On the principles and exact conditions to be observed in the artificial feeding of infants : the properties of artificial foods and the diseases which arise from faults of diet in early life ... / by W.B. Cheadle.

PRINCIPLES AND CONDITIONS
OF
ARTIFICIAL FEEDING

BY THE SAME AUTHOR.

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ARTIFICIAL FEEDING OF INFANTS:

THE PROPERTIES OF ARTIFICIAL FOODS:

AND

THE DISEASES WHICH ARISE FROM FAULTS OF DIET IN EARLY LIFE.

A SERIES OF LECTURES DELIVERED IN THE POST GRADUATE COURSE
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1887.

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PHYSICIAN TO ST MARY'S HOSPITAL AND LECTURER ON MEDICINE
IN ST MARY'S MEDICAL SCHOOL:
SENIOR PHYSICIAN TO THE HOSPITAL FOR SICK CHILDREN.

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PREFACE

THE reason and purpose of these Lectures is sufficiently set forth in the introductory portion, and I have here only to express my cordial and sincere thanks for much kind and valuable help received from many sources.

I am especially indebted to Dr. Arthur Luff, the Lecturer on Forensic Medicine at St. Mary's Medical School, for the accurate and repeated analyses of various foods and preparations which he has made for me; to Mr. Arthur Savory and Mr. Ekin for similar service; and to the makers of various articles of diet for information freely and generously supplied.

19 PORTMAN STREET,
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June 14, 1889.

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Reasons for choice of this subject.

I SHALL make no apology, gentlemen, for the subject of these lectures, trite and commonplace as it may seem to be; and for these reasons.

In the first place, the difficulty of artificial feeding a common one.

In the first place, because difficulties connected with this question of the feeding of infants are amongst the most common of the many troubles which beset the ordinary practitioner, and are constant sources of worry, of anxiety, and not unfrequently of discredit.

Unavoidable that a certain proportion of infants must be brought up by hand.

Owing to many different causes a very large number of children cannot be suckled by their mothers, or transferred to wet-nurses, and must be brought up by hand. The mother dies or falls into ill-health, or has no supply of milk, or is too closely occupied to attend to her child. A wet-nurse is expensive, troublesome, often difficult to obtain, and in a vast majority of cases practically out of the question. There is no alternative but artificial feeding. So that this question has constantly to be faced.

Secondly, errors of diet fruitful of disease in childhood.

In the second place, a large proportion of the diseases of early life, some of the most fatal, and some of the most lasting in their influence, have their origin in errors of diet.

It is not merely a question of overcoming a passing difficulty, or of effecting temporary

benefit, but one which largely affects the whole future of the child.

Importance of the question as a matter of national hygiene.

It is, therefore, of immense practical importance as a matter of national hygiene.

Of the four great external conditions which influence the development of the young organism—food, air, heat, and sunlight—food is one of the most potent.

The main conditions which influence the development of the young organism.

Of course the intrinsic condition, original constitution, played upon by these external conditions, is the other great and prime factor. In some individuals there is a high capability for development, in others the organism is originally so weak and faulty that it is incapable of reaching any great degree of strength and perfection. But the peculiarities of original constitution may be largely modified by external influences. The feeble and imperfect body which under adverse conditions would fall still lower or dwindle and die, may, by favourable conditions, be fostered into some degree of vigour and stability; the well-made body of rich possibilities may under evil conditions be degraded, and grow stunted and deformed, while under favourable surrounding influences it will develop into the highest perfection.

The lack of precise knowledge.

A third reason which has influenced me is the discovery that there is a lack of correct and precise knowledge on this subject, not only amongst students, but amongst medical men in active practice also; and even more than this, a great deal of positively erroneous belief, and of mistaken practice founded upon it. The main cause of this serious deficiency is to be found, I think, in the fact that the subject is neglected in our medical schools. It is either not taught there, or only in vague generalities and in desultory fashion. No accurate and scientific exposition of it is to be found in the ordinary text-books.

Neglect of the subject in the medical schools.

The materials of knowledge exist, but they are scattered about in the pages of works on physiology and on hygiene.

And thus, when the student enters upon the actual work of his profession, he has no certain data to guide him. He lacks accurate knowledge (1) of the physiological laws which govern the needs and powers of an infant, with their variations in health and disease; and (2) of the exact nutritive value of the various materials adapted for artificial feeding.

The student, uninstructed,

And so the method followed is too often

routine and mere rule of thumb. The exact nutritive value of the food chosen and its relative digestibility is not estimated ; if one does not agree, another is substituted haphazard, not because its ingredients are known to be accurately adapted to the special needs of the particular child, but because some other child appears to have done well on it, possibly under quite different conditions—with different constitution, of different age, of different digestive power, in a different state of health.

follows rule of thumb.

Thus, to give examples from actual experience, I have seen a delicate little infant, with a stomach whose powers were utterly unequal to digesting the coarse heavy curd of cow's milk, which set up vomiting and purging, forthwith put on goat's milk.

Examples of common errors.

Now goat's milk is excellent food for children ; it contains more cream than cow's milk, and almost the same proportion of casein. But the casein coagulates in equally heavy masses, and therefore goat's milk was quite unsuited to meet the particular difficulty in the case, and the change, instead of doing good, made matters worse than before.

Substitution of goat's milk for cow's milk in curd vomiting.

Again, I have seen too frequently—the most

Placing a rickety, anæmic child upon a purely farinaceous diet.

common mistake of all, perhaps—a puny bloodless child, with incipient rickets, eminently suffering from want of animal proteid and fat, owing to its inability to digest cow's milk, placed upon a purely farinaceous diet, with the result of causing still further deterioration, and inducing scurvy in addition to rickets.

Such instances, gentlemen, I might multiply almost indefinitely. But these will suffice to indicate the evils which arise from the imperfect appreciation of physiological laws in relation to diet, and of the properties of the materials available for artificial feeding.

The conditions essential to diet of full nutrition.

I pass on now to the first point in the consideration of this subject, viz. the exact conditions essential to be fulfilled in the diet of a child in order that it may afford perfect nutrition. And here, before I proceed further, I must ask your indulgence. In order to place the question clearly before you, I shall be obliged to state many things which you probably know already.

Review of elementary facts of physiology in relation to diet.

But if we are to follow out readily what we have before us for consideration, it is necessary, I think, to refresh our memories with the groundwork ; and the time thus spent in

brightening the recollection of elementary facts will not be lost.

Materials required for repair,

First, then, the body requires a constant supply of materials for various essential purposes. In a full-grown person the chief of these are the repair of structures, many of them undergoing constant unceasing change and as unremitting self-repair; the supply of secretions requisite for vital functions, as the juices which effect digestion, for example; and also as fuel to be burnt in the body for the supply of heat, and of force or energy for every movement and action and operation of organic life.

secretions,

fuel.

In children need for another purpose still, viz.

But in children there is a need for materials for another grand purpose in addition, viz. for the structure and development of new parts.

The existing tissues have to be kept in repair, just as with adults, but what may be called building materials are also required for making the new tissues of the growing structure. So that a child requires certain materials in larger proportion than an adult.

structure of new parts.

The adult requires limited assortment of food elements;

Again, while a mature adult can thrive upon a limited assortment of food elements, provided that it contains combustible enough for the supply of energy, and enough of other materials

the child a larger and more varied assortment.

for the secretions, and for the repair of waste and wear, the child requires a more varied assortment, containing, in addition to the ordinary essential elements, certain special ingredients necessary for the original structures of fresh growth.

Some new structures permanent.

Some of these new structures — as the mineral portion of bones, for example—are permanent, and require little or no repair afterwards.

The essential elements of food.

Now the essential elements of food, I may be permitted to remind you for a moment, are of five chief classes.

1. Nitrogenous.

1. The nitrogenous elements, characterised by the presence of nitrogen, the chief of which are the albuminates or proteids, found most largely in animal foods. Of these the albumen of egg, the casein of milk, the syntonin of muscle, and the gluten of wheat are examples.

2. Hydrocarbons.

2. The hydrocarbons or fats.

3. Carbohydrates.

3. The carbohydrates, of which starch and sugar are the chief forms.

4. Mineral.

4. Mineral elements, of which the salts of lime, especially the phosphate and carbonate, potash, soda, iron, are the chief.

5. Water.

5. The most general and largely used of all, water.

Food must contain elements from each group.

It has been ascertained by numerous observations and experiments that, in order to afford perfect nourishment to the body, food should contain materials drawn from each of these five groups. A man may get on for a time without one or other, perhaps, such as the carbohydrates or fats; but not continuously. For perfect health all must be combined.

With a child as with adults, this essential.

For a little child, as for an adult, it is essential that food should contain elements from each class.

With a child, too, nitrogenous or proteids first in importance.

And with children, as with adults, the nitrogenous elements rank first in importance. They are used for the structure of brain, nerve, muscle, and gland. Protoplasm, the centre of life and energy in every individual cell, is formed of nitrogenous matters, and nourished out of them. Every structure in the body in which any form of force is manifested is nitrogenous. Nitrogen is indeed essential to every vital process. Deprived of it, every function of the body languishes. All vigour and power dwindle and die out.

Uses.

Nitrogen essential to every vital process.

Especially essential to children.

It is clear, then, that if a sufficient supply of nitrogenous material or proteid is of the first importance to mature adults, it is still more

essential in the case of children with growing bodies, who require this material for new structures, in addition to that necessary for the routine work of maintaining the existing structure.

How want of nitrogen tells on them.

Deficiency of this element of nitrogenous food shows its evil mark quickly: the child's growth is interrupted; it becomes flabby and

They grow pallid, soft, feeble.

soft of muscle, pallid, feeble; vigour and vitality and the power to resist disease decline.

The second group, hydrocarbons.

The second group, the hydrocarbons or fats, are inferior in importance only to the preceding.

Fat essential to every cell.

Fat, like the nitrogenous protoplasm, appears to form a necessary part of every cell, enters largely into the structure of brain and nerve, and the marrow of bone, and it is stored up in all nooks and corners of the frame.

The fuel of the body.

Probably its chief office is to serve as fuel—burnt in the body just as oil is burnt in a lamp or coal in a furnace.

Thus heat supplied, to keep up standard temperature, 98·5°,

Thus is supplied the heat required to keep up the temperature of the body to the standard necessary for vitality of the fluids and solids of which it consists, and thus also is supplied

and force.

chiefly the force (converted from its co-relative, heat) for every action and motion and function of the organism.

In the case of infants, again, it is obvious that this element of food, fat, must be of the very highest importance. It is wanted for the generation of heat and energy so largely called upon in the period of early growth. It is wanted for every tissue formed and forming, especially for brain and nerve cell, and for the marrow cells.[1]

In the case of infants,

equally necessary for heat and force,

for tissue-formation.

In children who are fed upon a deficient amount of fat the bony structures are imperfect and slow of growth; in a word, deficiency of fat in the food is one of the chief factors in the production of rickets.

Fat essential to formation of bony structures.

Deficiency of fat one cause of rickets.

The next group of elements, the carbohydrates, of which starch and sugar are the representatives, do not appear to be used directly in tissue-formation, although they are present in the form of glycogen (grape sugar) and inosite (or muscle sugar) in certain organs and fluids of the body. The carbohydrates in food are largely converted into fat, and serve also

Third group of elements, carbohydrates.

Not used directly in tissue-formation.

Largely converted into fat.

[1] It is probable, I think, in view of the imperfect tissue-formation which results from a deficiency of fat in the food of children, that all used for structural purposes is derived from that supplied from without in food *as* fat—not fat manufactured *in* the body, as it is so largely, from the carbohydrates, and by the splitting up of albuminous compounds, and which is used for combustion, or stored up in adipose tissue.

Also fuel.

for combustion, perhaps as a lighter kind of fuel than the more highly carbonaceous element fat.

These elements of less importance.

These elements, then, appear to possess less intrinsic value than the preceding, the proteids and the fats. Certain races of men, such as the

For some races of men do without them.

Esquimaux, who live almost entirely on animal food, get little or none—except from fruits in the short arctic summer, or in the form of lichenin in Iceland moss—and yet retain their

Yet children get sugar in mother's milk.

health. The children, however, get carbohydrate in infancy in the form of the sugar in their mothers' milk. Seeing how largely carbohydrate is present in ordinary food, and how plentifully it is supplied to infants in their

Probably essential to perfect nutrition of adult and of child.

natural diet, milk, this element is probably essential to the perfect nutrition of the adult organism, and certainly to that of the growing organism.

The fourth group, minerals.

The mineral constituents of food, which form the fourth group of elements, are many of them essential to life at every age, but some far more important to children than to grown persons.

Essential.

Iron, salts of lime, magnesia, potash, and soda are essential to bodily nutrition at all ages and in every phase.

The earthy phosphates.

The phosphate of lime appears, indeed, to be necessary to every tissue. Probably no cell growth can go on without the earthy phosphates. Even the lowest forms of life, such as bacteria and fungi, cannot grow if deprived of them.[1]

Additional need in children.

But there is an additional and special need for these salts of lime and magnesia in childhood for the building up of permanent structures, such as the mineral part of bone, which probably require little or no repair afterwards.

The fifth class, water

Water, again, is essential to all for the solution and carriage of peptones from the stomach to the blood stream, for the liquefaction of the blood and of the secretions, and for the restoration of tissue.

Uses of water

But more is needed in proportion by the infant organism for the building up of new tissues, four-fifths of which consist of water.

With infants elements from each group essential.

With infants, therefore, as with adults, it is essential that food should comprise a sufficient amount of ingredients from each of these five groups: proteids, hydrocarbons, carbohydrates, minerals, water.

Then comes the question, since these are the materials required by the growing body of the

[1] Parkes, *Manual of Hygiene*, 4th ed. p. 176.

child, and such being their relative importance, how much proteid does a child require? How much fat? How much starch, dextrine, or sugar?

How much of each?

Then in what proportion?

In what proportions should these ingredients be present in the food?

Proportions ascertained for adults.

Now it has been ascertained by numerous experiments that in order to keep an adult body in perfect health the various essential elements should be combined in the following proportions:

Nitrogenous elements or proteids (albumen, casein, &c.)	1·00 part
Hydrocarbons (fats)	0·60 ,,
Carbohydrates (starch, dextrine, sugar, &c.)	3·00 parts
Salts	0·23 part
Water	15·17 parts
	20·00

Or, raising the proportions to so much in 100 or a percentage:[1]

Proteids	5·00
Fats	3·00
Carbohydrates	15·00
Salts	1·15
Water	75·85
	100·00

[1] Moleschott's table quoted by Parkes, confirmed by numerous other experimenters sufficiently closely; by Pettenkofer and Voit, Von Ranke, Playfair.

Should, then, the proportions for a child be the same as for grown persons? The answer is unmistakably in the negative. The proportions should not be the same.

Should the elements be in the same proportions for a child? The answer.

The evidence afforded by physiology and the evidence obtained by actual observation agree on this point, and are absolutely conclusive.

Evidence of physiology and actual observation agree.

First, the evidence from physiology.

First, evidence from physiology.

Milk contains everything essential for the formation and nourishment of the child during the first months of life, out of which, without addition of other food, it can grow into complete perfection, just as an egg supplies every material out of which the chicken is formed complete, with bone and flesh and feathers.

Milk, like the egg, contains all the materials in due proportion.

Human milk, therefore, may be taken as the type-food for an infant, and the proportions of the different ingredients found to be contained in it may be taken as the standard of an infant's food when artificially made. Now human milk, according to the analysis of Gorup-Besanez, contains:

Human milk the type-food.

The proportions the standard for artificial foods.

Proteid	3·924
Hydrocarbon	2·666
Carbohydrate	4·364
Salts	0·138
Water	88·908
	100·000

Proportions of different elements in human milk.

Comparison of standard for a child with that for an adult.

A comparison of this standard with the standard proportions in the diet of an adult teaches some important facts, which are constantly disregarded or overlooked in actual practice.

Taking first the proportion of food-elements in this standard, and comparing it with the previous percentage of elements in the standard for adults, two things especially strike one at once.

First, the higher proportion of fats to carbohydrates,

The first is the higher proportion of fat in relation to the carbohydrate and to the proteid.

and to proteid.

To the carbohydrate it stands as 1 : 2 as compared with 1 : 5 in the proportion for adults, and with regard to the proteid it is nearly as 2 : 3 instead of as 3 : 5—the proportion for adults.

With analysis of Payen contrast still more striking.

If we take the analysis of Payen—

Proteid	3·35
Fat	3·34
Carbohydrate and salts . .	3·77
Water	89·54
	100·00

the contrast becomes still more striking.

Fat nearly equal to carbohydrate instead of 1 to 5.

Equal to proteid also instead of 3 to 5.

In this the fat is as nearly as possible equal to the carbohydrate, instead of as 1 : 5 only as with adults; and it is equal to the proteid also, instead of as 3 : 5 only as with adults' diet.

Then the evidence of actual observation as to the gross amounts of each ingredient required at different ages—evidence distinct from the inference drawn from the analogy of human milk.

Evidence from gross amounts.

Investigations conducted at Munich show that the smallest amount of food compatible with health at different ages is as follows: [1]

Age	Nitrogenous elements	Fat	Carbohydrates
Child under 1½ years . .	20 to 36 grms.	30 to 45 grms.	60 to 90 grms.
Child from 6 to 15 years .	70 ,, 80 ,,	37 ,, 50 ,,	250 ,, 400 ,,
Man (moderate work) . .	118 grms.	56 grms.	500 grms.
Woman (moderate work) .	92 ,,	44 ,,	400 ,,
Old man . .	100 ,,	68 ,,	350 ,,
Old woman .	80 ,,	50 ,,	200 ,,

We see that for children the proportion of fat to carbohydrates is 30 grammes (fat) to 60 grammes (carbohydrates), or 45 to 90, according to age, *i.e.* exactly as 1 : 2, the precise proportion found to exist in the standard food, milk. For the adult it is 56 : 500, or about 1 : 9 only.

For children, fat to carbohydrate as 1 : 2.

Same as in milk.

Further proof of the large amount of fat required by a child in proportion to that neces-

Further proof of large amount of fat required by children as compared with adults.

[1] Landois and Stirling, *Human Physiology*, vol. i. p. 481.

sary for a grown person is shown by this table of gross amounts.

A little child requires 30 to 45 grammes daily.

For a little child under 1½ years the total required in 24 hours is estimated at 30 to 45 grammes.

An adult only 56 grammes.

For a grown man in 24 hours, 56 grammes.

A child, half to three-quarters of what a man requires.

Or, roughly, for the tiny infant from half to three-quarters as much fat is necessary in food in 24 hours as for a full-grown man.

Then, again, the proteid should be in larger proportion to the carbohydrate than in an adult diet, as 3½ : 4, or nearly equal, instead of 1 : 3 only.

Similarly the gross amounts show that :

The proportion of proteid to carbohydrate for a child is . .	20 : 60 = 1 : 3 or 36 : 90
For an adult it is as . . .	118 : 500 = 1 : 5 nearly.

The outcome.

The outcome of this may be summed up thus :

Taking mean of two analyses.

Taking the mean between the two analyses of milk of Payen and Gorup-Besanez as the final standard, the proportion of fat to the other elements, viz. the proteids and the carbohydrates, should be very much larger than in the food of adults, *i.e.* the fat should be nearly equal to the

Much larger proportion for a child. Of fat about same as proteid instead of 3 : 5.

proteid (3·9 : 4·3) instead of only as 3 : 5, and the fat again should be to carbohydrate as 2 : 3, instead of as 1 : 5 only, as in the food of adults. And in the same way the proteid should be in higher proportion to the carbohydrate, $3\frac{1}{2}$: 4 instead of 1 : 3. The proportions essential in infants' food, thus deduced, may be stated broadly thus:

Fat to carbohydrate as 2 : 3, instead of 1 : 5.

The proportion for infants.

Proteid	$3\frac{1}{2}$
Fat	3
Carbohydrate	4

The existence of this large proportion of fat in the standard food, milk, is conclusive as to its great importance. A similar proportion obtains in the milk of all animals, not in human milk only. There can be no doubt that fat serves some most vital purpose in the nutrition of young growing animals. What that precise end may be we are not quite certain, but, as I pointed out, fat is largely concerned in all cell growth, and is probably vital to the perfect formation of bone.

Significance of this large proportion of fat in the type-food, milk.

The precise use of it not altogether made out.

I wish to lay especial stress upon the importance of a due proportion of fat in the food of infants, because it is a point most imperfectly recognised.

In spite of this indication in milk, artificial foods almost destitute of fat.

In spite of the significant fact that milk is a rich emulsion of fat, little children are constantly placed on artificial foods which are almost destitute of this vital element.

Proteid also often deficient.

Proteid is commonly deficient also, but usually in less glaring and extreme degree.

The first essential condition, viz. the elements must be in the standard proportions existing in human milk.

We may then lay down as a first proposition that children's food should contain the different elements in these proportions—

Proteid	3·924
Fat	2·666
Carbohydrate	4·364
Salts	·138
Water	88·908
Total	100·000

or roughly, taking the mean of the two analyses of human milk (except in salts, which are not estimated separately by Payen), the proportions of different elements are, for an infant—

Final standard of proportion.

	Per cent.
Proteid	3·500
Fat	3·000
Carbohydrate	4·000
Salts	0·138
Water	89·362
Total	100·000

as compared with the standard for adults—

Proteid	5·00
Fat	3·00
Carbohydrates	15·00
Salts	1·15
Water	75·85
Total	100·00

Whatever kind of artificial food we use, then, it ought to contain all these elements in these proportions. How little this grand first rule is regarded you will see presently.

Artificial foods must be made to correspond to this scale.

There is another quality in food essential to the healthy nutrition of infants, in addition to the due proportion of the different elements, the anti-scorbutic property.

Second essential condition, the anti-scorbutic element must be present.

As you know, it is found that, in the case of adults, every dietary must contain a certain amount of fresh vegetable food, or scurvy follows.

The exact nature of the ingredient which confers the anti-scorbutic power has not been ascertained with certainty; but it is known to be contained especially and abundantly in fresh vegetable juices, and has been inferred to consist in a combination of organic acids with potash.

The exact nature of the anti-scorbutic element not known.

Now children fed on fresh milk never get scurvy, except in the very rare instances where the mother who is suckling her child

Children fed on fresh milk do not get scurvy except from scorbutic mothers.

becomes scorbutic. This shows that where the anti-scorbutic element is present in the food of the milk-producer, it is transferred with other properties to the milk. Nursing mothers who get scurvy from the lack of anti-scorbutic food cannot transfer the essential element to the milk, and their infants may become scorbutic. Fresh milk therefore possesses, in addition to the other essential elements, this mysterious anti-scorbutic element which in an ordinary diet is supplied by fresh vegetables. Thus milk becomes an absolute and complete compendium of all essentials of food. It is perfect in all points. It would seem, however, as I shall show later, that condensed milk loses something of this special virtue. The anti-scorbutic element is present in fresh meat—especially in raw meat—as we should expect it to be in the flesh of herbivorous animals, and as proved by Dr. Rae's experience in the Arctic regions, and my own.

Milk, therefore, possesses this virtue in addition.

Condensed milk less certain.

Fresh meat contains anti-scorbutic element.

On the other hand, it is absent from all farinaceous food. If, therefore, the child cannot be fed on milk, the anti-scorbutic element must be specially supplied to the artificial food substituted for the milk. This is a vital point, essential to full health, yet its importance is

It is absent, however, from farinaceous foods. It must, therefore, be supplied to such artificial foods.

The importance of this little recognised in practice.

most inadequately recognised in practice.[1] We may, then, put this down as the second essential condition of an infant's food, viz. that it should contain the anti-scorbutic element.

Second essential condition.

Such, then, being the materials which an infant's food ought to contain, and the proportions in which the chief elements should be present, the next question to be dealt with is, How much food altogether must be given, combined in these proportions?

The next question. How much food, combined in these proportions?

This is a more difficult question to answer with precision than the previous one with regard to proportions. But an approximate answer may be offered. It is found from experiment[2] that each breast of a woman with a full flow of milk secretes on an average about 50 to 60 grammes, $=1\frac{1}{2}$ to 2 oz., every 2 hours. This would give for the two breasts 100 to 120 grammes, $=3$ to 4 oz., every two hours, or 1,200 to 1,440 grammes, $= 38{\cdot}7$ to $46{\cdot}5$ oz., in 24 hours.

A more difficult question, yet an approximate answer may be given.

Normal yield of breast-milk.

Gross amount in 24 hours.

[1] Some years ago I published a series of cases of true scurvy, as I shall have occasion to show later, arising in hand-fed children from this cause, and these observations have since been confirmed by my colleague, Dr. Barlow.

[2] Lamperière, *Comptes Rendus*, 1850, vol. xxx. p. 172, Lamperière's results are the average of 67 experiments.

But this, you will observe, is merely the average yield, when both breasts are emptied, and at different stages of lactation. The child does not empty both breasts each time of suckling—only one at first: hence it would not draw the whole 38 oz. probably, but much less.

The amount varies according to stage of lactation.

And then the amount yielded varies according to the stage of lactation. At first the milk is much less than at a late period of suckling. It has been calculated that a mother's breasts yield

Amount at different stages of lactation: 1 to 3 pints.

1 pint of milk during the 24 hours for the first few weeks, and that this quantity gradually increases until in the later months it reaches 3 pints. This, then, may be taken as the standard of quantity.

Another basis of calculation from gross amount of each element.

Taking, now, another basis of comparison, viz. the gross amount of each element of food required, observations [1] show, as noted previously, that a child under 1½ years requires at least—

Proteid . .	20 to 36 grammes	= 310 to 558 grains
Fat . . .	30 ,, 45 ,,	= 465 ,, 697 ,,
Carbohydrate .	60 ,, 90 ,,	= 930 ,, 1,395 ,,

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[1] Landois and Stirling, *Results of Investigations of the Munich School*, l. c. vol. i. p. 482.

Now, 1 pint of human milk yields, according to Gorup-Besanez' analysis— Amounts in 1 pint human milk.

Proteid	377 grains
Fat	256 ,,
Carbohydrate . . .	419 ,,

2 pints yield— In 2 pints of human milk.

Proteid	754 grains
Fat	512 ,,
Carbohydrate . . .	838 ,,

3 pints yield— In 3 pints.

Proteid	1131 grains
Fat	768 ,,
Carbohydrate . . .	1257 ,,

Or, taking Payen's analysis : On Payen's analysis.

1 pint contains—

Proteid	321 grains
Fat	320 ,,
Carbohydrate . . .	361 ,,

2 pints contain—

Proteid	642 grains
Fat	640 ,,
Carbohydrate . . .	722 ,,

3 pints contain—

Proteid	963 grains
Fat	960 ,,
Carbohydrate . . .	1083 ,,

To provide this 1 to 3 pints human milk required.

So that, to provide gross amount of elements necessary, from 1 to 3 pints of human milk would be required; or of cow's milk rather less, with sugar added.[1] This would give an excess of proteid and a deficiency of fat and carbohydrate for the smaller measures. The yield of mother's milk is probably the best guide—better than these estimations of gross quantities of each element, which are based upon too wide a range of age, viz. from birth to 1½ years, to be exact for young infants who get milk food only.

Third essential condition, the total quantity must be equal to the standard amount for an infant.

But the general result agrees sufficiently well with that obtained previously by calculating the breast yield to give it additional certainty.

There is no doubt considerable variation in the amount which is essential, according to the size and vigour of the child and the nutritive richness of the milk, and judgment must be used in individual cases.

Considerable variation in amount essential.

But we may take it as a general rule that anything materially under 1 pint of human milk,

[1] One pint cow's milk contains—

Proteid	519 grains
Fat	413 ,,
Carbohydrate . . .	388 ,,

or its equivalent, would be insufficient for full nutrition, even for the first month of life, and we may safely say that for the first month the child should have the equivalent of 16 to 24 oz. of human milk; in the second month the equivalent of 20 to 26 oz.; in the third month the equivalent of 24 to 30 oz.; in the fourth month 30 to 35 oz.; later, 35 to 45 oz., or more. Or, putting it another way, at first 1½ to 2 oz. every 2 or 2½ hours, gradually increased to 3 oz. every 3 hours after the first month, and the quantity augmented so as to give the amount calculated as necessary for each month of age.[1]

Gross amounts for each age.

Quantity at each meal, and times of feeding.

These quantities are not to be taken as absolutely and arbitrarily fixed. They will require to be varied within the limits named, according to the capacity of the child and its peculiarities, but will serve as a starting-point and safe guide at the outset.

These quantities not absolute,

but a close and safe guide.

The child's stomach acts in some degree as an indicator of quantity, too. If it is overfilled, the excess is readily rejected. If, after the meal,

[1] According to the observations of Rotch (*Annual of Univ. Med. Science*, vol. iv. 1888, p. 260), the stomach of an infant five days old has a capacity of 25 c.c., or about 6¼ fluid drachms.

craving still remains, the child cries for more, sucks its fingers, is restless and complaining.

Value of a regular record of weight.

With the data I have given, and watchful observation of the child's condition as to overloading of the stomach, and satisfaction of appetite, aided by a regular record of weight (the increase should be 2 or 4 oz. per week, or even more)—a most important help—the necessary quantity will be estimated with sufficient exactness ; and indeed this matter of quantity is much less important than the proportion of the elements. It is in great degree self-regulating.

Fourth essential condition, the food must contain a due proportion of animal matter.

Another condition which must not be overlooked in an infant's artificial diet, but a principle too often neglected, is that it should contain a due proportion of animal matter. It is difficult to supply sufficient nitrogenous material in vegetable food, which contains it in small proportion ; and it is practically impossible to obtain sufficient fat from vegetables, for in the available forms, such as the farinaceous preparations, it is present in smaller proportion still. Even maize, the richest of all grains in fat, contains only 7 per cent., and that, with the requisite dilution of 7 to 16 parts of water, would be far below the necessary standard.

Difficulty in supplying fat and nitrogenous elements from vegetable food.

Doubtful whether vegetable nitrogenous matter and fats would be efficient even if ample.

But apart from this difficulty it is doubtful whether, even if these ingredients could be supplied in vegetable form in sufficient quantity, they would be efficient for nutrition.

Children fed on vegetable food only, feeble, rickety, scorbutic.

Milk, the type-food, is entirely animal. Animal tissues are probably most easily made from animal materials, and little children brought up on vegetable food alone are soft, flabby, anæmic, rickety, and, if the food is solely farinaceous, scorbutic. Yet most artificial foods are entirely vegetable. We may unhesitatingly, I think, affirm the fourth Rule: That it is an essential condition that an infant's food should not be purely vegetable, but should contain a due proportion of animal matter.

The fifth essential condition, the food must be of a form suited to the physiological condition of the digestive function in infancy.

The next point upon which I must insist is this: That the food should be of a form suited to the physiological condition of the digestive function in infancy.

It must be remembered that the digestive organs have only just come into use, and are designed only to deal with the bland and easily-dissolved nutriment of the mother's milk.

Special features of infantile digestive function.

During the early months of life young animals, and human infants amongst them, have little power of digesting starch. It appears that

Absence of ptyalin.

in new-born children the parotid alone contains the diastatic ferment ptyalin. It is developed in the sub-maxillary gland at the earliest at two

Little saliva.

months, and during this time there is indeed little saliva secreted. It begins to flow after the second month, but not freely until the eruption of the teeth.[1]

Diastatic ferment absent also.

Moreover, the diastatic ferment is likewise absent in the pancreatic secretion for the first two months of life. It is not fully developed until a year old.[2] An infant, therefore, has at first small power of digesting starchy food.

In milk no starch; the carbohydrate exists as lactine.

In its natural food, milk, there is no starch; the carbohydrate is in the form of lactine, or sugar of milk. The starch is converted into sugar in the mother beforehand. Yet although nature has not endowed infants with the power of dealing with starch, and it cannot, therefore, possibly be a proper element of food, most

[1] Landois and Stirling, from various authors — Zweifel, Korowin, &c.—vol. i. p. 293-4.

[2] Landois and Stirling, vol. i. p. 344. 'The pancreas of new-born children contains trypsin, which acts on proteids, and the fat-decomposing ferment, but not the diastatic one.'—ZWEIFEL.

'A slight diastatic action is obtained after 2 months, but the full effect is not obtained until after the first year.'—KOROWIN.

artificial foods, with profound indifference to physiological teaching, have starch for their chief ingredient.

Yet most artificial foods chiefly starch.

A second notable deficiency in the digestive power of infants is the inability to deal with large masses of solid or semi-solid matter. Neither the solvent virtue of the digestive juices nor the feeble muscular power of the stomach is equal to this. They can only digest solids in a state of minute subdivision. This is seen in the disorder produced by cow's milk, when large coagula of curd are rejected by the stomach undissolved, or passed by the bowels.

Another deficiency in digestive power of infants.

Both solvent and muscular power of stomach unequal to deal with large masses.

Shown by effect of large coagula of milk.

In the same way the insoluble cellulose or woody fibre of the coarser vegetable products are irritating and injurious.

And, lastly, the sixth essential condition: The food must be fresh and sound, free from all taint of acidity or decomposition.

The sixth essential condition.

The stomach of a little child has a very delicate and sensitive reflex organisation, and is extremely intolerant of food which is in a state of fermentation or is affected by the least trace of decomposition.

Sensibility of a child's stomach.

Probably the products of such changes are absorbed and act injuriously on the nervous

Products of decomposition.

system when carried there in the blood stream, as well as locally upon the mucous membrane of the alimentary canal.

Danger with cow's milk.

Cow's milk is a constant source of danger in this way. As soon as it has been drawn from the cow it immediately commences to undergo change. The minute light oil-globules disseminated through the liquid rise to the surface as cream. Milk absorbs oxygen, and begins at once to give off carbonic acid from the decomposition of the nitrogenous matter.[1] This sets up fermentative change in the lactine, probably by the aid of the bacterium lactis. Lactic acid begins to form and causes the coagulation of the casein. The cream, which has previously risen to the surface, disappears. The products of these changes of fermentation are highly irritating, and the sensitive reflex apparatus is profoundly disturbed by them. Violent vomiting and diarrhœa are set up by food in a state of sourness and fermentation — consequences always serious, often fatal.

Fermentation quickly begins.

Coagula form.

Irritant products developed.

This and masses of undigested material the chief cause of choleraic diarrhœa.

This, and the presence of masses of undigested curd or dense food in the stomach and intestine, are the two chief causes indeed of

[1] Hoppe-Seyler, quoted by Parkes.

choleraic diarrhœa, so deadly to infant life—the Cholera Infantum of the American physicians, especially rife in hot climates, where decomposition proceeds most rapidly, and infants' food is most readily tainted by it.

Especially in hot climates.

Hence the prime necessity for extreme cleanliness in all utensils used for infants' food—milk cans, bottles, cups—and also the wisdom of boiling milk as soon as it is received, so as to stop at once all further changes of fermentation. Milk once boiled remains much longer free from sourness.

Hence prime necessity for absolute cleanliness.

Of this point I shall now take leave once for all. You are, no doubt, all alive to its importance, which is, indeed, in these days pretty generally recognised.

To sum up ; *the six essential conditions to be observed in the diet of infants*, then, are these :

Summary of essential conditions.

I. The food must contain the different elements in the proportions which obtain in human milk, viz.—(taking the mean between the two analyses of Gorup-

Besanez and Payen, and discarding small fractions)—

Proteid	3·5 per cent.
Fat	3 „
Carbohydrate . .	4 „
Salts	0·2 „

with water 85 to 90 per cent. for the first few months of life.

II. It must possess the anti-scorbutic element.

III. The total quantity in 24 hours must be such as to represent the nutritive value of 1 to 3 pints of human milk, according to age, viz. :

Proteid . . .	377 to 1,131 grains
Fat . . .	256 to 768 „
Carbohydrate .	419 to 1,257 „

IV. It must not be purely vegetable, but must contain a large proportion of animal matter.

V. It must be in a form suited to the physiological condition of the digestive function in infancy.

VI. It must be fresh and sound, free from all taint of sourness or decomposition.

Vital importance of observing these conditions.

I would urge you, gentlemen, to ascertain accurately in all cases that the food you order for a child satisfies these six essential conditions.

In the next lecture I hope to show how far these same essential conditions are met by the artificial foods in ordinary use, and how they may be satisfactorily secured in actual practice.

LECTURE II.

ARTIFICIAL FOODS.—THE VARIOUS FORMS OF MILK AND ITS PREPARATIONS.

Brief summary of conclusions reached in the previous lecture—Advantages of wet nurse—Difficulties in the way—Table of proportion of elements in various kinds of milk—Preparations of cow's milk—Asses' milk one of the best substitutes for human milk—Its advantages and disadvantages—Cow's milk diluted with water—Nutritive value of different degrees of dilution—Two parts milk to one part water essential to full nutrition—The real difficulty of cow's milk due to the character of the casein, not to excess of solids—Comparison of the casein of cow's milk with that of other kinds of milk—Its massive coagula—Experiments—Expedients for remedying this coarse coagulation—Boiling—Barley water—Lime water—Bicarbonate of soda—Peptonised milk—Qualities of the various preparations considered—Boiled milk with barley water or lime water preferred—Objections raised to boiled milk considered—Its advantages—Arrest of contagion from this source—Condensed milk : its good and bad qualities—Goat's milk—Artificial human milk.

Recapitulation of points established in the previous lecture.

IN the previous lecture, gentlemen, I endeavoured to trace out the exact conditions which should be observed in the composition and amount of infants' food.

First, the proportions in which each element

should be contained, laying especial stress, you may remember, upon the necessity for a sufficient supply of fat and a sufficient supply of proteid, and the high value of these elements—points constantly disregarded. First, the standard proportions.

Secondly, that it must contain the anti-scorbutic element, another essential condition constantly overlooked, with disastrous consequences. Secondly the anti-scorbutic property essential.

Thirdly, the total quantity in 24 hours should be the equivalent of 16 to 24 oz. of human milk for the first month, running up by gradual increase to 35 or 45 oz. or even 60 oz. at 8 or 10 months. Thirdly, the standard quantity.

But I pointed out to you also that there must be considerable variation in quantity, according to the capacity and constitution of the child. This variable.

This mere question of quantity in great measure settles itself. I do not wish to attach prime importance to exact observance of standard quantity. If the child gets too much it is sick. If too little it is restless and crying with hunger. Remember, if the proportions of food are right, the quantity may be easily adjusted, beginning, as a standard for the first If proportions are right, quantity easily adjusted.

month, with 1½ oz. to 2 oz. every 2 hours, or every 2½ hours.

Fourthly, the necessity for animal elements.

The next essential point on which I insisted was that the food should not be purely vegetable, but must contain a due proportion of animal matter. And first, because sufficient fat could not be supplied in vegetable form, and sufficient proteid with difficulty; and secondly, because, even if this were possible, it is doubtful whether the vegetable fats and proteids are equally as efficient for the formation of growing tissues as the same elements from animal sources, while the carbohydrates in the form of starch are used with difficulty, and are not so effective as sugar of milk or its analogues.

Difficult to supply sufficient fat and proteid from vegetable sources.

Also vegetable carbohydrate in form of starch less easy of digestion than lactine.

Fifthly, food must be adapted to the physiological needs of an infant.

Fifthly, I urged the importance of the foods being adapted to the digestive powers of an infant. I showed how this consideration was constantly neglected in giving starch foods, the young child having little or no power of digesting starch for the first few months of life, owing to the small amount of the diastatic ferment in the saliva, the paucity of the salivary secretion until the teeth appear, the entire absence of the diastatic ferment from the pan-

Peculiarities of the digestive functions in infancy.

Deficiency of diastatic ferment.

creatic juice during the first 2 months, and its imperfect development until the end of the first year. I alluded also to the inability of the gastric digestive apparatus to deal with solids in mass ; how they must be in a state of minute subdivision to enable the child's stomach to grapple with them, and how insoluble vegetable matter such as cellulose, and woody fibre of the coarser products, oatmeal or brown flour, are irritating and injurious.

Inability of child's gastric apparatus to deal with solid masses or other insoluble matters.

And lastly, I stated how intolerant the delicate and sensitive alimentary canal of an infant is of the slightest taint of sourness and decomposition in food.

Sixthly, food must be fresh and sweet.

Such, then, being the conditions to be observed in the provision of artificial food for an infant, let us see how they can be best fulfilled with the materials at disposal.

Such the conditions essential.

How they can best be fulfilled with the materials at disposal.

If the mother is unable to suckle her child the best substitute for the mother's milk is the milk of some other woman, whose child has been born about the same time, and whose milk, therefore, is in a similar stage of development. A good wet-nurse usually saves all further trouble.

Wet-nurse.

But the expedient of a wet-nurse cannot

Only rarely feasible.

always be adopted. It may not be possible to find a satisfactory one at the moment, or the expense may be too great for the parents' means, or the addition to the establishment too inconvenient, and the child must, of necessity, be brought up by hand. And I believe that, by proper management and precautions, all difficulties of the transfer from the breast to artificial feeding may be got over with absolute safety, and in all respects satisfactorily, so that the child shall escape gastric troubles, and shall thrive.

Artificial feeding perfectly safe with due care and proper knowledge.

And here let me notice for a moment a popular prejudice which exists against hand feeding and suckling combined. A superstition still survives amongst nurses and matrons that the cow's milk and the mother's milk do not agree, as if they quarrelled in some curious way within the child's body, and fought it out there to its great discomfort and damage. But this is a pure fallacy. The cow's milk may disagree with the child, but not the mother's milk, if it is healthy. All that the child can get of this is pure gain—half a loaf is better than no bread. The fact of the child having so much of the best and most nourishing food will in no possible

The popular fallacy about mixing milks.

way interfere with its power of digesting cow's milk. It may be that the child has not digestive power enough to deal with cow's milk; but this is all the more reason why it should have as much mother's milk as it can get, which it *is* able to digest. If it cannot digest cow's milk, other food must be given. Of this I shall speak presently. But it cannot be stated too strongly that a healthy mother should suckle her child, even if only able to give it a partial supply, to be supplemented by artificial means.

Partial suckling better than none.

One of the best temporary substitutes for human milk is asses' milk. It is, as you will see by Table I. (page 42), much weaker in every ingredient except in sugar, but it is of an extremely fine curd and easily digested.

Asses' milk

The chief objection to it is that it is somewhat laxative. The difficulty of its being weaker in proteid and fat may be got over for a time by giving a somewhat larger quantity. It would require nearly twice as much to make it equivalent to human milk. And it is not satisfactory as a permanent food for this reason.[1] More-

Objections to it: laxative, and a large quantity required.

Not satisfactory as permanent food.

Other objections.

[1] I have noted more than once that children do not thrive vigorously on asses' milk after the first few months. I have now under my care a child brought up entirely on asses' milk until

TABLE I.

SHOWING THE PROPORTIONS PER CENT. OF THE DIFFERENT ELEMENTS IN VARIOUS KINDS AND PREPARATIONS OF MILK.

Elements	Human milk (Gorup-Besanez)	Cow's milk							Asses'	Goat's
		Fresh					Condensed (Werner and Kofler)			
		Pure	Diluted with 2 parts water	Diluted with an equal quantity of water	Diluted with 1 part water to 2 milk	Artificial human milk [1]	Pure	Diluted with 7 parts water		
Nitrogenous elements or proteids	3·924	5·404	1·801	2·702	3·602	2·57	26·1	3·26	1·7	4·5
Hydrocarbons or fats	2·666	4·305	1·435	2·152	2·870	4·46	12·8	1·6	1·4	4·1
Carbo-hydrates: Lactine	4·364	4·037	1·345	2·018	2·690	5·02	16·0	2·0	6·4	5·8
Carbo-hydrates: Cane sugar	—	—	—	—	—	—	27·0	3·37	—	—
Salts	0·138	0·548	0·182	0·274	0·364	0·57	4·03	0·5	—	—
Water	88·908	85·706	95·237	92·854	90·474	87·38	14·07	89·27	90·5	85·6
Total	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

[1] Analysis furnished by Aylesbury Dairy Company.

over, the question of expense and supply again come in. It is not always possible to obtain asses' milk—except in London, where there are regular establishments for its supply—and its price is in most cases prohibitive. So that in the vast majority of instances we are compelled to fall back upon cow's milk—either cow's milk diluted with water or mixed with some preparation of farinaceous food—and the most common expedient, the thing first tried, is cow's milk diluted with water.

Expense.

Difficulty of obtaining it.

Usually obliged to fall back on cow's milk diluted.

It is found that for a child under a month old, or even for an older child at first, it is not safe to give a stronger solution than 1 part of cow's milk to 2 parts of water, with the addition of a little sugar. And this is the strength usually adopted. With a very young infant—under 1 month—it is not safe to begin with more than 1 to 3.

Proportion of milk to water.

1 to 2,

or 1 to 3.

Now a reference to Table I., annexed, will show you at once that cow's milk thus diluted, 1 to 2, is weaker in every constituent than human

If diluted 1 to 2, a large volume required,

1 year old. It was apparently fairly well, but white, flabby, and delicate. On cow's milk and water, with raw meat juice, it has become firm and rosy, and has gained weight with extraordinary rapidity.

milk. It would only contain 1·801 proteid, 1·435 fat, and 1·345 lactine. Thus a much larger quantity would have to be given than the 16 to 24 oz. of human milk we have seen to be required to bring up the total amount of nutriment to the required standard.

It has been shown in the first lecture that a child would require for the first month nearly 20 oz. of cow's milk daily to furnish the requisite amount of alimentary material.[1] Just consider what this means. It means 60 oz., or 3 pints of this mixture of 2 parts water to 1 of milk—a quantity quite out of the power of a small infant to take in and retain.

viz. 60 oz. of this 1 to 2 mixture.

As a matter of fact, however, the child gets on very well, as far as nutrition is concerned, for a short time with 16 to 24 oz. of this dilution, if it digests it thoroughly. If nutrition flags at all the proteid element may be increased by the addition of raw meat juice, and the fat by the addition of cream enough to bring them up to

The child gets on with less for a time.

[1] Bouchut's calculation (*Journal Officiel*, 1870, Nov. 23) comes very near this. He estimated that a child requires—

For the	1st	month	10	meals	per diem of	2	oz. cow's milk
,,	2nd	,,	7	,,	,,	6	,, ,,
,,	3rd	,,	7	,,	,,	8	,, ,,
,,	4th	,,	7	,,	,,	10	,, ,,

the standard $3\frac{1}{2}$ and 3 per cent. respectively. Then the strength of the dilution may be cautiously increased until equal parts can be digested, which gives a proportion, as you will see from the table, of proteid, 2·702 ; fat, 2·152 ; sugar, 2·018. The proteid is, therefore, still deficient (1 per cent.), the fat almost sufficient, the sugar deficient (more than 2 per cent.)

Gradual increase to equal parts.

In this the proteid 1 per cent. deficient. The fat nearly sufficient.

The sugar must be increased, and the total quantity of food given be increased also, to keep up a sufficient supply. Then the child thrives until the proportion can be still further increased as the digestive powers advance to 2 parts of milk and 1 of water ; or raw meat juice may be given to increase proteid, cream to increase fat. This, viz. 2 parts of milk to 1 of water, would give : proteid, 3·602 ; fat, 2·870 ; sugar, 2·690 ; which contains a nearly sufficient proportion of proteid, and almost a sufficient amount of fat, which is a great point ; and although the carbohydrate element is greatly deficient this can be remedied by adding $1\frac{1}{2}$ per cent. of sugar to make up for the want of lactine. Pure cow's milk should never be given before the sixth month.

The sugar increased and more food.

Advance to 2 milk and 1 water.

The nutritive value of this.

Yet, as Kehrer has pointed out, it is only a

Yet all children do not thrive on cow's milk.

portion of the children brought up on cow's milk in the ordinary way that thrive really well. These are children who have good constitutions and great digestive power. Some are behindhand in growth and development; they possibly do not get quite enough, or digest quite enough, for full nutrition. At the period of dentition they are more flabby, anæmic, and weakly than those brought up at the breast. And the fæces show constantly a quantity of undigested casein and fat, and this is probably the key to the defective nutrition. Yet they often gain on the sucklings later. Their alimentary canals learn to digest difficult substances better, and they meet the strain of change of diet, when put on more solid food, more easily than the less tried digestive organs of the breast-fed child.

Often backward in growth.

Improve later

Diluted cow's milk, of strength 2 to 1, would appear to satisfy all essential conditions.

The diluted cow's milk, with sugar added, at any rate as soon as the sufficient strength of 2 parts milk and 1 water is reached, would seem to satisfy all the essential conditions. It contains nearly the true proportion of each element; it possesses the anti-scorbutic property. The gross amount of nutriment will be sufficient; it is animal; and it can be kept sweet

Yet not completely.

and good, so as to satisfy the sixth condition. The real difficulty, however, does not lie in the inferior nutritive value of the cow's milk and water, although this may retard development at first. It lies in the fact that cow's milk is much less digestible than human milk. Some children cannot digest cow's milk, even in this diluted form, indeed in any degree of simple dilution compatible with fair nutrition. Often the weakest solution sets up colic, vomiting, diarrhœa. The point in which it fails and is unsatisfactory is the fifth condition. It is not perfectly suited to the digestive powers of an infant; its solids are too massive. For the reason that cow's milk is so much more difficult of digestion than woman's milk does not depend, as commonly supposed, upon the fact that it contains *more* solids, especially casein, but upon the peculiarly massive character of the curd when coagulated by the gastric juice—as it is, of course, the moment it enters the stomach. The mere addition of water does not affect this. It makes less casein in proportion: but it does not alter its nature.[1]

Fails to satisfy sixth condition.

The real difficulty in the fact that cow's milk is less digestible than human milk.

Inferior digestibility of cow's milk not due to excess of solid, as usually supposed.

But to the solid character of casein coagulum.

[1] The casein of cow's milk would appear to have a different chemical composition, its atoms differently grouped from those of human milk.

Goat's and ewe's milk.

Asses' milk.

Behaviour of various milks.

The distinctive character of the casein of cow's milk, of goat's milk, and of ewe's milk, as compared with that of human milk and of asses' milk, can be shown at once by experiments with artificial digestive fluid. The casein of human milk is thrown down in fine flocculent granules, readily dissolved by additional fluid; while the casein of cow's milk is cast down in great masses, and is not dissolved by the addition of more fluid.

When artificially digested.

Further, if human milk and cow's milk be placed in two glasses side by side with a small quantity of digestive fluid and kept at a temperature of 100°—*i.e.* artificially digested—the solid curd of cow's milk takes a very much longer time to dissolve than the light flocculi of human milk.

Experiments with acid. Human milk and cow's milk.

Anyone curious to do so may satisfy himself as to the difference in coagulability of the two milks by a more simple experiment still. Add a little dilute acetic acid or vinegar to cow's milk, and also to a sample of human milk.

In the latter the acid produces little appreciable change. It remains almost uniformly liquid; a minute, light, flocculent curd is alone precipitated. In the former it leads to the im-

mediate formation of large masses of coagulated casein. Goat's milk and ewe's milk behave in the same way as cow's milk, while ass's milk and that of the mare resemble human milk in this respect.[1]

Goat's, ewe's, ass's and mare's milk.

The true secret of the difficulty with which cow's milk is digested by infants, then, is the massiveness and insolubility of the coagulated casein.

The great difficulty of cow's milk the massive coagula of casein.

This fault, however, may be largely modified, and the casein rendered more flocculent by certain expedients.

This evil may be modified.

The fact that boiled milk agrees better than fresh milk with children prone to diarrhœa has long been known. Nurses say that it is constipating. Rather it should be said that it is less laxative. The explanation lies partly, no doubt, in the fact that boiling arrests decomposition, which so quickly commences, and that thus development of the irritant products which excite intestinal action is arrested. But this is not the sole reason of the less laxative character of boiled milk. There is another, viz., that the effect of boiling is to make the curd coagulate

Boiled milk.

Less laxative.

Re ason.

I. Fermentation arrested.

II. Curd coagulation altered.

[1] Hydrochloric, sulphuric, and nitric acids produce similar results to acetic acid on the two kinds of milk.

in much smaller masses. It produces less irritation, being less liable to ferment because more quickly digested.

Experiment with acid.

Dilute acetic acid, or vinegar, added to boiled cow's milk which has been allowed to grow cold, no longer produces the massive coagula characteristic of fresh cow's milk, but much smaller and lighter coagula, although still larger and coarser than those of human milk.

Smaller, lighter coagula.

Dilution with barley water.

Another device is to add barley water to the milk. Milk thus diluted is found to agree with children better than when pure water is used. Barley water appears to act by mechanically separating the casein, so that it coagulates on addition of acid in minuter flocculi than those of boiled milk even. Barley water has, moreover, the advantage of adding something to the nutriment in its mucilaginous property.

Mechanical action on casein.

Experiment with acid.

Effect of addition of lime water to milk.

A more favourite plan still is to add lime water to the milk, with the view of rendering the curd more easily soluble, and of neutralising acidity.

Mode of action.

The lime water has the effect of causing the casein to coagulate on addition of acid in smaller masses, and it is as efficient in this respect as barley water.

As efficient as barley water.

Another efficient plan is to add a little bicarbonate of soda, 5 grains to each oz. of milk. The result on adding acetic acid is to get a fine curd fairly flocculent.

Condensed milk.

Condensed milk again, if properly diluted, is more digestible than fresh unboiled cow's milk. This is due to the fact that the process of heating which it undergoes alters and lessens the coagulability of the casein. On the addition of acid it coagulates in lightish masses, coarser than those of human milk, or the milk mixed with barley water or lime water, or carbonate of soda, but vastly different from the great clots of fresh cow's milk.

Coagulability altered.

Fairly small coagula.

Peptonised milk no coagula.

In peptonised milk no coagula whatever are formed on addition of acid. The casein is converted into soluble peptone.

The various forms of milk of which I have yet spoken, in respect of easy digestibility of curd, appear to rank thus:

Summary of preparations.

Order of solubility of casein.

1. Peptonised milk.
2. Cow's milk with barley water.
3. Cow's milk and lime water.
4. Condensed milk.
5. Cow's milk with bicarbonate of soda.
6. Boiled cow's milk.
7. Fresh cow's milk.

If, then, it is decided to give cow's milk, as will be the case in the vast majority of instances—for various cogent reasons—how is it to be given? Shall it be peptonised?

Peptonised milk.

No doubt peptonised milk properly diluted with water agrees excellently; there is hardly a trace of casein unchanged to peptone, so there is no curd difficulty.[1]

Nutritious and digestible.

It contains of course the same amount of nutriment as unpeptonised milk. But although the peptonised milk is satisfactory as far as digestibility and nutrient value are concerned, there are reasons against its continued use. It is an excellent preparation for use in emergency, or in special cases of illness, but it is not fitted to be the regular diet of a healthy infant.

Reasons against its continued use.

I. Predigested food weakens digestive power.

One reason is that the continued use of predigested food weakens the digestive power of the stomach, which becomes enfeebled by want of exercise of its proper function.

II. Contains excess of carbonate of soda.

Another reason is that a considerable amount of carbonate of soda is used in the peptonising process, and this is liable to have a depressant effect in the long run.

[1] Casein . . . . . 0·96 per cent.
Peptone . . . . . 1·88 ,,
(Dr. Vieths' analysis, kindly supplied by the Aylesbury Dairy Co.)

III. Its bitterness.

And a third reason against the adoption of peptonised milk is its bitter flavour, so that some infants refuse it altogether. This difficulty may, however, usually be overcome by using peptonised condensed milk, which is highly sweetened. If peptonised milk is given, the peptonising process should be gradually reduced, both by lessening the quantity of the peptonising agent, and also by shortening the time during which the process is continued. By using peptonising powders this graduation can be effected with great ease and certainty.

The peptonisation to be gradually diminished.

What plan then is to be followed? The preparation of milk and water, with the addition of a little bicarbonate of soda, yields a flocculent curd, and might be suitable enough but for the objection to the continued daily ingestion of carbonate of soda.

Milk and water with bicarbonate of soda.

Objection to it.

So that we may put that on one side. Like peptonised milk, it is often useful for a time, but not suited for permanent feeding. These two may be put out of court at once as regular foods.

There remain boiled milk mixed with water, milk mixed with barley water, milk mixed with lime water, condensed milk, and of course

plain fresh unboiled milk diluted with pure water.

Fresh milk and water the common resource.

The last, fresh milk and water, is the common resort. I suppose that nine children out of ten are put upon this in the first instance, yet I think any one who has seen these massive coagula of fresh cow's milk when acted upon by an acid such as I have shown you, would be rather uneasy about the result when this plain milk and water came into contact with the acid gastric juice in the child's stomach.

How often disturbance follows.

And such apprehension of disturbance would very frequently be justified. How often do we see vomiting, and purging, and griping, and diarrhœa result from the administration of this mixture.

The safe and proper plan.

This risk ought always to be avoided. Let me advise you to adopt another plan.

In the first place, milk should be boiled.

In the first place, always have the milk boiled, so as to prevent souring and render the coagula of curd light and digestible. This is the first grand rule I would lay down, and it should be an invariable rule. Nurses will fight against it, and mothers object, perhaps, for there is a common prejudice against it ; they say it is less nourishing and that it is binding, and that the

Popular objections to boiling milk.

children don't like it. Well, as to the first objection, there is just this much truth in it, that the milk loses by boiling exactly the small amount of soluble albumen which rises as scum to the surface. With cow's milk, where the casein is in excess, this is no great disadvantage. Yet that there is a slight loss of good digestible proteid must be allowed.

A slight loss of nutritive material.

This no great disadvantage in cow's milk.

As to the second objection, that it is constipating, there is also some truth. As I pointed out before, the smaller curd masses, and the absence of acidity from incipient fermentation, render it less provocative of peristalsis and of secretion from the intestine than fresh milk. But this is a fault which may be easily remedied by the addition of a small quantity of carbonate of magnesia to each bottle, and later by the addition of some food which is laxative, as a malted food, for example.

Less laxative.

A fault easily remedied.

The last objection, viz., that children don't like it, does not apply to children who are given it from the first. They know no other, and take to it kindly enough. It is true that children who have been already accustomed to fresh milk will sometimes refuse it boiled; that is a different matter. Never let any-

The objection to boiled milk on account of children not liking it.

thing but boiled milk be used in the nursery from the first, and there will be no difficulty afterwards.

Another advantage in using boiled milk, viz., protection against infection.

There is another great advantage in using boiled milk, in addition to its greater digestibility, viz., the protection thereby afforded against infection. It has been proved beyond question by a series of conclusive and striking investigations, that the specific poisons of typhoid fever, scarlatina, and diphtheria, and possibly of other diseases, are communicated through the agency of milk, and it further seems to be proved, by a series of remarkable cases of exemption, that these specific poisons are rendered inert by heat at the boiling-point.[1]

Specific poisons often conveyed by milk.

Immunity of households where milk was boiled.

Wimpole Street epidemic.

Dr. Henry showed this with respect to scarlet fever; and there is evidence that in the epidemic of typhoid which broke out in the neighbourhood of Wimpole Street some years ago, and was traced to milk infection, those households escaped in which the milk was boiled.

Harewood Square epidemic.

This was also the case in the Harewood

[1] Dr. Russell finds, at the Glasgow Hospital for Infectious Diseases, that boiling clothes is sufficient to disinfect them thoroughly.

Square epidemic of scarlatina, traced to milk infection; all who drank boiled milk escaped.[1] Mr. F. W. Parsons, of Wimbledon, informs me that this was also the case in the epidemic there. And in the recent terrible epidemic of diphtheria at Ealing, which has been traced to milk infection, I am informed that those families who boiled their milk enjoyed complete immunity.[2]

Wimbledon epidemic.

Ealing epidemic.

Further, I have observed generally that those families who boil all milk used in the household enjoy a remarkable immunity from infectious disease of this kind.

We may then lay it down as a safe and wise rule, that in all cases where the milk supply is not private, and its conditions fully known, all milk for use in the nursery should be boiled immediately upon its arrival in the house.

All milk to be boiled immediately on arrival.

The water with which it is diluted for infant use should be boiled also. Its hardness, where excessive, as in London water, for example, is thus reduced, and any active contagion it may

Secondly, the water should be boiled also.

Lessens hardness.

[1] Vide *B. M. J.* Jan. 30, 1886.

[2] This becomes of still greater importance if the discovery, by Dr. Klein and Mr. Power, that scarlatina is sometimes conveyed from the cow suffering from the disease analogous to scarlatina—vaccine scarlatina, it may be called—should be eventually confirmed.

Destroys contagion and stops decomposition.

contain is thus destroyed, while other organic impurities are rendered innocuous. The milk may be made more digestible still by mixing

Or add barley water,

it with barley water instead of plain water, which, as I have shown, mechanically separates the coagulating casein into smaller molecules.

or lime water.

Or lime water may be added in the proportion of 1 part in 12. Lime water is extremely effective in moderating coagulation, as you will see from the specimen to which acid has been added. The objection to it is that it favours constipation. Boiled milk diluted with barley water is on the whole the best form for young infants.

Condensed milk.

Under certain circumstances, where fresh cow's milk does not agree well, or when it cannot be procured fresh and good, as on sea voyages, for example, or on long journeys, condensed milk may be used.

Its advantages.

The advantages of condensed milk are that it keeps perfectly, that it is always at hand sound and good, and that, as we have seen, the casein is rendered more digestible than that of fresh cow's milk.

Usually given in too strong a solution.

The mistake commonly made in feeding young infants on condensed milk is that of making the solution too strong at first. The

directions on the label state that for infants 7 to 14 parts of water are to be added. But this is far too concentrated for a child at birth, or during the first month ; at any rate, to begin with.

Dilution to be 1 in 24.

I have found by experience that it is not safe to give it, at first, in early infancy, of greater strength than a dilution with 24 parts of water.

Gradually increased to 1 in 10, or 1 in 7.

This, of course, as you will see by the Table, is far too weak—only about one-quarter the strength of human milk—to give sufficient nutriment for long. It must, therefore, be steadily increased until the dilution of 1 in 10 or 1 in 7 is safely reached.

Objections to use of condensed milk.

The objections to the ordinary condensed milk are that it contains a large excess of sugar, much of this being in the form of cane sugar, added for the purpose of preserving it.

Excess of sugar.

As a matter of physiological necessity, the cane sugar has to be converted into grape sugar before it can be absorbed. In the meantime it is liable to ferment ; lactic acid is formed, which sets up irritation of the stomach, flatulence and discomfort.

Leads to formation of lactic acid.

Causes undue fatness.

The excess of sugar also tends to make children, fed on condensed milk, wax fat out of all proportion.

I remember that it was alleged some years ago by some practitioner, in whose mind I think theory outbalanced actual observation, that this excess of sugar actually became a cause of diabetes. But this statement has not been confirmed by subsequent experience.[1]

Supposed to cause diabetes.

There is, however, doubt about another point. I am by no means sure that the anti-scorbutic property of milk is not greatly impaired by this process of condensation. I have seen a child of 11 months old, fed from birth entirely upon condensed milk, which developed spongy gums and tenderness of bones, which I could not doubt were of scorbutic character, and which disappeared entirely on change to anti-scorbutic diet of fresh milk and potato pulp.

Scurvy from condensed milk diet.

[1] The objection to condensed milk on account of excess of sugar has been in great measure overcome by the preparation of 'unsweetened' condensed milk. This, however, in the proportions of 1 of milk to 3 of water, the amounts stated, gives a mixture somewhat below the standard of ordinary cow's milk, viz.—

Solids, not fat . . .	8·54
Fat	2·00
Water	89·46
Total . . .	100·00

(Dr. Luff's analysis.)

And there is in my mind some doubt as to the perfect safety from sourness of milk thus prepared without excess of sugar.

Condensed milk poor in cream.

And I think further that the quality is not uniform. In some specimens the cream is deficient—at any rate, you will see by the Table of Proportions (Table I.) that when it is diluted with only 7 parts of water the proportion of fat is only 1·6, about one-half that of human milk—much too small to be safe or satisfactory. Hence not unfrequently, especially in the case of children with feeble digestive power, who cannot take a solution of full strength, the child, although fat enough, not only becomes soft of muscle and pallid, but actually soft in bone and rickety.

Deficient in fat.

Danger of anæmia and rickets from condensed milk diet.

Goat's milk.

Goat's milk is highly nutritious, richer in fat than cow's milk, and therefore excellently adapted for young children in this respect. It is often procurable, and may be used with advantage where extra richness of diet is advisable. But it is no whit more digestible than cow's milk. The casein coagulates in the same large masses, and it must therefore be treated in exactly similar fashion for very young children—viz., boiled, and barley water or lime water added.

Its richness in cream an advantage.

Yet not more digestible than cow's milk.

Goat's milk casein behaves as that of the cow.

Must also be boiled and lime water added.

Some children—a not inconsiderable proportion indeed ; one is constantly being confronted

Some infants cannot digest sufficient cow's milk, however diluted.

with such cases—appear to be unable to digest diluted cow's milk of a strength sufficient to support life. With even a dilution of 1 part of milk to 3 of water, they are sick, bring up undigested curd, are griped and flatulent, constantly crying with pain and discomfort, are restless and enjoy little sleep, suffer from diarrhœa as well as from colic. If nothing be done, the vomiting and purging go on and increase, and may lead to a fatal issue. The child becomes pallid, lean and flabby, with wrinkled, loose hanging skin, wastes away to a mere skeleton, and, if no change be made, dies eventually of inanition.

Morbid effects.

Artificial human milk.

A successful device in many cases is to put the child upon what is called artificial human milk. This is prepared by first removing all the cream by skimming, after the milk has stood some time. Then the remainder is divided into two equal portions. From one all the casein is removed by rennet, *i.e.* converted into whey. The other portion is then mixed with the whey and the whole of the cream added.

Mode of preparation.

Composition.

This preparation will therefore contain all the lactine, all the cream, but only half the

quantity of casein.[1] It will thus be nearer in composition to human milk than cow's milk, but somewhat short, of course, of proteid element. But it is not absolutely identical with human milk; the proportion of proteid is not the same,[2] and, what is of more importance, the curd is unchanged in nature. It is still, as ascertained by experiment, coarsely coagulable cow's milk curd. The fat and lactine are in larger proportion than in human milk. This is probably an advantage, and some children who are able to digest only a limited amount of cow's casein do remarkably well on it. Those who are quite intolerant of this casein cannot take even this dilute mixture. There is one warning I would give. It will not keep long. If the dairy where it is manufactured is not within reasonable distance, have it made freshly at home. After a time the cream separates with

Not identical with human milk.

Wherein it differs.

Dangers associated with the use of artificial human milk

[1] Proteid . . . . . 2·57
Fat . . . . . 4·45
Sugar . . . . . 5·02

See Table I. p. 42.

[2] As the child grows older the proteid element should be increased by removing the curd from *one-third* of the milk only, instead of from *one half*, as at first. This would raise the proportion of proteid to 3·6 per cent., or very nearly equal to that of human milk.

some curd in great clots, and does not easily mix again. I have twice seen children dangerously ill from taking artificial human milk which had been sent a long distance, and had changed in this way.

I must defer the consideration of farinaceous foods and meat juices to the next lecture.

LECTURE III.

ARTIFICIAL FOODS—*continued.*

GLUTEN FOOD—THE MALTED FOODS—OTHER FARINACEOUS FOODS—BEEF-TEA PREPARATIONS—RAW MEAT JUICE—ESSENCES OF MEAT.

Summary of conclusions reached in the previous lecture—Development of the child's power of digesting milk—Necessity for supplementing the milk with other food in certain cases—Table of nutritive values of various artificial foods and preparations—Bread jelly or gluten food—Mode of preparation—Insufficient alone and with milk—With meat juice and cream—Nutritive value of these preparations—Farinaceous foods—Conditions under which they are admissible—Deficiency of fat and of anti-scorbutic element—To be regarded as adjuncts or accessories only—Their value—They add nitrogenous and carbohydrate elements and salts—Malted foods; of two classes—Examples—Their insufficiency alone—Nutritive values of the various forms—When mixed with water only—When mixed with a due proportion of milk, or other animal elements—Objections which have been raised to the use of these foods—Their fallacy—The proper place of these foods in infant feeding—Pancreatised food — Distinction between this pancreatised food and a malted food—An excellent food in certain conditions—Reasons—Foods which are neither malted nor pancreatised—Their composition—Useful for older children as additions to milk—Entire wheat flour—Arrowroot—Cornflour—Rice

—Prepared barley — Tapioca — Sago — Oatmeal — Malted foods with desiccated milk—Composition—Other accessory foods—Meat juices and essences—Beef tea—Analysis—Small percentage of proteid—Poor in structural materials—Unsatisfactory results as a food for children—Veal broth—Raw meat juice—Mode of preparation—High nutritive value and digestibility—Analysis—Raw meat pulp—Mode of preparation—Patent meat juice—Its analysis and uses—Meat essences—Analysis—Their place as a food—The meat peptones—High nutritive value—Their special uses.

Brief recapitulation of points established in previous Lecture.

IN the last lecture, gentlemen, I explained to you the properties and special characters of the various kinds of milk, the different methods of preparing them, their nutritive value, and the qualities which determined the relative ease or difficulty with which their casein could be converted into peptone by the digestive fluids of an infant.

Difficulty of digesting cow's milk lies in the character of the casein.

I showed you, I think, that without doubt the great difficulty which children have in digesting cow's or goat's or ewe's milk does not, as generally supposed, lie in the fact that these contain a greater amount of solids than human milk. That could be easily remedied, of course, by the addition of water. This inferior digestibility of cow's milk is due to the character of the casein, some difference in its chemical composition, or the arrangement of its molecules, so that when in contact with the acid of

the gastric juice it coagulates in massive clots, which are in striking contrast to the small light flocculent coagula of human milk. The latter, of course, as may be shown by actual experiment, quickly and easily dissolved by the gastric juice; the former only after a considerable period. In the meantime the casein, thus unconverted, begins to set up fermentation, and irritant acids are formed, with the usual disastrous effects upon the alimentary canal of the child.

Contrast with human milk.

Experiments as to relative digestibility of the two.

Acids form from fermenting casein.

I then described various devices for rendering the casein coagula lighter, smaller, and more flocculent; such as boiling, and the addition of barley water or lime water, the combination of boiling with barley water or lime water being the most satisfactory and effectual.

Various devices for overcoming this difficulty.

The combination of boiling with barley water or lime water most effective.

Further, I affirmed, you may remember, that some very young children are unable to take cow's milk in any form, at any rate at first, even when its character is favourably modified after the manner I have described.

Some very young children cannot take cow's milk in any form.

For these it is necessary either to get a wet nurse, or to abandon all milk for a time, and substitute other food until digestive power strengthens.

For them milk must be stopped for a time.

TABLE

SHOWING THE PROPORTION PER CENT. OF THE DIFFERENT CONSTITUENTS

Elements of Food	Standard of Human Milk	Bread Jelly			
		Pure Jelly	One tablespoonful mixed with 8 oz. water	One tablespoonful mixed with 4 oz. cow's milk and 4 oz. water (Dr. Luff's analysis)	4½ parts of mixture with water only, and 1½ parts raw meat juice, and ¼ part cream (Dr. Luff's analysis)
Nitrogenous or Proteids	3·924	2·73	0·74	2·705	2·711
Hydrocarbons or Fats	2·666	0·50	0·13	1·695	3·632
Carbohydrates of various forms: Lactine or Sugar of Milk	4·364				
Carbohydrates of various forms: Grape Sugar	—				
Carbohydrates of various forms: Maltose	—	Total Carbohydrates 15·24	Total Carbohydrates 4·15	Total Carbohydrates 5·618	Total Carbohydrates 2·953
Carbohydrates of various forms: Dextrine	—				
Carbohydrates of various forms: Starch	—				
Carbohydrates of various forms: Cellulose	—				
Salts	0·138	0·51	0·14	0·339	0·250
Water	88·908	81·02	94·84	89·643	90·454
Total	100·0	100·0	100·0	100·0	100·0

II.

IN CERTAIN ARTIFICIAL FARINACEOUS FOODS AND PREPARATIONS.

Malted Food partially dextrinised			Malted Food more highly dextrinised		Malted Food with desiccated Milk			Prepared Entire Wheat Flour
Pure Food	Mixed with 15 parts of water to 1 part of food (Dr. Luff's analysis)	Mixed with 7½ parts water and 7½ parts cow's milk to 1 part of food (Dr. Luff's analysis)	Pure Food	½ a tablespoonful of the food mixed with ¼ of a pint of water and ¼ of a pint of cow's milk as directed for children under 3 months of age (Dr. Luff's analysis)	Pure Food (Dr. Luff's analysis)	Mixed with 10 parts water (Dr. Luff's analysis)	Mixed with 5 parts water (Dr. Luff's analysis)	Pure Flour
15·35	0·74	2·723	5·43	2·187	9·62	0·641	1·202	13·15
1·08	0·05	2·009	0·16	2·101	4·75	0·316	0·594	—
1·02								
—								
10·78 Total Carbo-hydrates 77·28	Total Carbo-hydrates 3·75	Total Carbo-hydrates 6·211	No starch, all changed to dextrine, maltose, and grape sugar 87·12	3·946	Total Carbohy-drates 80·02	Total Carbohy-drates 5·335	Total Carbohy-drates 10·025	Starch 50
64·12								
1·36								
0·92	0·09	0·438	3·53	0·425	1·39	0·093	0·174	—
4·37	95·37	88·619	3·76	91·341	4·22	93·615	88·005	—
100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	—

A temporary measure only.

And here I would impress upon you that this expedient is only a temporary measure to overcome a difficulty for the time, and again urge the paramount necessity of advancing gradually to a food which comes up to the standard of nutritive value in all ingredients, and which fulfils, indeed, all the several essential conditions laid down in the first lecture.

Substitutes for ordinary milk.

The safest plan, perhaps, with these children who exhibit such intolerance of dilute cow's milk, fresh, boiled or condensed, or even artificially humanised, is to stop milk in any of these forms altogether for the moment, and give for a time peptonised condensed milk, or ass's milk, if it can be obtained. These are, however, both expensive foods.

Another satisfactory plan is to adopt some other food as a basis, to which milk may be gradually added, increased as the child's digestive power developes.

The child's stomach may be educated.

The child's stomach may be educated to the digestion of cow's milk by careful training and management. If the process is sufficiently gradual and cautious, it is always successful in the end.

Bread jelly or gluten food.

The simplest and cheapest material and one of the best for this purpose is bread jelly, pre-

pared after the formula suggested many years ago by Dr. Churchill, of Dublin.

Mode of preparation.

Thus, a thick slice of bread (4 oz.), two or three days old, so as to be dry and sweet, and of seconds flour (since this is richer in proteid and phosphates than the finest white flour), is placed in a basin of cold water and allowed to soak for six or eight hours. It is then taken out, and all the water squeezed out of it. The object of this first soaking is to clear away the lactic acid formed in fermentation, and all other peccant matters.

Soakage in cold water.

Object of this.

Prolonged boiling: object.

The pulp is then placed in fresh water and gently boiled for an hour and a half. The object of this prolonged boiling is to thoroughly break up the starch corpuscles, and to promote the change of starch into dextrine and grape sugar.

The thick gruel thus made is strained, rubbed through a fine hair sieve, and allowed to grow cold, when it forms a fine, smooth, jelly-like mass. This should be freshly prepared night and morning, for it will not keep long.

Enough of the jelly is then mixed with warm water, previously boiled, to make a food of the consistence of thin cream (about one full

Proportions of mixture.

tablespoonful to 8 oz. of water), so as to pass readily through the bottle; a little white sugar may be added.

Addition of animal element, milk.

Bread jelly too weak alone.

Now the composition of this, as ascertained by actual analysis, is shown in the Table; and diluted as I have stated, you will see that it is far too weak in every element except carbohydrate to form a satisfactory food. It would fail in every one of the first four essential conditions.

Fails to satisfy the first four conditions.

Thus (Table II. p. 68), one tablespoonful diluted with 8 oz. of water contains—

Proteid	0·74
Fat	0·13
Carbohydrate	4·15

Wherein deficient.

1. It would therefore not contain the elements in due proportion.

No anti-scorbutic.

2. It would not contain the anti-scorbutic element.

Deficient in proteid and fat.

3. The nutritive value of the amount possible to be taken by a child would necessarily fall far short of the standard, except in carbohydrate.

No animal element.

4. And it would contain no animal element.

This must be remedied by the addition of an animal element supplying the requisite supplement of proteid, fat, and the anti-scorbutic property.

Add milk.

This may be done by adding boiled milk. The quantity should be extremely small at first, especially if the child has already shown intolerance of cow's milk—two teaspoonfuls of boiled milk, or even one only, to the 3 oz. or half bottle.

At first in extremely small quantity.

Gradually increased.

The milk may be gradually increased every few days as the child is found able to digest it, the stools being carefully examined for sign of undigested curd. Thus the child may be gradually advanced to the requisite quantity of milk.

You will see that this food, made with half milk and half water, comes still somewhat short of the standard in proteid and fat, but affords ample carbohydrate and abundant salts.

Thus (Table II. p. 68), bread jelly mixed with water, equal parts of milk and water, *i.e.* 3 oz. jelly (=one full tablespoonful) to 4 oz. milk and 4 oz. water—

Nutritive value of this food.

Proteid	2·705
Fat	1·695
Carbohydrate	5·618
Salts	0·339

Peptonised milk may be added at first, instead of boiled milk, and the quantity increased more rapidly.

In cases where there is absolute intolerance

Animal element may be supplied by raw meat juice and cream.

of cow's milk, the animal element, the additional proteid and fat, and the anti-scorbutic property, may be supplied by raw meat juice and cream.

It will be seen from Table III., given subsequently in p. 95, that raw meat juice is nearly double the strength of human milk in proteid, and more than double in nitrogenous matter if extractives be included.[1]

A reference to Table II., p. 68, will show that bread jelly with $4\frac{1}{2}$ parts of the solution in water (= five tablespoonfuls), $1\frac{1}{2}$ parts raw meat juice (= six teaspoonfuls), $\frac{1}{2}$ part cream (= two teaspoonfuls) contains—

Proteid and extractive . .	2·711
Fat	3·632
Carbohydrate	2·953

You will see that there is a slight deficiency of proteid and of carbohydrates, but an ample amount of fat.

[1] Raw meat juice . 4 to 1 water and extracted by pressure.

Nitrogenous elements	Proteid .	5·1	= 8·2
	Extractive .	3·1	

Cream contains—

Fat	46
Casein, milksugar, and salts . .	5
Water	49
Total	100

(Dr. Luff's analysis.)

The proteid element may be increased, but this albumen of raw meat juice appears to have a remarkable nutritive power beyond that of cow's milk casein, so that a child will, I believe, flourish on a smaller quantity.

Value of raw meat juice albumen.

This combination as a substitute for milk is of great value; the bread jelly is extremely bland; the raw meat albumen is most digestible as well as nutritious, and the cream supplies the necessary fat.

The combination of ingredients as substitute for milk.

When it is thought desirable, as the child's digestive power developes, to raise the strength to the full standard, the amounts stand thus: 4 parts bread jelly mixture with water only, + 3 parts raw meat juice, + $\frac{1}{2}$ part cream, + $\frac{1}{5}$ part sugar.

The composition of this mixture is—

Proteids	3·894
Fats	3·068
Carbohydrates	4·338
Salts	0·343
Water	88·357
	100·0

Nutritive value.

It must be borne in mind, however, that there is one source of danger in using this food, and that lies in the liability of the raw meat juice to undergo decomposition. To be safe

Precautions necessary in using this food.

it should be freshly prepared twice a day, as also the bread jelly. The cream should also be obtained fresh night and morning. Lastly, the meat juice must not be added to the food when hot, or the albumen is coagulated and its special digestibility thereby destroyed.

Other farinaceous foods.

I now come to the consideration of the other farinaceous foods, useful only, and to be used only, like the preceding, as adjuncts or accessory foods for the purpose of addition to milk or other animal elements.

Insufficient alone.

They cannot be regarded as complete foods sufficient in themselves; the deficiency in fat, and the absence of animal matter, and of the anti-scorbutic element, must absolutely disqualify them as sole foods.

Cow's milk and water 1 to 2, much below standard.

Now, as appears clearly from the Table, and as I think I made plain to you in the last lecture, cow's milk and water in the proportion of one part of milk to two of water is vastly below the standard of human milk in nutritive value, and this deficiency exists in all three chief elements—proteid, hydrocarbon, carbohydrate.

Even half and half, you see, is insufficient.

As I demonstrated to you, it is only when the proportion of two parts of milk to one of water is reached that it approaches the necessary standard.

This point is a most important one. Remember, then, that feeding by cow's milk and water is not satisfactory, unless the child can digest a solution so strong as two parts of milk to one of water, or can take an increased quantity of the more diluted kind sufficient to bring up the gross amount of the different elements to that yielded by the regulation quantity of human milk, which I gave you before.

2 parts to 1 essential.

If this cannot be done—and constantly the child cannot take enough of cow's milk alone to yield the required amount of nutriment—the deficiency must be made up by addition of fresh ingredients.

If this not digested,

The standard proportions must be reached, if not by milk alone, then by milk with additions.

the standard proportions must be reached by other means.

The deficiency of carbohydrate is usually remedied by the addition of sugar, but that of proteid and fat remains.

Now, as I have said, the value of the arti-

Value of the artificial farinaceous foods.

To supplement animal food.

ficial farinaceous foods consists really in their being supplements to animal foods. They are not to be regarded as chief foods, yet if the child cannot take cow's milk more than one part to two or equal parts, then farinaceous foods supply in digestible form additional nutriment.

They add proteid, and carbohydrate, but not hydrocarbon.

They supply additional proteid, they supply additional carbohydrate, but they supply hydrocarbon in infinitesimal degree only.

To be regarded as adjuncts only.

These artificial foods then are to be regarded as a means of supplying an additional amount of carbohydrate, and some additional proteid.

The proteid gluten.

The proteid, in the form of gluten, appears to be digested and assimilated by the child's stomach with ease.

Carbohydrate as starch or dextrine, or grape sugar.

The carbohydrate element is in some in the form of starch, in others converted, or in process of conversion, more or less completely into dextrine, maltose, or grape sugar.

Now starch, I need hardly remind you after what I have said previously, is a form of carbohydrate, which infants have only the most limited power of digesting, and its use in its simple unchanged state is most objectionable in very young children. It gives rise to acidity, flatulence, and is to a great extent use-

Objections to starch in food.

less as food, because unassimilable. For a child's use it should be converted into grape sugar, or the process must have been set in motion, to be carried on to completion in the duodenum and small intestine.

These foods are valuable in proportion to two conditions, viz. :

I. The amount of nitrogenous matter.

As a general proposition it may be affirmed that these foods are admirable in proportion to the amount of nitrogenous matter they contain, and in proportion to the conversion of the starch through some of the stages into sugar.

There are some medical men who object to the use of these foods altogether. I think they are undoubtedly in error.

II. Dextrine or sugar instead of starch.

Better than cane sugar.

For the proteid supplied is a valuable addition ; and if the carbohydrate is in the form of dextrine or grape sugar instead of starch, this is far better than the cane sugar used to sweeten foods, for this latter is more liable to ferment during the process of digestion, since it has to be changed into grape sugar before it can be assimilated. The grape sugar, ready made, can be absorbed at once. Moreover, the mixture with milk appears to favour mechanically the formation of smaller curd masses, and thus increase its digestibility.

The principle of a malted food, first sug-

The principle of malted food.

gested by Liebig, is the conversion of starch into sugar, and there are numerous preparations now manufactured on this principle.

Process of conversion of starch into dextrine.

Malt meal is mixed with wheaten meal, and the action of the diastase in the malt upon the starch of the wheaten meal, at a certain heat, changes it chemically ; first into dextrine, then into maltose, and then into grape sugar.

Two forms of malted food.

Malted foods may be divided into two classes, according to the extent to which the process is carried.

The first form.

In the first, the finest wheaten flour is mixed with malt flour, but the process of conversion into sugar is only carried to a slight extent. The process is set in motion again actively on mixing with water for use. The starch is then converted very rapidly, partly in the cooking, partly in the child's stomach. In the course of 10 or 15 minutes after mixture with warm water, only the merest trace of starch can be discovered. You will see, from Table II., that this food contains in the form of flour only 1 per cent. of sugar, 10·7 of dextrine to 64·12 starch, and at first sight this would appear unsatisfactory. But the work of conversion goes on quickly in the preparation for use,

In this the process only commenced.

Completed in the child's stomach.

Rapidity of the conversion.

and the food is transformed into a sugar food instead of a starch food.

Previous digestion of starch physiologically right.

Now I wish to draw your attention to this point. The process of converting the starch into dextrine and grape sugar artificially is not weakening and demoralising to the child's digestive functions as in the peptonising or pancreatising process. It is physiologically correct that the conversion of starch should take place outside the child's stomach. The diastase of the malt only does for the child what the mother does for her infant, viz., convert starches and sugars into lactine before they are supplied to the child in the mother's milk. With the other processes it is different. Peptonising digests proteids alone. Pancreatising, on the other hand, digests not proteids only, but starches and fat also. This office of digesting proteids and fats the child's stomach is fitted to do for itself.

But not the peptonising or pancreatising process.

Extremely rich in proteid.

You will note also that malted food has a high proportion of proteid elements in the form of the gluten and albumen of the wheat flour and of the barley. This richness in proteid is of course a valuable property, and it appears to be due partly to the choice of wheat flour

Explanation.

rich in gluten, partly to the starch in the malt being used up (after conversion into sugar) in the germinating growth. The little buds are of course removed in the riddling of the malt, the result of this removal being to leave the malt meal with less of the starchy element in proportion to the proteid or nitrogenous element, *i.e.* to leave it with a high proportion of proteid.

Unfit to be a sole food.

But as a sole food, *made with water only*, it is of course absolutely unsatisfactory. I have at this moment a patient, a child of 12 months, suffering from severe scurvy, brought up entirely upon food of this kind without the addition of milk. Pure farinaceous foods, as I have shown you, cannot contain everything necessary for the full nutrition of an infant. The absence of both animal and anti-scorbutic element would alone disqualify them.

Reasons.
1. No animal element.
2. Deficient in nitrogen.
3. Deficient in fat.
4. Mineral matter.
5. Anti-scorbutic element wanting.

As you will see from the Table, such food is deficient in every ingredient except the carbohydrate; even in mineral matter, but notably and especially in fat. The analysis of a sample of one of these malted foods diluted with 15 parts of water, according to directions, yields only (Dr. Luff's analysis)—

Proteid	0·74
Fat	0·05
Carbohydrate	3·75
Salts	0·09

Mixed with $7\frac{1}{2}$ milk and $7\frac{1}{2}$ water, satisfactory.

Mixed, however, with due proportions of fresh milk and water (in this case $7\frac{1}{2}$ parts of milk and $7\frac{1}{2}$ parts water), it becomes a highly satisfactory food in most respects; the gluten and albumen in the flour, added to the casein of the milk, bring up the proportion of proteids, although they stand still below the normal standard, 2·723 as compared with 3·924. The carbohydrate is in excess, 6·211 as compared with 4·364, but it is in the most desirable form of dextrine and grape sugar from the food and lactine from the milk; and the salts are also in excess, ·438 as compared with 0·138, a good fault, probably improving the food in bone-making material.

Proportion of proteid.

Of carbohydrate.

Salts.

Fat deficient slightly.

This mixture with milk is, however, still deficient in fat, though not to any great degree—2·009 as compared with 2·666 (*i.e.* less than $\frac{1}{2}$ per cent.). To make the food absolutely up to standard in this element, a minute amount of cream should be added (about five drops to each two ounces of food), or the proportion of milk raised to rather more than half. This would

Cream may be added.

Or milk increased to a little more than half.

bring up the proportion of both proteid and fat to the required amount.

Suitable for children over three months.

This form of malted food partially dextrinised agrees perfectly in most cases with children over three months, and those brought up on it with the proper addition of milk are firm-fleshed, lively and vigorous. It sometimes, however, proves laxative, and is not suitable to very young infants. For these the bread jelly, with milk or raw meat juice and cream, is far preferable; or a more perfectly dextrinised food, with milk; or artificial human milk.

Not suitable to very young infants.

Distinctive character of highly dextrinised food.

Process of conversion of starch into dextrine and sugar complete.

Analysis.

The second form of malted foods differs from the preceding chiefly in this, viz., that the process of conversion of starch is completed in the first preparation of the food flour; not a trace of starch remains. It is all changed into dextrine and sugar. According to the analysis of one of these foods the proportion of nitrogenous element is lower, viz., 5·43 only. There is also an inferiority in fat—a remarkable one, 0·16 only as compared with 0·313 in the other malted food—due possibly to the process of preparation, by which the soluble portions are chiefly retained, the other parts being strained off.

Deficient in fat.

Mixed with water only, it fails in all points, as will be seen by reference to Table II. Mixed with equal parts of milk and water it is still somewhat below the standard in fat, and considerably below in nitrogenous element. But duly enriched in fat and proteid by the further addition of milk, or of raw meat juice and cream, it forms an excellent food, the total absence of starch being its especially favourable feature. For this reason it is better suited for very young infants than the other class of malted foods.

Mixed with equal parts milk and water still weak in nitrogen and fat.

Requires to be further enriched.

Total absence of starch makes it especially suitable for young infants.

Another form of food largely used now is pancreatised food. I have no actual analysis of it; but it is made of the best wheat flour, containing a high proportion of proteids, probably about 12 per cent., the proportion which obtains in the finest wheaten flours, and in most of the foods made from them.

Pancreatised food.

Contains probably about 12 per cent. of proteid.

Mixed with a due quantity of pancreatic ferment, the starch is converted into dextrine and grape sugar, as with the malt process.

Process of preparing with pancreatic ferment. Action on starch.

But there is a further change. The pancreatic secretion acts also on proteids, converting them into peptones, and upon fats, emulsifying them. Now this, I must again insist, at once usurps a proper function of the infant's digestive organs.

Action on proteids and on fats.

Usurps proper function of digestive organs.

It is *not* their physiological function to convert starch into sugar, but it *is* their physiological function to convert albuminoids or proteids into peptones, and to emulsify fats.

Fit for a weak stomach.

Pancreatised food of this kind, being always prepared with milk, has the essential animal and anti-scorbutic elements. It is nutritious and easily digested; an excellent form of nourishment for a weakened or invalid stomach, but liable

Demoralising to a healthy stomach.

to debilitate and demoralise a healthy stomach by relieving it of work which it ought to do for itself,[1] and therefore not fitted for permanent

Not fitted to be permanent food.

use as a child's food. It is often of great service as temporary or additional food in sickness and debility. If it is given it should be gradually

To be gradually replaced.

replaced by some non-pancreatised food, such as a malted food, or finest prepared entire wheat

Method of effecting this.

flour, which may be mixed with it in increasing proportions, the pancreatised food being reduced in like ratio, but the proportion of milk retained. Or some other home peptonised food may be given, and the degree of peptonising

[1] Sir W. Roberts found that in the case of a kitten fed on predigested food exclusively, there was no marked loss of health, yet this kitten fell behind another fed on 'simple milk' in body weight, and he suggested that some atrophy of unemployed glands might be the cause of this failure of nutrition.

agent and time of digestion gradually reduced to nil.

Other patent farinaceous foods.

Other farinaceous preparations largely used are made from good flour which has been heated at high temperature, with the object of breaking up the starch and partially converting it into dextrine.

Starch very slightly changed.

But this is evidently only partially effected; the infusion gives but slight indication of dextrine.

UNMALTED FARINACEOUS FOOD.

Proteid	12·3
Starch (and dextrine). . .	69·0
Ash	1·06
Moisture	9·45

To be regarded as chiefly starch food.

So that such foods must be looked upon as chiefly starch, with, like all other farinaceous preparations, a deficient amount of proteid, and almost destitute of fat. They are less suitable than the malted foods as a diet for young infants in having unchanged starch instead of dextrine.

Proportion of food elements insufficient alone.

A food of this kind, prepared with water alone, would be of very faulty nutritive power. It would contain less than 1 per cent. nitrogenous matter, a trace of fat only, and carbohydrate in the form of starch; no animal

element, no anti-scorbutic element. I have lately seen a child suffering from scurvy as well as rickets, brought up on a food of this kind alone without the addition of a sufficient quantity of milk or its equivalent.

With sufficient milk. Satisfactory for older children.

Mixed with a due proportion of milk, it forms a satisfactory food for children after the first few months, when they have gained the power of digesting starch. But it is unsuitable for very young children.

Baked flour.

Baked flour, like the patent unmalted farinaceous foods, is prepared upon this principle of partially converting starch into sugar by heating at high temperatures. It corresponds very closely with the preceding in the proportions of proteid and of starch which it contains, and yields little dextrine. It is starchy food, not suited for very young children. Mixed with a sufficient amount of milk it forms satisfactory food for the later months of infancy.

Like preceding, much starch.

Little dextrine.

When mixed with ample milk, fit for older children.

Entire wheat flour. Process of preparation.

One of the best of the unmalted flour foods is entire wheat flour, prepared by Chapman's process. In this the inner portion of the husk of the wheat is separately ground down to finest powder, and added to the white flour. The mixture contains the whole of the mineral matter,

Advantages.

and the whole of the proteids. The objection to it is that it contains a slightly larger amount of cellulose than ordinary flour, and, of course, the starch is unchanged. Objections.

Much can be done in this latter direction by long boiling, but even with this improvement it cannot be accepted as a suitable food for very young infants. Its virtue lies in its richness in phosphates and in proteid.[1] How remedied. Yet unsuited for very young infants, unless malted. Its virtue.

Let me remind you again that the grand defect of all farinaceous foods is that they consist mainly of carbohydrates, and generally in the form of starch. As I pointed out to you, Nature gives conclusive evidence against starch as such—the infant's type-food, milk, contains no starch—and yet these preparations consist chiefly of starch. The grand defect of all artificial farinaceous foods. Evidence of Nature against this.

The starch should at least be partially changed into dextrine and sugar, and then the artificial farinaceous preparations form useful additions to milk or other animal aliment. When starch changed. Useful adjuncts.

But bear in mind that the chief evil of fari-

[1] At my suggestion a malted food is now prepared from this entire wheat flour. Its greater richness in phosphates and proteid renders it especially valuable, and it is thus rendered available even for infants too young to digest it in unmalted form.

naceous food does not lie in the mere positive quality of the presence of starch only, as commonly believed, although this is a grave fault, but rather in negative qualities: in the deficiency of proteid, in the still greater deficiency of fat, in the entire absence of all animal element, and of the essential anti-scorbutic property.

Household farinaceous preparations.

And more defective even than the patent foods, in this respect, are certain household farinaceous materials often made use of.

Arrowroot.

Cornflour.

Arrowroot, for example, is almost pure starch, and cornflour is little more, the maize from which it is prepared having been robbed of some of its most nutritious ingredients to render the flour white and attractive.

These substances largely used.

These substances are largely given—especially cornflour—chiefly by the poor; possibly because they make a smooth gelatinous fluid which looks the very ideal of a light digestible food. Children fed on this soon grow pallid, thin and feeble. Yet their appetites are voracious; they are always hungry, always crying for food. In spite, however, of the large quantity they consume, they grow thinner and thinner and die of atrophy, not so much from any over-

Children fed on starches pale, feeble, voracious.

Die of atrophy.

dose of starch, although that of course they digest imperfectly, as from the want of life-giving, tissue-making proteid and fat. They are starved to death in the midst of plenty.

Die from want of nitrogen and fat.

For little children arrowroot and cornflour are the poorest and least useful of foods. Prepared barley, sago, tapioca, rice, are open to the same objection in varying degree.

Barley, sago, &c.

Oatmeal is more nutritious, as containing more albuminate, fat and salts, but it is unsuitable for young infants on account of the large amount of coarse vegetable fibre which it contains.

Oatmeal contains more albuminates and fat.

Yet too coarse for infants.

And now I turn to preparations which are not purely farinaceous, but contain some animal element in addition.

Malted foods with dried milk.

Such foods would appear at first sight to be complete. They are composed of flour duly malted and dried milk; and, therefore, from their composition should contain ample proteid and fat, and a due proportion of animal matter.

At first sight seems to fulfil all essential conditions.

From the analysis given in Table II. you will see that when prepared for use, one tablespoonful to five of water, it is below the standard in proteid, and still more in the proportion of fat, as compared with human milk. Moreover, it

Yet on analysis deficient in proteid.

Deficient in fat.

Excess of carbohydrate.

contains a considerable excess of carbohydrate element, some of which is cane sugar. When prepared for very young infants, viz., one tablespoonful to ten of water, it will be only half the strength.

MALTED FOOD WITH DESICCATED MILK.

	Pure food	Mixed with 5 parts water	Mixed with 10 parts water
Proteid . . .	9·62	1·202	0·641
Fat	4·75	0·954	0·316
Carbohydrate (starch, cane sugar, dextrine)	80·02	10·025	5·335
Salts	1·39	0·174	0·093
Water . . .	4·22	88·005	93·625
Total . .	100·0	100·0	100·0

Attractive.

Digestible.

In theory this form of food is attractive, and it possesses useful qualities. It usually agrees well with the children's stomachs; they are free from sickness, flatulence, or food diarrhœa, are extremely comfortable, and do well on it for a time.

Satisfactory till signs of faulty nutrition appear.

Too weak in animal matter.

But these foods, although of good digestible materials, have too low a proportion of animal matter, especially in proteids and fat, to supply fully and permanently the ingredients essential to the perfect structure of tissues. Children brought up on dried foods alone, without any

addition whatever, are apt to become pallid, flabby, deficient in robust vitality, and even rachitic. A fresh animal element must be added.

Wanting in anti-scorbutic property.

For experience shows further that these dried foods are defective in the anti-scorbutic property. This, you will remember, is present in fresh milk, and of doubtful certainty in condensed milk. It would seem that the process of desiccation impairs that property in the milk, and its nutritive power in other respects, perhaps, also. Scurvy has been observed to arise on a prolonged and continuous diet of dried food alone; two cases of the kind in my own experience, and many others, are recorded. We must conclude, therefore, that, although sound and digestible, dried foods require to be supplemented by fresh animal material, such as milk, or cream and raw meat juice. They need these additions to bring them to the standard required for a regular and permanent food.

Desiccation appears to impair anti-scorbutic property and nutritive power.

An insufficient food alone.

I pass on now to certain other accessories of food, which are frequently given in addition to milk and farinaceous preparations. I mean the various forms of meat teas, juices, and essences.

Meat juices and essences.

Beef tea.

The one in most common use is beef tea.

Poor results with it as a child's food.

Yet beef tea is, after all, a very poor food for little children, and I have been much struck with the very small amount of advantage they appear to obtain from it. Sometimes it causes relaxation of bowels; and the children do not gain hardness of flesh and freshness of colour on it. If you look at Table III. you will, I think, see the explanation of this. You will be surprised, perhaps, to see how little proteid it contains, even when made in the best way by previous soaking in cold water. Beef tea made in the ordinary way yields—

Little proteid.

Proteid	0·82
Extractives	2·09
Fat	0·00
Salts	0·78
Water	96·31

Beef tea made by the more approved method, viz. soaking first one hour in cold water, yields—

Proteid	1·02
Extractives	1·82
Fat	0·00
Salts	0·88
Water	96·28

So that it still contains a low percentage of proteid.

TABLE III.

SHOWING COMPARATIVE PROPORTIONS OF DIFFERENT ELEMENTS IN MEAT TEAS AND VARIOUS OTHER JUICES, ESSENCES, AND LIQUID PREPARATIONS OF MEAT.

Elements.	Beef tea made in the ordinary way by stewing down in an earthen jar. 1 lb. beef to make 1 pint. (Messrs. Savory and Moore's analysis)	Beef tea made by soaking one hour in cold water, then stewing down. 1 lb. beef to make 1 pint. (Messrs. Savory and Moore's analysis)	Raw meat juice made by mincing beef-steak, soaking one hour, and forcibly expressing. 4 oz. meat to 1 oz. water. (Messrs. Savory and Moore's analysis)	Patent Meat Juice. (Dr. Luff's analysis)	Essence of Beef. (Dr. Luff's analysis)
	Total nitrogenous elements	Total nitrogenous elements	Total nitrogenous elements		
Proteids . .	0·82	1·02	5·1	a trace	a trace
Nitrogenous extractives, kreatin, &c. . . .	2·09 — 2·91	1·82 — 2·84	3·1 — 8·2	15·93	6·85
Non-nitrogenous extractives . .				14·95	0·23
Fat . . .	—	—	—	—	—
Salts . . .	0·78	0·88	0·7	10·85	1·14
Water . . .	96·31	96·28	91·1	58·27	91·78
Total . .	100·0	100·0	100·0	100·0	100·0

As much extractive.

There is also rather more than the same quantity of inferior nitrogenous matter—extractive—but it is a question yet unsolved how far these products are usable for tissue construction. They are probably of greatly inferior importance to albumen.

Doubtful value of extractive.

The coagulation of albumen by heat, or the effect of heat upon the other constituents, appears to lessen the value of these substances for the child. At any rate, the use of beef tea in cases of debility, anæmia, and atrophy yields much less satisfactory results than a smaller amount of raw meat juice. I constantly find the best results follow the substitution of the latter for the former in the case of growing children.

Greatly inferior to raw meat juice.

Veal broth of low nutritive value.

Veal broth, which was much used by the practitioners of the last generation as a food for infants suffering from gastric disturbance, is, like all broths, a poor food for structural growth, weak in proteids, and not over rich in extractive. It is far inferior in nutritive value to any of the other meat preparations—has no advantage, as far as I know, in point of digestibility. You may, without hesitation, dismiss it from your list of infant's foods.

Raw meat juice is the most easily digested

and restorative of all animal foods; the most valuable of all nitrogenous preparations for children. As I have previously shown, it may be given freely as a substitute for the casein of milk. Raw meat juice should be prepared by mincing finely the best rump steak, then adding cold water in the proportion of one part of water to four of meat. This should be well stirred together, and allowed to soak for half an hour, cold. The juice should then be forcibly expressed through muslin by twisting it. This process is the result of many experiments made for the purpose of ascertaining the best means of obtaining meat juice of the highest nutritive value. The result is far better than any which could be obtained by Liebig's process with the addition of hydrochloric acid. It is, moreover, nearly equal to juice obtained by simple pressure without water—a most tedious and unsatisfactory method.

Raw meat juice most digestible.

Best substitute for milk proteid.

Mode of preparation.

High nutritive value.

ANALYSIS.

Proteid (albumen)	5·1	8·2 total nitrogenous element.
Extractive	3·1	
Salts	0·7	

It is, as you will see from the Table, extremely rich in proteid, viz. 5·1 per cent. In

Rich in proteid.

addition to this there are 3·1 of extractives, equal to 8·2 total nitrogenous matter, and a large proportion of salts, 0·7.

Coagulates solid with heat or strong nitric acid.

So rich in albumen is it that it coagulates in a solid mass on boiling. And this material is what the child wants for structural purposes and for active vital processes; not inferior extractives, such as form nearly the whole nitrogenous material of beef tea and broths.

Mixed with milk does not coagulate it.

Mixed with milk it does not coagulate it—the taste is hardly perceptible in the mixture. When diluted in this way or with any watery solution it coagulates on addition of digestive fluid in small light flocculi. And these delicate atoms are artificially digested by the pepsine ferment much more rapidly and easily than albumen coagulated by boiling, as in beef tea.[1]

When diluted coagulates in small flocculi.

Digests more rapidly than beef-tea coagula.

Raw meat juice, too, besides these two vir-

[1] Dr. Luff has kindly tested this point for me. He finds that with pepsine ferment albumen of raw meat is fully peptonised.

Uncoagulated in 40 minutes.
Coagulated ,, 140 ,,

But with the pancreatic ferment the time for full solution was nearly the same for both, viz. :

Uncoagulated albumen . . . 160 minutes.
Coagulated . . . . . 150 ,,

tues of richness in proteid and easy digestibility, has a rich proportion of salts, and must contain the anti-scorbutic element in more active form than cooked beef tea. Experience shows that raw meat is far more anti-scorbutic than cooked meat, and cooked fresh meat than salted meat.

Also rich in salts.

Raw meat juice is without doubt the best material for supplying proteid to the food of children who cannot digest a sufficient amount of the milk proteid casein.

The best proteid for children next to casein.

As much as 2 to 3 oz. of the juice may be given in 24 hours, if necessary, in place of milk casein. The proper plan is to give the quantity equivalent in nutritive value to the casein of the milk for which it is substituted.[1] Even a larger quantity may be given when little other food can be taken. And here let me interpose a caution. Especial care must be taken to have raw meat juice fresh. It does not keep well, and should be prepared afresh at least twice a day.

Quantity.

Caution as to freshness.

Raw meat pulp, obtained by scraping the soft muscle elements from the fibre, may be substituted for the juice in children 10 or 12

Raw meat pulp.

Process.

[1] For example of proportions see p. 74.

months old with great advantage. It must not be minced but scraped. Mincing includes, of course, the hard tendinous portions, which are not easily digested uncooked. The albuminous pulp is more digestible raw than when coagulated by cooking, but the tendinous portion, on the contrary, less so: 2 oz. of pulp may be given to a child a year old—more even, if this be the sole nitrogenous food. A possible source of danger lies in the introduction of the cysticercus of tapeworm. I have seen four instances of this only out of a very large number of cases. In two the parasite was got rid of without serious harm, and in both instances, I think, the balance of good was largely in favour of the raw meat; the two other cases are still under treatment. In each case the raw meat probably saved the child's life. Moreover, the risk of ingestion of the cysticercus is small if only the finest quality of meat is used for the purpose. It is astonishing how firm, and hard, and muscular, children become on this food.

Scraped, not minced.

The soft pulp more easily digested raw than cooked.

As to danger of tapeworm.

Another valuable preparation for young children is patent meat juice. It mixes well with milk and other foods, does not coagulate the casein of milk, does not coagulate with

Patent meat juice. Mixes well with milk.

Non-coagulable.

heat or acid, and has marked reviving and restorative power. Yet you will see from Table III. that it contains a very minute proportion of proteid, with an enormous amount of extractive and a large proportion of salts. It must owe the restorative and nutrient properties which it undoubtedly possesses in high degree to these last two elements.

Trace only of proteid.

Enormous amount of extractive. Large proportions of salts.

PATENT MEAT JUICE (Dr. Luff's analysis).

Proteids	a trace
Nitrogenous extractives .	15·93
Non-nitrogenous ,, . .	14·95
Salts	10·85
Water	58·27
Total . . .	100·0

From its small proportion of proteid it is only suited for temporary use in conditions of exhaustion and debility, not for a permanent item of food like raw meat juice. It agrees with children—even small infants—remarkably well. I have just been giving it freely to a child two months old, suffering from catarrhal jaundice, with great advantage.

Its value as a temporary food.

Useful even in early infancy.

Meat essences are less concentrated than meat juice, although they are of great value in certain cases as a stimulant and restorative,

Meat essence.

Taken well by children.

and are, in some degree, directly nutritious. These essences can be taken by children freely without producing any digestive disturbance.

As you will see from the Table of analyses—

MEAT ESSENCE (Dr. Luff's analysis).

Proteids	a trace
Nitrogenous extractives . .	6·85
Non-nitrogenous ,, . .	0·23
Salts	1·14
Water	91·78
Total . . .	100·0

Little proteid. Yet has its place.

—it contains little proteid, but chiefly extractives. Yet it has its place as a useful means of giving easily assimilated nitrogenous matter in cases of severe or protracted illness.

Insufficient for permanent food.

The absence of proteid, however, renders it, like patent meat juice, insufficient for permanent use as a child's food.

Meat peptone.

Preparations of meat peptone differ from the two preceding. They are not only restorative but in the highest degree nutritious, and of special value in certain cases of extreme feebleness, atrophy, and anæmia.

Extremely rich in proteid (peptones).

A meat peptone yields, on actual analysis, no less than 71 per cent. of proteid and 8·4 extractive, or in all 79·4 of nitrogenous elements—

MEAT PEPTONE.

Proteid (diffusible peptones)	71·0
Extractive	8·4
Fat	1·7
Salts	3·4
Water	15·5
Total	100·0

—with a large amount of salts, 3·4, and a fair proportion of fat, 1·7. The proteids are in the form of peptones, immediately assimilable without further preparation. This is an advantage when digestion and assimilation are faulty. Rich in salts.

These foods are then extremely rich in nitrogenous matter, and are most valuable nutrients and restoratives. Valuable when quick nutriment wanted, and with enfeebled stomachs.

I have used them occasionally for children, and as with adults the results are most satisfactory. These meat peptones are, however, not very pleasant in flavour, and it is often difficult to get children to take them.

Another objection to their continued use is that which applies to all predigested foods. It tends to weaken digestive power by rendering the exercise of it by the stomach not only unnecessary but impossible; and peptones, therefore, are unsuitable as a regular food, although of the highest value as a temporary resource in serious illness, where digestive power is failing or deficient. Debilitating effect on digestive organs. As a temporary food only.

LECTURE IV.

DISEASES WHICH RESULT FROM ERRORS OF DIET, AND THEIR TREATMENT—DYSPEPSIA, DIARRHŒA, CONSTIPATION, STOMATITIS, ANÆMIA, ATROPHY.

Food disorders of two classes : (1) Those resulting from irritation of the alimentary tract ; (2) Those arising from defective nutrition—Class 1 : Dyspepsia, gastro-enteric catarrh, choleraic diarrhœa, constipation—Dyspepsia in hand-fed children — In sucklings — Its symptoms — Causes — Most common in hand-fed children—The prime error—How it is to be avoided—Danger of cow's milk and water—Importance of boiling—Of sufficient dilution—Gastro-intestinal catarrh—Something more than mere indigestibility necessary to set up severe forms, viz. decomposition—Conditions under which it arises — Danger greater in hot weather and warm climates—Mortality from this cause—Various degrees of gastro-enteric catarrh—Symptoms—Effect of loss of fluid on the body—Post-mortem appearances—Treatment—Broad principles on which treatment should be based—Diet—Non-fermenting—Non-irritant—Nutritive—Various modes of attaining this—Stimulants —External warmth — Bismuth — Opium — Ipecacuanha—Grey powder—Their action and effective combination—Chronic diarrhœa—Peristalsis too readily excited—Treatment—Constipation—Treatment by diet and simple laxatives — Thrush — Occurs chiefly in hand-fed children — The fungoid growth—Symptoms—Follicular stomatitis—Ulcerative stomatitis—Treatment—Atrophy—Due to many causes—Atrophy from too scanty food—From food deficient in certain elements—Atrophy from vomiting and diarrhœa—From imperfect digestive power—Cases in

illustration—Anæmia—Food one of the factors—Forms of food anæmia—Anæmia of starch-fed children—From deficiency in animal element of food—From defective digestive power—Treatment—Iron and arsenic—Raw meat juice—Sunlight—Pure air.

THE disorders which result from errors of diet in young children may be divided at once into two great classes.

Two great classes.

1. The diseases produced by irritation of the alimentary canal by decomposing or indigestible articles of food ; and,

2. Those arising from defective nutrition, from the want of sufficient food, or more often from a deficiency, not in the gross amount of food, but in certain elements of food, a defect of quality rather than quantity.

In the first class are such diseases as dyspepsia, stomatitis, thrush, and gastro-enteric catarrh, the more severe forms of choleraic diarrhœa or cholera infantum, and the contrary condition of constipation.

Diseases of first class.

Under the second class come such disorders as anæmia, atrophy, rickets, scurvy.

Diseases of second class.

It is clear that some of these disorders of the second class—general constitutional conditions—may be sequels to the former, and directly produced by them. Anæmia, atrophy, and rickets

Some of second class results of the first.

may result, and constantly do result, from the deficient preparation of nourishment for assimilation in dyspepsia, or in the rejection of it, or the draining of it away by vomiting and diarrhœa. But in such cases they are consequences—not immediate accompaniments—and may well be considered apart.

As consequences of deficient assimilation or undue drain.

In many cases there is no perceptible ailment of this kind—no vomiting, or diarrhœa, or dyspepsia—yet the child grows anæmic, atrophied, or rickety, from simple deficient supply of assimilable food of the right proportions.

Others, again, distinct.

It will be convenient to take the class of diseases due to direct irritation first in order.

Diseases of direct irritation.

DYSPEPSIA.

The commonest and simplest of these is *dyspepsia.*

Few children brought up by hand escape altogether, and many suckled at the breast of the mother or wet-nurse suffer in minor degree.

Few hand-fed children escape it.

Sometimes sucklings suffer;

In one instance, indeed, within my own immediate knowledge, the mother's milk disagreed so much in this way, causing colic, flatulence, with incessant crying and restlessness, and disturbed nights from pain, that it was found necessary to wean the child, and place it upon boiled cow's milk and water. This was done with the

case in which mother's milk produced excessive colic.

Boiled cow's milk substituted with success.

best and happiest results. From that moment there was peace. The child was free from all pain and discomfort, and throve apace.

The cause of difficulty.

Microscopic examination of the mother's milk showed numerous large granular corpuscles, apparently the epithelium of the lacteal gland acini, imperfectly changed persistent colostrum corpuscles.[1] No other fault could be detected in the milk. Possibly the difficulty of digestion arose partly from gulping it down too rapidly, with ingestion of air.

Such cases rare.

But such extreme dyspepsia from human milk is rare. I have met with only one other instance where the child was unable to digest the milk of a sound mother whose health was not disordered, although cases in which that of a wet-nurse proves unsuitable are by no means very uncommon.

Sometimes milk of wet nurse disagrees.

Summary.

To sum up. This trouble of food dyspepsia then arises sometimes with children who are flourishing on the wholesome milk of a healthy

Sometimes sucklings at mother's breast, or wet-nurse.

[1] Formerly it was supposed that the cells of the acini underwent fatty degeneration, and thus produced the fatty granules of the milk. It is more probable, however, from the observations of Stricker, Schwarz, Partsch, and Heidenhain, that the cells of the acini manufacture the fatty granules, and their protoplasm eliminates them, at the same time forming the clear fluid part of the milk.—*Landois and Stirling*, vol. i. p. 462.

mother or wet-nurse ; not often, and most rarely in extreme degree. But most commonly with bottle-fed children ; with them it may be of any degree of severity, from slight discomfort to violent colic, vomiting, and diarrhœa.

Usually, however, in hand-fed infants

in all degrees of severity.

SIMPLE INFANTILE DYSPEPSIA.

Symptoms.

Simple Infantile Dyspepsia.—The signs of imperfect digestion in an infant are usually palpable enough. After the meal the child becomes evidently uncomfortable ; it is restless, cries, draws up its legs, brings up wind, eructates a certain amount of food, keeps hiccoughing, or actually vomits curded masses ; or the pain may be so severe that the child kicks and screams violently. Sometimes there comes that blueness round the mouth, twitching of face, and contraction of the lips which nurses call inward convulsions, so graphically described by Dr. West.[1]

Discomfort after feeding,

colic, flatulence, eructations, hiccough, vomiting, crying.

If pain violent, kicking and screaming.

The 'inward' convulsion, or 'inward fits.'

Description.

'The child lies as if asleep, winks its imperfectly closed eyes, and gently twitches the muscles of its face—a movement especially observable about the lips, which are drawn as though into a smile.' If this condition increases, the child breathes with difficulty, its respiration seems for a moment almost stopped, and a livid ring sur-

[1] *Diseases of Infancy and Childhood*, p. 41.

rounds the mouth. Presently, it brings up a quantity of flatus, is relieved, and after a time, with much nursing, walking about, and coaxing, at last goes off to sleep. I believe this disturbance of circulation and respiration is due to the pressure of a gas-distended stomach upon the heart.

Relieved by passage of flatus.

Many children suffer from marked gastric discomfort after almost every meal, are constantly crying and restless, and wear out both mother and nurse by ceaseless fretfulness; and this may be the case without any serious vomiting, or diarrhœa, or obvious malnutrition.

Some children thus after every meal.

Yet not ill-nourished.

All these troubles may be avoided if proper means be taken at the outset, and even if they do arise, they can soon be arrested by appropriate treatment and management.

All these troubles may be avoided;

or, if they do arise, soon arrested.

If the child is at the breast, the cause of discomfort may be the too rapid gulping down of milk from a freely flowing breast, or the mother's food may have been such as to render the milk of an irritating nature. She may have been taking acid fruits or wines, or some medicine which affects the child.

Causes.

Gulping of air.

Irritating matters in mother's milk.

Faults such as these are easily rectified. The milk-flow can be moderated by pressure of the

How to be remedied.

fingers on the nipple, the mother's diet regulated, and with a few doses of alkaline carminative mixture immediately after feeding, acidity and flatulence will be relieved, and the child will be put at ease. Thus,

Management.

Medicine.

Antacid carminative.

℞ Sodæ bicarb. gr. iij., spir. ammon. aromat. ♏j., spir. chloroformi ♏j., syrupi ♏x., aquæ anethi ʒj.; for a child one month old. The doses usually given are too small.

Another variety of this.

Bismuth and prepared chalk may be added where there is much pain, or when there is diarrhœa; or prepared chalk may replace the carbonate of soda, and magnesia may replace the soda if there is constipation.

Sometimes human milk hopelessly disagrees.

Causes.

In certain extreme cases, as I have stated before, the human milk from some cause, possibly the presence of colostrum corpuscles, or, in the case of a wet-nurse, from the milk being in too advanced a stage for the infant—the nurse having been delivered earlier than the mother of the infant she is to suckle, and therefore her milk being too plentiful and too caseous—disagrees hopelessly.

The child to be weaned.

In such cases the best plan is to wean the child at once on to the bread-jelly food, or dextrinised food, with a small quantity of boiled cow's milk,

steadily increased as the child's digestive power improves. If the cow's milk cannot be digested, peptonised condensed milk may be given, or properly diluted raw meat juice and cream may be substituted. In the meantime, the child's stomach must be soothed by a mixture of soda, aromatic spirits of ammonia, and dill water, such as that previously mentioned.

The food to be substituted.

But it is the bottle-fed children who are the greatest sufferers, and it is with hand-feeding that mistakes are chiefly made, and difficulties stirred up which might and ought to be avoided.

Bottle-fed children the chief sufferers.

The mistakes made.

I am convinced that these difficulties and disasters of hand-feeding need never occur. An infant can be safely placed upon artificial food, without any serious gastric disturbance arising, if the food is carefully adapted to its powers at the outset.

May be absolutely avoided,

if sufficient care at the outset.

It is at the outset that the fatal error is usually made. It is the first step which is usually so productive of trouble. The great causes of irritation are, as you know, indigestible masses of casein fermenting in the alimentary canal, or indigestible starch which undergoes lactic fermentation Sometimes, perhaps, the lactic fermentation of cane sugar, or milk which is more

The prime error.

Irritants from lactic fermentation.

or less sour from commencing decomposition before it is taken, is the source of irritation.

The common practice.

The common practice, as I reminded you before, is to put the infant at once upon unboiled cow's milk and water, either half and half, or 1 part of milk to 2 of water, with perhaps some lime water added. The child has flatulence, hiccough, and cries and tosses with all the tortures of colic; or it is sick and purged, its stomach irritated by solid curd and distended by the gases disengaged from the fermenting coagula. Or the child is given starchy food, with or without milk, and in like manner suffers from flatulence and colic, due to lactic fermentation of the starch which it is unable to properly convert into grape sugar, while the cane sugar added increases the difficulty and acidity. The pancreas has too great an amount of carbohydrate to reduce, and this ferments in the intestine probably as well as in the stomach. I repeat that these consequences are all preventible.

Unboiled milk and water.

Consequences.

Results of acid fermentation.

Or starch food given.

Results.

All preventible.

The point is so important that you will forgive me for again enforcing the rules I have laid down before.

In the first p.ace, never put the child when it is first weaned upon unboiled cow's milk and water. Boil the milk and add barley water.

First precaution, boil the milk.

Second precaution, make the milk sufficiently dilute.

In the second place, carefully gauge the child's digestive power by making the solution of milk sufficiently dilute at first, 1 part of boiled milk to 3 of boiled water to begin with, instead of 1 to 2, as usually adopted. The strength can be gradually increased.

Water 3 to 1.

Increase gradually.

If condensed milk, 1 in 24 at first.

If condensed milk be used, begin with it sufficiently dilute, 1 part to 24 at first, instead of the usual 1 in 10 or 15.

If the child is very young, or exceptionally delicate, or if other children of the same parents have had difficulty in digesting cow's milk, do not attempt to put it on cow's milk and water; place it at once on bread jelly, with small and increasing doses of milk, until the necessary standard of nutrient value is attained. As a rule, I find the safest plan in all cases is to begin with bread jelly or highly dextrinised malted food, of the second form described (p. 84) with a tea- or dessertspoonful of boiled milk to the half bottle only. Or, better still perhaps, put the child on dilute peptonised milk, gradually lessening the amount of peptonisation. One of the best preparations for temporary use is the condensed peptonised milk.

Or give bread jelly and boiled milk.

Or peptonised milk.

But do not adopt the usual plan, of making

Do not make the child ill first,

and then make unreasoning efforts to cure it.

the child ill first with plain cow's milk and water, and then endeavour to remedy the fault by wild, haphazard, unintelligent changes to other milk, or to this artificial food or the other, without regard to digestibility or nutrient value.

Such mistakes common.

I constantly find this loose practice. A child which cannot digest cow's milk is put upon some equally difficult food, or on a purely farinaceous diet without any animal element.

Care at first will obviate difficulties,

even in weaning the youngest infant.

A cautious, watchful procedure at first, beginning with a sufficiently dilute food, will, I think, infallibly prevent all serious trouble in weaning even the very youngest and most delicate infant; remembering always to raise the strength of the food to the standard proportions. Do not be content without this. A food may agree perfectly well, and yet be entirely unsatisfactory from defect in nutritive value. Test all food by the data given in the previous lectures.

Faults of diet frequently produce still more grave results.

But these faults in the diet of infants, especially during the first few months of life, frequently produce much more grave consequences than mere dyspepsia.

Constant irritation produces inflammation.

The constant irritation of the gastro-intestinal tract by indigestible food causes, first

hyperæmia, and then catarrhal inflammation of the mucous membrane, and this may be in any degree, from slight sickness and diarrhœa to that incessant vomiting and purging which constitutes acute inflammatory diarrhœa, or cholera infantum. Gastro-enteritis forms one-third of the whole number of infantile disorders—a most deadly disorder, which it is of the utmost importance to arrest in its first onset.

Gastro-enteritis in any degree up to cholera infantum.

A deadly disorder.

Important to arrest it in its first onset.

In some mild cases, and in chronic cases, mere indigestibility of food may be, and often is, the sole cause. Sometimes the influence of rank food taken by the milch cow may give an irritant character to the milk.

But to set up gastro-enteritis in its severest and most fatal form, I believe something more than mere indigestibility of food is required. The most potent cause is souring and decomposition of food, and this usually results from neglect of scrupulous cleanliness in utensils in which food is kept, or even keeping it too long before using, especially in hot weather, or in foul air; near a drain or sink, for instance, or in an ill-ventilated room. Milk is a constant source of danger in this way; it readily takes up dangerous organic poisons, and, as I

Yet probably something more than mere indigestibility essential to cause disease in severest form, viz. decomposition.

Milk a great source of danger.

showed in the first lecture, soon undergoes change.

The merest trace of sour milk or other food will set up fermentation in a whole bottleful. Sometimes, I believe, the decomposition is started by keeping the food during the night gently heated in food-warmers. This favours fermentation.

Food-warmers the agents sometimes.

Further, it is to be remembered that with a food which, like milk, so easily undergoes fermentative change, undigested clots retained in the alimentary canal under the conditions of heat and moisture so favourable to all forms of fermentation and putrefactive change, would decompose with extraordinary rapidity. So that the irritant poison may in these cases be actually developed inside the child's body, not introduced ready-made from without.

Decomposition of undigested clots.

Whatever the active agents of disturbance may be, whether lactic acid or butyric, or other products of decomposition, such as ptomaines or the liquid products of bacteria, food in this state of change is profoundly irritating to a child's gastro-intestinal mucous membrane. That it is the decomposition of food which gives rise to these irritating products is supported by

The products of decomposition profoundly irritating.

the fact of the extreme prevalence and deadliness of choleraic diarrhœa in hot climates, where decomposition sets in so rapidly.

Fatality in hot climates.

In the United States, for example, it is far more deadly than in England. According to Dr. Lewis Smith, 1,500 deaths occur from it every year in New York alone. A large number of cases reported as 'marasmus' are probably due to the same cause.[1] It rages especially in the summer season.

In New York.

Especially common in young children at weaning.

Dr. Lewis Smith shows further that it occurs chiefly in young children, and is most common about the period of weaning; and, most significant fact, the younger the child the more likely it is to be affected, if bottle-fed.

Terrible mortality in Foundling Hospital.

In the New York Charity Hospital, before wet-nursing was adopted, a large proportion of foundlings died of entero-colitis during the first and second months. Few survived to the age of six months.[2] Similar disastrous results have followed bottle-feeding in the French foundling hospitals.

Effect of hot season.

Again, the warmer the season the greater the danger.

[1] *Diseases of Children*, 2nd edit. p. 594.

[2] *Op. cit.* p. 599.

In America the mothers dread the second summer after the child is born. In New York nearly every infant taken from the breast between April and October becomes affected with diarrhœa, which if not inflammatory in its commencement soon becomes so.

Few hand-fed children between April and October escape diarrhœa.

Moreover, hilly districts are comparatively free. On low grounds the disease is rife.[1]

High districts comparatively free. Low damp grounds hurtful.

This all goes to show that heat, damp, foulness, favouring decomposition and perhaps poisoning of food, act as septic agents, so that we must take indigestibility of food and decomposition, or fermentation, as the two great agents in the production of gastro-enteric catarrh in all its degrees.

Showing septic agency.

Indigestibility of food and decomposition the two potent causes.

There are a great number of varieties of diarrhœa described — simple diarrhœa, non-inflammatory diarrhœa, inflammatory diarrhœa, entero-colitis, choleraic diarrhœa, cholera infantum, dysenteric diarrhœa. This multiplication of names has led to much confusion, and is not warranted by either the clinical characters of disease or its morbid anatomy.

Varieties of diarrhœa.

With one exception, viz. dysenteric diarrhœa, the differences are those chiefly of degree.

Chiefly differences of degree.

[1] Lewis Smith, *Diseases of Children*, p. 595.

Catarrhal disturbance and inflammation of the mucous lining of the alimentary canal occur in every degree of intensity, from the slight disturbance produced by irritation of a little undigested food, to the violent and extreme choleraic disturbance set up by the poisons of decomposition. Some difference is traceable according to the portions of the canal chiefly involved, but the varieties shade into one another indefinitely.

The symptoms and the lesions vary in acuteness, severity, and extent, according to the nature and degree of virulence of the cause which sets them up. And so you may have gastro-enteritis of every grade from a simple diarrhœa to cholera infantum. There is probably a difference according as the disorder is set up by local irritation of undigested or irritant food acting directly upon the mucous lining, or is due to the central action of a septic poison absorbed into the blood. Yet this probably has a local irritant action also, and it is impossible to distinguish except by degree, the more severe cases being, I imagine, septic always.

Gastro-enteritis of every degree, from simple diarrhœa to cholera infantum.

Dysenteric diarrhœa has distinct characters of its own. It is characterised by the passage of mucus and blood, by straining, with fever and

Dysenteric diarrhœa.

Special symptoms of dysenteric diarrhœa.

some vomiting at first, but there is no copious colliquative diarrhœa constant and incessant. We may then make two distinct forms of infantile diarrhœa :

1. Gastro-enteritis.
2. Dysenteric diarrhœa.

Not usually due to food.

Of dysenteric diarrhœa I shall say nothing here, for it is not properly a food disorder, but, according to my observation, in the case of children at any rate, usually the result of a definite chill, a catarrhal inflammation of the large intestine analogous to that of the bronchi in bronchitis.

GASTRO-ENTERITIS.

Symptoms.

At first, moderate diarrhœa.

Loose greenish stools.

Gastro-enteritis.—The first symptom is usually moderate diarrhœa, four to six actions in the twenty-four hours. Yellow stools first, then greenish, like chopped spinach—offensive, acid. The child is feverish, fretful, cries or screams, draws up its legs, moves restlessly in pain with stomach-ache ; usually there is little sickness for a day or two at first ; then vomiting begins, of sour, curded, undigested food. In cases of extreme severity, however, vomiting sets in at once, with purging. In such cases often the very smallest quantity of food, even water, is instantly rejected. The bowels act every hour,

Vomiting, fever, pain, and fretfulness.

In extreme cases, vomiting constant, intense.

perhaps, or even several times an hour; the stools become more and more serous and colourless. The child may be dead in two or three days. Purging frequent.

The incessant draining off of food, and especially of liquid, by the incessant vomiting and purging, causes the child's tissues to shrink. It dwindles rapidly, remarkably. This rapid shrinking in fulness and size is striking and characteristic. The cheeks become hollow, the eyes sunken, the skin wrinkled, the fontanelle depressed. The subcutaneous fat, so plentiful in a plump, healthy child, rapidly disappears. The sunken cheeks and eyes, the pinched features, give it a most ghastly, unnatural look, like a death's head. Later the eyes become bleared; there is puriform secretion between the lids. More strange and significant still, the eyes and mouth remain open during sleep, due to loss of tonicity and contractile power in the orbicularis palpebrarum and orbicularis oris—a sign of extreme muscular feebleness. The muscular weakness is further evidenced by the quietness of the patient. It lies still, exhausted; with eyes half open, taking little notice, in contrast to its former active restlessness.

Effects of rapid draining of nutriment, especially of liquid.

Child shrinks and shrivels.

Pinched face.

Eyes and mouth open during sleep.

Reason of this.

Muscular feebleness.

Pallor cause.

The constant drain, again, produces pallor. The red corpuscles decline; the vessels are half empty. The deficiency of hæmoglobin, the failing circulation, and the want of combustible food, cause coldness of extremities and chilliness of surface. The pulse grows small, frequent, thread-like (120 to 130, 140, 160). The temperature becomes subnormal—at first it may be 100 to 104 or even 105—but it falls after a few days to 96 or 97, if the drain continues. The tongue, coated at first, becomes dry and red.

Coldness; cause.

Pulse.

Temperature.

Tongue.

Pneumonia.

Hypostatic pneumonia may arise and add a fresh danger to the crisis. There may follow also the condition known as spurious hydrocephalus. The child becomes drowsy, almost insensible; the pupils respond no longer to light, and the child dies exhausted or convulsed. In some instances sudden collapse comes on when improvement appears to have set in, and death takes place quickly and unexpectedly.

Spurious hydrocephalus.

Convulsions perhaps.

Sudden collapse.

Examples of sudden collapse.

Twice within the year have I seen this sudden change for the worse set in, when the case seemed to be proceeding hopefully. In each instance the child was beginning to take food, the vomiting had ceased, the diarrhœa was subsiding. Then came on pallor, coldness

of extremities, unconsciousness, and death in the course of three or four hours. The prognosis in these cases, therefore, must always be most guarded.

Post-mortem changes.

The morbid changes found on post-mortem examination are vascularity of the mucous membrane, with swelling and infiltration, thickening, excess of mucus coating the surface, softening, and occasionally small superficial ulcers. The glands are tumid, enlarged. The solitary glands, those of Peyer's patches, and the mesenteric glands are affected in a similar manner. The brain is excessively anæmic.

Treatment.

Treatment.—The rule of first importance is, always to arrest infantile diarrhœa as soon as possible. The broad principles on which treatment should be based are these:

The broad principles on which it should be based.

1. Stop all food which favours fermentation and acidity, or causes irritation by indigestibility.

2. Neutralise acidity developed by fermentation.

3. Soothe the irritability of the stomach and intestine, and stop the excessive peristalsis.

4. Sustain strength and repair the loss of fluid through the excessive liquid drain by easily digested nutritious food.

5. Assist further the depressed circulation and heat production by stimulants and by external warmth.

Stop irritant food.

In the first place then stop at once the cow's milk, or whatever irritant food has produced the disturbance. Give no cow's milk until the symptoms largely abate. But do not commit the common, fatal mistake of putting the child on mere barley water, or arrowroot and gelatine, or veal broth, except for a short time at first. This may agree, but it is starvation diet; the danger is of death by exhaustion and collapse. Give food that will stay on the child's stomach, but let it be nutritious and stimulating also, and given in small quantities at a time.

Give bland food of good nutritive value.

Various methods. Wet-nurse.

This end may be attained in one or two different ways. If the child is very young, a wet-nurse may be obtained, and the baby allowed to suck small quantities only at a time. If it cannot or will not take the breast, milk may be drawn off and given with a teaspoon, or ass's milk may be given in like manner. Another plan, and in my experience the most successful of all, is to place the child on bread-jelly food, to which a small quantity of condensed pepton-

Ass's milk.

Bread jelly.

Peptonised milk.

ised milk has been added; or weak peptonised milk alone may be used.

The food should be given frequently in small quantity, one or two teaspoonfuls only every hour or half-hour. If the sickness abates, half a teaspoonful of Brand's essence, or a teaspoonful of a solution of Valentine's meat juice diluted with 20 parts of water, may be given every 2 hours. The best pale old French brandy should be added in the proportion of half a teaspoonful to a tablespoonful of food every 2 to 4 hours, according to the degree of feebleness and collapse.[1] The doses usually prescribed are too small, and their effect spoilt by over-dilution. It is no use putting 10 drops in a bottleful of food. When the sickness has completely ceased for at least 24 hours, more nutritious food may be cautiously ventured upon, such as the raw

Brand's essence.

Valentine's meat juice.

Brandy.

Quantity and mode of administration.

Increase of food.

[1] 5 to 10 drops every 4 hours for a child 1 month old.
10 ,, 20 ,, ,, ,, 2 months old.
20 ,, 30 ,, ,, ,, 3 ,,
30 ,, 40 ,, ,, ,, over 3 ,,
60 ,, ,, ,, ,, 4 ,,

Brandy is an excellent sedative for children as well as a stimulant. It probably acts favourably also by helping to arrest fermentation. When opium is given at the same time, it is necessary to bear in mind that brandy has a narcotic action, which, added to that of the other drug, may cause too great drowsiness.

meat juice and cream, added in small quantities to bread jelly or Mellin's food, and gradually increased to the standard proportion. If cow's milk is resumed, take care that it is boiled immediately it is brought into the house, and begin with a weak dilution in barley water, or add it to the other food in small quantity. Above all, see to the cleanliness of vessels, and the purity and freshness of the food given.

If collapse, nutrient enema with brandy.

If the collapse is great, give at once an enema of peptonised beef jelly or beef tea, if the other is not at hand at the moment; with brandy, a dessertspoonful to an enema of 2 oz.; and place the child in a warm bath.

Warm bath.

Importance of warmth.

Heat is essential. You will find that the body temperature has fallen far below the normal; the child has not the means of keeping up its body heat by internal combustion. Wrap it in warm flannels, give it a hot bottle in bed; or one to the feet and one on each side if the collapse and coldness are great.

Drugs also effectual.

Grey and Dover's powder.

In such cases much may be done by drugs as well as by diet and warmth. If the sickness is great, give grey and Dover's powders. For an infant under 3 months, $\frac{1}{6}$ to $\frac{1}{4}$ grain of Dover's

powder, with $\frac{1}{4}$ grain grey powder every 3 hours; for a child over 6 months $\frac{1}{2}$ grain of each every 4 hours.

Bismuth and opium.

If diarrhœa be the most urgent symptom, and the sickness not so extreme as to prohibit liquid medicine in larger volume, give bismuth. I would impress upon you that the liquid preparations of bismuth are very ineffectual for this purpose, and the small doses of nitrate usually given of little use. Large doses of the insoluble nitrate are essential, or smaller doses very frequently repeated: 3 to 5 or 6 grains of the nitrate may be given every 4 hours. With this, opium and ipecacuanha; $\frac{1}{6}$ to $\frac{1}{4}$ or $\frac{1}{2}$ a drop of liq. opii sedativus, according to age, with 2 or 3 drops of ipecacuanha wine in 2 teaspoonfuls of water; or the bismuth may be given in powder combined with Dover's powder.

Amount and form of bismuth

of opium;

of ipecacuanha.

Chalk or soda.

To this mixture may also be added with advantage prepared chalk, 3 or 5 grains, or bicarbonate of soda to neutralise the acid formed by fermenting food. Mere astringents alone are of little use. But decoction of hæmatoxylum may be used as the basis of the mixture if the flux is watery and excessive. The great drugs, however, are bismuth, in full doses, to soothe the

Astringents of little use.

The most efficient drugs.

Their mode of action.

mucous tract by local application ; opium (with caution), to lessen peristalsis and reflex irritability ; ipecacuanha, to ease the inflamed membrane by aiding secretion ; or grey and Dover's powder, in frequent doses, for similar purposes.

Chronic vomiting.

Chronic Vomiting and Diarrhœa.—Sometimes, when the disorder is subacute, the diarrhœa and vomiting, especially the former, tend

Chronic diarrhœa.

to become chronic. The mucous membrane not only secretes too freely, but its reflex apparatus

Undue secretion.

remain so sensitive, that the contact of food excites vermicular action. Thus the induced

Excessive peristalsis.

peristalsis of the intestines may cause the bowels to act every time food is taken. These conditions should be treated by bismuth and opium,

Treatment.

or grey and Dover's powder, and most careful dieting on unstimulating food, such as peptonised milk, or raw meat juice and cream food. The continued use of small doses of opium is essential to the permanent cure of this peristaltic excitability.

Constipation.

It is more difficult to trace constipation to errors of diet than the opposite condition of diarrhœa. It is common in healthy, milk-fed

How caused.

children, due perhaps in part to great uniformity of food, or food of too unstimulating a

character, which leaves little débris behind. It is a condition easily remedied by simple saline laxatives and appropriate diet. I have so recently stated my views on this subject in lectures published in the 'Lancet' (1886), that I shall not touch further upon it now, except to remind you of the two main points in treatment. They are that the laxative should be given for some time continuously, not intermittingly, and that it should be mild and unstimulating.

Treatment.

Another common affection which is liable to supervene on improper feeding is *thrush*. This is characterised by the presence of milk-white patches, due to the development of a fungus, which grows upon the mucous membrane of the mouth and tongue, and spreads sometimes to the œsophagus, and even to the stomach and intestine in rare cases.[1]

THRUSH.

Characteristics.

Oïdium albicans, or wine-mould.

The fungus grows sometimes upon what appears to be healthy mucous membrane in the case of very young infants. But it grows most luxuriantly where the membrane is inflamed and its secretions disordered. Its growth is favoured by the acid reaction; the decomposing or soured

Sometimes appears on healthy surface in very young infants.

But usually on inflamed surface.

[1] The *Oïdium albicans* of Berg; it has lately been classified with the moulds, and as identical with the mould of wine.

milk adhering to the inflamed membrane forms a congenial soil for this, as it does apparently for various other low forms of life. Grave cases of severe thrush are usually sequent upon chronic diarrhœa, vomiting, starvation, or other disease; most frequent of all after gastro-enteric catarrh from food irritation in bottle-fed children.

Always in grave cases, sequel of chronic diarrhœa, &c.

In bottle-fed children.

Condition of mucous membrane in such cases.

In such cases there is dryness and injection of the mouth; the tongue looks rough, red, and dry; the papillæ are vascular and prominent, there may be superficial ulceration—thick patches of white fungoid growth adhere to the tongue, the inside of the cheeks and lips, and the roof of mouth. Very often in these cases the first thing noticed by the mother or nurse is that the child refuses food. It dreads the pain caused by its contact with the tender mouth. Remember, then, always to examine the state of the mouth in every case where the child refuses food. The bowels are loose and discharges acrid, excoriating the nates.

Patches of fungus film.

Significance of refusal of food.

Stomatitis.

Not unfrequently thrush is complicated or added to stomatitis, either aphthous or follicular stomatitis, or often, amongst the poor, ulcerative stomatitis. The former, follicular stomatitis, is an inflammation of the mucous follicles of the

Follicular, or ulcerative.

mouth, characterised by the presence of small round ulcers, the size of a pin's head ; the latter, an erosion of the mucous membrane along the edges of the gums and cheek, due to impaired vitality of tissue.[1]

All these conditions—thrush, follicular stomatitis, ulcerative stomatitis—are closely connected with errors of diet ; the first two due to irritant food, the latter to gravely defective nutrition ; and I mention them briefly in order to draw attention to this connection, and because they are all curable by similar means.

All closely connected with diet.

All curable by similar means.

First, regulate the diet. Stop all pure starchy foods and in extreme cases milk, substituting peptonised milk with malted food or Valentine's meat juice ; or raw meat-juice, with cream and water.

Treatment : first regulate the diet.

Give chlorate of potash and bark internally.[2] Locally paint the patches of fungoid growth or ulcerations with a solution of borax and chlo-

Chlorate of potash.

[1] I omit gangrenous stomatitis, which, although probably due in part to feeble vitality of malnutrition, is usually directly set up by preceding measles, or other exanthem.

[2] ℞ Pot. chlor. . . . gr. iij.
Ext. cinchonæ liq. . . ♏ x.
Syrupi . . . . ʒss.
Aq. ad . . . . ʒij.
For a child 1 year old.

rate of potash, of each 10 grains to the ounce, or the glycerine of borax—although this causes much smarting, it is effectual—or a solution of glycerine of tannic and glycerine of carbolic acid, ½ a drachm of each to the ounce. The most effective drugs are borax, or weak tannic and carbolic acid locally ; chlorate of potash internally. These, with bark, full feeding, and brandy or wine if necessary, good fresh air and favourable hygienic conditions, will usually soon effect a cure.

Borax.

Summary of treatment.

ATROPHY.

Another common result of defective feeding is *atrophy*.

Due to many and various causes, yet most commonly to errors of diet.

Now atrophy is due to very many causes ; to congenital syphilis, to prolonged pyrexia, to tuberculous disease, and so on. But it is very constantly associated with errors of diet, notably when food in gross amount is too scanty—starvation—and it is a frequent result of food vomiting and diarrhœa. I have now (April 1887) under my care in the Children's Hospital a child 8 months old, reduced to a mere skeleton by vomiting and diarrhœa, induced by careless feeding with cow's milk in the workhouse. It is getting rapidly fat and strong upon peptonised milk and raw meat pulp.

From vomiting and diarrhœa.

Case.

Simple atrophy, the result of want of proteid and fat.

Simple atrophy often follows mere deficiency of the most important elements of food, proteid and fat, as in the wasting of starch-fed children.

As in starch-fed children.

The want of proteid and fat apparently lessens the vital power essential to growth and nutrition, by causing failure of protoplasm in each cell, so necessary for every vital process of the body.

Treatment.

This is remedied by the addition of animal food, milk, or meat juices, and the substitution of a malted food for the starch, with perhaps cod-liver oil, or cream if possible.

Occasionally atrophy supervenes in children brought up on good cow's milk, owing to their imperfect power of digesting it, although there may be no vomiting or diarrhœa at any time. Of this, the following case forms a good example:

Case of simple food atrophy, from imperfect digestive power.

An infant, aged 4 months, was brought to me on January 5, 1887. It had been weaned at three months, and put on cow's milk and water; at first 1 part to 2 parts of water, since raised to 1 to 1. After weaning, the child had a good deal of vomiting of curd, no diarrhœa, but constipation.

History.

The bowels now act every day, but the stools are dry, light-coloured, and contain undigested curd. The child is occasionally sick. It is

always hungry, takes food eagerly, and sleeps well. But it gets thinner and thinner. It was on account of this steady loss of weight that the child was brought to me. There was no abnormality discoverable in chest or abdomen on careful examination. The child's skin was mottled, healthy; it was not very flabby, but extremely thin, and the fontanelle was widely open. Here was evidently a case in which the cow's milk was not digested and assimilated, and also the gross amount was somewhat less than the standard quantity.

Condition of patient.

Treatment.

Diet.

The only change I made in treatment was to have the milk boiled and given with the bread-jelly food; $2\frac{1}{2}$ oz. of milk, with an equal quantity of food every 3 hours. This amounted to 1 pint of cow's milk; in addition one tablespoonful of raw meat juice was given instead of milk in one bottle. I prescribed no medicine whatever.

Result.

Gain in weight.

The change which followed was very striking. The gain in weight for the first fortnight was only 2 oz., then 4 oz. every week, then 11 oz. The milk was increased and the food further thickened, and in the next month the child gained 2 lbs. 4 oz., or an average of

9 oz. per week. Then Chapman's flour was substituted for the bread jelly, and the next month showed a gain of 2 lbs. 13 oz., or an average of 11¼ oz. a week.

The child is now, at 8 months, the picture of robust health, big, hard-fleshed, rosy.

Case of slight atrophy, on ass's milk.

I have now under my care a child, M. L., who became atrophic, flabby, and anæmic when fed on ass's milk up to a year old. The gradual substitution of cow's milk, with some raw meat juice and malted food, at once caused rapid gain of weight, firmness of flesh, and increase of colour. In the course of three weeks that child gained 37 oz., or an average of 12⅓ oz. per week.

Anæmia. From various causes.

Another common result of faults in diet is *anæmia*. Anæmia of course results from many varied causes—from organic disease, from foul air or lack of fresh air, and in London, notably, lack of light; it is also, let me remind you, a constant feature of rickets and scurvy.

But anæmia of a simple kind is often seen in children who are apparently fat and well, but yet in reality imperfectly nourished. It occurs notably in those who cannot take or are not

From too little fresh animal food.

allowed a sufficient amount of fresh animal food, *i.e.* of fresh milk or some equivalent.

Starch-fed children.

Anæmia is present in all starch-fed children, and in those brought up on the vegetable foods, when given alone, or with too small an amount

In those fed solely on farinaceous foods.

of fresh milk. It is seen even in children brought up on farinaceous foods which contain a dried animal element, unless fresh milk be given in addition. The anæmia may be partly

Even foods containing desiccated milk.

due in the latter case to the altered character of this animal element. Experience shows that by desiccation milk loses some anti-scorbutic

Explanation.

property, and it would seem that its power of making red blood—its hæmic virtue—is in some degree impaired likewise.

Anæmia in milk-fed children.

Children fed on cow's milk or ass's milk are occasionally anæmic, owing in some instances to causes apart from food, but in others, I think, owing to imperfect digestion and assimilation of the nitrogenous casein.

Treatment.

Iron and cod-liver oil are excellent remedies, and to these minute doses of arsenic may be added in severe cases.

Drugs.

But far better than all drugs in most cases is an addition to the animal element of food in the shape of raw meat juice or pulp. The im-

provement which follows the administration of raw meat in such cases is most remarkable. Diet
Abundance of fresh air in the day, and especially in sleeping rooms at night—a point constantly wofully neglected—pure hygienic surroundings, and sunlight, are other powerful agents in the cure of the anæmia of childhood.

LECTURE V.

DISEASES WHICH RESULT FROM ERRORS OF DIET, AND THEIR TREATMENT.

Rickets.

Occurs chiefly in first two years of life—The affection of the bones—Type of the rickety child—Bone defects not the sole lesion—Other constitutional peculiarities—Affection of muscles—Anæmia—Night-sweats—Tendency to catarrhs—The nervous system shares the general malnutrition—Its higher excitability—Laryngismus—Tetanus—Convulsions—Symptoms may be slight—Signs which should excite suspicion—Rickets largely a food disorder—Usually several factors—Influence of inheritance—Of syphilis—Of want of air and light—Rickets may arise where all points of hygiene are good except food—This the most constant factor—Evidence of the connection of rickets with defect of diet—Occurs chiefly in hand-fed children—Immunity of children at the breast—Artificial production of rickets in animals—Experiments of Guérin and Tripier—Experience at the Zoological Gardens—Theory of its dependence on lack of lime—Experiments of Chossat and Wegner—The lactic acid theory—Evidence from the simplest cases—Fat most probably essential—Importance of proteid—Of phosphate of lime—Remarkable results of change of diet in arrest of rickets in young animals—Influence of other causes—Vomiting and diarrhœa—Varieties of rickets according to causes at work—Starvation rickets—Syphilitic form—Cranio-tabes—Enlargement of liver and spleen—Large rickets—Rickets in sucklings—On diet of cow's milk—Explanation—Fœtal rickets—Congenital form—Late rickets—The common form of food rickets—An

eminently preventible disease—Treatment by diet chiefly—Value of cream and raw meat—Mode of preparation of the latter—Cod-liver oil—Recovery favoured by fresh air and sunlight—*Case I.* Typical example of severe rickets: Chief symptoms: Remarkable family history: The prevalence of the rachitic state explained by the regimen: Faults of feeding aggravated by want of light and air: Treatment: Recovery without any change in hygienic conditions except food—*Case II.* Rickets arising under exceptionally perfect general hygienic conditions: Food only defective: Effect of faulty diet mitigated by hygienic conditions: Treatment by anti-rachitic diet: Recovery—*Case III.* Rickets occurring under ordinary favourable hygienic conditions: Food alone faulty: Condition of patient: History: Recovery under proper feeding.

Rickets

ONE of the most interesting and remarkable of the disorders which result from the faulty feeding of young children is the condition of rickets. Its occurrence is limited almost entirely to the first two years of life, in children fed entirely by hand, or after weaning.

A disease of the first two years and of hand-fed children.

It is not, however, my intention in the present lecture to describe all the morbid changes found in the bones and tissues. These are given in detail in all the text-books, and to these I must refer you. What I desire to do is to give a broad clinical picture of rickets and its ætiology in relation to food, and to this I shall chiefly confine myself.

The affection of the bones, so striking and

Not merely an affection of bones.

so obvious, has given this characteristic of the rachitic state undue prominence and importance, and rickets has been in danger of being regarded as simply a morbid state of the bony structures,[1] leading to certain deformities and defects of the osseous skeleton. It is something far more than this.

The type of the rickety child.

Condition of bony skeleton.

Teeth.

Relaxed ligaments.

These defects not the sole lesion.

You are no doubt familiar with the type of the rickety child: the square projecting forehead, the open fontanelle, the beaded ribs, the enlarged ends of the long bones, and their soft yielding structure producing deformities such as the pigeon breast, the depressed ribs, the protuberant belly, the curved arms and clavicles, the bowed legs or knock-knees, the contracted pelvis; the delay in the appearance of the teeth and their early decay; the relaxed ligaments producing the yielding ankles and the knock-knee, and the curved spine. But these palpable defects of the

[1] In one of the most recent works on Medicine, that of the late Dr. Fagge, rickets is classed as a disease of the bones and defined simply as 'defective and perverted development of the osseous tissues of growing bones, attended with an enlargement of certain parts of them, and leading to a distortion of their shape;' although he says later, 'There are indeed certain reasons which make it difficult for us to look upon rickets as a mere affection of growing bones and of structures allied to them, although I do not think they compel us to throw it into the vague class of general diseases.'

bony framework do not comprise the whole morbid condition. The name of rickets[1] is perhaps unfortunate, as tending to identify the pathological condition with bone changes alone. For there are distinct deviations from the normal healthy constitutional state in other organs and functions which are less prominent, yet more important, than the bone faults. The lymphatic glands generally become enlarged, sometimes also the liver and spleen; the lungs partially collapsed by the pressure of the depressed chest-wall, with compensatory emphysema and perhaps a friction patch upon the heart and a pressure murmur there. Moreover the rickety child suffers from general constitutional debility in various forms. It is soft-fleshed and flabby, the muscular feebleness being often so great that it cannot sit upright; is unable to walk perhaps until it is two years old or more. This feebleness is indeed so extreme in some instances that the child is supposed to have paralysis. I have several times been consulted with regard to paraplegia in a child, when the affection turned

Other distinct constitutional features less prominent but more important.

General constitutional debility.

Evidence.

This muscular debility sometimes mistaken for paralysis.

[1] Trousseau speaks of 'riquets,' an old Norman word applied to deformed persons. Glisson refers it to 'rachis' (ῥάχις), on account of the dorsal spine being first affected.

out to be nothing but the muscular debility of rickets, and the patient was restored to full walking by appropriate diet and cod-liver oil. This feebleness of muscle as well as softness of bone interferes seriously with the action of the intercostals in respiration. There are other constitutional signs too—anæmia, profuse night-sweats, and a remarkable tendency to catarrh of all mucous membranes ; of the bronchi, and of the intestine, so that bronchitis is set up on slight cause, and diarrhœa is a constant symptom. Moreover, the lungs are injured by collapse and compensating emphysema, the mechanical result of the giving way of the soft chest walls in respiration.

Other constitutional signs, anæmia, night-sweats, catarrh.

The nervous system suffers, too, from the general malnutrition. A peculiar excitability and instability of the reflex motor system arises, which is evidenced by the special liability to convulsive disorder, viz., laryngismus stridulus, or spasm of the glottis, tetany, or carpopedal contractions, *i.e.* tonic spasm of the hands and feet, and general convulsions.

The nervous system shares the general malnutrition.

Unstable, undue reflex excitability.

Tendency to convulsion.

Laryngismus.

Tetany.

Now these various signs and symptoms are not all present together, and the absence of the most prominent—as, for instance, curving of the

These symptoms not all present in every case.

long bones—sometimes leads to the existence of the disease being entirely overlooked. This is especially the case with the children of the better class, amongst whom slight cases are by no means uncommon. Now and again the signs are extremely unobtrusive, limited perhaps to an abnormally open fontanelle, some backwardness in teething, a little enlargement of the long bones, slight contraction of the chest antero-laterally, and maybe a just perceptible curving of the legs, or a laxness of knee or ankle ligament causing genu valgum, or weak ankle. But with this a distinct anæmia, a general softness of flesh, sweating about the head at night, a notable tendency to catarrhs, both bronchial and intestinal, trouble in teething, and not unfrequently attacks of laryngismus.

Hence rickets sometimes overlooked.

This especially so with children of people well to do.

The signs may be limited to a slight affection of bones or ligaments,

with anæmia.

Flabbiness.

Sweating.

Tendency to catarrhs.

Backward teething.

Laryngismus.

If a child has marked predisposition to mucous catarrh, or protracted, or late, or painful dentition, or attacks of laryngismus, however slight, always examine carefully the bony structure for evidence of rickets there.

Bones to be examined in such cases.

Now this general fault of constitution affecting bone, muscle, nerve, and mucous membrane, which is known by the term rickets, is largely a food disorder.

Rickets largely a food disorder.

There are, I believe, generally several factors concerned in the production of rickets. Defects of diet, food disorders causing prolonged vomiting and diarrhœa, foul air, want of light and general malhygiene, congenital syphilis, inherited tendency—all may play a part. But these factors are not all in action in every instance. Is any one of them efficient alone? Is any one of them constantly present?

The factors of rickets.

Not all present in every instance.

To begin with the last. Although some statistics have been given to show that rachitic parents tend to have rachitic offspring, I have seen nothing to confirm this. Rickets dies out with childhood, and is not likely to be transmitted. I believe the sole influence of heredity is the transmission of a weakly constitution in some instances; that inheritance is not a constant factor seems proved by the fact that the children of perfectly healthy parents may become rickety.

Inheritance not a constant or sole factor.

In the next place we may, I think, be quite certain that rickets is not a simple expression of congenital syphilis, as M. Parrot contended. In many cases the history is absolutely beyond suspicion, and the children bear about them none of the well-established signs of congenital syphilis The eruption, the snuffles, the pegged

Congenital syphilis not a constant or sole factor.

teeth, the keratitis, the linear scars, are alike wanting. And conversely, many cases of congenital syphilis are not rickety. It is clear that syphilis is not a constant factor. The cases in which it does play a part have very special features, of which I shall speak presently. Congenital syphilis modifies rickets, it does not create it.

Evidence of this.

It modifies, but does not create it.

Again, conditions of general malhygiene are not constant factors in the production of rickets. Many cases arise where the patients are under excellent sanitary conditions as far as air, and light, and cleanliness, and warmth are concerned. A child may enjoy all these to perfection, and yet become rickety in marked degree. We see this constantly in children of perfectly healthy well-to-do parents, amongst whom rickets is by no means uncommon. It is impossible to say in such cases that faults of hygiene of this kind are concerned, and these examples, where so many of the causes commonly credited as essential to the production of the disease are absent, throw great light upon its ætiology. They simplify the problem, and help to distinguish the essential from the non-essential. The truth is that these general conditions of malhygiene connected with air, and light, and cleanliness,

Rickets may arise under excellent general sanitary conditions.

Rickets in children of well-to-do parents.

Value of such simple cases.

and warmth, are not essential factors always present, but favour the production of rickets by degrading nutrition ; they are generally at work, too, in the most extreme cases, but they are not essential. I have never seen a child develop rickets in the most unhealthy surroundings if properly fed and free from food disorder. The only constant factor, always present, is the food factor. Sometimes it is the only factor. The chief cause, this fault of diet, is the commonest, the most potent and dominant of all. This much is, I think, well established : the vast majority of cases of rickets arise directly in connection with food.

Influence of unfavourable hygienic conditions.

Defect of diet the only constant factor.

The first fact which comes out with regard to the relation of food to the production of rickets is, that it is a question of quality rather than quantity—of special fault of nutrition, not a general fault of nutrition. A child may be in the last stage of atrophy, and yet not rachitic. It may be fat and gross, and yet extremely rachitic. The second point to be noted is that it occurs almost entirely amongst children brought up by hand, or after weaning. It does not appear in children at the breast, except in special instances where the milk is insuffi-

Rickets occurs almost entirely in hand-fed children.

In children at the breast rarely.

cient or defective, as from special debility of the mother or prolonged lactation. I think it may be affirmed broadly that children feeding well on a full supply of good breast milk up to the age of 8 or 10 months do not become rickety during the time of suckling. Even with congenital syphilis at work, the suckling does not become rickety. Dr. Barlow and Dr. Lees[1] found that in eleven children with cranio-tabes who were brought up entirely at the breast, not one showed the smallest sign of rickets. Elsasser, who first described cranio-tabes, noted a similar absence of general rachitic signs. If these children do become rickety it is later—after weaning. I think it may also be affirmed broadly, on the other hand, that children fed almost entirely on farinaceous food, even if taking it well, without apparent drawback, as certainly become rickety. We see these experiments made daily before our eyes with uniform result.

But after weaning.

The special association of rickets with an artificial diet is strongly supported by results of observation and experiments on the lower animals. The artificial production of rickets by

Rickets in lower animals, due to artificial diet.

[1] *Path. Trans.* vol. xxxii. p. 330.

Experiments of Guérin and Tripier.

Guérin, who substituted meat for the mother's milk, although impugned by the later experiments of Tripier, has been remarkably confirmed by the experience at the Zoological Gardens in London. The lion whelps weaned early and put upon a diet of raw flesh only, invariably became rickety in such extreme degree that it has been found impossible to rear them. Mr. Bland Sutton, the hon. pathologist, informs me that the young monkeys, deprived of their mother's milk and fed entirely upon vegetable food, became rickety. The most remarkable case observed was that of two young bears who were fed exclusively upon rice, biscuits, and raw meat, which latter they licked but hardly ate, and who died of extreme rickets. That the condition is a true rachitis there can, I think, be no doubt. There is the same muscular feebleness, the same bending of bones, the same general debility; and the identity of the bone changes has been shown by the observations of Mr. Sutton, who has so ably investigated the morbid anatomy of the disease.

Experience at the Zoological Gardens.

Occurrence of rickets in young animals there.

Identity of the disease with human rickets.

Theories as to the exact nature of the diet fault.

Now various theories have been put forward as to the exact nature of the diet fault productive of rickets. The first which naturally sug-

gested itself was that the bones being obviously soft and deficient in mineral matter, a want of lime salts in food was at the bottom of it. Chossat and Milne-Edwards produced curvature of the bones in pigeons and dogs by privation of the earthy salts ; these results are, however, impugned by the later experiments of Friedleben,[1] who found that, although atrophy follows, the characteristic features of rachitic bone are wanting. Wegner, however, claims to have produced rickets by administration of phosphorus and privation of lime salts at the same time.[2] And the amount of lime salts in rickety bone is below normal. Yet that mere want of lime, in the form of hydrate or carbonate, is not the essential cause of rickets, seems proved by the fact that rickets is common in limestone districts where the drinking-water is heavily charged with lime and the children must necessarily take abundance of it. In my native town, situated in one of these districts, goitre and rickets were both extremely common. Moreover, many children of the better class who become rickety have had lime water regularly added to their food.

Supposed deficiency of lime salts.

Experiments of Chossat and Friedleben.

Experiments of Wegner.

Mere want of lime insufficient to produce rickets.

Evidence from limestone districts.

Lime water constantly added to food.

[1] Vide Fagge, *Path. Trans.* vol. xxxii. p. 318. [2] *Ibid.* p. 320.

Lime may be important in form of phosphate.

It is possible that it may be essential for the lime to be in the form of phosphate, and that the absence of this special salt plays a part in certain cases. But these earthy salts are probably present in sufficient quantity in most articles of an infant's diet.

The lactic acid theory.

Another theory, suggested by the special association of rickets with farinaceous food, is that lactic acid is the evil agent. Starch, imperfectly digested, ferments, and lactic acid is formed in excess; this is supposed to unite with the lime about to be deposited in the bones, and carry it off in soluble form; or, according to a later theory of Heitzman, by irritating the ossifying tissue and provoking growth when the necessary lime was wanting for the structure. Heitzman found lactic acid in the tissue of rickety animals, and claims to have produced rickets by the administration of lactic acid.[1]

Heitzman's observations.

Factsagainst the lactic acid hypothesis.

But against this hypothesis there are these weighty facts: first, that rickets arises in children who have no apparent disorder of digestion to favour lactic acid formation, who digest the starch or dextrine or maltose, assimilate it, and wax fat on it; and, secondly, the

Often no excess,

[1] Fagge, *Path. Trans.* vol. xxxii. p. 321.

fact that if the food on which the child has grown rickety be continued, without other change than the addition of certain elements which are deficient, the child gets well. Moreover, if lactic acid did exist in the blood, it would be neutralised by alkali there, so that clearly the starchy element is not directly harmful.

and could not exist in free state in blood.

Now if we take cases of the simplest kind, viz. those of the children of healthy parents, born healthy, and brought up under perfect hygienic conditions as far as air, light, cleanliness, and warmth are concerned, who become rickety, we find these constant features—they have been brought up by hand, and the artificial food on which they have been fed is uniformly deficient in certain elements, viz. animal fat and proteid. How sadly wanting in the foods in common use are these vital ingredients I have shown in my earlier lectures; and the evidence is set forth in Tables I. and II. Possibly deficiency of earthy phosphates may be a factor of some influence, also, in certain cases. But animal fat is probably the most essential. The abundance of it in the type food milk, which is a rich emulsion of fat, as I showed you before, indicates its high importance in the nutrition of

Cases of the simplest kind in children of healthy parents with healthy surroundings afford the clue.

The diet.

Shows certain uniform features.

Deficiency of animal fat, of proteid,

possibly of phosphates.

Animal fat the most essential.

Evidence of its importance, from its abundance in milk,

the young organism. The occurrence of rickets in a child brought up on skim milk, all other hygienic conditions being unimpeachable, which came under my personal observation, seems to indicate that privation of fat alone is sufficient. The acknowledged curative power of cream and cod-liver oil affords further evidence in the same direction. Fat is present in every cell, and animal fat, introduced *as* fat from without, is probably essential to vigorous cell-life and structural power. The deficiency of animal proteid in these rickets-producing foods is probably of an importance second only to the absence of fat. It is true that the presence of proteid in abundance will not prevent rickets. The experiments of Guérin and the experience of the Zoological Gardens prove this. Yet it may be an important aid in addition to the fat, and, as a matter of clinical experience, rickety children improve much more rapidly if they are given raw meat or its juice in addition to cream or cod-liver oil, than on the latter alone. The nitrogenous element, as I have urged before, is essential to the nutrition of protoplasm—the indispensable active agent in all vital processes—and benign or injurious in action according as the other materials are present or absent.

from effect of privation,

from curative power.

Function of fat in nutrition.

Proteid only second to fat in importance.

Clinical evidence of this.

Function of nitrogenous elements in nutrition.

Function of phosphates in nutrition.

Phosphate of lime appears to be present in every tissue, and there are grounds for believing that no cell-growth can go on without it; in rapidly growing cells it is present in large amount. The lowest forms of life, even, will not grow without earthy phosphates.[1] The dependence of rickets on the absence of these elements of food, therefore, would explain something more than the mere bone changes; it would equally explain the imperfect nutrition of brain and muscle and nerve structure, which no theory of mere excess of lactic acid or lime salts would account for. It explains, moreover, why rickets is so prevalent in large towns and dense populations, where milk is scarce and dear, deprived of cream and watered, and the poor driven to feed their children on the cheaper farinaceous foods. That defect in diet alone is sufficient to produce rickets, and that these three elements, fat, proteid, and earthy salts, are some or all of them chiefly concerned, is strikingly shown by the recent experience at the Zoological Gardens to which I have already alluded. As I told you, many young animals become rickety there, and it has been found impossible to rear

The want of these elements would explain the whole pathology, not merely the bone changes.

Evidence from recent experience at the Zoological Gardens.

Former diet of young animals.

[1] Parke's *Hygiene*, 4th ed. p. 176.

Disastrous effects.

Food deficient in fat and earthy salts.

the young lions from this cause ; they invariably died up to last year. They were fed upon the flesh of old horses, almost entirely destitute of fat. The bones were found to be proof against the teeth even of adult lions, and those of the cubs were powerless against them. About once a week they had goat's flesh, which is about the fatness of venison. So that in this case, again, animal fat and earthy phosphates would be deficient. The food of the young bears who became rachitic on biscuits and rice, and that of the young monkeys fed chiefly on bananas and fruits, would be deficient in the same elements. The feeding of the last litter of lion cubs was commenced in the same way. The dam had very little milk, which ceased entirely at the end of two weeks, and they were put on flesh as before ; they became extremely rickety, and one died.

Remarkable effect of change of diet.

Then at Mr. Bland Sutton's suggestion the diet was changed. The meat was continued, but in addition to it, milk, cod-liver oil, and pounded bones were given.

No other condition altered.

No other alteration whatever was made in any way. They were kept in the same dens with the same amount of air, and the same light and warmth as before. The change which followed was remarkable. In three

months all signs of rickets had disappeared, and now, at fifteen months old, they are perfectly strong and healthy and well developed. It is a unique event in the history of the society.

The exact changes made in elements of food.

You will observe that no change was made in the conditions of existence except in feeding only, and the change in the food consisted practically in the simple addition of fat and bone-salts.

An addition of fat and bone salts only.

A crucial and conclusive experiment.

This is a most striking and crucial experiment in the production and prevention of rickets, and seems to be absolutely conclusive as to the chief points in its ætiology.

Common rickets can be caused and cured at will by diet.

Ordinary rickets can be set up by a rachitic diet, and cured by an anti-rachitic diet, as certainly as scurvy can be caused by a scorbutic diet and cured by an anti-scorbutic diet.

Other causes concerned in rickets.

But do not forget that there are generally other factors engaged in the production of rickets in addition to the food factor. Bad air and want of light lower vitality, syphilis seriously impairs nutrition, and in many instances these agents probably aggravate and emphasise the disease. But far more potent still are chronic vomiting and diarrhœa in the production of rickets ; but these latter act practically as food factors, since they no doubt produce their effect

Want of ai and light.

Syphilis.

Vomiting and diarrhœa.

The latter really food causes.

by draining off nourishment. The loss, indeed, would fall chiefly on the proteid and fat, which require time for digestion before they can be absorbed, whereas the carbohydrate element, sugar of milk, is already in a state of solution, and fit to pass at once into the circulation.

Rickets shows same variety of form according to special cause.

The disease is undoubtedly modified by the action of other factors. It is probably only developed in its most extreme form when the food defect is aggravated by generally bad hygienic conditions, or by syphilis, and exhibits a variety of forms according to the particular cause or combination of causes which give rise to it.

Rickets from general loss or from syphilis.

When rickets is produced by chronic vomiting and diarrhœa, when it is merely a part of general starvation, and when it is the result of congenital syphilis, the child is usually small, puny, wasted. We have a small rickets. In the case of syphilitic rickets there are further distinctive features: thinning of the flat bones of the skull, the cranio-tabes of Elsasser, and projections on the frontal and occipital bones—the so-called syphilitic bosses. These, I am convinced, are characteristic of syphilitic cases. Dr. Barlow and Dr. Lees [1] found a certain history of syphilis

Small or wasted.

Also in syphilitic form.

Cranio-tabes.

Bossing of skull.

These changes confined to syphilitic form.

[1] *Path. Soc. Trans.* vol. xxxii. p. 223 *et seq.*

in 47 per cent., and Dr. Baxter found 75 per cent. clearly syphilitic. I think that it may eventually turn out to be the case also that the enlargement of the liver and spleen, which is found in certain instances, described by Sir W. Jenner and Dr. Dickinson, is a syphilitic change, not a true rachitic change, although this point has not been actually established. Dr. Gee states that he can find no difference between the enlargement of spleen found in rickets and that found in ague and syphilis, a pure fibroid change.[1]

Enlargement of liver and spleen probably syphilitic.

Contrasted with these cases of rickets accompanied by wasting are those in which the child is plump or even excessively fat. This occurs in a considerable proportion of cases—notably in those in which the disease is the result of mere deficiency of certain elements in food. These children get abundance of carbohydrates, or starch and sugar to make fat.

Large, fat rickets.

When only certain ingredients wanting.

Fat made out of abundant carbohydrates.

When, some fifteen or twenty years ago, there was a great baby show held at Greenwich, the prize baby, who won its honours by virtue of its weight and size, was brought to me in the out-patient room at Great Ormond Street on account of bowed legs and arms and muscular

The Greenwich prize baby

[1] *St. Barth. Hosp. Rep.* vol. iv. p. 78.

the subject of marked rickets.

feebleness, and I found that it was suffering from well-marked rickets. It was a starch-fed child, excessively fat.

It arises in children who are suckled, in rare instances only.

I have said that rickets occurs in breast-fed children after weaning only, except in rare instances, where the mother is sickly and feeble, or has suckled the child into the second year, and the milk has thus become deteriorated in quality. In one interesting case which came under my own observation, rickets was developed at six months in a child at the breast in this way. The mother became pregnant while suckling, and apparently a large portion of the nutriment which should have gone into the milk was diverted to the fœtus in utero. This was born strong and healthy and plump, while the infant at the breast dwindled into puny rickets.

Case of rickets from deterioration of milk by pregnancy.

The fœtus in utero well nourished. The child at the breast became puny and rachitic.

Rickets on diet of cow's milk.

Again, I have seen rickets arise on a full diet of cow's milk. This needs some explanation. A very extreme case of the kind came under my observation, in which the child was fed abundantly on cow's milk, and apparently digested it thoroughly. The parents were a coachman and his wife, living in the country, and they told me that they were allowed an unlimited supply of milk from the dairy at the Hall.

This at first was a great puzzle. But on further investigation I discovered that the milk thus bounteously given was skim milk, *i.e.* milk with the cream removed. The child had nothing but this and farinaceous food ; it practically got no animal fat. In every other respect the conditions under which the child lived were exceptionally good. I have already instanced this as an instructive experiment showing the effect of deprivation of animal fat upon the production of rickets.

Case on skim milk.

The child deprived of animal fat.

Instructive experiment on value of fat.

But, further, rickets appears occasionally in children fed on good cow's milk of a strength containing all essential elements in standard proportion. This occurs when the child is unable to digest it in sufficient quantity, as evidenced by the appearance of curd in the stools. It happens also when the milk produces vomiting or diarrhœa, and the nutriment is drained off: the result is the same as if an insufficient amount had been given. Yet this can be prevented in the vast majority of cases, and as a rule it ought to be prevented.

Rickets may arise on diet of good cow's milk

from imperfect digestion.

Explanation of rickets in diet of cow's milk, from vomiting and diarrhœa.

Often preventible.

Sometimes, no doubt, rickets is the result of a drain on nutrition, such as vomiting and diarrhœa produced by causes unseen or uncontrollable at the time, or by a combination of conditions

Sometimes uncontrollable.

of malhygiene. Such cases are exceptional, and in nearly every instance which came under my observation the faulty state might have been prevented.

Fœtal rickets.

The so-called *fœtal rickets* observed in the bodies of some still-born children is now generally allowed to be a condition allied to cretinism.

Allied to cretinism.

Yet congenital rickets possible.

With regard to *congenital rickets*, I think it possible that it might occur. The feebleness of health and malnutrition of the mother might well cause rickets in utero.

There is another form of the disease which deserves a passing mention, viz. *late rickets*.

Late rickets.

Bone changes.

Occasionally bone changes occur—curvature of the long bones, contraction of the thorax and beaded ribs, in children long past the ordinary rickety period of the first two years of life, to which as a rule the disease is so strictly limited.

Example of this form.

A curious case of this kind came under my care a few years ago, in a boy nearly ten years of age.

Disease commenced at 9 years.

The disease had only commenced to show itself nine months before, yet it was already so advanced that the patient had become unable to stand. The ribs were beaded, the chest walls driven in, the ends of the tibiæ much enlarged.

Tenderness of joints.

There was much pain and tenderness of

the knees, but no rise of temperature. The case was clearly not one of food rickets. Anti-rachitic diet, cod-liver oil, and steel wine were given, but the patient grew worse instead of better. Iodide of potassium was then tried, and remarkable improvement followed for a time, and the condition was thought to be syphilitic, although there was no positive evidence beyond this.

Anti-rachitic diet useless.

Improvement on iodide of potassium.

Eventually the child went out, and subsequently died of bronchitis. A cast of his distorted limbs and body is now in the museum of the Hospital. That this case was one of true rachitic change in the bones was subsequently almost certainly proved on post-mortem examination,[1] and similar cases have been recorded by others. Yet the whole pathology of these cases is very obscure, and requires investigation.

Pathology of late rickets obscure.

The ordinary form of rickets, with which we are concerned, being due so largely to faults of feeding, aided in many cases by other conditions of bad hygiene or by the cachexia of congenital syphilis, is clearly a preventible disease. I will not go so far as to say that rickets ought never to occur as a result of artificial feeding, but it

Ordinary rickets an eminently preventible disease.

[1] Vide *Path. Trans.* vol. xxxii. p. 391.

Should be extremely rare.

should, at least, be extremely rare. A careful observance of the essential conditions as to the proportions of the different ingredients in an infant's food, its quantity, digestibility, and other points laid down in the first of these lectures, would reduce the disease to very small dimensions. Its occurrence is too often a grave reflection upon medical man, or nurse, or mother, under whose directions the diet of the child has been regulated.

Its occurrence often a grave reflection upon management.

Treatment.

There ought to be little rickets to cure, but since it exists how is it to be treated?

To be cured by diet chiefly.

As it is due to fault of diet chiefly, so it is to be cured by diet adapted to remedy the deficiencies of previous feeding. And here I find fault with the common practice in these cases. Far too much reliance is placed upon the mere giving of drugs, cod-liver oil, chemical food, lime, iron.

Too much reliance commonly placed upon drugs.

The patients starved of fat first and drenched with it afterwards.

Dosing with these remedies is often the sole treatment. We starve the infant of fat in its daily food, and try to make up for this by drenching it with cod-liver oil afterwards.

Drugs not the chief thing.

The remedies I have named are useful, but they are by no means of the first importance in the treatment of rickets.

Cod-liver oil supplies the deficiency of fat in the food in satisfactory form, but cream is equally efficient, and how about the other important element, the nitrogenous proteid? This must be supplied by additional animal food.

Cream or cod-liver oil supplies fat wanted.

Proteid must be given too by increase of animal food.

Proteid may be added in the shape of casein if the child can take more milk, but many children cannot digest a sufficient amount, and the best substitute, as I have shown in an earlier lecture, is raw meat pulp or raw meat juice. The mode of preparation of these I have already explained.[1]

Value of raw meat. The juice.

I doubt very much whether the administration of lime salts in the form of drug has really any important influence on the affection, although I would make a reservation, perhaps, in favour of the lacto-phosphate. Certainly lime water is quite ineffectual. Earthy salts are probably contained sufficiently in milk, and raw meat, and cream. On a diet in which these are leading ingredients, a rickety child grows rapidly strong, firm, and hard in bone and muscle, loses its pallor and night sweats, and feebleness and tendency to convulsion. It grows vigorous,

Administration of lime.

Present in most foods.

[1] Lecture III. pp. 100, 102.

Efficacy of anti-rachitic diet.

lively, and robust to a degree that no amount of chemical food, or salts of lime, or iron, or cod-liver oil alone can bring about. Children are generally overdosed with these things; I more often stop them than order them. Yet cod-liver oil must be given in default of cream or good milk, if not too laxative.

Drugs useful adjuncts.

Fresh air and sunlight more useful still.

Drugs are, however, useful adjuncts in certain cases; more important still are fresh sea or mountain air, sunlight, and an outdoor life. These materially aid vigorous nutrition, and hasten recovery. Yet, where these cannot be obtained, I constantly find that a mere regulation of diet is in itself sufficient to effect the required transformation, although perhaps more slowly.

Case I. Typical example of rickets.

The following case admirably illustrates rickets in all its leading features, and exhibits forcibly the efficacy of proper dieting.

In December, 1883, I saw in consultation with Dr. Spence a child of 11 months. The parents were small but prosperous tradespeople in Soho. A thin, miserable, white-faced baby, with projecting forehead, flabby muscles, widely open fontanelle, pigeon-breast, beaded ribs, and enlarged ends of the long bones. It had no

Physical state of child.

Bone faults.

teeth ; at this age it should have had five or six at least. The child had, in a word, all the signs of well-marked rickets. It had had repeated attacks of sickness, and constant diarrhœa ; no food seemed to agree with it. It was anæmic, chill ; its temperature subnormal. I was asked to see it, however, chiefly on account of attacks of spasm of the glottis. These were so severe and prolonged occasionally as to bring the child to the verge of suffocation. They were brought on by the smallest excitement, but, as is usually the case, they were most intense on first waking in the morning, or when induced by crying or laughter. On examining the child more minutely the thumbs were seen to be tightly drawn towards the palm, which was arched longitudinally, the fingers adducted and overlapping each other—the typical so-called accoucheur's hand of tetany. The feet were arched, and the toes flexed. The dorsum of each foot was much swollen, as if dropsical, but there was really no œdema, the swelling being due probably to pressure of the contracting muscles, yet not sufficient to produce effusion —the condition often produced by a tight bandage.

Vomiting and diarrhœa.

Anæmia. Subnormal temperature.

Laryngismus.

Tetany.

Contraction of hands.

Of feet.

Swelling of hand and dorsum of foot.

Cramps.

The child was constantly crying with the pain of cramp, when the spasm was most intense. Twitching of the orbicularis and levator anguli oris could be induced by scratching the skin over the pes-anserinus. The attacks of laryngismus had lately been increasing in severity.

Twitching of orbicularis.

Family history.

The family history of the patient was remarkable and highly significant. The parents had had five children born alive, all strong, plump, and apparently healthy, yet of these five, three died early.

First child died of laryngismus.

The first had general convulsions at 3 months, and died in an attack of laryngismus at 6 months.

Second child died of diarrhœa.

The second died at $6\frac{1}{2}$ months, of diarrhœa and wasting—no laryngismus or convulsions.

Third child alive, but had convulsions.

The third is still alive and fairly well, but she was weakly as an infant, and had two convulsions when teething.

Fourth, croup and fatal convulsions.

The fourth had croup when 4 months old—probably catarrhal laryngitis—and died at the age of 1 year and 10 months, from general convulsions.

Fifth, the patient.

The fifth was the youngest, who came under my observation in the condition I have described.

So that four out of the five children had convulsive seizures, and the one who escaped convulsions had diarrhœa and atrophy. Thus four out of five had convulsive disorder.

What is the explanation of this remarkable predisposition to convulsion? The explanation.

Was it an inherited tendency—a congenital nervous hypersensibility? There was no family history of neurotic disease or constitution. The parents were strong, healthy people of the middle class. No, the tendency was not inherited, it was acquired—developed by defective nutrition. The story of their manner of life, and the food on which they had been brought up, afforded an ample explanation of their constitutional state. Tendency not inherited, but acquired.

The children had all been brought up by hand. The mother, closely engaged in business, could not give time to suckle her children. They were fed chiefly upon cornflour, a patent farinaceous food made without milk, and arrowroot. They had very little milk, for cow's milk disagreed with all of them, and caused vomiting and diarrhœa. No other animal food was given to make up for the want of milk. The condition explained by mode of life and feeding. Brought up on farinaceous food. Milk did not agree. No other animal food given.

So two of the canons laid down in my first lecture were broken. Two canons broken therefore.

The food did not contain proteid and fat in due proportion.

It did not contain an ample amount of animal matter.

It was a diet almost purely vegetable, consisting of little but starch and sugar; a food in which the carbohydrates were the chief elements, largely in excess, and the fat and the nitrogenous proteids almost absent. The carbohydrate was, moreover, in the form the least available for infants viz., starch; cornflour and arrowroot are almost pure starch.

Carbohydrates in excess. Fat and proteids almost absent.

So these little children were starved, although fed abundantly. They suffered grievously from want of fat and nitrogenous food. Thus not only were bones soft and rickety, muscles flabby, the blood short of red corpuscles, but the nerves and nerve centres grew unstable, hypersensitive, ready for convulsive spasm on small irritation. Such was the explanation of the tendency to convulsive disorder exhibited by four out of the five children. The only one which did not suffer from convulsion in some form died of diarrhœa and atrophy, doubtless a food disorder likewise.

Starved from want of these two principles of food.

Hence the rickety state.

The youngest, our patient, had slightly better fare than the elder children. The parents had

The patient fared better

risen in the world a little, and the mother was able to find time to nurse her baby, but her supply of milk was very scanty. So this child, too, had corn flour, bread and butter, and various farinaceous foods, but no cow's milk, which did not agree. The child's appetite was ravenous; it had constant diarrhœa and frequent vomiting.

than her predecessors.

Partially suckled for a time.

Ravenous appetite, diarrhœa, vomiting.

The treatment adopted was first to relieve the laryngeal spasm by chloral (gr. ½) and bromide (gr. 4) given every 4 hours, and thus, by soothing the nervous system and guarding against the danger of convulsion, to gain time for the cure of the rickety atrophic condition which was the prime source of the nerve disorder. To this end the diet was changed to one of animal food chiefly, with fat and abundant nitrogenous matter; 2 oz. of raw meat pulp daily, boiled milk diluted with one-third water, entire wheat flour.

Treatment.

First, the relief of laryngismus.

Then the rickety state.

Abundant nitrogenous food with fat.

When the diarrhœa declined cod-liver oil was given to make up for the deficiency of fat in the food, and lactophosphate of lime, which, I am inclined to think, has a beneficial influence on the rachitic fault.

Cod-liver oil.

Lactophosphate of lime.

The laryngismus at once declined, fits were less frequent (two or three in the week instead of

Result.

ten or twelve a day) and less severe, the tetanoid spasm relaxed, and complete recovery quickly followed. When I saw the child six months later she was plump, hard-fleshed, robust, and had got five teeth without trouble or disturbance.

The preceding case an example of severe form of disease.

The preceding case affords an example of the disease in its most severe and complete form. The food defect was extreme, and no

Many causes at work.

doubt the most potent cause at work. Yet the action of this had been intensified by want of fresh air and of sunlight. The house was in a crowded district, and the dwelling-rooms were

Yet food alone sufficient to effect cure.

dark and not well ventilated. Yet it is significant that as in the case of the young lions the addition of certain ingredients of food alone was sufficient to cure, the other conditions remaining absolutely unchanged.

Case II.

In the next case which I shall give, however, the surrounding conditions were very different. They were indeed perfect as far as air, light, clothing, and cleanliness were concerned.

Rickets arising under hygienic conditions perfect except as to food.

The patient was two years and ten months old, the child of wealthy parents of high social position, brought up in a great country house and enjoying air and light freely, both indoors and out. It was brought to me on account of

general feebleness of health. It was pallid, spiritless, and soft-fleshed. It had sweating about the head, the fontanelle was not quite closed, the bones of the margin thickened, the forehead projecting, the ribs beaded, the ends of the long bones enlarged. The legs were knock-kneed, one tibia slightly bowed, the ankles yielding, the teeth already decaying. Symptoms.

The history was this. The child had been brought up entirely by hand, for the first six months on condensed milk, and then cow's milk was given. This, however, did not agree; it was frequently vomited, and could only be taken in small quantity. There had been no diarrhœa, but constipation throughout. Lately the child had had 1 pint of milk, bread and butter, fish or meat or beef-tea once daily, stewed fruit, no milk puddings. History. Cow's milk only in small quantity.

The treatment consisted of 2 oz. of raw meat pulp daily, milk puddings made with prepared entire wheat flour, and an increased allowance of milk. No medicine was given except some carbonate of magnesia daily, to relieve the chronic constipation. Treatment. Anti-rachitic diet.

Firmness of flesh and colour quickly returned; the relaxation of ligaments and softness of bone Result.

went no further, and the child grew healthy and strong without drawback.

This case shows how the defect in food caused rickets.

In this case the food defect, the lack of milk or equivalent animal food, was the sole cause to be discovered. The diet failed to fulfil the essential conditions; it was clearly deficient in fat and proteid and the animal element. The child got rapidly well directly this defect was remedied. The ill effects of the defect of diet were mitigated no doubt by the generally favourable hygienic conditions, instead of being aggravated by evil sanitary conditions as in the case I first related to you.

Supply of missing ingredients removed it.

CASE III. Rickets under generally favourable hygienic conditions.

Let me now give an example of rickets occurring under the ordinary favourable conditions of middle-class life in a good house in the suburbs of London.

Food alone faulty.

In this instance again, the only fault to be discovered was connected with the food. In all other respects the child was well managed and well cared for. I was asked to see it on account of general debility. A number of different medical men in the country had already been consulted, and all had agreed that the child was weakly and backward, but that it had no special ailment of any kind. It was two years and four

months old, yet the anterior fontanelle was still widely open, and it had only twelve teeth. It was extremely pigeon-breasted, had beaded ribs, enlarged wrists, the arm bones were bent, the legs knock-kneed. It had profuse head sweats, and suffered from frequent catarrhs. Condition of child.

The history was this. The child had been suckled up to three months, then cow's milk was tried. It did not appear that this disagreed, but condensed milk was found to be less troublesome, especially in hot weather, and so it was substituted. Of this it had only one pint of the ordinary dilution. In addition, bread and beef tea only. Its history. Diet : bread, beef tea, and a little condensed milk.

The treatment consisted in two pints of fresh cow's milk boiled, raw meat pulp, with prepared entire wheat flour. Syrup of lactophosphate of lime and cod-liver oil were given at first, but for a few days only, since they seemed to cloy appetite, and the child rapidly recovered without medicine, quickly becoming firm-fleshed and robust. Treatment. Recovery under proper feeding.

LECTURE VI.

SCURVY, OR SCURVY-RICKETS.

Infantile scurvy—Identification of the disease—The acute rickets of German authors—Records of the disease in England—The characteristic symptoms of scurvy—The condition set up by privation of certain constituents of fresh food—The disease cured by the supply of these—Scurvy occurs in young children in all degrees of severity—Mortality—The symptoms correspond closely with those met with in adults—Occasional variation in the condition of the gums and in pyrexia—Other symptoms and morbid anatomy identical—The cause the same—Examples of children's diet producing scurvy—The disease cured as in adults by anti-scorbutics — Example showing extreme rapidity of recovery — *Case I.* Typical scurvy in a child of 16 months—Severe symptoms accompanying rickets : Diet both rachitic and scorbutic : All other hygienic conditions excellent : Value of milk and potatoes in a child's dietary : Rapid effect of anti-scorbutic diet, all other conditions being unchanged—*Case II.* Scurvy in a child 10 months old : symptoms : Concurrent rickets. Food : Effect of anti-scorbutic diet : Brief account of recent cases—*Case III.* Scurvy in a boy of 14 months : Full series of scorbutic symptoms : Concurrent rickets : Previous regimen : Difficulty in feeding : Death on fourth day from hæmorrhage into the lung : Post-mortem appearances—*Case IV.* Patient aged 13 months : Well-marked signs of scurvy : Concurrent rickets : Previous feeding : Effect of full anti-scorbutic diet—*Case V.* Persistent hæmaturia in a child 12 months old : Other symptoms suggestive of scurvy : Cachexia : Syncopal attacks : Spongy gums : Hæmorrhages : Periosteal swellings : Concurrent rickets : Previous feeding :

Difficulty in feeding: Recovery—*Case VI.* A child 9 months old: Previous diet: Great tenderness of legs and inability to run, supposed to be rheumatic: Periosteal swelling: Other signs of scurvy doubtful: Subsequent occurrence of extensive hæmorrhages under the lower eyelids: Immediate improvement on addition of certain elements to former food—The association of rickets with scurvy—Explanation—The tenderness of limbs in rickets possibly scorbutic—Necessity for bearing in mind the frequent association of the two diseases—Conclusion.

Infantile scurvy, a food disorder often associated with rickets.

THERE is still another morbid condition met with in children, dependent on faulty diet, and usually if not invariably associated with rickets; namely, scurvy, of which I spoke incidentally in my first lecture, when laying down the canons of correct feeding. The subject is one in which I take great interest, since I was, I think, the first to identify the disease in this country, to demonstrate its exact nature, and to trace with precision its source in a scorbutic diet.

Identification of the condition as scorbutic.

Traced to special defect of diet.

Cases recorded.

In 1878, in a clinical lecture published in the 'Lancet,' I gave an account of three cases observed during the preceding year, which I identified as true scurvy occurring in young children, associated with rickets, and dependent upon the absence of the necessary anti-scorbutic element in their food.

Previous observations.

I recorded other cases of like kind subse-

quently in 1879,[1] and again in 1882.[2] It appears from the researches of Dr. Barlow[3] that isolated cases of similar character had been noted in Germany from 1859 to 1873, by Moller, Bohn, Hirschsprung, and Senator, as examples of acute rickets, and one in 1873 very briefly by Ingelev, as infantile scurvy. The first case observed in this country appears to have been one recorded in the 'Pathological Transactions,' by Mr. T. Smith, in 1876, under the provisional title of hæmorrhagic periostitis; but the condition was not recognised as scorbutic. Similar cases attracted the attention of Dr. Gee in 1881, who described them in 'St. Bartholomew's Hospital Reports' under the designation of osteal or periosteal cachexia.

Acute rickets of German authors.

Mr. T. Smith's case of hæmorrhagic periostitis.

Dr. Gee's cases (osteal and periosteal cachexia).

In 1883, Dr. Barlow, in an admirable and exhaustive paper read before the Royal Medical and Chirurgical Society, gave the history of eleven cases of infantile scurvy which had come under his own care, and twenty others collected from various sources. Dr. Barlow's conclusions fully confirmed my own as to the nature of the affection and its causation. In the same year Mr. Herbert Page brought a case of sub-periosteal

Dr. Barlow's investigations.

Mr. Page's case of sub-

[1] *Brit. Med. Journ.* 1879.
[2] *Lancet*, July 15, 1882.
[3] *Med. Chir. Trans.* 1883.

hæmorrhage before the Medical and Chirurgical Society, which he judged to be probably scorbutic. In addition to much valuable matter relating to the clinical features of the disease, Dr. Barlow gave a full account of its morbid anatomy, and proved how closely the lesions found in infantile scurvy correspond with those found in the sea scurvy of adults.

periosteal hæmorrhage.

The morbid anatomy established by Dr. Barlow.

For this portion of the subject especially I would refer you to his paper, which is published in the sixty-sixth volume of the 'Medico-Chirurgical Transactions.'

Scurvy, as ordinarily observed in adults, is characterised by progressive anæmia, accompanied by a cachectic earthy complexion, marked muscular debility, mental apathy, and depression. Before long, however, more characteristic signs develop; petechial spots appear on the skin, then larger, superficial, and deep-seated extravasations of blood, giving rise to puffy swellings on the periosteum, in the muscles, especially at the anterior aspect of the legs, the popliteal spaces, and flexures of the elbows. Hæmorrhages also take place in the subcutaneous connective tissue, as in the loose tissue below the eyelids, or in parts exposed to pres-

Signs of scurvy.

Anæmia.

Petechiæ.

Subcutaneous hæmorrhages.

Swellings.

sure or slight injury, showing as discoloured bruise-like patches. The limbs become tender and painful, the ankles œdematous. Often albumen and sometimes blood appears in the urine. But the most characteristic feature of all, and the one which serves especially to distinguish scurvy from purpura and all other diseases, is the condition of the gums; they become soft, livid purple, spongy, and sometimes so swollen as to protrude from the lips in lobulated masses, hiding the teeth altogether. They bleed freely, soon begin to ulcerate or slough, and the decaying blood imparts a horribly fetid odour to the breath. The teeth become loose and frequently fall out; bruise-like extravasations and even unhealthy ulcers follow the least injury, or even the rough pressure of handling. The temperature is normal or subnormal, except in case of hæmorrhages into the lung or pleura, when inflammatory changes are set up. If the scorbutic state continues, there comes increasing debility, a tendency to syncope on exertion, often of extreme danger, hæmorrhages from the stomach, bowels, or lungs. Unless the condition be relieved, death takes place at the close of some weeks or months by sudden syncope, or gradual

Bruisings. Tenderness.

Œdema of ankles.

Gums spongy. Swollen.

Bleeding.

Ulcerating.

Foul breath.

Loose teeth.

Syncope on exertion.

Internal hæmorrhages. Death if unrelieved.

asthenia, or the supervention of some acute inflammation. Such is a picture of scurvy in the adult.

Causes strictly known, viz. privation of certain constituents of food.

This condition has been traced to simple definite causes. There is nothing more certain in pathology than that scurvy is produced absolutely and invariably by want of certain constituents of food.

Probable nature of anti-scorbutic element.

These are probably organic acids, such as citric, malic, tartaric, in combination with potash.

Present in fresh vegetables, milk, raw meat.

Whatever their exact nature, however, they are known to be contained abundantly in fresh vegetable juices, in fresh raw meat, and in milk, and as the privation of these elements produces the disease, so their free supply absolutely and quickly cures it.

Cured by supply of these.

The effect of scorbutic diet is increased by want of light, of air, and defective hygiene; and, on the other hand, the curative influence of anti-scorbutic diet is aided by fresh air and sunlight.

Scurvy met with in children. Sometimes in dangerous degree.

Now scurvy, as I have shown, is met with in children, and in all degrees of severity. Sometimes it is developed in its most extreme and dangerous form.

Mortality.

Seven out of the thirty-one cases in Dr. Barlow's list were fatal. I have seen

about twenty cases. Of twelve of these I have accurate knowledge, and out of ten which were under my own care, one only was fatal. The child was in a condition of extreme debility, took food with great difficulty, and died three days after admission into hospital from hæmorrhage into the lung.

Occur during period of bottle-feeding.

These cases of scurvy, like rickets, occur as a rule in infancy, the period of bottle-feeding. In Dr. Barlow's thirty-one cases twenty-five were under two years. In all my cases the patients were under two years, *i.e.* the period of diet of narrow range. When the child grows older the diet becomes more varied, and scurvy rarely occurs.

Symptoms agree with those in adults.

The symptoms correspond with those observed in adults. The spongy bleeding gums, which present such a notable feature of scurvy in adults, are usually remarkable enough in children. This sign may be absent, as Dr. Barlow points out, in cases arising before the eruption of the teeth ; the sponginess being found chiefly in the neighbourhood of teeth which had been cut, or just above the pushing teeth not yet through. In some instances the condition was represented by small sub-mucous ecchymoses

Spongy gums may be absent before teeth appear.

only. This I can confirm from my own observation. It is consistent with the occasional absence of sponginess of gums in certain cases of scurvy in adults, as where the teeth have previously fallen out.

Sometimes wanting in adults.

Pyrexia appears to be more common in children than in adults, but depends probably, as in adults, upon the amount of hæmorrhage, and the consequent presence of inflammatory change set up.

Pyrexia exceptional.

For the rest, the earthy pallor, the anæmia, the muscular feebleness, the listlessness, the tendency to syncope, the œdema, the hæmorrhages, the albuminuria or hæmaturia, tenderness, and swelling of the limbs both in muscle and periosteum, are the same.

Other signs the same.

The morbid anatomy of the disease in children corresponds with the morbid anatomy of scurvy in adults. And with children as certainly as with adults, the cause can be traced to a scorbutic diet. In no instance have I seen the disease arise in an infant at the breast, or when fed on an ample supply of good cow's milk. Oatmeal and water, bread and water, various patent farinaceous and desiccated foods, German sausage, bread and butter and tea, beef tea,

Morbid anatomy the same.

The cause the same, viz. scorbutic diet.

Examples of such infants' diets.

gravy and bread, in most cases with no fresh milk at all, in a few with a very small amount only, are the dietaries on which I have seen scurvy develop. And in these cases in children again, as with adults, the improvement which immediately follows the administration of anti-scorbutics is one of the most remarkable facts in the whole range of medicine, and a convincing proof of the condition being a true scurvy. How almost incredibly rapid this change is in some instances may be judged from the following circumstance.

Cured, also, as in case of adults, by anti-scorbutic diet.

Rapidity of recovery.

Instance of this.

A child suffering from well-marked scurvy was admitted into the Children's Hospital under my care. The spongy swelling of the gums was such a conspicuous and typical feature, that I determined to have a sketch made of it; and I went the same evening to the late Dr. Westmacott, a skilful artist in this line, to ask him to make the drawing for me. The day chanced to be a Friday; the following days, Saturday and Sunday, were not convenient, and it was agreed that the matter should be postponed until Monday. The child had been at once placed upon an anti-scorbutic diet of potato pulp, fresh milk, and raw meat. On the Monday, or in three days'

time, the child had wonderfully improved in strength, and the swelling of the gums had subsided to such a degree that the sketch had to be abandoned as useless.

Most typical signs subsided by fourth day.

The special and striking features of infantile scurvy in a typical form are well shown in the following instance, the case which first disclosed to me the true nature of the affection.

Case illustrating typical form of infantile scurvy.

The patient was a child sixteen months old, born of middle-class, well-to-do parents, living in a large house in St. John's Wood, seen in consultation with Mr. Sumner in January 1877. It presented a very striking appearance. Large purple gelatinous-looking masses protruded from between the lips, and gave the child the appearance of being engaged in sucking pieces of raw flesh. On examination these projections were seen to be the gums swollen to this extreme degree, livid and bleeding. These projections, I learnt, had been still greater, having been partially excised by the medical attendant, who thought they interfered with feeding. The mucous membrane of the roof of the mouth was similarly swollen, livid and spongy, the swelling being so great as almost

CASE I. The first case of scurvy observed. Status of patient.

Appearance.

Gums.

Swelling of roof of mouth.

oozing blood.
Offensive breath.

to be in contact with the tongue, and oozing with blood. The breath was horribly offensive, the odour of carrion. The complexion was anæmic, earthy; the skin harsh and unhealthy-looking.

Purpuric blotches.
Tender bones.
No muscular or periosteal swellings.

There were some purpuric blotches on the limbs, which were tender on being handled, and the legs œdematous, but no muscular or periosteal swellings could be detected. The muscles were flabby, and so feeble that the child could not sit up, but fell over immediately on being placed upright. It had all the characters of extreme rickets in skull and long bones and chest.

Extreme muscular debility.
Extreme rickets.
History.

Its history was this:

The child was born stout and healthy, and continued so until the end of the first six months; during that time it was suckled, and had in addition oatmeal and water, condensed milk being also given for a short period at first only. This was discontinued after three months, as it was thought to disagree.

Suckled 6 months. Remained well.

At the end of six months the infant was weaned, and fed entirely upon oatmeal and rusks made with water, no milk; at ten months some mutton broth was given in addition. This

Then weaned on to oatmeal and rusks.
At ten months, mutton broth in addition.

diet was continued without any change until the sixteenth month, so that from the sixth to the sixteenth month, *i.e.* for ten months, this unfortunate baby had no milk, no meat, no potatoes—nothing but oatmeal, rusks, and water, with a small quantity of broth. On such a diet the child was certain to become rickety. It was almost destitute of animal fat, and greatly deficient in proteid, lacking the animal element almost entirely. But the diet was something more than a rickety diet; it was a scurvy diet. It contained no anti-scorbutic element, no fresh milk, no fresh vegetable, no fresh meat.

For ten months only oatmeal, rusks, water, broth.

A rickety diet.

Also a scurvy diet.

Most children get a certain amount of fresh milk, which is a perfect anti-scorbutic—until they are able to take solid food, at any rate; and then they almost invariably get potatoes, one of the best anti-scorbutics. This child had neither, and scurvy developed. Chlorate of potash and bark had been given, and subsequently syrup of the iodide of iron. The swelling of the gums, however, increased, with occasional hæmorrhage from the mouth; and alum and glycerine were applied locally. This, however, failed to have any effect. The swelling of the gums grew still more extensive, until the whole of the

Most children get milk.

Then potatoes.

This child neither.

Previous treatment.

Great swelling of gums.

Of mucous membrane of mouth.

mucous membrane of the upper and lower jaw seemed to be involved, and the bleeding became more profuse. The treatment was then

Iron and cod-liver oil given.

changed to perchloride of iron and cod-liver oil internally, and the glycerine of tannin was applied to the fungous excrescences. The local application reduced the swelling to some extent, but the child grew weaker in spite of iron and cod-liver oil, and became unable to sit upright.

Œdema of legs sets in.

Feet and legs began to swell, dyspnœa came on with stridulous respiration, especially during

Dyspnœa.

sleep, occasionally developing into paroxysms

Laryngismus.

of laryngismus.

Treatment.

The treatment now advised consisted in simply placing the unfortunate little patient

Anti-scorbutic diet.

upon anti-scorbutic food : fresh milk, fine potato gruel, and raw meat. The child had been taking

Tonics, and cod-liver oil continued with bromide of potassium.

cod-liver oil and perchloride of iron for some time without benefit. The only change made was to substitute steel wine for the perchloride, with some glycerine and 5 grains of bromide of potassium to relieve the laryngismus. The child remained at home until convalescent. Practically no change of any kind was made in the conditions of life except in the diet. Improvement at once followed, uninterrupted recovery took place, and

in the course of a few months the child was running about strong and well.

In this case there could be no doubt as to cause. All hygienic conditions were excellent, except one. The child was well clothed, lived in a large house, well ventilated, and had abundance of fresh air. The only fault was the absence of anti-scorbutic and anti-rachitic elements from the diet, and the disease was cured at once by their free supply.

In this case, again, no question of any fault of hygiene, except food; all other conditions excellent.

Let me give you another out of many striking instances which have come under my personal notice.

CASE II.

The patient was an infant 10 months old, the offspring of parents in prosperous circumstances, living in a healthy suburb of London.

Healthy surrounding conditions.

The child from birth had been well housed, clothed, and cared for—brought up, indeed, under highly favourable sanitary conditions in most respects. Yet it was a miserable object, emaciated, anæmic, cachectic, with earthy dry skin, the muscles flabby and soft. It was so feeble that it could not sit up or even lift its head up for an instant, but lay perfectly limp, almost motionless. Yet, although hardly able to move its limbs, it was extremely restless and irritable,

Yet the child a miserable object. Anæmic, emaciated, cachectic.

Extreme debility.

Irritability.

fretful, wakeful, never sleeping more than half an hour at a time. It cried out when touched, being evidently tender everywhere, most tender of all, however, in the right leg, which was greatly swollen just above the ankle. The swelling was clearly seated partly in the periosteum of the tibia, and partly in the anterior tibial muscles. There was a similar swelling, but smaller, on the left tibia. Both ankles were œdematous. There were no petechial spots. The gums of the upper jaw in front were greatly swollen, and of a deep livid purple, bleeding, spongy, protruding between the lips. The lower gums were slightly swollen also, and marked by ecchymoses.

Tenderness.

Swellings, in the periosteum, muscles.

No petechiæ.

Gums extremely spongy.

Advanced rickets.

The child was rickety. Both the lower arm bones were much curved, the ribs beaded, the joints enlarged, the chest laterally compressed, the fontanelle widely open. Careful examination of the chest and abdomen showed no sign of tuberculosis or enlargement of organs. The temperature was barely 98°. There was a considerable quantity of albumen in the urine. The child took food greedily, had no vomiting or diarrhœa, yet in spite of this became more feeble and pallid daily.

No other organic disease.

Temperature subnormal. Albumen in urine.

The history was this :

History. The child was suckled for the first two months, then partly weaned, and fed in addition on a farinaceous food with desiccated milk. Food. It throve well until it was five months old, then suffered from a severe attack of vomiting and diarrhœa, which was attributed to sunstroke. Attack of diarrhœa and vomiting. This continued for several days, during which time it was fed on arrowroot and isinglass only. When the symptoms ceased it was again put on farinaceous and desiccated food, and had been fed on that solely ever since. Changes of diet. It had grown steadily worse from the first. Daily worse.

Here, then, was a case of undoubted scurvy developed upon a diet of arrowroot and isinglass with farinaceous and dried milk food. Scurvy developed. No fresh milk was given in addition. As I told you, other cases of scurvy supervening on this diet have been recorded. The child was now put upon potato pulp, raw meat juice, and milk. No medicine of any kind was prescribed. Recovery took place with extraordinary rapidity. Recovered rapidly on anti-scorbutic diet. The child is now robust and hearty, the picture of perfect health.

Here, again, the diet had been scorbutic as well as rickety, and immediate recovery followed the change of food alone, without any assistance Here, again, disease produced by a diet scorbutic as well as rachitic.

The only remedial agent used, a change in food.

from medicine, or any other remedial agent of any kind. The child remained at home, no condition being changed except the food.

Summary of four other recent cases.

I could relate many other cases of like kind, but I shall content myself with a brief summary of four which have come under my care during the last few weeks, viz. two in the Children's Hospital and two in private. They illustrate one or two points of special interest.

Case III. A child of 14 months.

The first of these is that of E. L., a little boy of 14 months, admitted to Great Ormond Street on January 25, 1888, for extreme cachexia, emaciation, and debility. The child was wizened in appearance, had scattered hæmorrhagic blotches on the body, notably on the eyebrow and round the right eye. There were two sloughing sores on the inner margin of the right thigh. The gums were spongy, swollen, and blue. The scrotum was œdematous and covered with eczematous eruption. There were no periosteal or muscular swellings. No albumen was found in the urine.

Symptoms: extreme cachexia.

Subcutaneous hæmorrhages.

Spongy gums.

Sloughing sores.

Slight rickets.

The only signs of rickets were an open fontanelle and slight beading of the ribs; no enlargement of long bones, or curvature or collapse of chest wall.

The account given of the feeding was this:

The child had been brought up by hand; always vomited when given milk and water, so that bread soaked in water had been given, and for the last three weeks nothing else. Raw meat juice, peptonised milk, and potato pulp were ordered, but the child took food with great difficulty, the attempt to swallow giving rise to cough and return of food through the nose. No improvement took place, and the child died on the fourth day after admission. This is the case previously mentioned as the only one I have seen which ended fatally.

Previous regimen: bread and water chiefly.

Treatment by anti-scorbutic diet.

Difficulty in taking food.

Death on fourth day.

Post-mortem examination disclosed extensive hæmorrhage into the lungs, the whole of the lower lobe, and part of the middle lobe on the right side, and part of the lower on the left side being solid from extravasated blood. There was bloody fluid in the pleural cavity. Numerous small hæmorrhages were found under the serous membranes of all the chief organs of the thorax and abdomen. The bronchial and mesenteric glands were infiltrated with extravasated blood.

Post-mortem appearances. Copious hæmorrhage into lungs, and extravasation in numerous organs.

The next case is that of a child, H. H., aged 13 months, admitted into Great Ormond Street in April last (1888). It was brought

Another recent case. CASE IV. A child of 13 months.

Symptoms. Periosteal swellings. Extreme tenderness.

for tenderness and swelling of the legs immediately below the knees, but the child seemed tender all over, and cried on being handled; the skin was tense and shiny over the swollen parts, and there were numerous petechial hæmorrhages on the surface of the legs. The gums were swollen, purple, and spongy. The signs of rickets were a widely open fontanelle, large square head, and beaded ribs. The temperature was normal, the urine free from blood and albumen.

Petechial hæmorrhages.

Spongy gums. Rickets.

Scurvy in moderate degree.

The case was clearly one of true scurvy, of no extreme severity. The state of gums had been noticed coming on for three months, but the tender swellings of the legs had commenced only three weeks before.

Previous regimen.

The child had been brought up by hand from six weeks old; on farinaceous and desiccated food without the addition of any fresh element up to eleven months. From that time it was said to have had a pint and a half of cow's milk thickened with fine oatmeal. The father was a dairyman, and said he suspected the milk of being adulterated.

Addition of milk saved extreme symptoms.

In this case the late addition of milk to the food no doubt saved the child from any extreme

symptoms, which commenced with spongy gums a month before the change was made.

Placed on anti-scorbutic diet.

It was at once put on raw meat juice, milk, and potato pulp, and the result was remarkable. In four days all the petechiæ had disappeared, the blueness of gums had gone, although some swelling remained, and the tenderness and swelling of the legs had greatly subsided. The child took food freely, and at the end of three weeks was discharged absolutely well.

Instant improvement, and recovery.

A third recent case. CASE V. Unexplained hæmaturia.

The next case is an unusually interesting one. The patient, a child of 12 months old, was sent to me from the country in January last (1888), as a case of obstinate and unexplained hæmaturia. When the mother brought the child into my room I saw that it was extremely pallid and cachectic, and lay very limp and helpless in its mother's arms. She told me that its limbs were tender, that it cried when they were touched, and that the flesh bruised on handling. It was feeble, drowsy, and listless, and it became panting, breathless, and so faint on the smallest exertion that they were frightened and thought it would die. About a month ago the urine became dark like blood. I found it loaded with blood

Appearance of patient suggestive.

Limp.

Limbs tender, feebleness extreme.

Bruises.

Syncopal attacks.

Hæmorrhages from bowel.

and albumen. The child had once or twice passed blood with the stools. The fontanelle was unduly large, the ribs beaded, and the wrists a little enlarged, showing a slight degree of rickets. The gums were dark and spongy, and there were distinct swellings on the front of each tibia, which were very tender; the feet were œdematous, and there was a large bruise in the right iliac region.

Spongy gums. Tibial swellings.

The history was this:

Previous regimen.

The child had cow's milk and water up to three months. Then it had an attack of diarrhœa and vomiting attributed to the milk. This was accordingly stopped, and it was put on a malted farinaceous food with a small quantity of condensed milk, viz. one small teaspoonful to three bottles of food. The only treatment ordered was, as before, dietetic. No medicine was given, but raw meat juice, cream, potato gruel. But the case proved a little difficult. The stomach had become so sensitive that the child was frequently sick after the richer food, and it was found necessary to reduce the quantity of cream, and give half a bottle of food only every two hours. Yet, in spite of this drawback, the limbs were already less tender, the gums less swollen, there were no

Treatment by anti-scorbutic diet.

Some difficulty in feeding at first.

Improvement.

fresh bruises, and the urine was only slightly discoloured with blood. In a fortnight all trace of blood and albumen had disappeared from the urine. The meat juice and cream were increased gradually, and milk added. In less than a month the child was well and playing about. In this case, again, the food deficiency was clearly sufficient to cause scurvy. Condensed milk, as I told you before, is of slight, or even doubtful, anti-scorbutic virtue. One-third of a teaspoonful in each bottle would be utterly inadequate.

Hæmaturia ceases.

In this case also disease traced to fault of diet.

The rapid recovery on anti-scorbutic diet, again, was a convincing proof of the nature of the malady.

Rapid recovery when this fault was rectified.

The last example which I have to relate is also of special interest, since the child was so unusually well-nourished that at first I was doubtful whether the condition was really scorbutic after all. This was, however, unmistakably proved before long.

Fourth recent case. CASE VI.

Diagnosis doubtful at first. Clearly established later.

The patient, P., a child of nine months old, was sent to me on the 11th of April last (1888), by my friend Dr. Liveing, on account of great tenderness of the limbs. It had suffered from eczema almost from birth, but this had disappeared under treatment. The child lay with its

Condition of patient.

Extreme tenderness of limbs.

legs drawn up, quite motionless; the least attempt to straighten the legs or offer to touch them caused it to cry out. The periosteum of the tibia was obviously swollen, and extremely tender. There was a faint bruise on the right cheek, near the ear. The gums looked a little dark in colour, and slightly swollen; but they could not be positively identified as spongy. There was no albumen in the urine. The child was plump and of fair colour. The signs of rickets were, however, distinct: the fontanelle was widely open, the size of a florin; the teeth showed no sign of appearing, and the ribs were well beaded, but this was all. The child had been fed entirely upon farinaceous and desiccated food without the addition of any fresh element.

Swelling of periosteum.

Gums purple, not spongy.

The child fairly well nourished. Slight rickets.

I had little doubt that the disease was scurvy, but the absence of any decided sponginess of gum, and, more still, the tolerably fresh complexion and healthy look of the child, made me hesitate to give a positive diagnosis.

Signs not conclusive.

Anti-scorbutic elements, viz. potatoes, milk, and raw meat juice, were added to the food. No medicine was given except a few doses of grey powder with Dover's powder, to check

Anti-scorbutic elements added to existing food.

slight diarrhœa from which the child was suffering. The scorbutic nature of the case was speedily confirmed by two pieces of evidence. In the first place, a violent fit of crying produced copious extravasation beneath each lower eyelid, so that the child appeared at its next visit, to my great satisfaction, with two tremendous black eyes; and, secondly, it got rapidly well on the anti-scorbutic diet.

Confirmation of the scorbutic nature of the affection.

Sub-palpebral hæmorrhages occur.

Immediate improvement on anti-scorbutics being given.

The food was clearly lacking in anti-scorbutic elements, and it is significant that recovery immediately followed the simple addition of potatoes and fresh milk and meat juice to the previous dietary.

Previous diet.

All the cases of scurvy I have seen have exhibited some evidence of rickets. In some instances, however, it has been very slight, and I doubt whether it is an absolutely invariable or essential accompaniment. Obviously, from the origin of both conditions in fault of diet, they are extremely likely to be produced together.

All cases of scurvy seen showed evidence of rickets.

Possibly not invariably present. Yet from nature of case likely to arise together.

On the other hand, I think it highly probable that many rickety children are also scorbutic in some degree, although the distinctive signs of scurvy, such as spongy gums and hæmorrhages, may be wanting.

Many rickety children probably scorbutic.

The tenderness of bone and muscle in some cases very suggestive.

The tenderness of bones and muscles often present in rickets is very suggestive of this. It is reasonable to suppose that a slight degree of scurvy should arise together with rickets on artificial foods, since they are usually lacking in the anti-scorbutic and anti-rachitic elements together.

Scurvy a likely complication on rachitic diet.

Importance of this consideration.

I call your attention to the point in order that you may bear it in mind in your treatment of rickets, and direct the child's diet so that the anti-scorbutic element is fully represented.

Conclusion.

This concludes, gentlemen, what I have to say on the diet and food disorders of early childhood. As I said at the outset, the subject may seem to be commonplace, but its practical importance is great. If I have assisted you to an accurate knowledge of it, you will, I think, acknowledge hereafter that I have not spent your time and mine in vain.

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