by the amylopsin contained therein. This amount will vary, in the main, according to the amount of Benger's Food employed, and the length of time allowed for digestion. In the formulæ more suitable for infants under six months of age, it will vary from under ½ to 1 per cent. which is less than the amount in barley water.

On the question of the use of Benger's Food for infants under six months of age, the proprietors consulted the late Henry Ashby, M.D., F.R.C.P.—a recognised authority on Infant Feeding and Children's diseases—in 1907, in connection with the setting up of a starch-free Infants' Food Standard in Victoria, Australia. His opinion—which he gave permission to quote—was as follows :—

" The great value of Benger's Food in softening the curd of cow's milk, so that it can be utilised by these young infants, far outweighs any disadvantage there may be from the presence of the small amount of unconverted starch, which is almost negligible in the Benger's Food as prepared for their use," and he further added, " *It is exactly in the first six months of life that I find Benger's Food most useful.*"

The following is from a report and analysis of Benger's Food by John C. Thresh, M.D., D.Sc., &c., London Hospital Medical College :—

" I know of no objection to the presence of a small proportion of starch in the food of young infants, so long as all the necessary constituents for its growth are also present, as is the case in the food in question. If not utilised it is simply excreted, whilst at a later period when the saliva becomes capable of acting upon it, it is dissolved and increases the nutritive value of the food."

Extract from an article by Edmund Cautley, M.D., F.R.C.P., entitled The Use and Abuse of Proprietary Foods in Infant Feeding, *in " The Practitioner,"* May, 1909.

The same objections hold good for condensed milk. Perhaps malt sugar is less injurious than cane sugar. The foods which contain starch are only suitable, except in very small amounts, after the sixth month of life. Two other foods worthy of mention are Benger's Food and . . . The latter is composed of desiccated milk, malted wheat flour, and lactose, and, in the process of preparation, the casein is partly digested by extract of pancreas. It is comparable with the foods made from condensed milk and partly malted flour, and is much inferior to Benger's Food, as that is made with fresh milk. Benger's Food is a mixture of cooked wheaten meal and extract of pancreas. In the process of preparation mixing it with warm milk and water, the ferments partially peptonise the proteins, and partially convert the starch into soluble dextrines and sugars. The fat is unaffected. It is most valuable for marasmic infants after the sixth month of age, but can be used even three months earlier, if given in small amounts, say one half to one teaspoonful in each feed. The addition of a small half teaspoonful to each feed is about equivalent to using thick barley water instead of water in the food mixture and has the additional advantage of partly digesting the food. If it agrees with the child it can be continued for some months, provided it is never forgotten that the prime constitutents of the diet are the milk and cream with which the food is mixed, and that it must not be increased in quantity at the expense of these constituents. As a recent instance of its value, the addition of one teaspoonful to the diet of a child, aged four months, who had remained practically stationary in weight for a month, resulted in a gain of nearly a pound in weight in one week.

Dr. Cautley also contributes a valuable article on "Patent and Proprietary Foods" in Dr. Sutherland's "System of Diet and Dietetics," in which reference is made to the value of Benger's Food.

During the past year most eminent physicians have been consulted on the use of Benger's Food in Infancy, and the matter in Chapter VIII. has been most carefully considered by them, and has received their unreserved approval. The names of these gentlemen will be given privately to any medical man sufficiently interested in the subject.

CHAPTER VIII.

THE FEEDING OF INFANTS
AND THE
USE OF BENGER'S FOOD.

(See last paragraph on page 61.)

When it is necessary to replace natural feeding, either partially or entirely, some modification of fresh cow's milk is usually given. This modification is necessary because cow's milk differs in composition from human milk. It contains more proteins (or flesh-forming materials) and more inorganic salts, about the same amount of fat, but less sugar. In the presence of the acid fluid in the stomach cow's milk produces large curds, which are digested with difficulty by an infant, whereas human milk produces very fine and easily digestible curds.

Cow's milk is intended by nature for the rearing of calves, and if used for infants it requires some modification. By dilution with water and the addition of sugar and fat, a mixture can be made which approximately corresponds to the composition of mother's milk.

The usual proportions of milk and water employed are as under :—

For infants of 1 to 2 months.	One part of milk to two parts water.
For infants of 2 to 6 months.	Equal parts of milk and water.
For infants of 6 to 9 months.	Two parts milk to one part water.

If good milk is available it is not imperative to add cream, but it is necessary to add a little sugar of milk or ordinary lump sugar.

Many babies thrive on these mixtures, but others cannot digest the diluted milk, probably on account of the nature of the curd formed in the stomach. In some cases the substitution of barley water for plain water yields a food which can be digested when plain milk and water does not agree. Some babies cannot digest even the barley-water mixture at any time, and with others there are periods when it does not appear to give satisfactory results. In these cases the diluted milk must be so treated as to render it more readily digestible.

Benger's Food was specially designed for this purpose, since, when properly prepared, it partially digests the casein contained in the milk, preventing the formation of large curds and enabling the stomach to complete the digestion. At the same time it increases the amount of sugar present and renders the mixture more comparable in composition with mother's milk. The prepared food can be used temporarily or even continued for months if necessary.

The proportions of Food, milk, and water can be varied so as to serve for infants of different ages, the general rule being to increase the amount of milk and food, and to decrease, in proportion, the amount of water as the baby gets older and the food is found to agree. It is important that the increase should take place gradually, the food being strengthened little by little as the baby grows.

Special mixtures have been devised to meet all ordinary cases and to guide medical men in their selection of the food most suitable for special cases. The results of the analyses of mixtures made from various formulæ are given in the table following page 69.

In consulting this table it is important to remember that variations can be effected. If, for example, a medical man desires to give a higher percentage of fat, this can be done by adding cream, whereas the proteins and sugars can be increased by using a little more of the Benger's Food. With this table as a guide the physician can prescribe a food containing whatever proportions of the various constituents he may desire.

The following mixtures are suggested for general use.

FORMULÆ SERIES A.

For babies 1 to 3 months old, or at other ages (over one month) when first commencing to use the food, or whenever digestion is much enfeebled.

For example, Formula A (1):—

Take of Benger's Food ¼ ounce or two teaspoonfuls, sugar of milk ⅓ of an ounce or two rather large teaspoonfuls. Mix together in a basin and stir in 4 tablespoonfuls (2 fluid ounces) of cold water. To this add gradually, with constant stirring, the following mixture just off the boil :—

Milk, 4 ounces }
Water, 6 ounces } =10 ounces.

Then set it aside 30 minutes to digest. At the end of this time return it to the saucepan and raise to the boiling point, stirring all the while. When cool the food is ready for use.

Various ways for increasing the amount of fat in the food are given in Formulæ A (2), (3), and (4).

FORMULÆ SERIES B.

These Formulæ are devised for children of from 3 to 6 months of age, and for younger infants who are already digesting a weaker mixture and need a more nutritious food. They are richer in proteins and sugar.

FORMULÆ SERIES C.

Applicable for children of 6 to 9 months and for younger infants who need a stronger mixture than those of Series B.

For example, C (1) :—

Take of Benger's Food ½ an ounce, water 2 ounces. Mix together in a basin and add, just off the boil, a mixture of

Milk, 6 ounces }
Water, 4 ounces } =10 ounces.

Set aside for half an hour. Then raise to the boiling point, stirring continuously.

FORMULÆ SERIES D.

From 6 to 9 months and occasionally under 6 months of age, Formulæ Series D, in which the proteins, fat, and sugar are further increased, can be employed.

For example, Formula D (1) :—

Take of Benger's Food ½ an ounce, water 2 ounces. Mix and add, just off the boil,

Milk, 8 ounces }
Water, 2 ounces } =10 ounces.

Set aside for half an hour, &c.

At 8 or 9 months of age and sometimes earlier a less-digested Benger's Food may be used, made by allowing the mixture to stand only 15 minutes to digest instead of half an hour; or the meals may consist alternately of milk and barley water, and prepared Benger's Food, and subsequently of four feeds of milk and barley water, to two of Benger's Food, prepared according to the Formulæ of Series E, up to 12 months of age. One such feed daily may be given with advantage until the child is taking an ordinary mixed diet.

Whenever necessary the fat in any of the series can be increased by adding more cream, or using a richer upper milk, *e.g.*, the top half, third, or quarter. An excess of fat must always be avoided, as many infants can only tolerate it in small amounts, but when it can be taken it is a preventative of constipation and rickets. Shop (centrifugal) cream is not recommended, but if it must be used in an emergency remember that it contains twice as much fat as ordinary (gravity) cream. It does not mix so well as gravity cream, and is less likely to agree. Special care should be taken to see that the cream is fresh, perfectly sweet, and free from preservatives, otherwise it is sure to disagree. When adding cream, one teaspoonful to one or two tablespoonfuls may be added to each 12 ounces of the prepared food, and it may be added just before the final boil, or incorporated with the milk mixture.

Upper or top milk may also be used for increasing the proportion of fat. This is simply fresh milk set aside for four hours in a lightly covered jug for the creamy portion to rise. The jug should be kept in a cold place, a refrigerator if available in summer, otherwise on a window ledge having a north aspect. At the end of the four hours the upper half can be ladled off. If only the upper third or one-quarter be taken off it will be still richer in fat. (See pages 35 to 37.)

Amount of Food Required for Each Meal.

The quantities given on the labels of the tins of Benger's Food are about the average. Be careful not to overfeed. If a baby is much above the normal weight for its age, or is increasing in weight too rapidly, it is probably being overfed.

A baby may be said to be progressing favourably :—

When the bowels are regular and the stools normal ;

When it is bright and cheerful, and sleeps comfortably ; and

When the weekly increase of weight is :—

Up to 3 months of age, 5 to 7 ounces.
3 to 6 months of age, 4 to 6 ounces.
6 to 9 months of age, 3 to 5 ounces.

How to use the Formulæ in the following Schedule.

The ordinary method of preparation, as given on page 80, is to be followed, but in each case two ounces of water are taken from the total of 12 ounces of fluid, and this cold water is mixed with the dry food ; the remaining 10 ounces are to be brought to the boil and added according to the usual directions.

Double the quantities given in the Schedule may be used at one operation when a little over a pint of prepared food is required. Not more than this quantity should be made from these formulæ, as too hot a mixture for satisfactory digestion would be obtained. Should 30 ounces, or thereabouts, be wanted during the day, it is preferable to make one lot of one pint, and later in the day a second lot of half-a-pint, or vice versâ.

Quart quantities should be prepared by making two separate lots from the one-pint proportions.

Any prepared food not required for immediate consumption should be cooled down and kept in a covered jug in a cold place. Stir up well before taking the required amount when wanted. No prepared food should be kept longer than a day in cold weather, and not more than eight or ten hours in warm weather. See specimen prescriptions pages 68 and 69.

Specimen prescription using ordinary milk, sugar of milk, and cream.

Suppose No. 4 Formula of Series B was selected.

Take of

Benger's Food, one level tablespoonful

Sugar of Milk, one heaped teaspoonful

Water, four tablespoonfuls (2 fl. ozs.).

Mix together in a basin to a smooth paste, then add gradually, whilst stirring, half-a-pint of milk and water,* just off the boil, as instructed in the directions on the tin. Set aside away from the fire, or other source of heat, to digest for 30 minutes then pour into a saucepan and slowly heat, whilst stirring, until it comes to the boil. When sufficiently cool it is ready for use.

* Use milk, water, and cream in the following proportions :—

Milk, three ounces ...	Half-a-pint.
Cream, one ounce ...	
Water, six ounces...	

The cream to be obtained by setting aside a pint of fresh cow's milk in a cool place for six hours, then skimming off four tablespoonfuls.

A tablespoonful equals approximately half an ounce.

Specimen prescription using "upper" milk and no sugar of milk.

Suppose No. 2 Formula, Series D, was desired.

Take of

Benger's Food, one level tablespoonful

Sugar of Milk, none

Water, four tablespoonfuls (2 fl. ozs.).

Mix together in a basin to a smooth paste, then add gradually, whilst stirring, half-a-pint of milk and water,* just off the boil, as instructed in the directions on the tin. Set aside away from the fire, or other source of heat, to digest for 15 minutes then pour into a saucepan and slowly heat, whilst stirring, till it comes to the boil. When sufficiently cool it is ready for use.

*Use milk and water in the following proportions :—

Upper Milk,	8 ounces	Half-a-pint.
Water,	2 ounces ..	

The "upper" milk to be obtained by setting fresh new milk aside in a covered vessel for 4 hours, and then taking off the upper half Dilute this upper milk as directed above.

A tablespoonful equals approximately half an ounce.

FORMULÆ AND TABLE SHOWING COMPOSITION OF BENGER'S FOOD WHEN PREPARED FOR USE.

SERIES		FORMULÆ FOR PREPARING BENGER'S FOOD. Benger's Food	Sugar of Milk	Fresh Cows' Milk	Upper Half of Milk	Gravity Cream	Water	PERCENTAGE COMPOSITION OF AVERAGE PREPARED FOOD, BASED ON NUMEROUS ANALYSES. Fat	Proteins	Sugars (Lactose Dextrines and Maltose)	Starch	Ash	Caloric Value per 100 grammes of food	Caloric Value per 10 ounces
SERIES A. For Infants of from 1 to 3 months or when Digestion is very weak.	1*	¼ oz. or 2 teaspoonfuls.	⅓ oz. or 2 larger teaspoonfuls.	4 ozs.	—	—	8 ozs.	1·21	1·45	5·6 to 5·9	·7 to ·4	·28	43	122
	2	,,	,,	—	4 ozs.	—	,,	1·81	,,	,,	,,	,,	48·6	138
	3	,,	,,	3½ ozs.	—	½ oz.	,,	1·96	,,	,,	,,	,,	50·0	142
	4	,,	,,	3 ozs.	—	1 oz.	,,	2·6	,,	,,	,,	,,	55·9	158
SERIES B. For Infants of from 3 to 6 months.	1	½ oz. or 1 level tablespoonful.	⅕ oz. or 1 heaped teaspoonful.	4 ozs.	—	—	8 ozs.	1·22	1·70	6 to 6·5	1·0 to 0·5	·29	47·0	133
	2	,,	,,	—	4 ozs.	—	,,	1·81	,,	,,	,,	,,	52·5	149
	3	,,	,,	3½ ozs.	—	½ oz.	,,	1·96	,,	,,	,,	,,	53·9	153
	4*	,,	,,	3 ozs.	—	1 oz.	,,	2·6	,,	,,	,,	,,	59·8	169
SERIES C. For Infants of from 6 to 9 months.	1*	,,	None.	6 ozs.	—	—	6 ozs.	1·89	2·32	5·2 to 5·7	1·0 to 0·5	·43	52·5	149
	2	,,	,,	—	6 ozs.	—	,,	2·73	,,	,,	,,	,,	60·3	171
	3	,,	,,	5½ ozs.	—	½ oz.	,,	2·61	,,	,,	,,	,,	59·2	168
	4	,,	,,	5 ozs.	—	1 oz.	,,	3·30	,,	,,	,,	,,	65·6	186
SERIES D. For Infants of from 6 to 9 months.	1*	,,	,,	8 ozs.	—	—	4 ozs.	2·49	2·90	6 to 6·55	1·0 to 0·5	·56	63·7	181
	2	,,	,,	—	8 ozs.	—	,,	3·62	,,	,,	,,	,,	74·3	211
	3	,,	,,	7½ ozs.	—	½ oz.	,,	3·20	,,	,,	,,	,,	70·4	199
	4	,,	,,	7 ozs.	—	1 oz.	,,	3·90	,,	,,	,,	,,	76·9	218
SERIES E. For Older Children and Adults.	1*	¾ oz. or 1½ level tablespoonfuls.	,,	10 ozs.	—	—	2 ozs.	3·05	3·66	7·9 to 8·7	1·5 to 0·5	·70	81·5	231
	2	,,	,,	—	10 ozs.	—	,,	3·36	,,	,,	,,	,,	84·4	239
	3	,,	,,	9½ ozs.	—	½ oz.	,,	3·74	,,	,,	,,	,,	87·9	249
	4	,,	,,	9 ozs.	—	1 oz.	,,	4·5	,,	,,	,,	,,	95·0	270

NOTES

(i.) *Gravity Cream* means cream skimmed from fresh milk which has stood in a covered basin for 6 hours. One pint of milk should yield 2 ozs. of cream.

(ii.) *Upper Milk* means the upper half of milk which has been set aside in a covered vessel for 4 hours. It should be removed by a dipper or "Gourmet" separator.

(iii.) In each series the fat can be varied at will by varying the proportion of milk and cream, or if the upper ⅓ of milk which has stood 4 hours be used instead of the upper half, the fat will be increased 0·5 %.

(iv.) The lower proportion of sugar in each case is the result of 15 minutes' digestion, the higher from 30 minutes, a correspondingly smaller quantity of starch remaining in solution.

(v.) Formula No. 1, Series E, will be found to be the most generally useful for older children and adults. Allow fifteen minutes for digestion.

* These formulæ are incorporated in the general directions enclosed with each tin of Benger's Food.

PART II.

PART II.

In this part it is proposed to answer, briefly, questions which are repeatedly put to the manufacturers on the composition of the "Benger" products, their preparation or use. A list of the more important of these is here given :—

(1) Benger's Food.
(2) ,, Pancreatised Lentil Flour.
(3) ,, Liquor Pancreaticus.
(4) ,, Peptonising Powders.
(5) ,, Peptonised Beef Jelly.
(6) ,, Peptonised Chicken Jelly.
(7) ,, Liquor Pepticus.
(8) ,, Pepsin Pills.
(9) ,, Pancreatin Pills.
(10) ,, Essence of Rennet.
(11) ,, Liquor Thyroidin.
(12) ,, Extract of Red Marrow.
(13) ,, Peptone Suppositories.

BENGER'S Food

TRADE MARK.

(BENGER'S FOOD IS A REGISTERED TRADE MARK IN THE CHIEF COUNTRIES OF THE WORLD.)

A mixture of wheat flour and pancreatic extract. When prepared according to the directions, most, but not all, of the starch is converted into soluble forms. The proteid is partially digested as well as that of the milk used in mixing it.

(From "Food and the Principles of Dietetics," Robert Hutchison, M.D., F.R.C.P., third edition, 1911, page 468.)

WHILST THE ABOVE IS SUBSTANTIALLY CORRECT AS A GENERAL DESCRIPTION, IT IS IMPORTANT TO NOTE THAT THE COMPOSITION OF THE PREPARED FOOD VARIES WITH THE FORMULA USED, *i.e.*, WITH THE AMOUNT OF FOOD, PROPORTION OF MILK, OR "UPPER" MILK, AND WATER, CREAM, ETC., ADDED, AND THE LENGTH OF TIME FOR DIGESTION GIVEN. *(See schedule following page 69.)*

The following is the result of an

ANALYSIS OF BENGER'S FOOD AS IT STANDS IN THE TIN.

Moisture		5·273
Ash		0·969
Fat		0·919
Proteins		12·187
Carbohydrates	Dextrines and Sugars	3·337
	Starch	77·023
	Cellulose	0·292
		100·000

The composition of the Benger's Food, when prepared and ready for consumption, will be found in the Schedule following page 69.

A careful analysis of the above Ash gave the following results expressed in parts per 100 :—

Ferric Oxide and Aluminia	0·570
Calcium Oxide	3·606
Magnesium Oxide	4·292
Potassium Oxide	15·027
Sodium Oxide	30·158
Sodium (in combination)	3·625
Silica	1·332
Sulphuric Anhydride	6·927
Carbonic Anhydride	5·580
Phosphoric Anhydride (P_2O_5)	23·261
Chlorine	5·596
	99·974

Present knowledge of the mineral constituents of both cow's and human milk is, as yet, incomplete, and the subject is still under revision. The following may be taken as representing the average composition of the ash of each. It will be seen that the ash of human milk is richer in potassium and chlorine, and poorer in phosphorus and calcium than that of cow's milk.

MINERAL CONSTITUENTS OF COWS' AND HUMAN MILK

	Cows' Milk.		Human Milk.
Potassium Oxide	20·67	..	23·92
Potassium (in combination)	3·38	..	8·07
Sodium (in combination)	8·24	..	8·22
Calcium Oxide	22·78	..	15·25
Ferric Oxide	0·30	..	0·22
Chlorine	15·75	..	20·04
Magnesium Oxide	2·62	..	2·93
Phosphoric Pentoxide $P_2 O_5$	26·26	..	21·35
	100·00	..	100·00

Benger's Food is a special wheaten flour preparation containing in suitable amount the two active digestive principles—Amylopsin and Trypsin.

Further it is devised and expressly intended to be used in conjunction with fresh cows' milk, or diluted milk if desired.

The properties of the two enzymes have been stated already, but, briefly, their function in this combination of milk and Benger's Food is as follows :—

In the first place, the two enzymes are in such a condition as to readily exert their digestive powers under the suitable conditions which obtain during the preparation for use, as given on page 80, and in the directions which accompany each tin. The Amylopsin acts on the carbohydrate (Starch) of the Food, and gradually changes it into soluble sugars (Dextrine and Maltose, mainly, and, possibly, some little Dextrose), more or less according to the length of time allowed for digestion. The Trypsin acts on the gluten of the flour and on the proteins (Casein, &c.) of the milk, so that the curd is softened, and as a result it separates in the stomach in fine flocculæ instead of large curds ; very little, if any, peptone being formed. As stated on page 49, there is not sufficient of the tryptic enzyme present to thoroughly convert or peptonise the casein of the milk. The milk fat is unaffected.

Finally, Benger's Food contains no preservatives, and is free from rough irritant particles.

These considerations show that Benger's Food is not merely a mechanical milk modifier—it is a real modifier of a peculiar character.

Further, it will be recognised, which some critics of the Food have failed to do, that Benger's Food is *not* consumed in the condition in which it stands in the tin—this must be remembered when considering the analysis given on page 76.

The delicate nature of Enzymes, and the care and skill requisite for their extraction and manipulation is well known. It is important to remember, also, the effect which heat has on these digestive principles and their activity, especially when using them in the preparation of partially-digested foods. The endeavour in these cases is to obtain the most appropriate range of temperature within which they work to best advantage. As applied to the pancreatic ferments, experiment and experience have shown this to be between 100° and 150° Fah. Below the former the action is retarded and from 160° to 170° Fah. is likely to be destroyed, especially if the temperature is maintained. Higher temperatures destroy them.

Probably the difficulties at first experienced in the practical application of these digestive agents arises in the majority of cases from this peculiar susceptibility to heat.

These and other considerations entered into the problem of drawing up the directions for the preparation of Benger's Food, so that they might be as simple as possible having regard to the objects in view.

The following are the "Directions for Use" as they appear on each tin of Benger's Food. It will be noticed they are general directions, and so framed as to allow of variation when this is desired.

Revised Directions.

These revised directions are the outcome of special investigations which have been going on for some time. They have been submitted to, and approved by, eminent medical authorities.

Directions for Use.

To obtain the full effect of the digestive principles contained in the Food, it is important that the Directions contained in the Pamphlet enclosed with each tin, and as given below, be carefully followed. Use fresh cows' milk, free from preservatives, and never prepare the Food with water only.

To prepare HALF A PINT OF FOOD for older Children and Adults:—

Take of Benger's Food .. .. ¾oz. (1 table-spoonful),*
Cold Milk or Water .. 2 fluid ozs. (4 table-spoonfuls),
Mix to a smooth paste in a basin, and then add gradually, whilst stirring, Boiling Milk, or Milk and Water, ½ a pint (a breakfast-cupful) (see N.B. on page 81).

Set aside, away from the fire, or other source of heat, for quarter of an hour, when the digestive process will have sufficiently advanced, then pour into a saucepan and slowly heat, whilst stirring, till it boils. When sufficiently cool it is ready for use.

To make about a pint of Food, double the above quantities are to be taken, but not more than this quantity should ever be made at one time from the above proportions.

For INVALIDS.—Whenever the digestion is very weak, the mixed food may be allowed to stand for half or three-quarters of an hour† before the final boil. By this means the self-digestion is carried further. In most cases, however, fifteen minutes is sufficient (see explanation of process opposite). For Adults, and Children over nine months of age who have taken the Food for some time, milk only may be used in its preparation, and, if required, any suitable flavouring agent added, such as salt or celery salt. A little cocoa or milk chocolate is found agreeable by many.

For INFANTS.—The proportions of milk and water will vary with the age and condition of the child. Infants under three months will only require one-third milk and two-thirds water, and the proportion of milk must be gradually increased until milk only is used.

* For Infants one to three months old use two tea-spoonfuls (¼oz.) of the Food: three to nine months of age, use one level table-spoonful (½oz.) of the Food, or less if ordered, and, at first, set aside to digest for half an hour. One or two tea-spoonfuls of sugar or sugar of milk may be added, and a little cream in certain cases. Formulæ for use at various ages are given in the pamphlet enclosed with each tin, pages 5 to 8. This Pamphlet should be kept and carefully studied if the best results are to be obtained.

† The period of digestion may be increased or decreased if desired in stages say of five minutes. See Stage III., page 82. A copy of this Pamphlet will be sent free on application.

Benger's Food in its dry state contains no added sugar, but when prepared the starchy matter is converted into sugar, and the prepared Food is agreeably sweet and quite liquid, so that it can be readily administered to infants from an ordinary feeding bottle.

Always stir before use, to ensure uniformity in composition.

N.B.—It is preferable to add the hot fluid when just off the boil, that is, when it has just settled down after it has first risen in the pan. When undiluted milk is being used it is as well to mix the dry Food with cold water.

See also Recipes for the use of Benger's Food in various dishes for Invalids.

NOTE ON FEEDING INFANTS.

Infants of the same age vary in their needs, in weight and consequent food requirements. The following Table will be found useful as a *general guide* to the amount and frequency of meals for hand-fed children.

Age of Infant	Time of Meals	Number of feeds in 24 hrs.	Quantity at each meal	Total amount in 24 hours
2nd Month	Every 2½ hours 5 a.m. to 10-30 p.m.	8 or 9	4 to 6 table-spoonfuls	¾ to 1¼ pints
3rd & 4th Month	Every 2½ or 3 hours	7	6 to 9 table-spoonfuls	1¼ to 1½ pints
5th & 6th Month	Every 3 hours	6 or 7	9 to 12 table-spoonfuls	1½ to 1¾ pints
7th to 9th Month	Every 3 hours	6	12 to 14 table-spoonfuls	1¾ to 2 pints

One feed may be given during the night for the first two or three months. Afterwards it may, usually, be discontinued with advantage. As a rule all changes should be made gradually.

As an antiscorbutic, a dessert-spoonful of sweetened fresh orange juice, or grape juice, may be given three times a week between meals.

Explanation of Process.

In these directions the desired range of temperature is obtained by mixing first a cold fluid and the Benger's Food, then to this gradually adding a hot fluid; the mixture is then set aside for the desired length of time for the digestion to proceed, and, finally, further action is checked by raising the mixture to boiling point.

These or similar directions have been in use for over thirty years, and, in the main, have met all requirements. The maximum temperature usually obtained is from

150° to 158° Fah., and the mixture when set aside immediately begins to cool, which is intended, and may go down to 110° Fah. Within this range is found the best all-round temperature for the purpose.

The directions are very simple, and the process consists of four stages.

Stage I.—This consists in taking the desired amount of the Benger's Food and incorporating with it the indicated quantity of cold fluid for the amount of prepared food being made. If Sugar of Milk is part of the formula, this should first be mixed with the dry Food before the fluid is added.

Stage II.—This stage consists in heating the milk, or milk mixture, and adding it to the cold mixture provided in Stage I. When the directions are followed the resulting mixture has the proper temperature for the action of the digestive principles in the Benger's Food.

Stage III.—Period of digestion, *i.e.*, the time during which the warm mixture is set aside to digest. The value of being able, by varying the time allowed for digestion, to obtain a more or less thorough pre-digestion, and the application of this in the adjusting of food for particular requirements will be appreciated.

Stage IV.—At the end of the time desired for the period of digestion in Stage III. the mixture is returned to a clean saucepan (aluminium pans answer best), and heated to boiling. This checks any further action of the digestive enzymes. When cool it is ready for consumption.

If the finished product is slightly sweet and like cows' milk in consistence, it has been correctly prepared, and these two conditions obtained prove that the enzymes were active and have done their work.

Benger's Food is much more easy to prepare than either barley water or a gruel. All that is needed is to

(1) Follow the Directions.

(2) Use good fresh Cows' Milk free from preservatives.

METHODS FOR THE PREPARATION OF BENGER'S FOOD IN WHICH A TEMPERATURE NOT HIGHER THAN 170° FAHR. IS ATTAINED, AND THAT ONLY FOR A MINUTE OR TWO.*

Place the required amount of Benger's Food, or Food and Sugar of Milk, in a dry basin. Then take the whole of the milk, or milk mixture, cold, and gradually mix with the Food. In practice it will be found best to proceed by measuring first about four tablespoonfuls of the fluid, rub this to a creamy mixture with the Food, then add, whilst stirring, the remainder of the cold fluid. Now pour the whole into a saucepan, and heat on a gas burner. Place in the fluid a thermometer, and stir whilst warming until exactly 150° Fah. is attained. Remove immediately from burner, and set aside, away from heat, to digest. During this period the temperature falls, which is intended. At the end of the time allowed for digestion, return to the gas burner and warm to 170° Fah., stirring the while and noting the temperature by a thermometer. Remove immediately 170° Fah. is attained.

The object of this method is to injure as little as possible the natural antiscorbutic property of fresh cow's milk, and to avoid coagulation of the lactalbumin. The more harmful bacteria are probably also destroyed.

As this method requires the use of a thermometer and more skill in preparation than is usually available, it can, in practice, only be used in Institutions and other cases where these requisites are to be found. Some physicians have been in the habit of giving instructions to decide the temperature by tasting, and others use the ordinary method of preparation given on the labels, but instruct

* See Report to Local Government Board (New Series No. 63) upon the available data in regard to the value of boiled milk as a food for Infants and young animals. *By Janet E. Lane-Claypon, M.D., D.Sc. (Lond.)*

that the hot fluid be added when it is hot enough to be sipped with comfort. These methods are not recommended as they do not give uniform results, and there is a possibility of more unconverted starch remaining in the prepared food, which will consequently be thicker. Where this is not an objection they may be adopted.

It may be pointed out, however, that for general use, the customary method of preparation as given in the Directions with each tin is more easily followed, gives the best uniform results, and effects a more certain conversion of the starch.

The second heating in the method of preparation is to restrain further action of the digestive principles, by destroying them, and to burst any unbroken starch grains. It also improves the flavour. In cases where the Food is for immediate consumption, and where the starch question is not important, this second heating may be omitted.

Special formulæ.

There are sometimes special cases in which a physician wishes to give the various food elements in known proportions.

The formulæ given in the Schedule following page 69, and the information given in Chapter II. on Milk, Cream, and Upper Milks, will supply the requisite information for this purpose.

The manufacturers of Benger's preparations will be pleased to answer enquiries relating to the preparation of Benger's Food; and for use in Institutions and for other cases where larger quantities or special formulæ are desired, they will be gladly supplied.

The Composition of the Prepared Benger's Food.

This will be found in the Schedule of Formulæ referred to above.

On the Flavour of Prepared Benger's Food.

This is of a slightly sweet, biscuity character, and most people prefer it as it is.

It is sometimes, however, desired to flavour it, and it lends itself readily to the addition of whatever is permissible. Some, usually adults, add Salt or Celery Salt, which cover the slight sweetness, and others prefer Sugar or a piece of Milk Chocolate dissolved in the hot prepared food. Flavouring essences may be added to obtain variety, or spices such as grated nutmeg or cinnamon, or a piece of lemon rind.

A raw egg beaten up with the prepared food is a favourite addition.

Brandy or whisky is sometimes ordered to be added to the prepared food just before being consumed.

Some people, again, like the prepared food mixed with an equal amount of freshly-made tea or coffee.

Special Invalid Dishes will be found in a booklet, obtainable from the manufacturers, entitled "Benger's Food and How to Use It."

Administration of Fruit Juice.

When the prepared food is being taken by Infants for lengthened periods, it is suggested, as a precautionary measure, that a little fresh fruit juice or raw meat juice be administered for their antiscorbutic properties.

Sugar of Milk (Lactose).

This form of sugar is preferred, as a rule, for use in Infant feeding. It does not ferment so readily as cane sugar, and is less sweet. Sugar of Milk possesses slightly laxative and diuretic properties; for these reasons it may be desirable to reduce the quantity, or omit it altogether, in diarrhœa or where there is looseness of the bowels.

The B.P. quality should be used.

Cost to Consumer of Prepared Benger's Food.

Assuming that fourpence per quart is paid for milk, the cost of a quart of prepared Benger's Food will be from fourpence to eightpence, according to the proportion of milk, etc., used.

Measures.

The capacity of domestic spoons varies very much, and, therefore, where accuracy is desired the dry materials should be weighed and a graduated measure used for fluids.

The following are approximate :—

One level dessertspoonful of Benger's Food	¼oz.
One level tablespoonful ,, ,,	½oz.
One slightly heaped tablespoonful ,, ...	¾oz.
A little less than a level tablespoonful of Sugar of Milk (Powder)	½oz.
A little less than a level dessertspoonful of Sugar of Milk	¼oz.
A level teaspoonful of Sugar of Milk	60–70 grain.

PANCREATISED LENTIL FLOUR.

This preparation is made on the same principles as Benger's Food, but with specially prepared and baked Lentil Flour. It contains the enzymes Amylopsin and Trypsin, and, like the food, is used with fresh cow's milk.

Lentils form a highly nutritious food, being especially rich in nitrogenous material, and the method of preparation makes them more easy of digestion.

LIQUOR PANCREATICUS* AND PEPTONISING POWDERS.

A description of the pancreatic secretion, its composition and properties will be found in the first chapter of this book. Here we may say, briefly, that the action of the pancreatic juice consists in the digestion of carbohydrates and proteins, such as casein of milk and those belonging to the same category as the fibrin of flesh, as well as in the hydrolysis and emulsification of fats. Unlike pepsin, the enzymes of the pancreas perform their functions in an alkaline medium, but they can carry them out in neutral or even slightly acid media. When the Liquor Pancrcaticus is to be administered it is desirable to avoid mixing it with mineral acids, but there is no reason to fear that its action will be inhibited at once if given to a patient during a meal or immediately afterwards, because the amount of acid in the gastric juice at those times is too small to effect the amylopsin, and, further, the hydrochloric acid of the stomach contents is not in a free state but in combination with the organic constituents. See also Digestion in the stomach, page 7.

The Present State of Knowledge

concerning the digestive processes confirms clinical experience in the beneficent results which are obtainable by the use of Liquor Pancreaticus.

The Composition

of the Liquor Pancreaticus is precisely that of the natural secretion with the exception that it contains a small quantity of dilute alcohol, which is added for the purpose

* Liquor Pancreaticus (Benger) is the original preparation, and as made for the late Sir W. Roberts, M.D., &c.

of preventing decomposition. When the delicate nature of these enzymes is remembered it will be apparent how essential it is that they should not be submitted to any degree of desiccation before being used for medicinal purposes. The Liquor Pancreaticus is a simple liquid extract prepared with the aid of the most efficient apparatus and care direct from the fresh gland, and therefore possesses, when properly administered, a maximum efficiency.

As fluid preparations of enzymes gradually lose their activity on keeping, it is desirable that they should be used within a reasonable time, say twelve months.

LIQUOR PANCREATICUS WITH OR AFTER MEALS.

One or two teaspoonfuls of Liquor Pancreaticus may be mixed with a wineglassful of water, and sipped *during* meals consisting of starchy or farinaceous foods. It may also be taken two or three hours *after* meals ; in the latter case it is well to add about 15 grains (quarter of a level teaspoonful) of Bicarbonate of Soda, to protect the pancreatic ferments, for a time, against the action of the acid juices of the stomach.

PEPTONISED MILK AND NUTRIENT ENEMATA.

Whatever be the nature of the foods given by nutrient enemata, most prescriptions order some peptonised milk to make up the bulk to the necessary number of ounces to be administered. Liquor Pancreaticus is peculiarly adapted for the predigestion of the milk, and the process should be carried out more thoroughly for use this way than it can for oral feeding, the bitterness which results from more prolonged or thorough predigestion being no objection.

PEPTONISING OF MILK AND MILK FOODS.

USE FRESH COWS' MILK OF GOOD FLAVOUR, FREE FROM PRESERVATIVES.

A PERUSAL of Chapter II. will show the importance of taking care to secure a cow's milk suitable for invalid feeding. Whilst some preservatives in the amount generally used to preserve milk appear to have little action on the enzymes, others interfere and retard their digestive power. That the milk be of good flavour and fresh is important, for if one peptonises an already flavoured milk the objectionable features seem to be accentuated, and much the same applies to peptonising old milk or milk kept by means of preservatives, in which slow change of the milk constituents has probably already taken place. There is a considerable difference between peptonised *fresh* milk, and the same milk peptonised after it has been kept, especially if it has not been stored in a suitable manner. Many of the complaints or defects of peptonised milk and milk foods arise from one or other of these causes.

The peptonisation of milk is brought about by the use of the pancreatic enzyme trypsin in the presence of bicarbonate of soda. Liquor Pancreaticus (Benger) or Benger's Peptonising Powders may be used for the purpose; they contain both trypsin and amylopsin in a specially suitable and active form, purified from inert protein material. It will be remembered that these ferments act best in alkaline solution and within a certain range of temperature only. The temperature of greatest activity of trypsin on milk is about 60° C. (140° Fah.); at ordinary temperatures the change is slow, from 160° to 170° Fah., the activity gradually becomes weaker.

The milk for peptonising is always diluted, as by this means the action of the clotting ferment, associated with the other pancreatic enzymes, is obviated; the alkali, besides increasing the action of the tryptic ferment, keeps in solution bodies formed during the process of digestion which, in the absence of the alkali, would precipitate on boiling. The alkali also restrains the curdling of the peptonised fluid by the gastric juice when consumed.

Artificial digestion, like cooking, must be regulated as to its degree, and it is easy to regulate it by the length of time during which the process is allowed to go on. The practical rule for guidance in peptonising articles of food containing milk is to allow the process to go on until a perceptible bitterness is developed, but not unpleasantly pronounced, and not longer.* As soon as this point is reached, or just before, the milk or milk mixture should be consumed, or, if not required at once, should be quickly boiled for a minute, so as to put a stop to further changes which would render the product less palatable. The extent of the peptonising action can be regulated either by increasing or diminishing the quantity of the Liquor Pancreaticus or Peptonising Powders, and by increasing or diminishing the time during which they are allowed to act on the milk, &c. The bitter taste referred to is only produced in articles of food containing milk. In peptonising these, therefore, it is important not to carry the process so far as to render them unpalatable.

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* In the majority of cases it is not necessary to digest until this bitterness is noticed; having once ascertained the onset of bitterness, it is advisable to boil up quickly a little before the bitter stage. By this means a partially-peptonised milk of good flavour is obtained which is more palatable and acceptable to invalids.

PREPARATION OF PEPTONISED MILK IN THE COLD.

(*Sir W. Roberts' Process.*)

THE action of pancreatic extract on milk goes on at the ordinary temperature of the air exactly in the same way as at blood heat, except that it is slower and requires a longer time for completion. The cold method has, however, a convenience and simplicity which recommends it for general use in the sick-room. The following directions have been drawn up for the preparation of peptonised milk at a temperature of 60° to 65° Fah., which may be regarded as the ordinary degree of warmth maintained in rooms occupied by invalids. In the winter season it will be necessary to slightly warm the ingredients beforehand in order to bring them to the due temperature, but in the warmer seasons the operations can be carried on without any preliminary heating.

A pint of milk is diluted with half a pint of water containing 20 grains of bicarbonate of soda in solution. To this are added one to three teaspoonfuls of Liquor Pancreaticus (Benger).* The mixture is then set aside in a jug or other convenient vessel for a period of three to four hours. At the expiration of this time the milk is far advanced in the process of digestion, and has developed a slightly bitter taste. It is now ready for use. It may be used cold, either alone or with soda water, which covers the bitterish taste remarkably well, or it may be warmed and sweetened for administration to infants.

If milk thus prepared be consumed at the period indicated—that is to say, at the end of three or four hours

* If Peptonising Powders are preferred use half a powder and no bicarbonate of soda.

it need not undergo any final boiling ; it is better, indeed, to use it without boiling, because the half-finished process of digestion will still go on for a time in the stomach. But if the milk thus prepared has to be kept much longer, it is advisable to raise it for a moment to the boiling point, so as to bring the action of the ferment to a termination, and thus prevent ulterior changes which render the product disagreeable to the palate.

The process can be regulated with the utmost nicety by occasionally tasting the mixture, and noting the development of the bitter flavour, and it can be permanently arrested at any moment by heating the product to the boiling point.

PEPTONISED MILK—WARM PROCESS.

This yields a well-digested, but usually too bitter a peptonised milk for many. It can be used for enemata without objection.

Mix two-thirds of a pint of fresh milk with one-third of a pint of water, and warm in a saucepan to a temperature of about 140° Fah.—that is, as hot as can be tasted without burning the mouth ; then pour into a jug or basin ; add one or two teaspoonfuls of Liquor Pancreaticus, and half a level teaspoonful of Bicarbonate of Soda, or half a Benger's Peptonising Powder and *no* Bicarbonate of Soda ; stir, and set aside. In a few minutes a considerable change will have taken place in the milk, but in most cases it is best to allow the digestive process to go on from ten to twenty minutes, according to the degree of peptonisation or predigestion desired. Partially peptonised milk is scarcely distinguishable in taste from ordinary milk, though it is very much more digestible. As the process of peptonisation or digestion goes on a bitterness is developed which is unobjectionable to many palates; a few trials will, however, indicate the limit most acceptable to the individual patient, and as soon as this is reached the milk must, if not required by the patient at once, be boiled up to prevent further action of the Liquor Pancreaticus. The addition of a little coffee to peptonised milk effectually covers the slightly bitter taste. If peptonised milk is consumed at the period indicated, that is to say, at the end of ten to twenty minutes, it need not undergo any final boiling; it is better, indeed, to use it without boiling (unless it is desired to sterilise the milk), because the half-finished process of digestion will go on for some time in the stomach.

PARTIALLY PEPTONISED MILK.

This process is recommended where, as in the majority of cases, partial peptonisation is all that is required. It yields a fluid of good flavour, free from any disagreeable bitterness, and the curd is softened sufficiently so that on the addition of Essence of Rennet and HCl. (0·2 per cent.) after the alkali has been neutralised, the casein precipitates in fine flocculæ.

Process.

Mix together two-thirds of a pint of cows' milk and one-third of a pint of cold water. Take one-half of this and raise to boiling. Remove from the fire and mix this immediately with the remaining half of cold milk and water. This yields a temperature suitable for the action of the tryptic ferment—there is no fear of destroying this by the temperature being too high. Now add one-half of a Benger's Peptonising Powder. Allow to stand away from the fire for five to ten minutes—not longer—then raise the whole quickly to boiling point to check further action, unless it is for immediate consumption.

Instead of the Peptonising Powders, one teaspoonful of Liquor Pancreaticus (Benger) and ten grains (a salt-spoonful) of Bicarbonate of Soda may be used. If more thorough digestion is desired, use a little more of the Peptonising Powder, or Liquor and Soda, or allow to stand a little longer before boiling up.

The following is the composition found by analysis of a peptonised milk prepared by the process, using the Peptonising Powders and digesting ten minutes.

Fat	3·02	per cent.
Milk Sugar	3·50	,,
Casein	1·60	,,
Soluble Proteins	0·84	,,
Ash	0·60	,,

It may be sweetened and flavoured with vanilla or lemon rind, or made up with cocoa or chocolate, &c.

PEPTONISED BEEF-TEA.

Half a pound of finely minced lean beef is mixed with a pint of water. This is simmered for an hour and a half and then cooled down to a lukewarm temperature (about 140° Fah.); a tablespoonful of the Liquor Pancreaticus is then added, and the whole kept warm for two hours, and occasionally stirred. At the end of this time it is boiled for five minutes, and the liquid portion, measuring about half a pint, is strained off. Beef tea prepared in this way is rich in peptone, highly nutritious, and of very agreeable flavour.

N.B.—Flavouring agents may be added to any of the above preparations if thought desirable.

Either Liquor Pancreaticus or Benger's Peptonising Powders may be used in the above preparations.

These directions for the use of Liquor Pancreaticus have been revised, and are mainly reprinted from Sir William Roberts' Lumleian Lectures.

PEPTONISED BEEF AND CHICKEN JELLIES.

These preparations are carefully made by methods similar to those used in the preparation of Peptonised Milk. Selected meat and chickens are taken, and the peptonised broth made from each is concentrated, and solidified by means of gelatine. They are slightly flavoured, but can be supplied unflavoured if so desired.

By request of medical men, and for reasons readily understood, no preservatives are put into these Jellies. As a consequence, effective sterilisation and hermetic sealing have to be looked to for their keeping good. The Jellies are sent out in glass jars. When opened, the contents should be consumed within three or four days.

For use, one or two teaspoonfuls of the Jelly are dissolved in hot water and flavoured according to taste.

LIQUOR PEPTICUS (BENGER).

The Aim

to be held in view in administering Pepsin, and its preparations, is the reinforcing of the action of the natural secretion—the gastric juice. In order to do this intelligently it is necessary to have a clear idea of the composition of the natural fluid, otherwise there is considerable risk of the patient deriving no benefit from the medicine, and there is consequent condemnation of the medicine.

Gastric Juice,

according to the most trustworthy researches, consists of a nearly colourless fluid having a strongly marked acid reaction. The acidity is due to free hydrochloric acid, which is present to the extent of from two to three parts (of true hydrochloric acid—H Cl) per thousand; in perfectly healthy persons it may be somewhat more. There is good reason for believing that a portion of the acid is in combination with organic substances. In addition to the hydrochloric acid there are two other bodies of physiological significance, namely, rennin and pepsin; the latter is of the first importance, and is the active agent of the Liquor Pepticus.

Numerous researches and an immense volume of clinical experience have shown that the maximum activity of pepsin is only displayed in the presence of hydrochloric acid.

A knowledge of the essential composition of the gastric juice indicates the conditions under which the peptic enzyme carries out the digestive process as far as proteolysis is concerned. The delicate nature of this substance is frequently overlooked. It is most desirable that we should know the conditions which may annul its activity or destroy it. Pepsin will not dissolve proteins in either neutral or alkaline solutions. A weak solution of sodium carbonate suffices to destroy it at the body temperature. The Liquor Pepticus, therefore, should

NOT BE PRESCRIBED

with **alkaline** substances in any proportion whatever. The following prescriptions represent combinations which should be **most carefully avoided,** because the resulting mixture in each case would be alkaline, and the Liquor Pepticus would be rendered inert.

(1)	Liquor. Peptici (Benger) ..	℥*i.*
	Spirit. Ammon. Aromat.. ..	ʒ*ii.*
	Tinct. Nucis Vomic.	ʒ*i.*
	Infusi Gentian. Comp. ad ..	℥*viii.*
	M. ft. Mistura.	
(2)	Liquor. Peptici (Benger) ..	ʒ*vi.*
	Liquor. Bismuthi	ʒ*iv.*
	Tinct. Chloroform. et Morphin..	ʒ*i.*
	Sodii Bicarbonat..	ʒ*ii.*
	Infusi Aurant. Recent. ad ..	℥*viii.*
	M. ft. Mistura.	

In the following example the acid in the Liquor Pepticus destroys the enzymes in the Liquor Pancreaticus:

Liquor. Peptici (Benger).
Liquor. Pancreatici (Benger).
Equal parts.

Equally lacking in peptic efficiency, and for the same reason, are numerous mixtures and elixirs containing pepsin and bismuth, and often other constituents. Nearly all these preparations have an alkaline reaction fatal to pepsin. Another substance which is incompatible with the Liquor Pepticus, is **alcohol** in a concentrated or moderately concentrated state. If it is desired to administer them together, the alcoholic fluid should be diluted before mixing. The proteolytic power of pepsin is materially retarded by **preparations of iron, metallic salts,** preparations containing **tannin,** and many synthetic remedies such as **gluside (saccharin)** and **phenazone (antipyrin).** In order to obtain the best results from the use of Liquor Pepticus, it is recommended that it should be prescribed alone. Should the prescriber wish to combine with it medicaments of a tonic nature, he will understand, from what has been said, how desirable it is that he should select such as are free from astringency and alkalinity.

It is also advisable that preparations containing **alkaloids** should be avoided, as these bodies for the most part retard the activity of peptic digestion. If a knowledge of the conditions of, and the substances taking part in, the normal proteolytic digestive process are allowed to govern the administration of the Liquor Pepticus, the prescriber will not fail to confirm the experience of a generation of practitioners to the effect that the Liquor Pepticus (Benger) is the most efficient preparation of its kind.

PEPSIN PILLS (BENGER).

Each Pill contains two grains of purified pepsin prepared in the Benger laboratories. They are active and convenient when this method of administration is desired. Their action is on protein material only.

PANCREATIN PILLS (BENGER).

Each Pill contains one grain of purified pancreatin extracted and prepared in the Benger laboratories. They contain the starch converting and protein digesting properties of the pancreatic fluid. The Pills are coated with Keratin to protect the enzymes from the acid in the stomach ; they dissolve in the alkaline secretions in the duodenum.

ESSENCE OF RENNET.

This is a permanent and very active preparation containing the enzyme rennin, which has the property of curding or coagulating milk. It is not a brine preparation. The Essence is chiefly used in the preparation of Whey (see page 38), and for producing curds and junkets.

LIQUOR THYROIDIN.

A glycerine and water extract of selected fresh Thyroid glands obtained from healthy sheep. Care is necessary in their selection and preparation, and this is guaranteed. One fluid ounce equals two lobes, *i.e.*, one complete Thyroid gland. Dose : One teaspoonful.

RED MARROW EXTRACT.

This is made according to the instructions of the physician who originally suggested its use in medicine. Care in the selection and manipulation of suitable raw material is very necessary. The menstruum is a mixture of glycerine and water, and the marrow is obtained from the bones of calves.

Marrow Extract appears to be an agent capable of affording valuable aid in the treatment of Anæmia, and also of Oligæmia due to loss of blood from causes such as Placenta prævia, Hæmorrhoids, and Wounds.

Dose: One teaspoonful.

PEPTONE SUPPOSITORIES.

These are prepared from Meat Peptone, which is incorporated with olive oil and the mass enclosed in a shell of Cacao Butter.

QUOTATIONS AND REFERENCES FROM MEDICAL WORKS, MEDICAL JOURNALS, NURSING JOURNALS, &c.

Benger's Preparations are mentioned in many Medical Works, &c. Below are given a few quotations and references.

Messrs. Benger acknowledge their indebtedness to the authors and publishers of the various works and periodicals from which quotations have been taken or to which reference is made.

MEDICAL WORKS.—

DISEASES OF THE STOMACH, *by S. H. Habershon, M.A., M.D., F.R.C.P.*, 1909.

Frequent mention is made of the use of Liquor Pancreaticus (Benger) and Benger's Food in dietetic treatment and nutrient enema.

From the recent edition of the ROTUNDA PRACTICAL MIDWIFERY, *by E. Hastings Tweedy, F.R.C.P., &c., and G. T. Wrench, M.B., M.R.C.S. Page* 414:—

"Benger's Food we have found of real use in quite young infants who were going progressively backwards or were stationary on other foods."

SYSTEM OF MEDICINE, *edited by Sir Clifford Allbutt, K.C.B., M.D., Vol. III.*, 1897. *Article on* ULCER OF THE STOMACH, *page* 543, *by Professor Dreschfeld, M.D., &c.*

"Before giving the nutritive injection, the rectum should be emptied by one of water. The nutritive enema may be given every four to six hours. Milk gruel is prepared by mixing equal parts (about 10 oz.) of milk and thick gruel, and to this two teaspoonfuls of Benger's Liquor Pancreaticus and 30 grains of bicarbonate of soda are added."

"If the patient gets tired of milk, or if it be not well borne, Benger's Food may be tried."

WASTING DISEASES OF INFANTS AND CHILDREN, *by Eustace Smith, M.D., F.R.C.P. Sixth edition,* 1899, *page* 40.

"Instead of malt, Pancreatine may be employed as the digestive agent of starch. This plan has been adopted with great success by Mr. Benger. In Benger's Food the farinaceous meal, finely ground and well cooked, is mixed with pancreatine. When the Food is added to warm milk or milk and water, the digestive principle not only converts the starch more or less completely into dextrine, but also acts upon the casein, reducing it to a form in which it is as readily digestible as the curd of human milk. The Food is a very good one, and usually agrees well."

ENCYCLOPŒDIA MEDICA, *edited by Chalmers Watson, M.D., F.R.C.P. Vol. V.,* 1900. *Article on* INFANT FEEDING, page 244.

"Partly-malted cereal foods . . . . Benger's Food is somewhat similar, but the partial conversion of starch is accomplished by pancreatic ferments."

FUNCTIONAL AND ORGANIC DISEASES OF THE STOMACH, *by S. Martin, M.D., F.R.C.P., M.R.C.S.,* 1895.

"DIET IN GASTRIC IRRITATION," *page* 324. "For the mid-day meal, 12 to 1, milk and Benger's Food, made quite thin, with the white of an unboiled egg beaten up in it, a little salt being added."

"DIETETIC TREATMENT OF PERMANENT GASTRIC INSUFFICIENCY." *page* 334. "Sir William Roberts recommended extraction of the pancreas by means of weak spirit, and this was utilised in the preparation of Benger's Liquor Pancreaticus, which is largely used in the manufacture of peptonised food." . . . .

MANUAL OF MEDICINE, *edited by Sir W. H. Allchin, M.D., F.R.C.P., M.R.C.S.* 1903. *Vol. V., page* 379, DISEASES OF THE PANCREAS.

"Partially-digested foods, such as Benger's and the various malted foods and peptic preparations, minced raw pancreas, or the Liquor Pancreaticus (Benger) may be administered with distinct advantage, especially in the diabetic cases."

Page 277, Chronic Gastritis.

"Such food as is required should be of the simplest character; milk and soda water, thinly prepared Plasmon or Benger's Food, are quite sufficient."

Page 283, Acute Enteritis.

"Thinly-made Benger's Food or Plasmon is often most useful."

Page 329, Dilatation of the Stomach.

"Minced freshly-cooked meat, peptonised milk, Benger's Food, and Plasmon are the most suitable, and should be given in small quantities at intervals of four hours."

Page 319, Cancer of the Stomach.

"Peptonised foods, including milk, Benger's Food, Plasmon, soups, and meat extracts come to be the nutriment that has to be relied on."

Infectious Diseases (Oxford Medical Publications), 1909, *by Claude Buchanan Ker, M.D., Ed.; F.R.C.P., Ed.,* Medical Superintendent City Hospital, Edinburgh; Lecturer on Infectious Diseases to the University of Edinburgh.

In the introduction, page 17, referring to the Diet in Infectious diseases, the following appears:—

"I have always found Benger's Food a most useful preparation, and employ it perhaps more frequently than any of the others named."

Benger's Food is also mentioned in the above work—

On page	121	Diet in	Scarlet Fever.
	167	,,	Small Pox.
	313	,,	Enteric Fever.
	467	,,	Whooping Cough.

System of Diet and Dietetics, 1908, *page* 226. *Extract from article by E. Cautley, M.D., F.R.C.P., &c.* :—

"Benger's Food is, in my opinion, the most valuable proprietary food on the market. It is a valuable food in typhoid fever, gastric and intestinal troubles, anorexia from any cause, convalescence from acute illness, and in malnutrition generally."

THE CHILD, *by A. Westland, M.A., M.D., on pages* 41, 42, 45, *and* 47. *On page* 42 *Dr. Westland writes* :—

"Benger's Food differs slightly from others in containing an active principle which assists in digesting the milk with which it is mixed, as well as the starch in the food itself. Being more easily digested than the foods of the second class, a small amount of milk may usually be employed in preparing them from the commencement of their administration, and the quantity of milk should be gradually increased until at six months the baby takes the food mixed with milk altogether undiluted."—*And on page* 45.

"Benger's Food is often very valuable when the progress of the child is not satisfactory, in spite of its apparently digesting the humanised milk with comfort."

FROM PRACTICAL MOTHERHOOD, *by Helen Y. Campbell, L.R.C.P. and S., Edin.; L.F.P. and S., Glas.;* 1910.

FEEDING AFTER WEANING: Page 178.

"If the baby has had no cow's milk, it is necessary to introduce it gradually, and a weak mixture, or ordinary mixture peptonised, of this, should replace each breast feed as this is dropped. If this method is not followed, Benger's Food, which I have found very useful for this purpose, should be given for a few weeks, to lead the child gradually on to cow's milk and starchy food."

Other mention is made of the use of Benger's Food for mothers and children, and on page 189 is given a list of formulæ and a method of gradually reducing the process of self-digestion. Commencing with 45 minutes and reducing this, in stages of five minutes, to 10 minutes digestion.

PULMONARY TUBERCULOSIS AND SANATORIUM TREATMENT, 1910, by *C. Muthu, M.D.*, on page 105.

THE HYGIENE OF INFANCY AND CHILDHOOD, 1910, by *A. D. Fordyce, M.D.*, on page 66.

HANDBOOK FOR NURSES, by *J. K. Watson, M.D.*, on page 83.

PHYSIOLOGICAL FEEDING OF INFANTS, by *Eric Pritchard, M.D.*, on pages 445, 453, and 454.

FOOD AND FEEDING IN HEALTH AND DISEASE, by *Chalmers Watson, M.D.*, on pages 178, 179, 183, 281, 293, &c., &c.

INDIGESTION. A Post-Graduate Lecture delivered at the London School of Clinical Medicine, by *Guthie Rankin, M.D.*, reported in the "British Medical Journal," of March 25th, 1911, page 668.

NURSING: ITS THEORY AND PRACTICE, by *P. G. Lewis, M.D.*, on page 71.

QUESTIONS ON SICK NURSING AND HOME HYGIENE, by *D. M. Macdonald, M.D.*, on page 17.

THE HEALTH OF OUR CHILDREN IN THE COLONIES, by *Dr. Lilian Austin Robinson*, on page 46.

PRACTICAL DIETETICS, by *W. Gilman Thompson, M.D. (U.S.A.)*, on pages 113, 120, and 152.

FOOD AND DIETARIES, by *R. W. Burnet, M.D.*, on page 169.

A SYSTEM OF DIET AND DIETETICS, 1908 (Oxford Medical Publications). Edited by *G. A. Sutherland, M.D.*

Reference is made to Benger's Food in the following chapters:—

PATENT AND PROPRIETARY FOODS, by Edmund Cautley, M.D., on pages 214, 226, 227, and 236.

DIET IN FEVERS AND ACUTE INFECTIOUS DISEASES, by C. B. Ker, M.D., on pages 306, 314, 322, 337, 339, and 353.

DIET IN TUBERCULOSIS, by N. D. Bardswell, M.D., and J. E. Chapman, M.R.C.S., on pages 371, 375, 396, 397, 400, 402, 403, 404, 405, 408.

DIET IN DISEASES OF THE STOMACH AND INTESTINES, by H. P. Hawkins, M.D., on pages 498, 501, 504, 523, 524, 530, 532, 547, and 551.

DIET IN DISEASES OF THE LUNGS, by G. A. Sutherland, M.D., on pages 582 and 588.

DIET IN DISEASES OF THE BLOOD AND BLOOD-FORMING ORGANS, by John Cowan, M.D., on pages 633, 634, and 649.

THE FEEDING OF INFANTS AND CHILDREN IN HEALTH, by G. A. Sutherland, M.D., on page 784.

FOOD AND THE PRINCIPLES OF DIETETICS, by *Robert Hutchison, M.D.*, 1911 edition, on pages 468, 471, and 483.

CHILDREN—THEIR CARE AND MANAGEMENT, by *E. M. Brockbank, M.D.*, page 53 (Essence of Rennet), pages 64 and 75 (Benger's Food).

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Intersusception in Infants .... "Practitioner," Dec. 1905.

Vomiting in Pregnancy .... "Nursing Times," March 31st, 1906.

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(Article by G. A. Gibson, M.D.)

Infantile Diarrhœa .... "British Journal of Nursing," Oct. 6th, 1906.

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(Hector Mackenzie, M.D.)

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Gastric Ulcer ......" Medical Press and Circular," June 12th, 1907.

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Gastro-Enterostomy .... "Nursing Mirror," Dec. 21st, 1907.

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(Dr. Morgan.)

Diet after Abdominal Operations........" Practitioner," March, 1910.

A Case of Rickets......" British Homeopathic Journal," April, 1910.
By A. E. Hawkes, M.D.

Feeding in Acute Diseases......" Nursing Times," June 18th, 1910.
By R. B. Wild, M.D.

After Treatment of Abdominal Operations (Nursing of Sick Children) "Nursing Mirror," June 25th, 1910.

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Symptoms and Treatment of Duodenal Ulcer, by R. J. M. Buchanan, M.D....... "Liverpool Medical and Chirurgical Journal, July, 1910.

Scarlet Fever .... "West London Medical Gazette," July, 1910. By F. G. Crookshank, M.D.

Rennet and Its Uses.................... "Baby," August, 1910.

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Home Treatment of Scarlet Fever .... "Practitioner," December, 1910. By F. G. Crookshank, M.D.

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Congenital Hypertrophic Stenosis of the Pylorus in Infancy. By C. Paget Lapage, M.D. "Practitioner," (Page 425.) March, 1912.

PLATES.

The following plates have been selected and reproduced, etc., from the "Benger" series of original, untouched, copyright photographs. They show the effect of an artificial gastric juice (containing Rennin and Hydrochloric Acid 0·2 per cent.) on milk, etc., at 98° Fahr., in glass, under identical conditions.

Magnification: Plate I., Three-sevenths natural size.

Plates II. to VII., two diameters.

PHOTOGRAPH I.

CURD FROM COWS' MILK (FIG. 4), AND FROM THE SAME MILK AFTER TREATMENT WITH

(1) Benger's Food* for fifteen minutes. Fig. 4B.

(2) ,, ,, ,, thirty ,, Fig. 4C.

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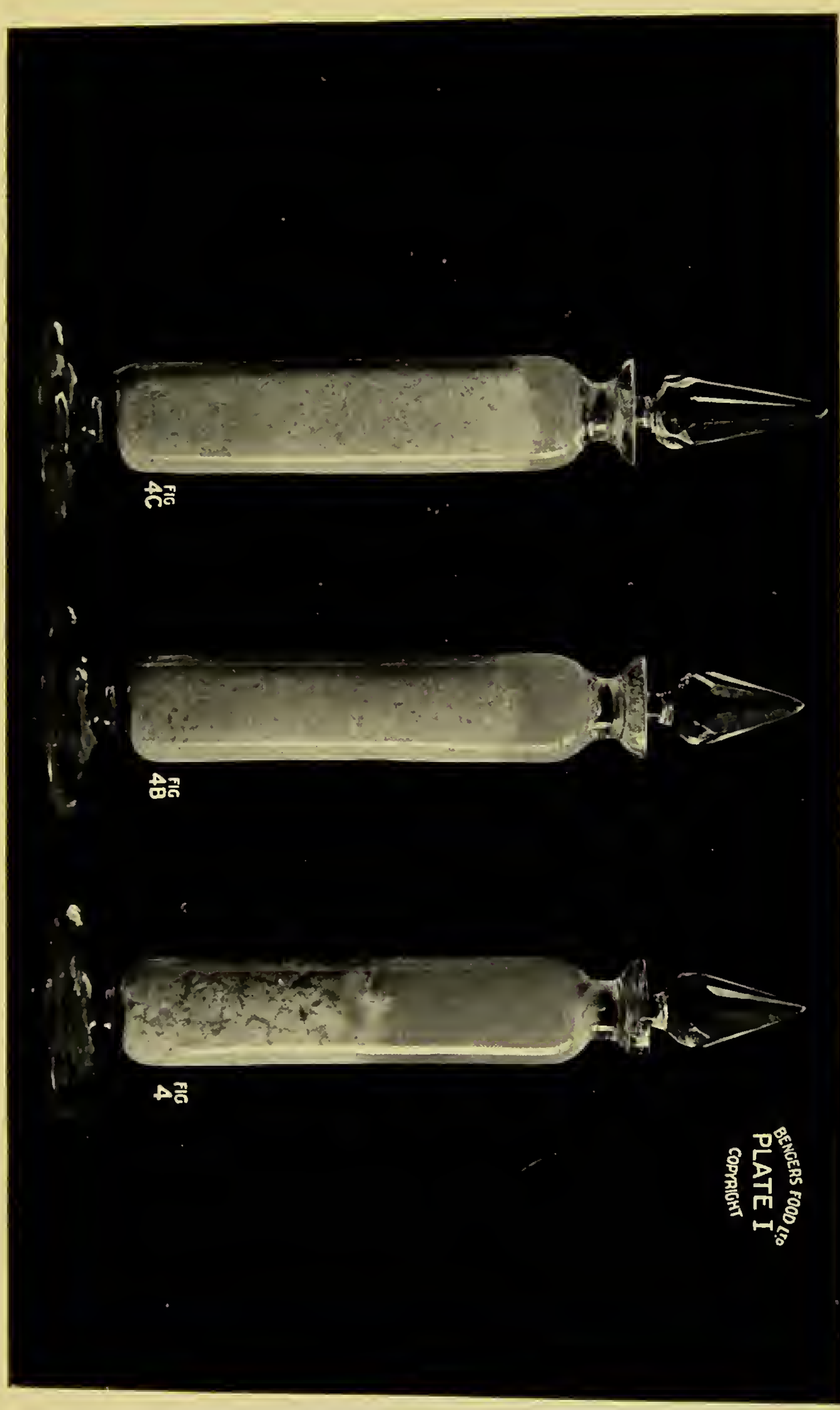
* *¾ oz. Food to 12 fluid ounces of milk.*

PHOTOGRAPH I. Plate I.



Three-sevenths Natural Size. *Copyright.*

PHOTOGRAPH II.

Cows' Milk sets in a solid curd, and has to be broken with a glass rod. This photograph shows the broken curd. (Compare with Plate III. *Photograph III.*)

PHOTOGRAPH II. Plate II.

× 2 *Diameters.*

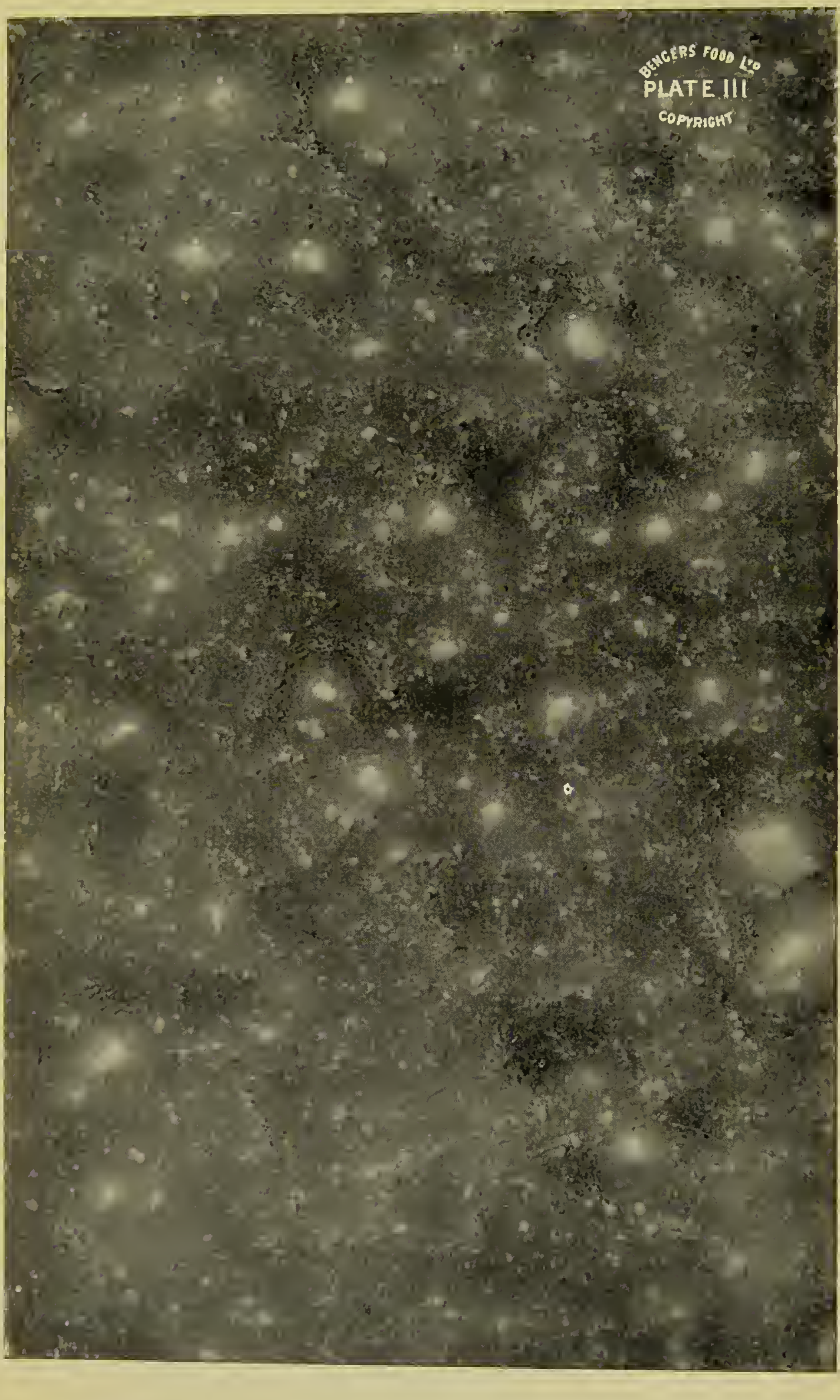
Copyright.

PHOTOGRAPH III.

COWS' MILK TREATED WITH BENGER'S FOOD.* Showing that it does not set in a solid curd, but can be poured out easily from the test glass. (Compare with Plate II. *Photograph II.*)

* ¾ oz. to 12 fluid ounces of milk.

PHOTOGRAPH III. Plate III.



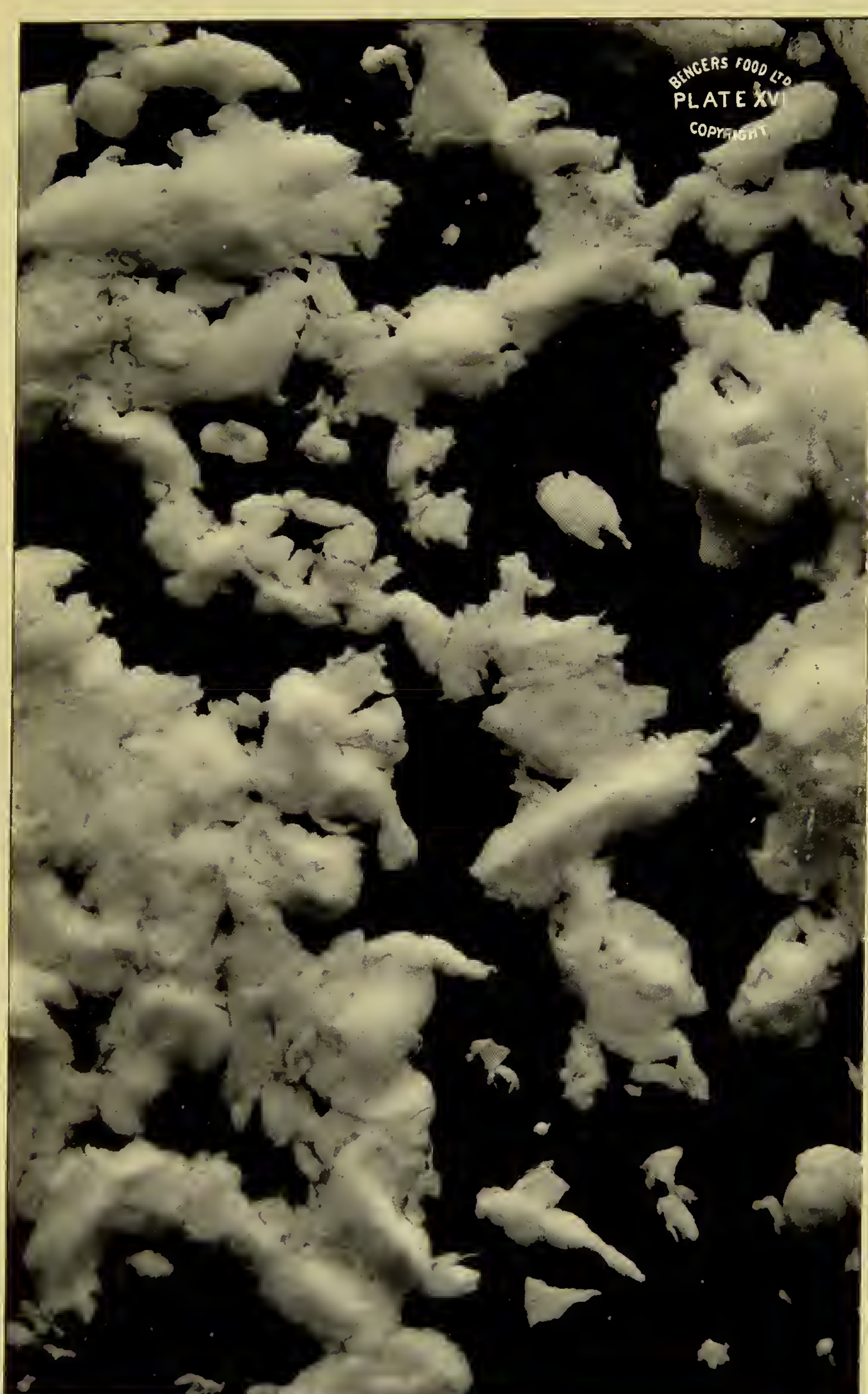
× 2 *Diameters.*

Copyright.

PHOTOGRAPH IV.

Curd formed in a mixture containing 44·4 per cent. Cows' Milk and 55·6 per cent. of water. (Compare with Plate XVIII. *Photograph VI.*)

PHOTOGRAPH IV. Plate XVI.

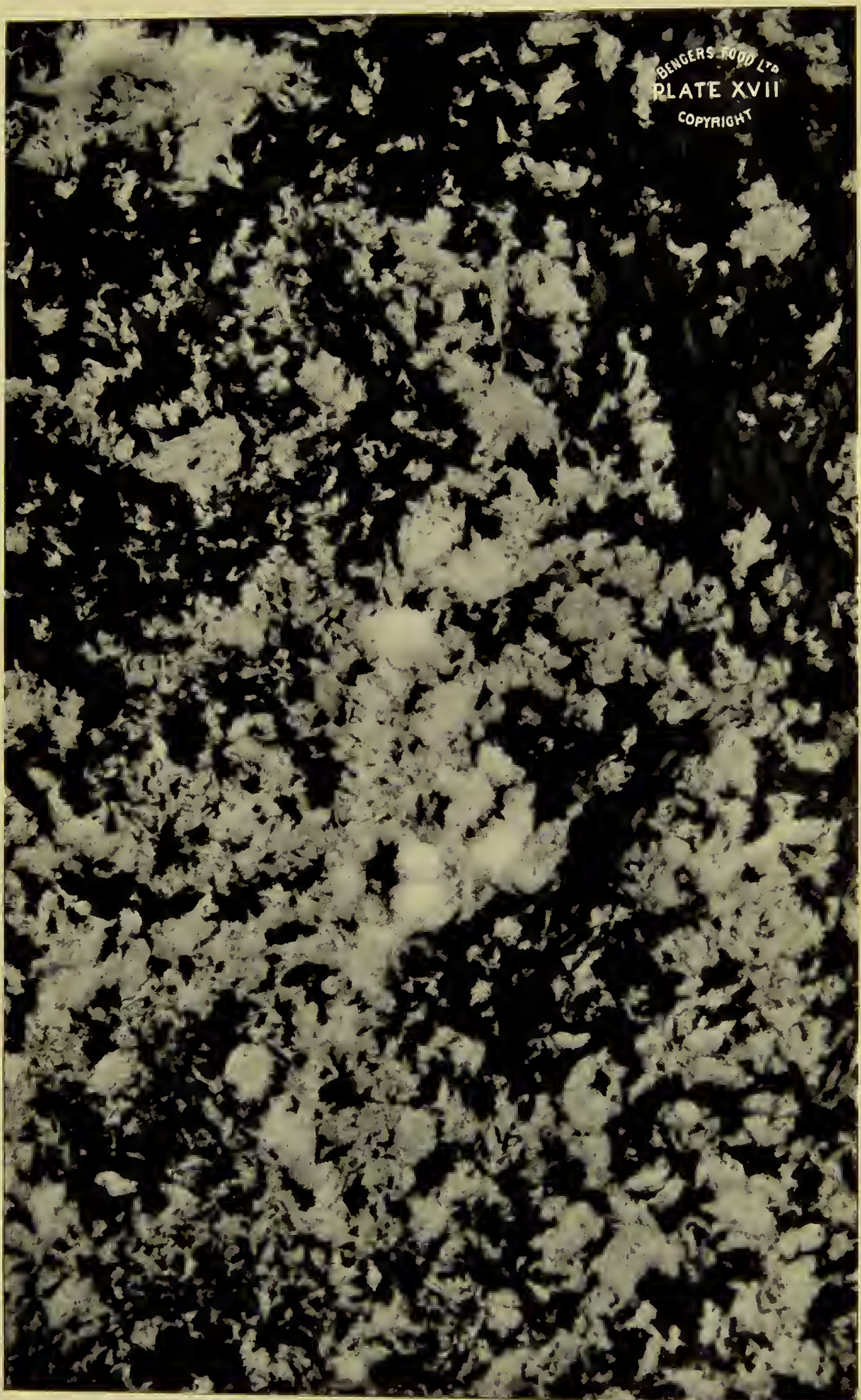


× 2 *Diameters.*

PHOTOGRAPH V.

Curd formed in a mixture containing 44·4 per cent. Cows' Milk and 55·6 per cent. of barley water. (Compare with Plate XVIII. *Photograph VI.*, also Plate XVI. *Photograph IV.*)

PHOTOGRAPH V. Plate XVII.



× 2 Diameters.

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PHOTOGRAPH VI.

Curd formed from same dilution of milk and water as in previous experiments (see Photographs IV. and V.), but first treated with Benger's Food,* and digested for fifteen minutes. (Compare with Plate XVI. *Photograph IV.*)

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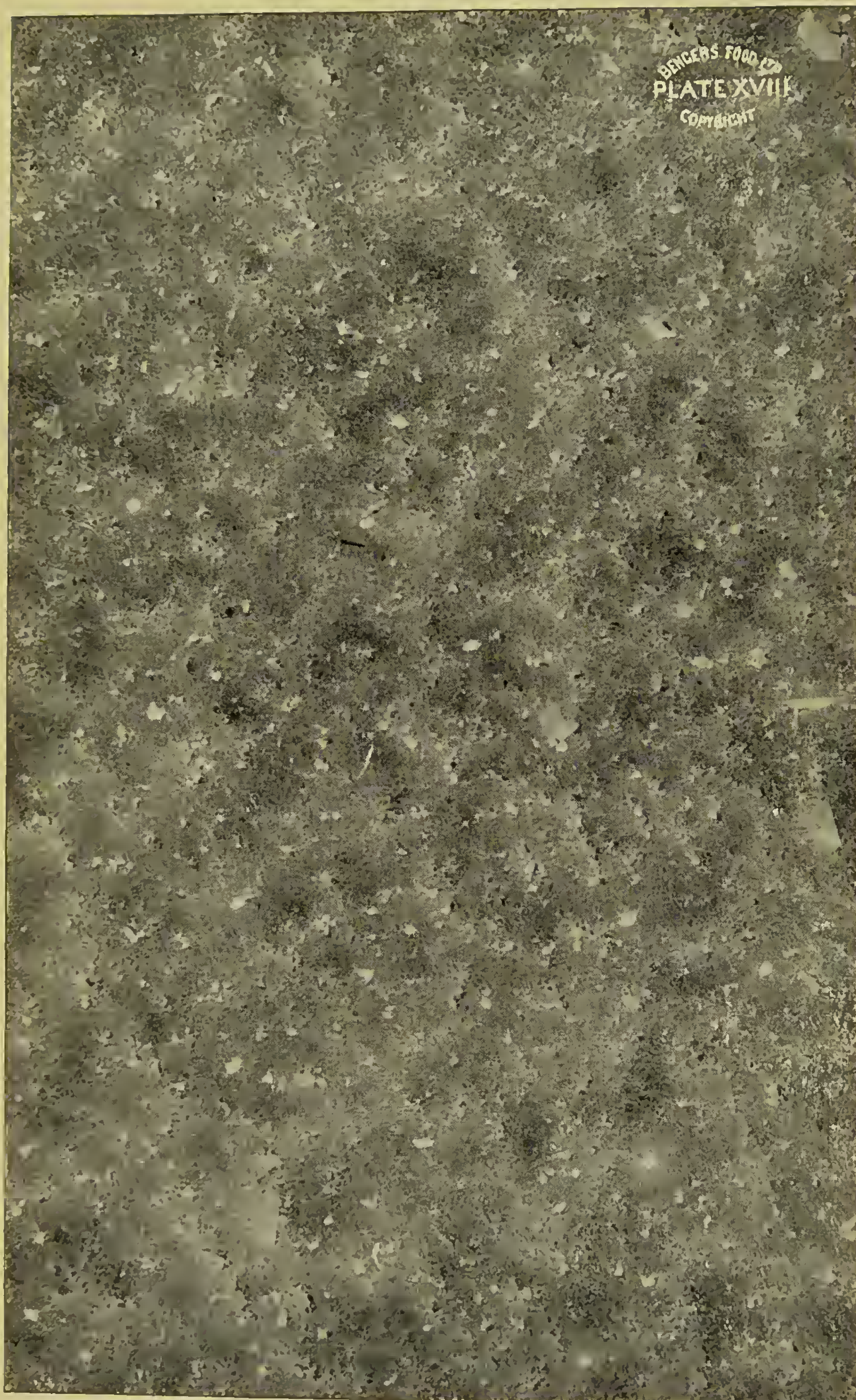
* *½ oz. Food to 12 oz. milk and water.*

PHOTOGRAPH VI. Plate XVIII.



× 2 Diameters.

PHOTOGRAPH VII.

THE SAME (see previous Photograph) AFTER THIRTY MINUTES' DIGESTION. Compare with Plates XVI.—XVIII. *Photographs IV., V., and VI.*)

PHOTOGRAPH VII. Plate XIX.

× 2 Diameters.

Copyright.

PHOTOGRAPH VIII.

The blue colour formed by the action of iodine on starch in barley water, showing unchanged starch.

PHOTOGRAPH VIII.

PHOTOGRAPH IX.

Colour obtained by the action of iodine on prepared Benger's Food* For this purpose made with water only. Showing extent of starch conversion. (Compare with Photograph VIII.)

---

* ½ oz. Food to 12 oz. water.

PHOTOGRAPH IX.

PHOTOGRAPH X.

Effect of excess of iodine on the same. (Compare with *Photographs VIII. and IX.*)

PHOTOGRAPH X.

INDEX.

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