WHAT WE SHOULD EAT.

The ideal diet is that combination of foods which, while imposing the least burden upon the body, supplies it with exactly sufficient material to meet its wants.— DR. SCHUSTER.

BLOOD and muscle, bone and tendon, brain and nerve, all the organs and tissues of the body, are built from the nutritive ingredients of food. As the child grows to the man the parts of his body are formed from food. With every motion of the body, and with exercise of feeling and thought as well, material is consumed and must be resupplied by food. The above definition of the ideal diet, as that which supplies the ingredients the body needs and no superfluous material to burden it, expresses very aptly the fundamental principle with which we have now to deal.

The body is a machine. Like other machines, it requires material to build up its several parts, to repair them as they are worn out, and to serve as fuel. In some ways it uses this material like a machine, in others it does not.

The steam-engine gets its power from fuel; the body does the same. In the one case, coal or wood, in the other, food, is consumed. But the body uses not only food, but its own substance also, for its fuel. When the fuel is burned in the furnace, only part of its latent energy is transformed into the mechanical power which the engine uses for its work; the larger part is changed to heat, which the engine does not utilize. A large part of potential energy of the food and of its own substance which the body consumes is likewise transformed into heat, but this heat the body uses and must have to keep it warm. And finally, metal from which an ordinary machine is built and repaired is very different from its fuel, but the same food which serves the body for fuel also builds it up and repairs its wastes.

The body is more than a machine. We have not simply organs to build, and keep in repair, and supply with energy: we have a nervous organization; we have sensibilities and the higher intellectual and spiritual faculties; and the right exercise of these depends upon the right nutrition of the body.

Different people differ greatly in the demands of their bodies for material to be consumed. Those with active exercise need more material, both to repair muscle and to yield muscular power, than those of sedentary habits. A person in the Arctic region requires fuel to keep his body warm which would be superfluous in a warmer climate. The demands of a child are not those of an adult, and the food of an invalid needs to be very different from that of a person in vigorous health. Even for healthy persons of like age, sex, occupation, and surroundings individual differences require different diets. A food which agrees with one person may disagree with another — indeed, late research implies that it is literally true that "one man's food is another man's poison"; and what is enough for one man is too little for another and too much for a third.

Regarding the adaptation of food to the mental and nervous organization physiological chemistry has but little to say; it accepts the hygienic doctrine that health of mind is promoted by health of body. The fitting of diet to the demands of health and work and purse is a matter about which later research has brought a great deal of definite and useful information.

For the best knowledge of this special subject we have to go to Europe. While we may learn a great deal from what has been done in England, France, Italy, and other countries, the largest part of the accurate information has been obtained in Germany. The Germans have studied the science of food and nutrition as they have the sciences of biblical criticism and of war. Their investigations are conducted with wonderful patience and thoroughness. The Government supplies the means, the great universities furnish the laboratories and the opportunities for research, the rewards are such as to attract the ablest intellects, and the amount of information acquired within a comparatively few years past is remarkable.

The proper adjusting of food to the wants of the body is in reality a balancing of income and outgo. The body has certain necessary expenditures. To maintain it in health and strength it must have income to meet these. If it has too little or too much nutritive material to supply its wants, or if the proportions of the different nutrients are not right, injury must result to health and strength, to say nothing of purse.

Standards for dietaries are commonly calculated, not in pounds of meat, or bread, or other food-materials, but in quantities of the nutritive ingredients, protein, fats, and carbohydrates.

The first question, then, is this: What amounts of these nutrients are appropriate for different classes of people under different conditions of life? A former article (THE CENTURY, June, 1887) described experiments for determining the amounts of income and outgo of the bodies of men under different conditions. The most thorough are those with the respiration apparatus. In these not only the food and drink and its solid and liquid products in the body, but even the inhaled and exhaled air are measured, weighed, and analyzed. The balance, by proper chemical calculation, shows just how much of protein and fat the man's body has gained or lost. If, now, we can find a food-mixture which will just enable the man to hold his own when he is at rest or when he is hard at work, we have the quantities of nutrients which he requires. This has been done in a number of cases, but the apparatus for experiments of this sort is complicated and costly, and the experiments are laborious and time-consuming, so that comparatively few have been made, and more are very much to be desired. Another method consists in observing simply the amounts of food used by people whose circumstances in life permit of reasonably good nourishment and at the same time preclude any considerable waste of food, and estimating the quantities of nutrients consumed. Hundreds of observations of this sort have been made in Europe, and a considerable number in the United States.

STANDARDS FOR DAILY DIETARIES.

LET us take, for instance, the case of an average man — say a carpenter, blacksmith, or day laborer — who is doing a moderate amount of muscular work. To make up for the constant wear and tear of muscle, tendon, and other nitrogenous tissue, he needs food containing nitrogen. That is to say, he must have protein, in the gluten of bread, in the myosin of lean meat or fish, the casein of milk, the albumen of egg or other food. To use the muscles, strength, muscular energy, is required. Furthermore, his body must be kept warm. These two kinds of energy, muscular energy and heat, his body gets by transforming the potential energy of either protein, or fats, or carbohydrates. The most of the energy is supplied by the fats, such as the fat of meat and butter, and the carbohydrates, such as starch of bread and potatoes, but some comes from the protein. Our working-man, then, needs in his daily food:

(1) Enough of protein to make up for the protein of muscle and other nitrogenous tissues consumed in his body;

(2) Enough energy to supply the demand for heat and muscular work.

The problem, then, is this: How much protein, fats, and carbohydrates does the average man, with a moderate amount of manual work to do, require in a day's food? Here are estimates by several European authorities. Those by Voit are based upon experiments with men in the respiration apparatus and upon simple examinations of the food eaten. For the other standards the food consumed was the principal basis of the calculations.

STANDARDS FOR DAILY DIETARIES FOR ORDINARY MAN DOING MODERATE MUSCULAR WORK.

	NUTRIENTS.			*Potential Energy.*
	Protein.	*Fats.*	*Carbohydrates.*	
Playfair ..	119 grams.	51 grams.	530 grams.	3135 calories.
Moleschott	130 "	40 "	550 "	3160 "
Wolff.....	120 "	35 "	540 "	3032 "
Voit......	118 "	56 "	500 "	3055 "

These four dietaries, which have for a long while been accepted by chemists and physiologists as probably expressing about the average quantities of nutrients which a man doing moderately hard work would need in his food each day, vary considerably from one another. That of Moleschott, for instance, calls for 130 grams of protein; that of Voit, only 118. There are similar differences in the quantities of fat and carbohydrates. But no one adjusts his food exactly to chemical standards. Different people consume very different foods and yet they get on very well, and it is perfectly clear that either of these standards may be right enough. And different as they are, a remarkable agreement between them has lately come to light.

When the above standards were proposed, experimental science had not taught how to measure the fuel value of food by the potential energy of its constituents. Late research has told how this may be done.* The energy is measured in heat-units called calories. A gram of protein or of carbohydrates is assumed to contain 4.1, and a gram of fats, 9.3 calories. Applying this measure to these dietaries by the computations in the last column of the table, the extreme variation in the four is only from 3032 to 3160 calories. That is to say, four of the most prominent investigators, Playfair in England and the others in Germany and Italy, working with different people and by more or less different methods, arrived at estimates which vary somewhat in the proportions of the nutrients, but when the different standards are reduced to terms of potential energy, they agree almost exactly. The closer scientific scrutiny which the latest and most painstaking research has made practicable serves only to bring the apparent discrepancies into accord, and thus confirm, in an unexpected and most striking way, the correctness of the standards.

* See article on "The Potential Energy of Food," in THE CENTURY for July, 1887.

Of course these are only general estimates. It is assumed that for an ordinary laboring man, doing an ordinary amount of work, such amounts of nutriment as these standards give will suffice; that with them he will hold his own; and that any considerable excess above these quantities will be superfluous. No one expects any given man to adjust his diet to these figures. He may need more, and he may, perhaps, get on with less. He may eat more fats and less carbohydrates, or he may consume more protein if he is willing to pay for it; though it is worth remembering that protein costs several times as much as the other nutrients. But if he has less protein and keeps up his muscular exertion, he will be apt, sooner or later, to suffer.

In general, the larger the person,— that is to say, the more bulky the machine and the more work done,— the more nutriment is needed. For these reasons men require on the average more than women, and aged people less than people in the more active period of life. Children need less than adults, although they must have material for growth. Of the dietary standards proposed by different investigators, those of Professor Voit and the Munich school of physiological chemists are most generally current. A number of such standards are given in tabular form below.

A great deal more of accurate experiment in the laboratory and of observation of dietary habits of different classes of people is needed before such standards can be made entirely accurate; and the differences in individuals must always be such that any standard can express at best only the average requirement for people of a given class. But these, such as they are, are probably not very far out of the way. Perhaps the main thing to criticise in those of Voit and his school is in the small proportions of fat. They are based largely on food consumed by people in Germany, whose incomes were small and who had to live chiefly on vegetable food, which contains but little fat. It is a question whether a larger proportion of animal food with more fat would not be really better. Certainly many people in this country would be very ill content with such food, though doubtless many of us would be far better off in health and pocket if we were to bring our diet nearer to these standards. Those of Playfair make more of protein as a source of muscular power than later research seems to warrant.

AMERICAN VS. EUROPEAN DIET.— FOOD AND WAGES.

AFTER the correctness of the standards for dietaries proposed by the distinguished European authorities above named has been so strikingly confirmed, it may seem presumptuous for me to propose different ones. I have, nevertheless, ventured to do so, as appears in the table. The standard proposed by myself for a "man at moderate work" is nearly equivalent to Voit's (German) for a "man at hard work" and Playfair's (English) for "active labor," while mine for a "man at hard work" is larger than even Playfair's for a "hard-worked laborer." The reason for this more liberal allowance is, that a not inconsiderable number of observations of dietaries in the United States reveal very much larger quantities of both protein and energy in them than in those of corresponding classes of people in Europe. The explanation is apparently not far to seek. We live more intensely, work harder, need more food, and have more money to buy it. The better wages of the American workingman as compared with the European, the larger amount of work he turns off in a day or a year, and his more nutritious food are, I believe, inseparably connected.

The main difference between the diet of

STANDARDS FOR DAILY DIETARIES.

WEIGHTS OF NUTRIENTS AND CALORIES OF ENERGY (HEAT-UNITS) IN NUTRIENTS REQUIRED IN FOOD PER DAY.

	NUTRIENTS.							*Potential Energy.*
	Protein.		*Fats.*		*Carbohydrates.*		*Total.*	
	Grams.		Grams.		Grams.		Grams.	Calories.
1. Children to 1½ years	28	(20 to 36)	37	(30 to 45)	75	(60 to 90)	140	767
2. Children 2 to 6 years	55	(36 to 70)	40	(35 to 48)	200	(100 to 250)	295	1418
3. Children 6 to 15 years	75	(70 to 80)	43	(37 to 50)	325	(250 to 400)	443	2041
4. Aged woman	80		50		260		390	1859
5. Aged man	100		68		350		518	2477
6. Woman at moderate work. Voit	92		44		400		536	2426
7. Man at moderate work. Voit	118		56		500		674	3055
8. Man at hard work. Voit	145		100		450		695	3370
9. Man with moderate exercise. Playfair	119		51		531		701	3139
10. Active labor. Playfair	156		71		568		795	3629
11. Hard-worked laborer. Playfair	185		71		568		824	3748
12. Woman with light exercise. Writer	80		80		300		460	2300
13. Man with light exercise. Writer	100		100		360		560	2820
14. Man at moderate work. Writer	125		125		450		700	3520
15. Man at hard work. Writer	150		150		500		800	4060

Nos. 1, 3, 4, and 5 are as proposed by Voit and his followers of the Munich school; No. 2, by the writer. One ounce = 28⅓ grams, nearly.

people of moderate means here and in Europe is that the people here eat more meat and other animal foods and more sugar. The European wage-worker usually has but little meat, butter, or sugar. In England he often enjoys a richer diet, I suppose, but on the Continent ordinary people live mainly upon the cheaper vegetable foods. Meats and fish supply a good deal of protein and fat. The fats, including butter, are rich in energy, and sugar supplies more energy than most vegetable foods. While the energy in the working-people's dietaries in England, France, Germany, and Italy, as reported by Playfair, Moleschott, Voit, and others, ranges from 2500 calories, or less, to a maximum of 5700, those that I have found in this country range from a minimum of 3500 to 8000, and even higher. The differences in the protein in American and European dietaries are similar, though not quite as large. Without doubt we waste more of our food than the Europeans do, but the amount which we do eat is evidently very much larger. And though many of us eat far too much meats and sweetmeats for the good of our health or our pockets, the evidence seems to me to imply very clearly that we must keep on eating more than our transatlantic brethren if we are to keep on working as intensely and as productively as we now do. The question of high wages and short hours is largely a question of nutritious diet. Meats, eggs, milk, butter, and sugar can be had, when there is money to pay for them. They are toothsome, and hence people who can get them eat a great deal. They are easily digested and rich in protein and energy, and hence sustain a high degree of activity.

COMBINATIONS OF FOOD.—REASONS FOR MIXED DIET.

THE standards for proportions of nutrients help to explain why we need combinations of different food-materials for nourishment. Almost any one kind of food would make a one-sided diet.

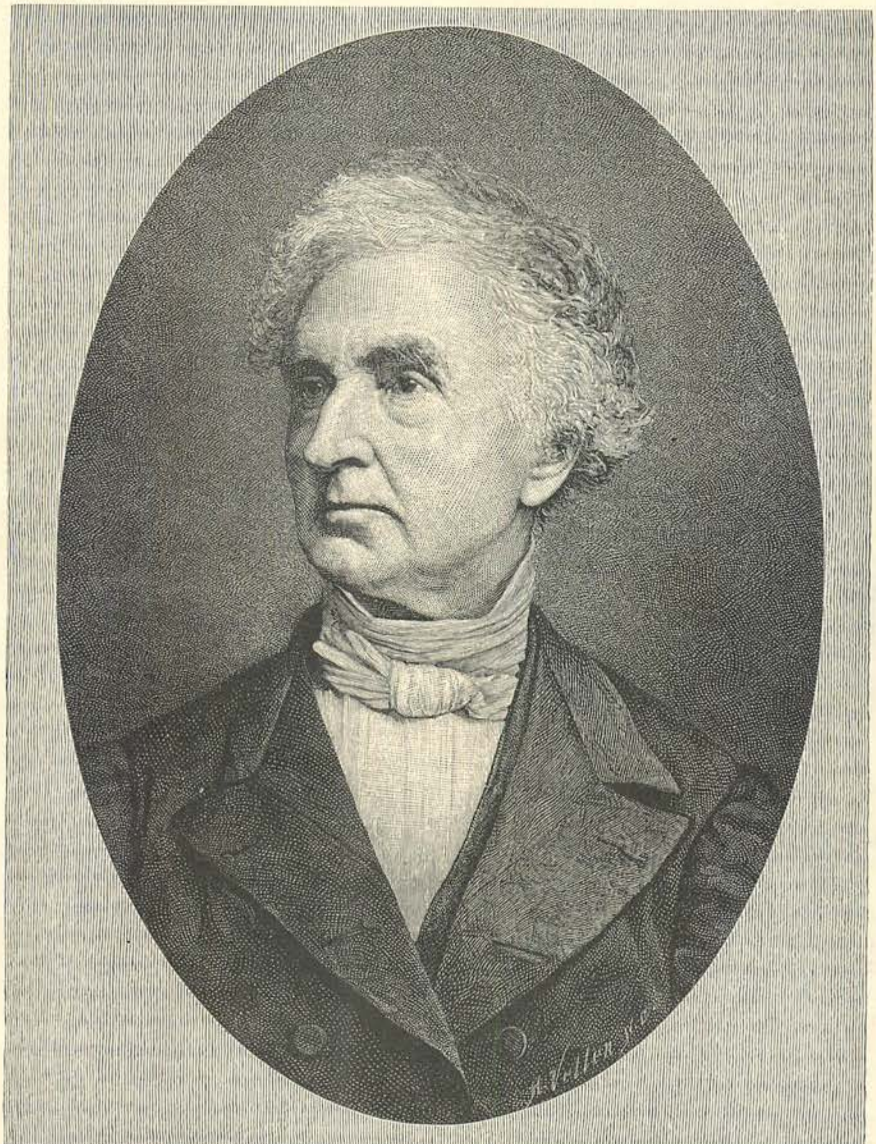
Suppose, for instance, a working-man is restricted to a single food-material, as beef or potatoes. A pound and thirteen ounces of roast beef, of the composition here assumed, would furnish the required 125 grams (0.28 lb.) of protein, and with it 0.26 lb. of fat, but it has no carbohydrates. Yet nature has provided for the use of these in his food. Three pounds of corn-meal would yield the protein and with it a large excess of carbohydrates — over two pounds. A pound and three-quarters of codfish would supply the same protein, but it would have very little fat and no carbohydrates, to furnish the body with heat and strength. Potatoes or rice would have even a greater excess of the fuel which the beef and fish lack than has corn-meal. Assuming that the man needs 3500 calories of potential energy in his daily food, the one and three-quarter pounds of salt codfish which would furnish the needed protein would supply only 540, while to get the needed protein from the fat pork would require 9.8 pounds, which would supply 7½ pounds of fat and over 32,000 calories of energy!

Putting the matter in another way, we might estimate the quantities of each material which would furnish the required energy. A ration made up exclusively of either kind of food would be as one-sided in this case as before. The fish would be mostly protein, the fat pork nearly all fat, and the potatoes or rice little else than starch. With almost any one of these food-materials, in quantities to meet the demand of his body for heat and muscular strength, the man would have much more or much less protein than he would need to make up for the consumption of muscle and other tissues. If he were obliged to confine himself to any one food-material, oat-meal would come about as near to our standard as any. Wheat-flour with a little fat — in other words, bread and butter — would approach very close to Voit's standard for European working-people with chiefly vegetable diet, but it would need a little meat, fish, eggs, milk, beans, pease, or other nitrogenous food to bring it to the proportions that the American standard calls for.

Rice, which is the staple food of a large portion of the human race, is very poor in protein; beans have a large quantity. The different plants which are together called pulse are botanically allied to beans and are similar in chemical composition. We have here a very simple explanation of the use of pulse by the Hindus with their rice. The Chinese and the Japanese, whose diet is almost exclusively vegetable, follow a similar usage.

The codfish and potatoes and the pork and beans which have long been so much used in and about New England form a most economical diet; indeed, scarcely any other food available in that region has supplied so much and so valuable nutriment at so little cost. The combination is likewise in accord with the highest physiological law. Half a pound each of salt codfish and pork, two-thirds of a pound of beans, and three pounds of potatoes would together supply almost exactly the 125 grams of protein and 3500 calories of energy that our standard for the day's food of a working-man calls for.

I am told that the mixtures of these materials locally known as fish-balls and baked beans are being exported from Boston in large quanti-



BARON JUSTUS VON LIEBIG. (FROM A PHOTOGRAPH BY FRANZ HANFSTÄNGL.)

ties. Possibly this is an indication that the outer world is growing wiser, and it is doubtless a compliment to Massachusetts legislators that the restaurant under the gilded dome on Beacon Hill is popularly called "The Beanery."

Although the pride of a loyal son of New England may perhaps prejudice his opinion as physiological chemist, I venture to ask, in all seriousness, whether there may not be, between the intellectual, social, and moral force of its people and the dietary usages of which those here instanced are a part, an important connection, one that reaches down deep into the philosophy of human living?

To those interested in the elevation of the poor whites and the negroes of the South, whose aliment consists so largely of corn-bread and bacon, or, in purer vernacular, "hog and hominy," I would suggest the consideration of the one-sidedness of such diet. A quarter of a pound of bacon and two pounds of corn-meal would furnish 4100 calories of energy and 85 grams of protein; in other words, a large excess of heat and force yielding substances, and about two-thirds the muscle-forming material the standard calls for. Instances of the connection between such ill-balanced dietaries and a low standard of physical, intellectual, and moral efficiency are sadly frequent in human experience; but the cases in which the highest planes have been reached with such bodily nourishment are, I think, rare, if not unknown.

The grocer, the butcher, and the fishmonger supply us with a great variety of food-ma-

CLAUDE BERNARD.
(FROM A PHOTOGRAPH BY TRUCHELUT AND VALKMAN.)

terials, and the practice of mankind justifies their use in still more varied combinations. What kinds and proportions are adapted to a healthful and economical diet? To answer this would require a book rather than a magazine article, but I may say that it is the comparison of the food consumed by people in this country with such standards for dietaries as those here given and with the food consumed by people in corresponding circumstances in other countries, especially on the Continent of Europe, that has led me to assert so confidently that many of us eat far too much of meats, of fats, and of sweetmeats. Not only are the quantities of nutrients in the dietaries of our working-people very large, in some cases enormously so, but those of people whose occupation involves little muscular work supply protein and fats and energy far in excess of what the best evidence indicates as the actual demand, even for active exercise. One of the instances that have come under my observation was that of a well-to-do professional man's family. None of the members except the servants were engaged in at all active muscular work. The estimates were of food actually consumed, due allowance being made for waste, which, under a careful mistress, was unusually little. The protein exceeded that of either Voit's standard or the writer's for a laboring man at moderately hard muscular work. The energy, the amount of which was made very large by the fat of meat and butter and the sugar consumed, exceeded the amount called for, either by Playfair for a "hard-worked laborer," or by Voit or the writer for a "man at hard work," and was over fifty per cent. larger than that of any of the few European dietaries of people of similar occupation which I have found reported. Yet this family regarded themselves as rather small eaters, and would really be so if the other American dietaries were to be taken for the standard. I surmise that many a family would, if they were to compare their daily food consumption with the figures here given, find similar excess of food and of nutritive substance. In a large number of dietaries that have come under my observation there has been, in nearly every case, an excessive quantity of fat; and in several, if half of the meats and sugar had been left out, there would have remained considerably more of both nutrients and energy than either the standards above given calls for. This all means great waste of money, and, as the hygienists tell us, still greater injury to health.

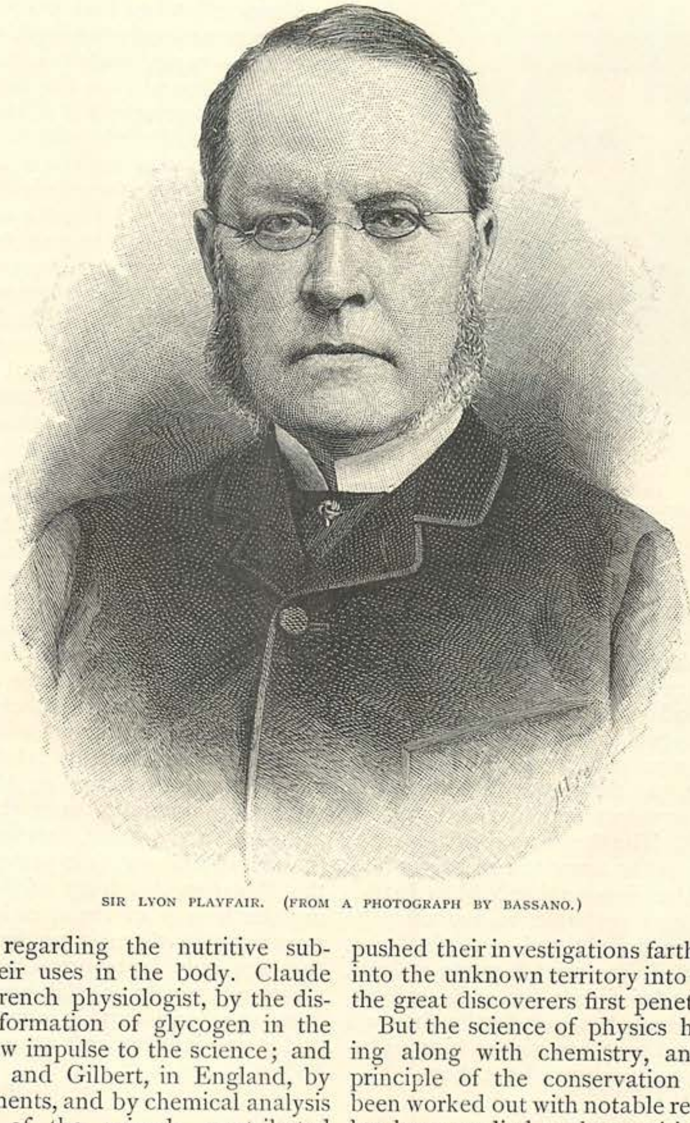
It is often urged that appetite is the proper measure of one's wants. As regards the kinds of food best for each of us, doubtless rational experience gives the most reliable information. A man ought to eat that which, in the long run, agrees with him. But either the concurrent testimony of an immense amount of the most accurate experimenting and observation is radically wrong, or a great many of us eat far too much. Appetite would be a better guide if it were not for the demands of the palate.

PROGRESS OF THE SCIENCE OF NUTRITION.

It is very interesting to note how the science of nutrition has passed through several clearly marked stages of development, each of which corresponds to an epoch of discovery in chemical and physical science.

The first long step forward was made near the close of the last century, when Lavoisier, the French chemist, explained the principle of combustion with oxygen and applied it to the consumption of food in the body.

The next important epoch was ushered in by the German chemist Liebig, whose researches and whose reasoning give him a place among the great philosophers of our time. He invented new methods of chemical analysis and experimenting, and opened up new fields of research in chemistry in its application to physiology and to agriculture, and as part of his work propounded the first at all satisfac-



SIR LYON PLAYFAIR. (FROM A PHOTOGRAPH BY BASSANO.)

tory doctrine regarding the nutritive substances and their uses in the body. Claude Bernard, the French physiologist, by the discovery of the formation of glycogen in the liver, gave a new impulse to the science; and Messrs. Lawes and Gilbert, in England, by feeding experiments, and by chemical analysis of the bodies of the animals, contributed greatly to the knowledge of the subject. The German experimenters Bischoff, Pettenkoffer, Henneberg, and especially Voit, with untiring patience, elaborate apparatus, and refined chemical methods, have studied the changes that go on in the animal body. Moleschott in Germany and Italy, Payen in France, and Sir Lyon Playfair in England have devoted especial attention to food and dietaries. A number of other names of note might be mentioned. By far the greatest of all was Liebig, who died a few years since. Among the men now living Voit has, without doubt, rendered the most useful service. During the last two decades a large and constantly increasing number of gifted and zealous workers have availed themselves of the fruits of chemical research, and pushed their investigations farther and farther into the unknown territory into whose borders the great discoverers first penetrated.

But the science of physics has been growing along with chemistry, and the general principle of the conservation of energy has been worked out with notable results. This too has been applied to the nutrition of the body, in ways such as those pointed out in these articles.

Of late, biological science has made remarkable revelation of the actions of the enzymes and microbes, which together are classed as ferments, and the biological chemists are now telling us that back of the chemical activity which we call metabolism, and in which the transformation of energy plays so important a part, the ferments are at work, and that a considerable part of the chemical changes that go on in the body are caused by them. That ferments in the alimentary canal are the chief agents in the digestion of food has long been known, but investigators have lately been finding them in other parts of the body, and we are beginning to think

ANSELME PAYEN.
(FROM A PHOTOGRAPH BY PIERRE PETIT.)

that they work almost everywhere within us, and that the complex compounds which make up our food and our tissues must to some extent, at least, be broken up by these ferments before they can unite with oxygen and yield heat and muscular energy. In the beginnings of the modern science of nutrition it was taught that oxygen was the first great agent by which chemical changes in the body were brought about, but of late we are coming to think that the ferments begin the work and the oxygen ends it. The ferments thus appear as indispensable to the functions of life as they are direful in the diseases that lead to death.

While it seems probable to-day that the theories here so briefly and imperfectly set forth will, in their essential features at least, stand the test of future research, nobody can tell in just what minor details they will be changed, and past experience bids us beware of being too positive about them.

A generation ago Liebig and others taught, and it was generally believed, that the carbohydrates — sugar, starch, etc.— of the food were transformed into the fats of the body. In Liebig's later years a school of physiologists arose in Munich, with Pettenkoffer, and especially Voit, as leaders, who denied, or at least seriously questioned, the formation of fat from carbohydrates. Though much of the talk in the laboratories continued to favor the old theory, and many physiological chemists privately clung to it, and some, like Messrs. Lawes and Gilbert in England, stoutly maintained it in public and defended it by their experiments, yet so powerful was the later Munich school that it was hardly counted in good form to urge that carbohydrates were transformed into fats. Dr. Gilbert, some years ago, in a meeting of German agricultural chemists, explained the views held by Mr. (now Sir John) Lawes and himself, but his paper was scarcely noticed in the report of the meeting. Since then, however, evidence in favor of the view maintained by Liebig, and by Lawes and Gilbert, has accumulated. Animals have in numerous cases been found to store in their bodies large amounts of fat, which could have had no other possible source than the sugar and starch of their food; indeed, some experiments lately made in the physiological laboratory at Munich with the respiration apparatus have given convincing evidence in the same direction; and a short time ago Professor Voit presented a paper to the Bavarian Academy of Sciences reviewing the history of the question, and frankly avowing that there is no longer any doubt that not only herbivorous animals, but carnivorous animals as well, are able to transform very considerable quantities of sugar and starch into fat, and store this fat in their bodies.

W. O. Atwater.