is of the most value which can be trusted to the child under the supervision of the parent or caretaker, rather than one to be used for a brief time in the office of the surgeon.

As has been indicated above, these exercises must be practiced a considerable portion of the time to be of great service. The object of the first exercises with the stereoscope is to cultivate the ability to see with both eyes at once. For this purpose a series of pictures is required, the two halves of which differ, but are so related that they may be appropriately superimposed. The picture of the bird presented to one eye, and its cage to the other, is typical of this sort. The stimulus to co-ordinate action is given, when the child is induced to try to get the bird into the cage, or into the center of the cage. Exercises of this character prepare the way for more advanced efforts. They also remain of great use throughout the treatment. Even when normal binocular vision has become habitual, it is worth while to recur to them.

If the child has previously had some practice with fusion tubes, the second class of pictures may soon be brought into use. In these, some portion is common to both pictures. This portion must be fused to avoid diplopia, while the completeness of the picture proves that single vision is not obtained by excluding one eye. Pictures of this sort are less interesting to the child, because their component parts have a single fixed relation; and do not offer the same opportunity of conscious adjustment. On this account one should have a large series of them and should supply them a few at a time. They may be made out of ordinary stereoscope pictures by cutting off different corners from each, or by placing a dot on one, and a cross on the other, and making sure that the whole picture, or both dot and cross are seen.

When binocular fusion is well advanced, the distance between the pictures and the lenses may be varied. If the pictures be wider than the pupillary distance of the patient, variation of the distance from the eye will cause slight variations in the actual amount of convergence. If the width between corresponding points of the pictures equals the pupillary distance, pushing them nearer to or farther from the lenses will make no difference in the convergence required. But it will alter the necessary state of accommodation; and a change of relative accommodation is an exercise of very much the same value as change in relative convergence.

The Reading Bar.—One other practical device remains to be noticed—the reading bar. It provides a highly specialized exercise, depending for its value on the fact that our printing arranges words in long lines, each of which must be followed throughout its whole extent in rapid succession. The bar excludes the habitually seeing eye from seeing some portion of each line, compelling the use of the deviating eye for that part of the time. It has the advantage that it can be employed while pursuing a customary occupation. This is a great advantage within its somewhat narrow sphere of usefulness. I have found it of most value in the preparation of older patients for operation; and in establishing a new co-ordination of eye movements after operation.

Increase in Population in France.—The latest census shows that France has gained 412,364 inhabitants during the last four years. The *Sem. Méd.* adds that this is three times the gain of the preceding four years.

THE STRABISMUS OPERATION.*

C. F. CLARK, M.D.

COLUMBUS, OHIO.

Though a somewhat hackneyed subject, the last word has not yet been spoken upon the strabismus operation, nor will it be for many years to come. While without doubt it is true that excellent results may be obtained in the correction of strabismus by a variety of operative procedures, it is also true, as I think every operator present will acknowledge, that there is a diversity in the results of this operation which plainly indicates that perfection has not yet been obtained. I offer no apology for occupying your time with the consideration of a department of ophthalmic surgery on which such diverse opinions are expressed as we may find in the text-books and articles which appear from time to time on the various phases of this subject.

An analysis of the opinions expressed by a limited number of operators of national and even international reputation will show a divergence of views not only as to details, but on such important points as the following: 1, as to the degree of deviation and the character of the cases which they consider proper subjects for operation; 2, as to the age at which an operation should be performed; 3, as to the choice between tenotomy and advancement; 4, as to the amount of deviation that may be safely corrected by tenotomy; 5, as to whether the operation should be confined to the eye which most constantly deviates or its effect distributed between the two eyes so as to preserve the ocular balance; 6, as to full correction of the error in the first operation or delaying a portion of the operative procedure until the effect of the first division may be properly estimated; 7, as to the practicability of partial, or graduated tenotomy or advancement; 8, as to the value of orthoptic exercises before and after operation; 9, as to the value of tests made with prisms and otherwise during the progress of an operation; 10, as to the importance of the subconjunctival method of Snellen and of suturing the conjunctival wound; 11, as to the necessity of bandaging one or both eyes after an operation for tenotomy or advancement; 12, as to the relative importance of operations upon the superior and inferior recti muscles in cases of hyperphoria and hypertropia associated with lateral deviations, and 13, as to the most approved form of operation for tenotomy and advancement.

I fully realize that different methods will always have their advocates and it is no part of my intention to undertake to harmonize the views of the members of this Section, but in view of the divergence of theories and methods of procedure which now prevail, is it not proper that each of us should study the plan pursued by his associates and assure himself that he has not been committing that common error of successful surgeons of being too well satisfied with his own methods and results? I am persuaded that when the last word has been spoken on this subject we will have greater consistency in methods and far greater uniformity in results than now prevail.

Dr. Herman Knapp in his excellent chapter on operations,¹ makes the following statements: "1. After a tenotomy of the internal rectus the primary effect is apt to diminish for several days, but then, as a rule, it increases gradually for weeks, months and years. In

* Read at the Fifty-second Annual Meeting of the American Medical Association, in the Section on Ophthalmology, and approved for publication by the Executive Committee of the Section: Drs. J. A. Lippincott, Casey A. Wood and H. V. Würdemann.

1. Norris and Oliver's "System of Diseases of the Eye," vol. III.

many cases we rejoice at having obtained a perfect cosmetic result, but when we see our patient again in later years his eyes diverge more or less. 2. The immediate effect of a tenotomy of the external rectus increases the next three or four days, then it diminishes very gradually, so that the ultimate result is frequently not more than two or three millimeters, and at times it disappears altogether."

An over-correction after division of the internal, and an under-correction after division of the external rectus is then of not infrequent occurrence after a tenotomy even when performed by so careful an operator as Dr. Knapp, and I think every operator of wide experience will agree with me that, in spite of the most painstaking observance of every rule which prudence may dictate, in the correction of high degrees of convergence, we are often disappointed in our final results.

In contrast with this note the following statement made by Landolt,² who for a number of years past has been advocating the substitution of advancement for tenotomy as a routine measure: "In twenty years' practice we have never had an over-correction after advancement, which is frequent after tenotomy. We have never produced a strabismus, which can hardly be avoided after tenotomy, at least in the secondary position. The advancement has also the cosmetic advantage of not causing annoying protrusion of the eyeball, sinking of the caruncle, or exposure of the sclera."

If one of these plans of procedure is correct the other is certainly questionable, and yet there are many advocates of each. By far the majority seem, at least in their practice, to still prefer tenotomy when it can be made to serve their present purpose. It is more in keeping with our traditions and is less tedious; but it is a significant fact that, while even approximately perfect equilibrium of the ocular muscles after well-marked strabismus is, as we all realize, most difficult of attainment, such a result is claimed in many instances by those who advocate Landolt's method, and are willing to take infinite pains to obtain it.

A few years ago there was, as will be remembered, a strong reaction against those extremists who claimed to be able to work miracles in all nervous diseases by slight-of-hand performances upon the ocular muscles. This reaction was timely and proper, but we should not be led so far in the direction of conservatism as to prevent our accepting and adopting every improvement in method and technique which has a rational basis.

A careful review of the subject and what personal experience I have had in this direction, leads me to make the prediction that within a few years many of those who have heretofore depended mainly upon tenotomy for the correction of strabismus will find themselves adopting the more tedious but far more conservative operation of advancement, or resection almost as a routine practice.

While, for the purposes of this paper, it is not practicable to consider fully the anatomy of the ocular muscles, there are a few practical points which it will be well to review before passing on to the subject of operations. The oculo-orbital fascia, in the descriptions of which great variations are found, should be dealt with as a mass of more or less condensed connective-tissue fibers, differentiated into a dense membrane in certain portions, while in others it is made up of somewhat loose connective tissue joining the conjunctiva to the eyeball and to the sheaths of the tendons of the recti muscles and also uniting the sheaths of these muscles

somewhat loosely to the sclera. The lateral or restraining fibers connect the sheaths of the muscles with the more condensed portions known as Tenon's capsule. The effect of this anatomical arrangement is that a division of the tendon at its insertion, provided the lateral fibers remain intact, results in a limited retraction of the tendon and its secondary insertion at a point only a short distance posterior to its former point of union with the sclera. The passing of a hook beneath the tendon and breaking up of the loose fibers which unite its sheath with the sclera, adds very little to this retraction. The division of the fibers which unite the sheath of the muscle with the conjunctiva, adds more to the power of retraction, but if we wish to obtain free retraction of the muscle we must divide the lateral fibers connecting it with the more dense portions of Tenon's capsule which lies between the muscles, or what in fact amounts to the same thing, separate this capsule from the sclera above and below the point of insertion of the tendon. The foundation of all theories which deal with the subject of tenotomy and advancement lies in the relations of the tendons and muscles to this oculo-orbital fascia, or to be more exact, that portion of it which is termed Tenon's capsule. The tendons of the recti muscles are inserted at points varying somewhat in distance from the margin of the cornea: The internal rectus at a distance of 5.5 mm., the inferior 6.5 mm., the external 6.9 mm., and the superior 7.7 mm. The widths of the tendons also differ in the following order: internal 10.3 mm., inferior 9.8 mm., external 9.2 mm., superior 10.6 mm.—Fuchs. In length the tendon of the internal is 8.8 mm., the inferior 5.5 mm., the external 3.7 mm., and the superior 5.8 mm.—Merkel.

It is well in operating to remember also the peculiar insertion of the superior rectus muscle. It is quite wide, and at the nasal side is inserted much farther forward than at the temporal. It is so set that the bulk of its insertion is on the outer half of the eyeball. The inferior rectus on the other hand is so inserted that its temporal border is slightly in advance of the nasal. The measurement (3.7 mm.) given above by Merkel as the average length of the tendon of the external rectus muscle, does not conform to the impression I have obtained in the advancements and tenotomies which I have made.

In a number of resections of this tendon I have removed more than 3.7 mm., and obtained excellent results. It is possible that in doing so I may have included some of the muscular fibers.

For our purpose the various operations resorted to for the correction of strabismus may be classified under the following heads:

Tenotomy.—1. Partial division of the tendon (graduated tenotomy). 2. Complete division of the tendon. 3. Complete division of the tendon, with division of the lateral fibers of the capsule.

Advancement.—1. Partial advancement of the tendon (graduated advancement). 2. Complete advancement of the tendon. 3. Complete advancement of the tendon with advancement of the capsule. 4. Resection of the tendon. 5. Resection of the tendon and capsule.

In all of our operations for the correction of strabismus, the following general rule should be observed and exceptions to it are seldom justifiable: Whether we operate by tenotomy or adopt the more conservative method of advancement, the effect of the operation must be so distributed between the various muscles as to preserve the control of the eye in all ordinary movements.

2. Archives of Ophthalmology, vol. xxvi, p. 8.

A simple tenotomy will, according to Fuchs, correct about 3 or 4 mm. of convergence. In divergent strabismus, he has found that a simple tenotomy will not correct more than 2 mm. as an average. In view of the effects which we have all obtained in some of our earlier operations, this rule seems extremely conservative, but if we confine our division to the tendon at its point of insertion and avoid division of its lateral attachments, I do not believe it is safe to expect a much greater result than he has indicated, and in my own operations where I have depended upon tenotomy, I have seldom gone far beyond this limit without having reason to regret it.

Many rules have been laid down to enable the operator to avoid the excessive effects which often follow as a late result of tenotomy, but in difficult cases it not infrequently happens that, in order to obtain even a moderate degree of correction, these rules are violated. When more than 3 mm. of convergence, or 2 mm. of divergence is present, if tenotomy is relied upon, the effect should be divided between the two eyes rather than by operating upon one alone to obtain a correction at the expense of a free division of the lateral attachments.

Knapp lays down the following rules to govern the operator in tenotomy: "A. As a rule no squint operation should weaken the muscle beyond its physiological limit of power. B. After a tenotomy of the internal rectus, the result of the immediate examination should be as follows: 1. In adduction the medial margin of the cornea should readily reach the caruncle. 2. The near point of binocular fixation should not be less than 5 centimeters—two and one-half inches. 3. The eyeball should not protrude. 4. There should be some convergence left."

If these rules are strictly adhered to and the lateral fibers are left undisturbed, we may undoubtedly avoid an—immediate—over-correction, but the weak point in such a system of rules is that, if strictly adhered to, only a slight correction of 3 or 4 mm. is obtained and, even if the operation is divided between the two eyes, a careful examination of the field of fixation will almost certainly reveal some limitation of motion.

How often it has happened in the experience of each of us that after such a tenotomy the immediate result has been not only insufficient but almost nil and to save ourselves and the patient from the chagrin of a sense of failure, we have divided first a few and then a few more of the lateral fibers and then wondered whether we would not at some future time discover that we had slightly over-corrected the error.

Now it is a fact that even the setting back of the tendon alone, if it is sufficient to give us 3 or 4 mm. of correction must, to a limited degree, restrict motion and violate the spirit of the first of these general rules.

The very essence of such an operation consists in the fact that the control which the muscle exercises over the eye is made less effective, whereas it should be our object not to lessen but to increase this control. The movement of an eye, in a given direction, depends not alone upon the contraction of the single muscle which turns it in that direction but also, and only to a less degree, upon the co-ordinated movement of its antagonist, while both of these must again act in harmony with the corresponding muscles of the other eye. In any squint not dependent upon paralysis or traumatism, surgical or otherwise, of one of the muscles the squinting eye, while having an improper direction, still moves in harmony with its fellow and its excursions are usually

of the same amplitude. If we wish to preserve the harmonious relation of the four muscles which take part in this somewhat complicated act of co-ordination it is reasonable to begin by an avowed attempt to cripple one of them?

It is a mistake, as Landolt has pointed out, to suppose that the antagonist gains in strength what the tenotomized muscle loses and, even if it did, it is not proven that the muscle we divide has more strength or more power to move the eye than it should have. It is a question not of power but of direction with which we are dealing and the choice between tenotomy and advancement reduces itself to this: Is it better that the group of four muscles acting to produce harmonious movements of the two eyes, should have the aggregate of control which they exercise over the eyes increased by giving one of its members a more advantageous attachment, or diminished by setting another back and thereby lessening its control?

In the latter case we gain the proper direction, but in so doing we make a distinct sacrifice of a portion of the control which the group exercised over the eye, while in the former we also gain the proper direction but increase the aggregate of control by giving to one of the members an advantage in moving the eye which may be exercised or not as circumstances may demand.

I do not wish to be understood as advocating so radical a change in the accepted method of dealing with squint as the entire substitution of advancement for tenotomy, though that would seem to be the logical outcome of the above reasoning.

Advancement is so tedious and tenotomy so simple an operation that the latter will probably always be preferred in slight deviations, but whenever a deviation exceeds 5 mm. it is proper to raise the question whether an advancement should not be substituted for tenotomy; and whenever in any case of tenotomy it is found that the proper effect can not be produced without considerable division of the lateral attachments of the tendons an advancement should be substituted or should supplement the tenotomy.

As to the best method of performing a tenotomy or advancement, it is my opinion that equally good results may be obtained in a variety of ways, provided certain general principles are observed, and it is with general principles that we are here dealing rather than with the details of special methods of operating. These principles the most important relates to the division of the effect between the various muscles and the preservation of as complete control of the eye by each muscle as may be practicable. If the deviation is slight and a tenotomy is decided upon I greatly prefer the method of Snellen as modified by Stevens—a sub-conjunctival operation—buttonholing the conjunctiva and tendon and cutting both ways. But in those relatively frequent cases in which, after the first incision, there is well-marked hemorrhage beneath the conjunctiva, I at once convert the small incision into a large open wound in order to avoid a troublesome sub-conjunctival thrombus.

Careful measurements, linear, angular and by prisms before, during and after the operation, I consider of the utmost importance, but in cases in which there is marked amblyopia we must judge mainly by inspection and for this purpose there is a great advantage in operating in a dental or other reclining chair and in having the patient in the upright position while testing so that the operator may stand off at a distance of eight or ten feet

and observe the movements of the eyes. An examination made at the near point is often very misleading. If the operation is divided between the various muscles of the affected group and, in case the deviation is marked, is corrected mainly by a well-performed advancement or resection, measurements are of great value, but in the old method of operating in which the tendon was divided at one cut and what deviation remained was corrected by free division of the lateral attachments, the eye became so unstable that measurements made at the time of operation afforded very little information as to what the final position of the eyes would be.

It is not infrequently the case after a carefully performed operation for convergent strabismus as a result of which the eyes occupy approximately the proper position, to have, owing to the presence of what is sometimes termed a false macula, a well-marked heteronymous diplopia with the images widely separated.

This is probably due to what Dr. Berens has well termed "neuro-muscular memory," and should not disconcert us as it seldom causes serious disturbance, though it may make it more difficult to judge of the accuracy or the result obtained. We are, in fact, forced in such cases to depend entirely upon objective tests. It must, of course, be borne in mind that the more extensive the traumatism inflicted during the operation the more unreliable are the results of measurements made immediately after operating, and this is an additional argument in favor of advancement in its various forms, as by this means we seldom have an over-correction and by allowing a portion of the deviation to remain, we may at a subsequent operation gauge the result accurately in a supplemental tenotomy, correcting the slight remaining defect.

In tenotomy we should, so far as may be practicable, let the capsular attachments alone if we wish to avoid crippling the combined movements of the eyes, but in advancement or resection it is desirable, in our attempts to increase the control exercised by a given muscle, to bring forward or shorten the capsule with the tendon. In so doing we gain another advantage which is of great importance, in obtaining a firm hold for our sutures. In fact, in the resections which I have performed of late, I have made free use of sutures, practically quilting the tendon and capsule together, and have thus avoided a very annoying feature of some of my former advancements in which the effect would be in part lost within a few days owing to the insufficient and uncertain hold obtained by sutures introduced in the usual manner in the tendon alone.

While it has been greatly improved within a few years, there is room for still greater improvement in the operation for advancement. Before the days of asepsis advancement was indeed a formidable operation, often being followed by decided reaction, and even as now practiced when we compare it with tenotomy it is not strange that a beginner in ophthalmic surgery should, when in doubt, prefer the latter. But the question of a little more or less annoying detail in the operation should not be allowed to weigh against any advantage we may gain for our patients, and advancement should be unhesitatingly performed when it is apparent that it will produce a better final result.

The old operation, by which the tendon is split in its center and one portion drawn forward above and the other below the cornea, while certainly effective, has seemed to the writer unnecessarily complicated. Any method which, with a freely exposed field of operation, succeeds in securing and evenly mooring the tendon and

capsule of Tenon to the sclera at a point well in advance of its former point of attachment will accomplish the desired end and, in cases of less marked deviation, a method which resects a sufficient amount of the tendon and capsule and firmly sutures the distal to the proximal portion will also yield an excellent result.

Because of the thorough manner in which the field of operation is exposed, probably no method is a greater favorite with those who have tried it than that devised by Dr. Savage of Nashville, by which an L-shaped primary incision is made, one side of which is parallel with the line of insertion, and the other parallel with one border of the tendon and the flap turned well back and held out of the way by a suture while the tendon is advanced or resected.

The method of capsular advancement advocated by Dr. Fox of Philadelphia for cases in which there is extreme deviation certainly has the advantage of simplicity and the results he reported to this Section last year were excellent, but I have been thus far deterred from adopting it owing to the amount of traumatism inflicted and a feeling that I would prefer to see the tissue with which I am dealing in an operation of such delicacy.

With the exception of those cases in which the degree of deviation is excessive, resection affords excellent results and for several years I have been endeavoring to discover some method by which I could simplify the ordinary procedure and substitute it, so far as is practicable, for tenotomy. I found that by introducing a tenotomy hook in the ordinary manner and then seizing the fold of tendon beneath the hook with Prince's advancement forceps, I could gauge the amount of tendon removed by the point at which the forceps' blades were applied and suture it thoroughly and evenly at my leisure.

This led me to devise the small double hook which is figured in the report of this Section for last year and which in a number of instances has since served an excellent purpose.

After making a vertical conjunctival incision as long as, and one or two millimeters behind the insertion of the tendon, I make in Tenon's capsule two short cuts with the scissors parallel with and a short distance above and below the tendon and extending from its point of insertion backward to a distance equal to the amount of shortening desired. The central blade of the hook is now inserted below and made to include the tendon and that portion of Tenon's capsule which covers it and by turning the milled head this central hook with the tendon and overlying capsule is drawn up between the other two blades to such a distance as may be desired. Interwoven sutures are then inserted, firmly stitching the two surfaces of the folded tendon together, after which the hook is removed, the apex of the fold cut away with the scissors and the conjunctival wound closed with fine silk sutures.

A comparison of the writings of various acknowledged authorities on strabismus reveals in the after-treatment the same diversity of opinion as is observed in other departments of this subject. While Dr. Duane of New York prefers after tenotomy to keep the eyes open and practice orthoptic exercises before the wound is firmly united in order to obtain binocular fixation, Dr. Landolt, on the other hand, keeps both eyes bandaged during the healing process, often insisting upon the patient remaining in bed for six days. Between these extremes we may find every variety of directions given to patients as to

their conduct after operation, which only proves that, as in other departments of surgery, fair results may be obtained in a variety of ways. And, while I have obtained good results by the course I have pursued, which may be said to be midway between these extremes, I am free to admit that it would give me the greatest pleasure to be able to observe minutely the progress from day to day of the patients treated by both the methods described, as certainly Dr. Landolt's reports indicate a higher standard of final results than is claimed by many operators, and under such circumstances it is becoming that we should at least hold our minds open to conviction.

In conclusion, I would state as my conviction that, in the correction of strabismus, advancement, or resection combined with a very limited tenotomy, should, as a rule, be substituted for simple tenotomy.

ARTIFICIALLY PREPARED FOODS, THEIR NUTRITIVE VALUE AND DIETETIC APPLICATION.

L. BREISACHER, M.D.

Consulting Gastro-enterologist, Harper Hospital; Formerly Professor of Comparative Physiology, University of Pennsylvania; Member of American Physiological Society.

DETROIT, MICH.

The history of the scientific production of artificially prepared foods, like that of the subjects of digestion, nutrition and metabolism, is nothing more than a summary of the achievements of the experimental sciences relating to general biology and the science of medicine.

Investigation of the various empiric dietetic systems, from the time of Aristotle up to the end of the eighteenth and the beginning of the nineteenth century, shows that, while various grain decoctions, ptisan, almond, egg and sugar-water and probably a few other dietetic preparations were used for invalids, no preparation existed which might lay claim to being an artificially prepared food in the sense that the term is used to-day. Far reaching and revolutionary were the discoveries which ushered in the birth of the exact knowledge of nutrition and dietetics! On the one hand we had the discovery of oxygen by Priestly and Scheele in 1774, and the subsequent development of the theory of oxidation by Lavoisier in 1780; on the other hand was the investigation of Spallanzani and Reaumur, in 1752, on the subject of digestion.

Let us here rapidly sketch the outlines of the growth of our subject and review the fundamental principles by which the nutritive value of foods may be judged and the nutritive demands of the human individual adjusted. In this manner we shall be able to appreciate the status of our subject and to determine the applicability of artificially prepared foods to the diet of man in health and disease.

Although from the time when Lavoisier defined the processes of oxidation, up to, and even beyond, the first quarter of the nineteenth century, considerable work had been done on the subject of nutrition, little was really accomplished until the theories of Liebig, the greatest chemist of that century, were shown to be incorrect. As late as 1842 very little was known of the nutritive and physiologic significance of albumin, fat and carbohydrates. It was during this period that Liebig believed that the destruction of albumin served the purpose of furnishing the organism with energy for the

execution of mechanical work, while the oxidation of fats and carbohydrates was supposed to furnish heat to the body and protect the albumin from unnecessary oxidation. It was very soon shown, however, that this explanation was incorrect, for experimental evidence was brought forward which proved that the increased ingestion of albumin by an animal at rest was accompanied by a corresponding increase of nitrogen excretion. Important as was the demonstration of this fact, its exact significance was unfortunately misconstrued, and, in consequence, gave rise to much controversy and years of laborious experimentation. It was now taught that the minimum quantity of albumin necessary to the animal organism was expressed by the quantity of albumin disintegrated during inanition. Finally, during the years 1857-60, Bischoff, Voit and Pettenkofer published the results of their experimental work, and it was at this time really that the cornerstone of nutrition, as an exact science, was laid.

For the continued normal expressions of the functions of an organism, the ingestion of a certain and definite quantity of food is requisite. This general biologic law manifests itself, irrespective of theoretical speculation or scientific observation, in the expression of the instinctive impulse which guides every organic entity in its selection of the requisite quantity and quality of food. However, not until Helmholtz and Meyer formulated the theory of the conservation of energy, did we fully appreciate the philosophy of this law.

Every organic function is accompanied by the production of heat, which finds its origin in the oxidation of definite chemical combinations, the absorbed and assimilated products resulting from the digestion of substances termed foodstuffs. The amount of heat which an organism gives off is equivalent to the calorimetric value of the food which it requires in a given period of time. The food which the system requires is represented by the nutrient principles, albumin, carbohydrates and fat, each one of which may substitute or replace the other, but only, as we shall point out later, within the limit of their minimum nutritive or physiologic quantity. Irrespective of the relative proportions of each one of these food principles, the total heat requirement of the organism remains the same.

Every foodstuff possesses a certain caloric value, which is expressed by the term calorie, and each represents that quantity of heat necessary to raise one kilogram of water from 0 to 1 C. It is customary to express the total quantity of nutriment necessary to maintain the nutritive demands of an organism by the caloric value of the food introduced into the system. Instead of simply stating that the system requires so much each of fat, albumin and carbohydrates, we express it by the number of calories which the system requires in a given period of time under definite circumstances, presupposing always that these three foodstuffs be contained in certain proportions and in definite relationship to each other. Although this is a very convenient method and the one now generally followed, it is not strictly logical, because it neither embraces the valuation of the nutriment required to rebuild the wasted tissue of the body, nor, in the organism at rest, the amount of energy expended in the carrying on of circulation, heart beat, respiration, gastro-intestinal and glandular activity.

Expressing, therefore, only partly the metabolic significance of a given food, the caloric method is, nevertheless, the most convenient we have at our disposal at the present time. This method is founded upon the fact, to

1. Breisacher: The Principles of Metabolism and Nutrition.