THE CHEMISTRY OF FOODS AND NUTRITION. I.*

THE COMPOSITION OF OUR BODIES AND OUR FOOD.

"Half the struggle of life is a struggle for food."— EDWARD ATKINSON.

"I have come to the conclusion that more than half the disease which embitters the middle and latter part of life is due to avoidable errors in diet . . . and that more mischief in the form of actual disease, of impaired vigor, and of shortened life, accrues to civilized man . . . in England and throughout central Europe from erroneous habits of eating than from the habitual use of alcoholic drink, considerable as I know that evil to be."— SIR HENRY THOMPSON.

"If we will care for men's souls most effectively, we must care for their bodies also."— BISHOP R. S. FOSTER.

WHAT proportion of the cost of living might be saved by better economy of food; how dietary errors compare in harmfulness with the use of alcohol; whether, as some urge, our next great reform is to be in our dietetics; and to what extent the spread of the gospel and the perfection of its fruit are dependent upon the food-supply, are questions which it is not my present purpose to discuss. I have quoted the foregoing statements, however, because they come with authority, and because, starting from the widely different standpoints of the economist, the physician, and the divine, the conclusions tally perfectly with those of some studies of my own.

Mr. Atkinson cites statistics to show that all but the very few who are especially well-to-do, in this country as in Europe, must expend half or more than half of their earnings for their food; calls attention to our wastefulness, and urges the need of better economy in the purchase and use of food-materials. The error which Sir Henry Thompson most seriously deplores is over-eating. "It is a failure to understand, first, the importance of preserving a near equality between the supply of nutriment to the body and the expenditure produced by the activity of the latter; and, secondly, ignorance of the method of attaining this object in practice, which gives rise to the various forms of disease calculated to embitter and shorten life." Bishop Foster, considering, on the one hand, the destitution that prevails, both at home, and especially in some of the countries where missionary effort is put forth so vigorously, and, on the other, the intimate dependence of man's intellectual and spiritual development upon his physical condition, urges that we may hope for the best culture of the Christian graces in the hearts of men only in proportion as adequate nourishment of their bodies is provided for.

I have been led to the conclusions that, in this country, many people, not only the well-to-do, but those in moderate circumstances also, use a needless quantity of food; that part of this excess, however, is simply thrown away, so that the injury to health, great as it may be, is doubtless much less than if all were eaten; that one great fault with our dietaries is an excess of meats and of sweetmeats; that even among those who desire to economize there is great pecuniary loss from the selection of materials in which the actual nutrients are really, though not apparently, dearer than need be; that many whose means are limited make still more serious mistakes in their choice of food, so that they are often inadequately nourished when they might be well fed at less cost; and, what seems the most painful thing of all, that it is generally the very poor who practice the worst economy in the purchase as well as in the use of their food.

The subject concerns the laboring classes in still other ways. Statistics as well as common observation bear emphatic testimony to the better condition of the American as compared with the European workingman in respect to his supply of the necessaries and comforts of life. Nowhere is this superiority more striking than in the quality and quantity of his food. And the difference in the dietaries of the two is especially marked in the larger amount of potential energy, of capability to yield muscular strength for work and to fulfill other uses in nutrition, which characterizes the food of the American. That the American workman, in many cases at least, turns out more work per day or per year than his European competitor is a familiar fact. That this superiority is due to more nutritious food as well as to greater intelligence is hardly to be questioned. But the better nourishment of the American wage-worker, as we shall see,

* See "The Food Question in America and Europe" by Edward Atkinson in this magazine for December, 1886.

is largely due to our virgin soil. With the growth of population and the increasing closeness of home and international competition, his own diet cannot be kept up to its present nutritive standard, nor can that of his poorer neighbor and his foreign brother be brought up nearer to that standard, without better knowledge and application of the laws of food-economy.

Some time since, at the instance of the United States National Museum, and in behalf of its food collection, I was led to undertake a study of the chemistry of foods. This has included with other matter a series of analyses of some of our common food-materials. To give some of the more practical results of this work, especially as viewed in the light of late research upon the more general subject of nutrition, is the purpose of the present articles.*

A POUND of very lean beef and a quart of milk both contain about the same quantity of actually nutritious materials. But the pound of beef costs more than the quart of milk, and its nutrients are not only different in number and kind, but are, for ordinary use, more valuable than those of the milk. We have here an illustration of a principle, or rather of two principles, of fundamental importance in the economy of nutrition: our food-materials contain nutrients of different kinds and in different proportions, and the nutrients have different functions, different sorts of work to do in the support of our bodies. Add that it is essential for our health that our food shall supply the nutrients in the kinds and proportions our bodies require, and that it is likewise important for our purses that the nutrients be obtained at the minimum cost, and we have the fundamental tenets of our system of food-economy.

The greater part of our definite knowledge of these matters comes from chemical study of food-materials, and from experiments in which animals are supplied with food of various kinds and the effects noted. In these latter, the food, the *egesta*, solid and liquid, and, in many cases, the inhaled and exhaled air are measured, weighed, and analyzed. Hundreds, indeed thousands, of trials have been made with animals of many kinds, and a great number with human beings of both sexes and different ages. The best work has been done during the last two decades, nearly all of it in Europe, and the larger share in Germany. It involves the study of the profoundest problems of chemistry, physics, and physiology, the most elaborate apparatus, and the greatest care and patience of the workers. The labor of days and weeks is often required for a single experiment of a series, and the result of many series may often be condensed in a very few words. If one seeks famous names in this field he may find them in Liebig, Pettenkofer, and Voit in Germany; Payen and Claude Bernard in France; Moleschott in Italy; and Frankland, Playfair, Lawes, and Gilbert in England, and many others. If he questions the practical value of the results, let him see how they are being applied in the construction of dietaries for the common people in Germany, and what they indicate as to the errors of our food-economy at home. If he would see how results of recent research in one country may be ignored, because unknown, by the writers of a different language in another, let him examine some of our latest magazine articles and text-books, the names of the authors and publishers of which ought to be a guarantee for better things.

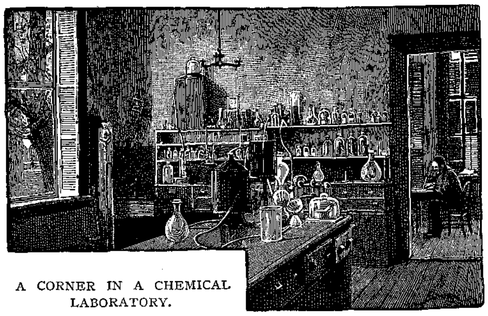
What we wish to consider now, however, is not the extent of the science, but some of its more important teachings in their applications to our daily life. Our task is to learn how our food builds up our bodies, repairs their wastes, yields heat and energy, and how we may select and use our food-materials to the best advantage of health and purse.

I begin our study together with a wholesome fear of the editor before my eyes, knowing well that back of the courteous hint to make these articles not too abstrusely scientific there was a repressed warning to avoid the tone and language of the college lecture-room as unsuited to the pages of a magazine. But I must crave a little latitude; the results of scientific research cannot be explained without some tedious technicalities and dry details.

HOW CHEMICAL ANALYSES ARE MADE.

IF I cannot be interesting, I will be orthodox, and go back to the Catechism, whose second question is "Of what are you made?" and the answer, "The dust of the earth." The fact that underlies this answer, namely, the identity of the elements of our bodies with those of the material objects around us, is one of the many which chemistry explains. This fact, embodied in the solemn language of the primeval curse, "for dust thou art, and unto dust shalt thou return," impressed upon us

* I am indebted to Professor Baird, Secretary of the Smithsonian Institution and Director of the National Museum, for permission to reproduce here several charts prepared to illustrate the food collection; nor can I forbear adding that it was through the generosity of Messrs. Thurber, Whyland and Co., of New York, in defraying a considerable portion of the pecuniary expense of the analyses hereafter referred to that the latter were made possible.



A CORNER IN A CHEMICAL LABORATORY.

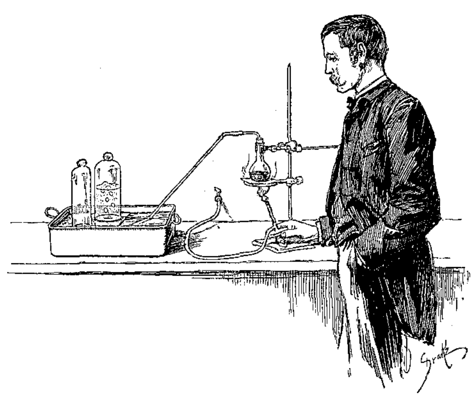
with our earliest religious teachings, clothed in fantastic imagery by poets, and understood so vaguely in the science, and dwelt upon so mysteriously in the philosophy of the past, is divested of much of its mystery by the matter-of-fact investigation of the present. The chemistry of to-day tells us of what elements and compounds our bodies consist. It gives us at least a glimpse of the ways in which they are framed together by the wonderful processes of life, and how they go through the round of growth and fruition, and are by decay resolved again into the forms from which they came. And the research of the past few years has shown us that even this decay is a vital process carried out by living creatures, whose mission is to take off the effete matter and fit it for use again.

A friend of mine tells of an editor of a prominent journal—and a Boston editor at that—who was much surprised to learn that it is possible to tell by use of the balance, the combustion furnace, the filter, and other appliances of the chemical laboratory, just what elements and compounds and what proportions of each make up the air or a mineral, or how much nitrogen there is in muscle or protein in wheat flour. But to the chemist these are the most commonplace, though not always the simplest, things. Indeed, our everyday handling of food materials often involves processes, though crude ones, of analysis.

We let milk stand; the globules of fat rise in cream, still mingled, however, with water, protein, carbohydrates, and mineral salts. To separate the other ingredients from the fat, the cream is churned. The more perfect this separation, *i. e.*, the more accurate the analysis, the more wholesome will be the butter. Put a little rennet into the skimmed milk, and the casein, called in chemical language an albuminoid or protein compound, will be curdled and may be freed from the bulk of the water, sugar, and other ingredients by the cheese-press. To separate milk-sugar, a carbohydrate, from the whey is a simple matter. One may see it done by Swiss shepherds in their rude Alpine huts. But farmers find it more profitable to put it in the pig-pen, the occupants of which are endowed with the happy faculty of transforming sugar, starch, and other carbohydrates of their food into the fat of pork.

The New England boy who on cold winter mornings goes to the barn to feed the cattle, and solaces himself by taking grain from the wheat bin and chewing it into what he calls "wheat-gum," makes, unknowingly, a rough sort of analysis of the wheat. With the crushing of the grain and the action of saliva in his mouth, the starch, sugar, and other carbohydrates are separated. Some of the fat, *i. e.*, oil, is also removed, and finds its way with the carbohydrates into the stomach. The tenacious gluten, which contains the albuminoids or protein and constitutes what he calls the gum, is left. When, in the natural order of events, the cows are cared for and the gum is swallowed, its albuminoids enter upon a round of transformation in the boy's body, in the course of which they are changed to other forms of protein, such as albumen of blood or myosin of muscle; or are converted into fat, or are consumed with the oil and sugar and starch to yield heat to keep his body warm and give him muscular strength for his work or play.

I am using such technical terms as protein and carbohydrates and speaking of chemical processes with which daily usage makes us chemists familiar and which the reader will find referred to so often in these articles that I wish him to become familiar with them also. Indeed, these things are so much a part of ourselves, so intimately connected with our every breath and motion and feeling, with our life and health and strength, that labor spent in learning about them cannot be lost. It will help toward understanding the facts if we note how some of them are found out. To this end I will introduce the reader into a laboratory, being aided in so doing by the illustrations of the chemical laboratory of Wesleyan Univer-



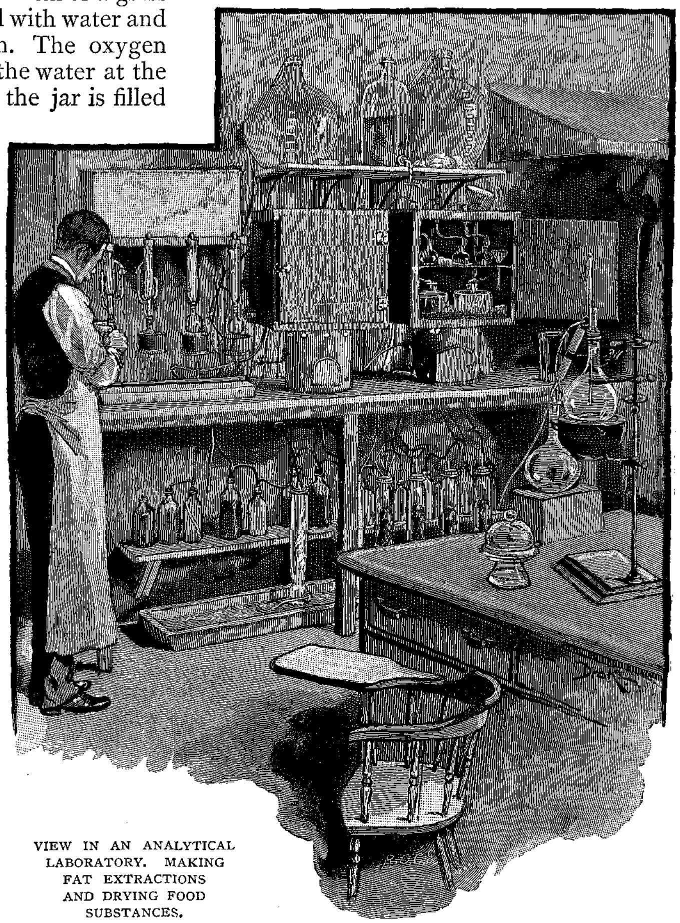
MAKING OXYGEN.

sity. They show the rooms in which some of the studies whose results are to be described beyond were made, and part of the apparatus actually employed.

At one of the desks a student may be seen preparing oxygen. In a little flask he places some chlorate of potash—the material which we use as a medicine for sore throat. This he heats by the flame of a peculiar lamp underneath the flask. The oxygen is given off as gas and passes through a glass tube which is bent downward so as to open under the mouth of a glass jar, which latter has been filled with water and inverted over water in a basin. The oxygen bubbles up into the jar, while the water at the same time runs out, and thus the jar is filled with the gas. It looks like ordinary air, but when the experimenter sets fire to a stick of wood, blows out the flame, thrusts the glowing end in the oxygen, it bursts instantly into a brilliant flame. A piece of phosphorus, kindled and placed in the oxygen, burns with a flame of blinding brightness. And a steel wire burns in this gas even more brilliantly than wood burns in ordinary air. Thus the student learns as he could not from text-book or lectures, that oxygen, which makes up nearly two-thirds of the weight of our bodies, and one-fifth of the weight of air, is the great supporter of combustion.

But our special purpose here is to note how chemical analyses are made. Let us take as an example a grain of wheat. It contains water, which we may dry out by heating; organic matter, which may be burned by combining with the oxygen of the air; and mineral matters, which remain behind as ashes. The organic matter contains fatty or oily substances, starch and other carbohydrates, and protein compounds.

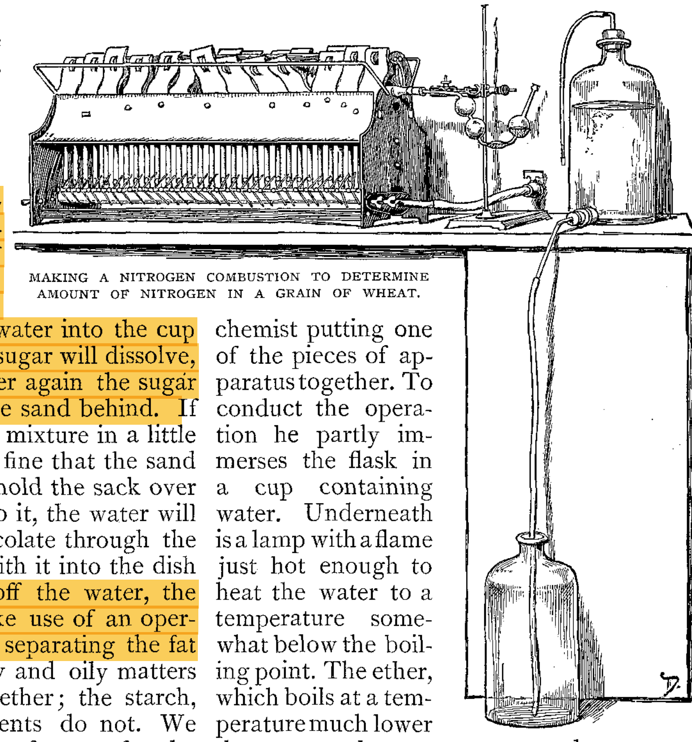
The object of the analysis is to separate these ingredients from one another and find what proportion of each is contained in the wheat. To make the analysis, we first grind the grain to flour. To find the proportion of water, we weigh off a small quantity very accurately in a chemical balance and put it in a little glass flask, the weight of which is known, and heat it for a number of hours, until the water is driven out. When it is perfectly dry it is weighed again. The loss in weight represents the quantity of water in the flour. This heating is conducted in a drying oven which is kept hot by a gas flame inside the support on which the oven rests. In order to prevent the action of the oxygen of the air upon the flour while it is being dried, we keep a current of hydrogen gas continually passing through it. The apparatus for generating the hydrogen and forcing it through the flasks is shown in the



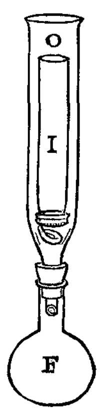
VIEW IN AN ANALYTICAL LABORATORY. MAKING FAT EXTRACTIONS AND DRYING FOOD SUBSTANCES.

picture. In the large bottles above is sulphuric acid. This runs down the pipes into the tall narrow glass vessels on the floor. These latter contain zinc. When the acid comes in contact with the zinc, hydrogen gas is developed, and passes up by tubes through the top of the drying oven into the flasks. Such devices as these are necessary if we are to make large numbers of analyses with the greatest accuracy and speed. Like a steam-engine, they seem a little complicated, but the engineer understands his engine, and to the chemist his apparatus seems perfectly simple.

We have next to find out how much oily matter the wheat contains. For this purpose we must have some means of getting the oil out, and weighing it. The operation is by no means a difficult one. Suppose we have a mixture of sugar and sand and wish to find out how much sugar it contains. Sugar dissolves in water, sand does not. If we pour water into the cup containing the mixture, the sugar will dissolve, and if we pour off the water again the sugar will go with it and leave the sand behind. If instead of a cup we put the mixture in a little cloth sack, with meshes so fine that the sand will not pass through, and hold the sack over a dish and pour water into it, the water will dissolve the sugar and percolate through the cloth, carrying the sugar with it into the dish below. If then we boil off the water, the sugar will remain. We make use of an operation analogous to this in separating the fat from our wheat. The fatty and oily matters of the wheat dissolve in ether; the starch, gluten, and other ingredients do not. We therefore use ether in place of water for the solvent. Instead of the bag we place the flour in a little glass cylinder (I) having its lower end covered with filter paper. This small tube is put inside a larger one (O) whose lower end is drawn out into a neck like that of a funnel. This neck is then passed through the stopper of a little flask (F). If now we pour ether into the inner tube, it will dissolve the fat, percolate through the filter paper, and fall into the flask below. By passing successive portions of ether through the flour, we shall, after a time, dissolve out all the fat. But this would require a great deal of time and ether, both of which are expensive. Suppose we had some means by which the ether, after bringing its freight of fat into the flask, could be driven out, leaving the fat behind, caused to return into the inner tube, dissolve another portion of fat and bring it into the flask, and be made to repeat the round again and again. Suppose, furthermore, this operation should be made to go on automatically, and that it could be carried on in several of these pieces of apparatus at once, while the analyst devoted himself to other work. Our analyses would thus be greatly facilitated. Precisely this is done in the apparatus at the left of the drying oven in the large picture, which shows the chemist putting one of the pieces of apparatus together. To conduct the operation he partly immerses the flask in a cup containing water. Underneath is a lamp with a flame just hot enough to heat the water to a temperature somewhat below the boiling point. The ether, which boils at a temperature much lower than water, changes to vapor and passes upward between the inner and outer tubes into a long pipe which winds upward through the tank above like the worm of a still. The tank is kept filled with cold water; the ether vapor is condensed to liquid, falls back upon the flour in the inner tube, dissolves out another portion of fat, carries it into the flask below, and is then once more evaporated, leaving the fat in the flask; and so the same portion of ether keeps on its round, passing up in the form of vapor, coming back as liquid, and bringing fat with it into the flask. When the fat is all extracted the operator takes the apparatus apart, boils off the ether once more, and weighs the flask with the fat. Knowing how much the empty flask weighs, he has simply to subtract its weight from that of the flask with the fat in it; the difference is the weight of the fat.



MAKING A NITROGEN COMBUSTION TO DETERMINE AMOUNT OF NITROGEN IN A GRAIN OF WHEAT.



APPARATUS FOR FAT EXTRACTION.

The ways of finding the amount of nitrogen in food materials are of especial interest to us, because we use the nitrogen as a measure of the amount of protein, the most important of the nutritive ingredients. One of the most common of these ways, the "soda-lime method," as it is called in the laboratory, is illustrated in pictures herewith. The flour is heated with a mixture of soda and lime in a combustion-tube. The small diagram shows the tube ready for the heating or "combustion," as it is termed. Connected with the long combustion-tube which holds the flour and soda-lime is a bulb-tube containing a little acid. When the combustion-tube is heated in the furnace, as shown in the larger picture, the nitrogen of the flour is changed to ammonia, which is caught in the acid in the bulb-tube. When this is done we have only to find the amount of ammonia and calculate from it the amount of nitrogen. The picture of a chemist sitting by the window shows this latter operation. He has poured the contents of the bulb-tube into a dish called a beaker, added a few drops of litmus, which colors the liquid red, and is carefully drawing another liquid containing ammonia from an upright tube, called a burette, into the beaker. When just enough to neutralize the acid has been drawn into the beaker the color suddenly changes from red to purple. The burette is marked so that he knows just how much of the ammonia is required to neutralize the acid not neutralized by the ammonia from the wheat, and thus the quantity of the latter, and with it the quantity of nitrogen in the wheat, are known.

DETERMINING THE AMOUNT OF AMMONIA WHICH CAME FROM THE NITROGEN OF THE WHEAT.

By such operations as these we are enabled to make analyses of different food materials, of the tissues and fluids of the body, and of other substances as well.

THE CHEMICAL ELEMENTS AND COMPOUNDS OF THE BODY.

BEFORE entering upon our study of foods it will be well to consider with some detail the composition of the human body. For a brief statement of the elements nothing can serve us better than the accompanying reproduction of some of the case-labels of the food collection in the United States National Museum at Washington. The figures are as computed by Messrs. E. A. Welch and R. H. Pomeroy, students in this laboratory, who have been at more pains than any one else, so far as I am aware, to use data collated from all available sources. No one has ever made a complete chemical analysis of a human body, but anatomists have made numerous weighings of the different organs, and chemists have analyzed their constituents. From the figures thus obtained it is possible to make an approximate estimate of the composition of the body of an average man, as is here done.

The diagram on the opposite page will help to a clearer idea of the relative proportions of the elements in the body. In the latter the proportions are expressed in percentages, while in the National Museum labels the estimated weights are stated in pounds.

These thirteen elements are combined with one another in the body, forming a great variety of compounds. Chemists have discovered more than a hundred different compounds in the bodies of man and other animals. Instead of attempting to enumerate all of them here, it will be more to our purpose to consider some of the principal ones. In doing so we may take advantage of the fact that the compounds in the body and those in the food are very similar, and discuss them together.

An ox eats grass and meal and transforms the compounds they contain into meat. We eat meat and wheat and change them into the materials of our bodies. Some of the compounds in the food are destroyed, others are only slightly changed in these transformations.

Water, which consists of the two elements hydrogen and oxygen, is a most important constituent of all animal and vegetable tissues. It makes up about seven-eighths of the whole weight of milk and of the flesh of oysters, one-fourth that of potatoes and very lean meat (muscle), one-third of bread, a little over half of well-fattened beef or mutton, and one-eighth of the weight of flour and meal. The body of an average man would, by the above calculation, contain about sixty-one per cent. or three-fifths water.

Of the materials of our bodies and of our foods the larger part is combustible, as was the case with the grain of wheat; that is to say, it will be burned if put in the fire. A small residue will, however, remain as ashes. This incombustible portion includes the so-called mineral matters. These latter consist of the metals potassium, sodium, magnesium, calcium, and iron, combined with other elements, as oxygen,

CHART I.—CHEMICAL COMPOSITION OF THE HUMAN BODY.

ELEMENTS.

The chemical compounds of which our bodies are made up are shown by chemical analysis to consist, mainly, of thirteen elements.

Five of these elements are, when uncombined (*i. e.*, each by itself and not united to any other element), gases. They are named:

1. Oxygen, 2. Hydrogen, 3. Nitrogen, 4. Chlorine, 5. Fluorine.

The other eight are solid substances. Of these, three are non-metals:

6. Carbon, 7. Phosphorus, 8. Sulphur.

The remaining five are metals:

9. Iron, 10. Calcium, 11. Magnesium, 12. Potassium, 13. Sodium.

Besides the above thirteen elements, minute quantities of a few others, as silicon, manganese, and copper, are found in the body.

CARBON — A SOLID.

The body of a man weighing 148 pounds would contain about 31 pounds of carbon.

The diamond is nearly pure carbon. Graphite (the so-called "black lead" of lead-pencils), anthracite coal, coke, lamp-black, and charcoal are impure forms of carbon.

Carbon exists in combination with other elements in the body, of which it makes about one-fifth the whole weight, and in food.

Carbon burns, *i. e.*, combines with oxygen. In this combustion, heat and force are generated and carbonic acid gas formed. The carbon taken into the body in food combines with the oxygen of the inhaled air, yielding heat to keep the body warm and force, muscular strength, for work. The carbonic acid is given out by the lungs and skin. Carbon thus serves as fuel for the body and is the most important fuel element.

PHOSPHORUS — A SOLID.

About 1 pound and 6 ounces of phosphorus would be found in the body of a man weighing 148 pounds.

Phosphorus is a non-metal, light, very inflammable, and so soft that it is easily cut with a knife. Since it burns so readily in air, it is here kept under water.

United with oxygen, phosphorus forms what is known as phosphoric acid. This, with lime, makes phosphate of lime. Most of the phosphorus of the body occurs in this form in the bones and teeth, though it is also found in the flesh and blood, and especially in the brain and nerves.

The composition of the bodies of different persons varies greatly with age, size, fatness, etc. The amounts of the several elements in the body of an average healthy man, five feet eight inches high, weighing 156 pounds with, and 148 pounds without, clothing, may be roughly estimated to be, in pounds and hundredths of a pound, somewhat as follows:

WEIGHTS OF CHEMICAL ELEMENTS IN THE BODY OF A MAN WEIGHING 148 POUNDS.

Oxygen	92.4	pounds
Carbon	31.3	"
Hydrogen	14.6	"
Nitrogen	4.6	"
Calcium	2.8	"
Phosphorus	1.4	"
Potassium	.34	"
Sulphur	.24	"
Chlorine	.12	"
Sodium	.12	"
Magnesium	.04	"
Iron	.02	"
Fluorine	.02	"
Total	148.00	pounds

HYDROGEN — A GAS.

The body of a man weighing 148 pounds is estimated to contain about 14½ pounds of hydrogen, which, if set free, would fill about 2600 cubic feet.

Hydrogen, when uncombined, is a gas. It is the lightest substance known. Combined with oxygen it forms water, of which it constitutes one-ninth of the whole weight. Hydrogen occurs in combination with other elements in the body and in food.

Hydrogen, like carbon, unites with oxygen of the inhaled air in the body, thus serving as fuel. The water produced is given off in the respiration through the lungs, and as perspiration through the skin.

CALCIUM — A METAL.

The body of an average man weighing 148 pounds has been estimated to contain some 3 pounds of calcium.

Calcium is a metal somewhat similar in appearance to magnesium or zinc. It is very difficult to obtain free from other elements. United with oxygen it forms lime. This, with phosphoric acid, makes phosphate of lime, the basis of the bones and teeth, in which nearly all the calcium of the body is found. With carbonic acid, it forms carbonate of lime, the chief ingredient of marble and limestone.

LABELS FROM CASE OF SPECIMENS, ILLUSTRATING COMPOSITION OF HUMAN BODY, IN FOOD COLLECTION OF NATIONAL MUSEUM.

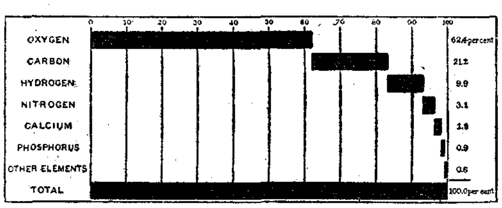


DIAGRAM I.

ESTIMATED PROPORTIONS OF CHEMICAL ELEMENTS.

phosphorus, sulphur, and chlorine. Thus, in bone we have phosphate of lime or calcium phosphate, which consists of calcium, phosphorus, and oxygen; in muscle, potassium phosphate and potassium chloride, the latter a compound of potassium and chlorine, and so on. The mineral matters make about thirty per cent. of the weight of bone, one per cent. of the flesh and blood of animals, and from one-half of one to two per cent. of our ordinary vegetable food materials. The mineral matters constitute about six per cent. of the whole weight of the body of an average man.

The combustible portion of the body and of the food that nourishes it consists of so-called organic compounds. Since these are the most important substances we shall have to do with in our study of foods and nutrition, we ought to have a tolerably clear understanding of the nature of at least the principal ones.

If from a piece of meat we remove the bone, gristle, and fat as completely as practicable, and subject the remaining "lean" (muscle) to chemical analysis, we shall find about one-fourth, or, to speak more accurately, from twenty-two to thirty per cent., of it to consist of organic compounds, the rest being water with a very little mineral matter. Even if all the visible fat is removed, part of this organic matter will consist of fat in microscopic particles. The fatter the animal from which the meat comes, the more of these minute particles of fat and the less water will there be in the muscle, a fact, by the way, which has the most interesting bearing upon the composition of our own bodies, as we shall see later on. If, however, we assume that the fat and the mineral matter are both out of the way, some very remarkable compounds will remain. The bulk will consist of substances very similar to the albumen or "white" of eggs, and hence called albuminoid — albumen-like — compounds. They are sometimes called proteids, but the name albuminoids is perhaps preferable. Albuminoids in different forms make the basis of blood and muscle. Fresh blood contains blood-albumen and other albuminoids; coagulated blood contains fibrine. Muscle contains muscle-albumen, and other albuminoids called syntonin and myosin. The last is the chief constituent, except water, of muscle. Many persons are surprised to learn that myosin, instead of being the tenacious substance of which muscle is commonly supposed to consist, is in living muscle probably liquid or semi-liquid. How the contractile power of the muscle of an athlete can be exerted by liquid or semi-liquid matter is one of the unsolved problems of chemical physiology.

Albuminoids occur in great variety in plants as well as in animals, but they all consist of the four elements carbon, oxygen, hydrogen, and nitrogen, with perhaps a little sulphur or phosphorus.

Along with muscle, the meat contains what we call gristle, the substance that bothers us so much when we try to carve with a dull knife. This name, however, is applied to several substances, as tendon and cartilage, which, with skin and bone, etc., are called connective tissues. These tissues consist mainly of compounds like the collagen of tendon and the ossein of bone. They are very similar to gelatin (glue) and are changed to gelatin on heating with water. They are hence termed gelatinoids. The gelatinoids are thus the principal ingredients of connective tissue, as albuminoids are the principal ingredients of muscle and blood. The gelatinoids consist of the same elements as the albuminoids; these two classes differ from the other organic compounds in that they contain nitrogen, which most of the others do not.

In speaking of the ingredients of foods, it is customary to give to both albuminoids and gelatinoids the generic name of protein. Protein compounds are the most important of all the ingredients of foods.

There is still another class of nitrogenous substances in meat which, though so small in quantity as to be often left out of account, are nevertheless extremely interesting. These are known in the chemical laboratory as creatin, creatinin, carnin, etc., and are designated collectively as "extractives," because they are extracted from flesh by water, as in the case with beef tea and Liebig's Meat Extract.

Chemists find certain analogies between these extractives from flesh and thein and caffein, the active principles of tea and coffee, which they likewise resemble in their stimulating effect. The African traveler Rohlfs tells how invigorating he found a little meat extract spread on a piece of dry bread. The familiar fact that dogs that are quiet and subdued with vegetable food grow fierce on meat is most probably explained as the effect of these same substances. Some people, oftenest those of a fine nervous organization, I presume, find in meat a stimulating effect approaching that of wine. The extractives are similar to alcohol in that they do not form tissue, flesh, or fat. They have, apparently, no effect as fuel. In brief, they are stimulants rather than nutrients.

The extractives give the taste to fresh meat. They impart their savory smell and taste to soups, give roast beef its appetizing odor, and steak its toothsome taste. Our craving for meat is largely due to our fondness for these extractives, as the tastelessness of meat from which they have been removed in making soups bears witness. Indeed, I mistrust that the excessive use of meat, from which the average gourmand — and many of us are veritable gourmands in this respect — suffers so much harm to health, is traceable to the redolence and relish of creatin and other extractives. Though the extractives are different from true protein compounds, they contain nitrogen, and we may follow a common usage and class them as protein.

The body of an average man will contain about eleven per cent. of albuminoids, a little over six of gelatinoids, and about one of extractives, making in all not far from eighteen per cent. of protein.

Among the most important organic compounds of the body and of foods are the fats, of which chemists recognize many different kinds. In the body of man and many other animals, the principal ones are stearin, palmitin, and olein. Stearin, which is obtained in large quantities from beef tallow, is much used for candles, because it does not melt readily. Olein, on the other hand, is an oil at ordinary temperature, and is a chief ingredient of olive oil. A large part of the fat of the human body consists of olein. The fats just named consist of the three elements carbon, oxygen, and hydrogen.

The brain, nerves, and spinal cord contain substances called protagon, lecithin, cerebrin, etc., which, though commonly classed as fats, contain nitrogen and phosphorus, and are therefore known as nitrogenized and phosphorized fats. They have an especial interest because they are believed to be somehow connected with mental activity.

The fats make up about sixteen per cent. of the weight of an average man.

The other compounds in the body are so small in amount that we might pass them by. One class, however, the carbohydrates, demand a moment's notice, because they make up a large part of our food. These include sugar, starch, dextrin, and like substances. The principal ones in the body are glycogen, or liver-sugar, and inosite, or muscle-sugar. They consist of carbon, oxygen, and hydrogen, the same elements as occur in the fats, though not in the same proportions. They constitute only a fraction of one per cent. of the weight of a healthy human body.

To recapitulate, the estimated weights of these compounds in the body of an average man weighing 148 pounds, or, with clothing, 156 pounds, may be stated as in the figures below. The percentage composition is set forth more graphically in Diagram II.

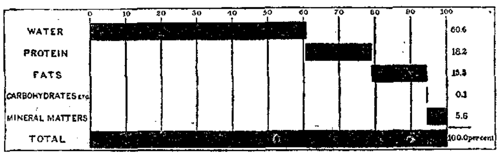


DIAGRAM II.—ESTIMATED PROPORTION OF CHEMICAL COMPOUNDS IN THE HUMAN BODY.

Compounds in the Body of a Man weighing 148 Pounds.

Water	90.0	pounds
Protein	26.6	"
Fats	23.0	"
Carbohydrates	0.1	"
Mineral matters	8.3	"
Total	148.0	pounds.

Of course I do not mean that this is an exact statement of the amounts of the compounds in the body of any given man or of an ideal man. These figures, like those above cited for the elements, are simply an attempt to show in a general way in about what proportions the materials probably occur in the body of an ordinary man of average size and weight. The bodies of different people vary widely in composition. The flesh of lean persons has more water, and that of fat persons more fat, in proportion to the whole weight. A lean man may gain in weight without corresponding gain of muscle or other protein compounds. The store of fat in his body increases. Part of this fat accumulates in adipose tissue next to the skin and in other masses such as we see in meats. Part is disseminated in small particles through the muscles, bones, and other tissues.

In studying the tissues of animals we find a considerable proportion of these particles of fat to be so small as to be visible only by aid of a powerful microscope. A piece of muscle in which no fat can be seen with the naked eye may yield a considerable quantity of fat when treated with ether in the apparatus for fat-extraction. The muscles, bones, and other tissues contain large proportions of water. As the fat accumulates in them, part of the water goes out to make way for it. When, on the other hand, fat is removed from the living tissues, more or less of the water is restored.*

Accordingly a gain of weight of the body may mean a gain, not only of a corresponding weight of fat, but of enough more fat to make up for the water that is lost. To "get stout" is really to grow fat faster than the scales tell us, and to grow lean is to grow watery.

Of course gain of weight of the body may be due to increase of other materials than fat, as in the case of growing animals. So, too, there may be increase of protein with loss of fat, as in the muscle of an athlete when in a course of training.

PROPORTIONS OF NUTRITIVE INGREDIENTS IN FOOD MATERIALS.

Having learned what our bodies consist of, we have next to study the composition of the food by which they are nourished. Viewed from the standpoint of their uses in the nutrition of man, our food materials may be regarded as consisting of edible material and refuse, and the edible material as made up of water and nutrients. The accompanying adaptation of charts prepared for the food collection of the National Museum summarize what is most necessary to say here about the constituents of food.

We have next to notice the amounts of these ingredients in different food materials. The details will perhaps be best explained by an example.

CONSTITUENTS OF SPECIMEN OF SIRLOIN OF BEEF.

	In flesh, edible portion.	*In meat as bought, including refuse.*
	Per cent.	*Per cent.*
Refuse, bones, etc.	None.	25
Water	60	45
Protein	20	15
Fat	19	14¼
Mineral matters	1	0¾
Total	100	100

As stated above, some fat sirloin of beef was found to consist of about one-fourth refuse

* This statement is based not only upon observations recorded in memoirs and text-books of physiological chemistry, but also upon a somewhat extended series made in this laboratory but still awaiting publication. It rests upon the assumption that the changes in composition of the tissues of the human body are similar

CHART II.—INGREDIENTS OF FOOD MATERIALS.

NUTRIENTS AND NON-NUTRIENTS.

Our ordinary food materials, such as meat, fish, eggs, potatoes, and wheat, etc., consist of:

REFUSE—as the bones of meat and fish, shells of eggs, skin of potatoes, and bran of wheat.

EDIBLE PORTION—as the flesh of meat and fish, white and yolk of eggs, wheat flour.

The edible substance consists of:

WATER,
NUTRITIVE INGREDIENTS OR NUTRIENTS.

The principal kinds of nutrients are:

1. PROTEIN,
2. FATS,
3. CARBOHYDRATES,
4. MINERAL MATTERS.

The water, refuse, and salt of salted meat and fish are called non-nutrients, because they have little or no nutritive value. The water contained in foods and beverages has the same composition and properties as other water; it is, of course, indispensable for nourishment, but is not a nutrient in the sense in which it is here used. In comparing the values of different food materials for nourishment, we may leave the refuse and water out of account and consider only the nutrients.

CLASSES OF NUTRIENTS.

The following are familiar examples of compounds of each of the four principal classes of Nutrients:

PROTEIN:
- *a* ALBUMINOIDS: *E. g., Albumen (white) of eggs; casein (curd) of milk; myosin, the basis of muscle (lean meat); gluten of wheat, etc.*
- *b* GELATINOIDS: *E. g., Collagen of tendons; ossein of bones, which yield gelatin or glue.*

Meats and fish contain very small quantities of another class of compounds called "extractives" (the chief ingredients of beef tea and meat extracts), which contain nitrogen, and hence are commonly classed with protein.

FATS: *E. g., Fat of meat; fat (butter) of milk; olive oil; oil of corn, wheat, etc.*

CARBOHYDRATES: *E. g., Sugar, starch, cellulose (woody fiber).*

MINERAL MATTERS: *E. g., Calcium phosphate, or phosphate of lime; sodium chloride (common salt).*

It is to be especially noted that the protein compounds contain nitrogen, while the fats and carbohydrates have none. The average composition of these compounds is about as follows:

	Protein.	*Fats.*	*Carbohydrates.*
Carbon	53 per cent.	76.5 per cent.	44 per cent.
Hydrogen	7 "	12.0 "	6 "
Oxygen	24 "	11.5 "	50 "
Nitrogen	16 "	None	None
	100 "	100.0 "	100 "

bone, etc., and three-fourths edible flesh. The edible portion was analyzed and found to contain, approximately, sixty per cent. of water and forty per cent. of nutrients. Of the nutrients the protein constituted, in round numbers, twenty, the fats nineteen, and the mineral matters one per cent.

Such numerical statements, however, are not entirely satisfactory, especially when a number are to be studied at once. Diagram III. (pages 70 and 71), in which the proportions of the ingredients are indicated by shaded bands, will doubtless be more acceptable.

Until within the past dozen years very little attention has been given in this country to the chemistry of animal and vegetable products, and most of the work actually done has had reference to their agricultural values. With the exception of analyses of cereals and dairy products we have very few American studies of materials used as food for man, aside from those referred to above as executed in behalf of the National Museum, and a series of investigations of the chemistry of food-fishes made for the United States Fish Commission. Much more work in this direction, including the more purely scientific study of the constitution of the materials, is, therefore, most pressingly needed. At the same time the analyses at hand, which have been used in compiling the figures of the diagram, will suffice to give a general and, I think, tolerably correct idea of the average composition of the materials. In some cases where American analyses are lacking, particularly of vegetable foods, I have used European analyses, of which a large number are on record.

I ought to say that different specimens of the same kind of food material may vary

to those found to take place in the bodies of other animals. It is by no means urged that the quantities of water and fat which thus mutually replace each other are exactly the same. A striking illustration of the mutual replacement of water and fat may be seen in the case of the lean and the fat mackerel in Part II. of the double-page diagram of composition of food materials beyond.

widely in composition and that the analyses here given represent averages. Examples of these variations are shown in the cases of oysters and of mackerel in Part II. of the table. In these, however, the differences are unusually wide, although very considerable variations are found in other materials, especially in meats.

The diagram tells its story plainly, and I need now call attention to but few points. It is interesting to note, in Part I., the differences in the amounts of refuse and edible portion in the different kinds of meats, fish, etc., as they are ordinarily found in the markets. Thus in some of the specimens of beef, as the round steak, the bone and other inedible materials amount to only ten per cent. of the whole, whereas in the flounder the refuse amounts to two-thirds, and the edible portion to only one-third, of the whole. The bone, though counted here as refuse, yields, when properly boiled, a considerable quantity of nutritive matter, chiefly in the form of gelatine and fats. Fish, as we buy them in the markets, have on the average a larger proportion of refuse and less edible material than meats. Dairy products and most vegetable foods have very little refuse.

In examining the edible portion of the materials, as shown in Part II., it is interesting to note the wide variations in the proportions of water and of nutritive substances. In general the animal foods contain the most water and the vegetable foods the most nutrients, though potatoes and turnips are exceptions, the former being three-fourths and the latter nine-tenths water. Butter, on the other hand, though one of the animal foods, has on the average about nine per cent. of water. The milk from which it is made is not far from seven-eighths water. As stated above, meats have more water in proportion as they have less fats, and *vice versâ*, the fatter the meat the less amount of water in it. Thus, very lean beef (the muscle of a lean animal from which the fat has been trimmed off) may have seventy-eight per cent. of water and only twenty-two per cent. of nutrients. The rather fat sirloin of the diagram has sixty, and the very fat pork only about ten per cent. of water. The flesh of fish is in general more watery than ordinary meats, that of salmon being five-eighths water; codfish, over four-fifths; and flounder, over six-sevenths. Flour and meal have but little water, and sugar almost none.

In examining the proportions of individual nutrients, protein, fats, and carbohydrates, the most striking fact is the difference between the meats and fish, on the one hand, and the vegetable foods on the other. The vegetable foods are rich in carbohydrates, starch, sugar, etc., while the meats have not enough to be worth mentioning. On the other hand the meats abound in protein and fats, of which the vegetable foods usually have but little. Beans and oatmeal, however, are rich in protein, while fat pork has very little.

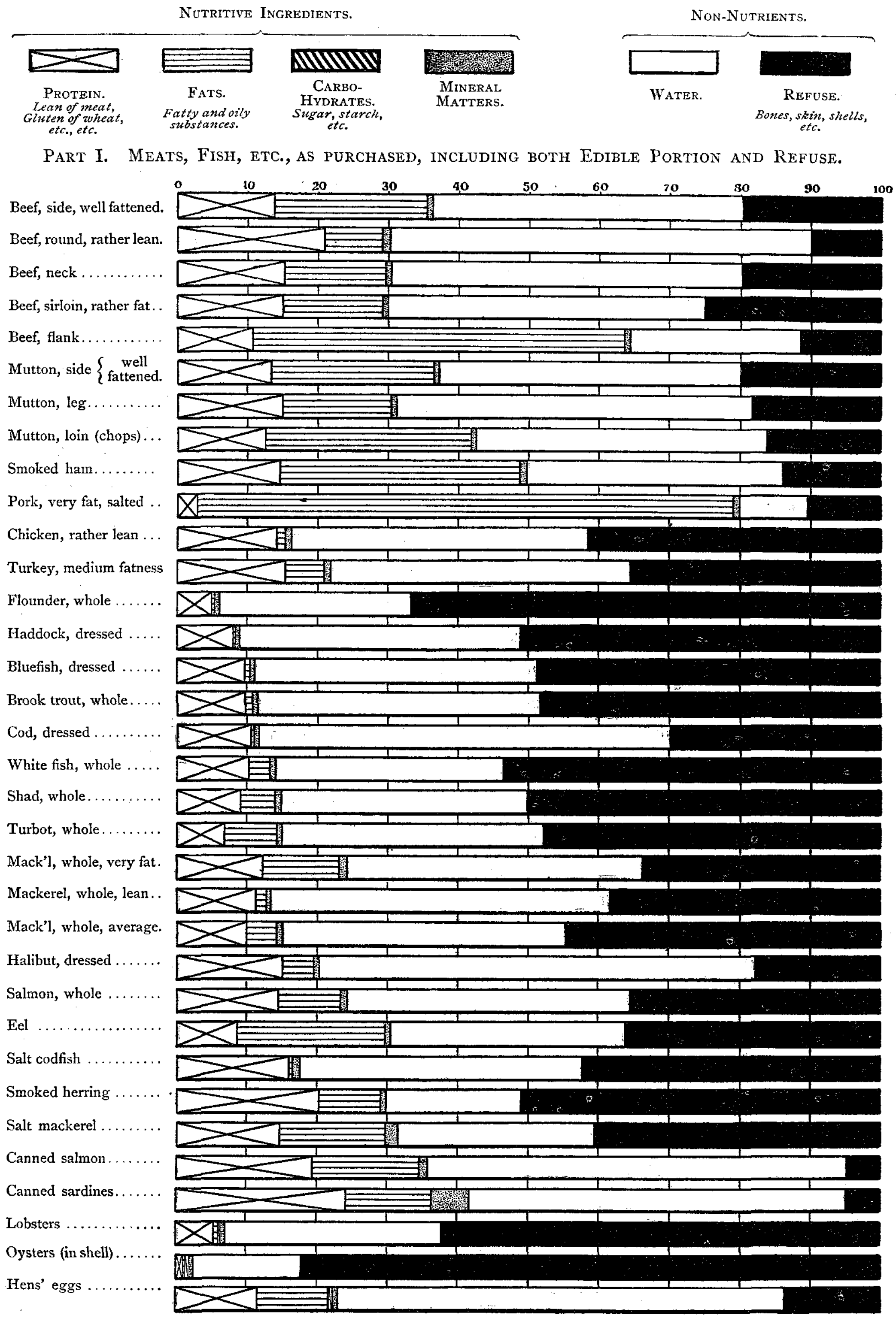
The comparative composition of oysters and milk is worth noting. Both contain about the same total amounts of nutrients, but the proportions are quite different, the oysters having the more protein, and the milk the more fat. Roughly speaking, we may say that there is not a very great deal of difference between the nutritive values of a quart of oysters and a quart of milk. Considering the cost, however, the oysters are far the more expensive food.

I have noticed that people in looking over such tables as this sometimes get at first a wrong impression. Thus rice contains about seven-eighths, and potatoes only one-fourth nutritive material. The first inference is that the rice is much more nutritious than potatoes. In one sense this is true; that is to say, a pound of rice contains more than twice as much nutrients as a pound of potatoes. But if we take enough of the potatoes to furnish as much nutritive material as the pound of rice, the composition and the nutritive values of the two will be just about the same. In cooking the rice we mix water with it, and may thus make a material not very different in composition from potatoes. By drying the potatoes they could be made very similar in composition and food value to rice. Taken as we find them, a pound of rice and three and a half pounds of potatoes would contain nearly equal weights of each class of nutrients and would have about the same nutritive value.

FLOUR AND BREAD.

The composition of wheat flour and wheat bread are worth notice here. The chief difference is in the water, which makes about one-ninth the weight of the flour and one-third that of the bread. Of course different kinds of flour and bread vary widely in composition. The composition of wheat flour here stated is the average of a large number of analyses of American specimens, and doubtless represents very closely the average composition of the flour which people ordinarily buy. The figures for bread are the average of four analyses of loaves purchased at different times at bakeries in Middletown, Connecticut. They agreed very closely in composition with each other and with an excellent specimen of home-made bread. I infer, therefore, that this was better than the average baker's bread, a supposition confirmed by published analyses of the latter,

PERCENTAGES OF THE DIFFERENT CONSTITUENTS

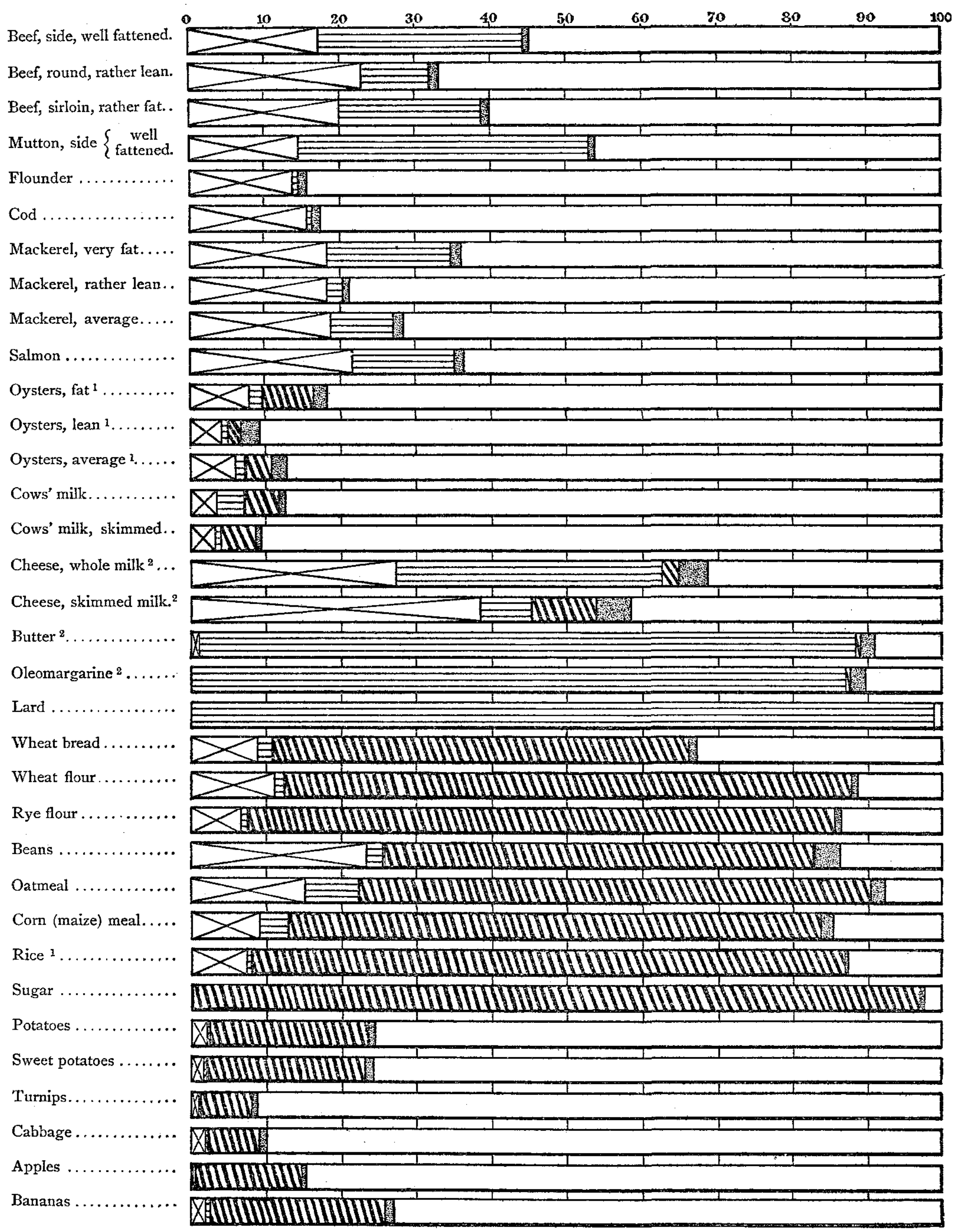


Where the ingredients amount to less than one-half of one per cent. they are omitted from this table.

INDICATED BY SHADED DEVICES.

EXPLANATIONS.—Of the different classes of nutritive ingredients or nutrients of food the protein compounds ("muscle-formers") are the most important in the sense that they alone form the basis of the blood, muscles, tendons, and other nitrogenous tissues of the body. Protein, fats, and carbohydrates of food are all transformed into the fat of the body and all serve as fuel to yield heat and energy (strength) for muscular work. As fuel, one part by weight of fats is estimated to be equivalent to over two parts of protein or carbohydrates. A proper diet will include all the nutrients in proportions fitted to the needs of the user.

PART II. MEATS, FISH, ETC., EDIBLE PORTION; DAIRY PRODUCTS; VEGETABLE FOODS.



1 In respect to quantity of nutrients.

2 Mineral matters include salt.

which often show a much larger percentage of water, sometimes forty per cent. or more. In using the word "better" I do not refer to flavor, color, or texture, but to the proportion of nutrients and water. In making bread, a very little butter or lard and yeast and a good deal of water, by itself or in milk, are added to the flour. In the fermentation of the dough in rising, minor transformations take place in the carbohydrates, the chief being the change of sugar to carbonic acid gas and alcohol. In the baking, the alcohol and gases are mostly driven off, and part of the water goes with it. The chief difference between the flour and bread, therefore, is that the bread is more bulky, the gases having expanded it, and that it contains more water. In other words, in making flour into bread the baker renders it more palatable and increases the bulk and weight, but adds very little nutritive material. For him to manipulate it so as to get the most bulk and weight from the least flour is perfectly natural, and his loaf is apt to contain a large percentage of water and have considerable space inside filled with air and gas. The price of the bread per pound is apt to be twice that of the flour. When the poor man buys his pound loaf of bread of the baker for seven or eight cents he thus gets no more nutritive material than the well-to-do man obtains for three cents in the flour which he has baked at home. But if the poor man's family have no conveniences for making the bread, there is nothing left for them to do but buy it from the baker.

BUTTER AND OLEOMARGARINE.

WITHIN a few years past substitutes for butter have become a very important article of commerce. The most important of these, oleomargarine, agrees very closely in chemical composition with butter from cows' milk, the chief difference being that the oleomargarine contains smaller proportions of the peculiar fats, butyrin, etc., which give butter its agreeable flavor. It is made by taking beef fat or lard, extracting part of the stearin, a material which is familiarly known in candles, and adding a small amount of butter to the residue. It is this small quantity of butter which gives the butter-flavor to the whole.

As will be explained when we come to consider the digestibility of foods, the difference in digestibility between butter and oleomargarine is at most too small to be of any considerable consequence for ordinary use. The nutritive values of the two are very nearly the same. In fulfilling one of the most important functions of food, that of supplying heat and muscular energy, butter and oleomargarine excel in efficiency all, or nearly all, of our other common food materials; at least such is the outcome of the best experimental testimony. In appearance and flavor the common kinds of oleomargarine resemble butter so closely that it is difficult even for an expert to distinguish between them.

These butter substitutes are manufactured at very low cost, so that they can be sold at retail at about half the price of butter. They are, therefore, food products of large economic importance and of great benefit to that large class of our population whose limited incomes make good dairy butter a luxury, and, for that matter, to all who need to economize in their living expenses.

Like many other manufactured food products, oleomargarine is liable to be rendered unwholesome by improper materials and methods of manufacture. Butter, likewise, is often improperly made and is liable to become unwholesome. In the considerable mass of evidence which has come under my own observation there is no indication that butter substitutes, as they are actually sold in our markets, average less wholesome or healthful or are in any way less fit for human food than ordinary butter, though some observers in whose judgment I have confidence are inclined to think that on the whole the advantage as regards wholesomeness is somewhat in favor of butter. Among the chemists who are recognized as authorities in these matters, both in this country and in Europe, there is very little difference of opinion as to the value of oleomargarine for food.

There is, however, a popular prejudice against imitation butter which is very unfortunate, especially for people in moderate circumstances and for the poor, whom it is most calculated to benefit. This prejudice, which a new food material very naturally meets, is fostered, and often conscientiously, by representatives of the dairy interest, which fears from imitation butter a damaging competition, though the most accurate statistics show it to be far less serious than is generally believed. On the other hand, the benefit which butter substitutes are calculated to bring is largely prevented, and an immense wrong is done by the very general sale of the imitation under the guise and name and at the price of butter.

In a number of States in which the dairy interests are large, the manufacture and sale of butter substitutes has been prohibited by legislative action. In other States laws have been enacted to regulate their sale and prevent fraud. An attempt was made in Congress to check the manufacture and sale by taxation sufficient to bring their cost nearly up to that of butter. In the law as actually passed, however, the tax was very much reduced, so that while it may help toward preventing improper sale of butter substitutes and, by obliging sellers to pay high license fees, may considerably interfere with their general use, it will not be as effective in excluding them from the markets as was desired.

This is a case where mechanical invention aided by science is enabled to furnish a cheap, wholesome, and nutritious food for the people. Legislation to provide for official inspection of this, as of other food products, and to insure that it shall be sold for what it is and not for what it is not, is very desirable. Every reasonable measure to prevent fraud, here as elsewhere, ought to be welcomed. But the attempt to curtail or suppress the production of a cheap and useful food material by law, lest the profits which a class, the producers of butter, have enjoyed from the manufacture of a costlier article may be diminished, is opposed to the interests of a large body of people, to the spirit of our institutions, and to the plainest dictates of justice.*

In discussing the composition of our foods we must consider not only the quantities of nutritive ingredients which they contain, but also the part each one of these classes of nutrients has to perform in the nourishment of the body, and the proportions which are appropriate for the diet of different persons.

The protein compounds, sometimes called "muscle-formers," are the only ones which contain nitrogen. According to the best experimental evidence they alone form the basis of blood, muscle, tendon, and other nitrogenous tissues of the body. As these tissues are worn out by constant use they are repaired by the protein of the food. The protein, fats, and carbohydrates are all transformed into fat. They all seem to share, therefore, in the formation of the fat of the body. They all likewise serve as fuel to maintain the heat of the body and to yield muscular energy for its work. Late experiments indicate that in those serving as fuel, one part by weight of fats is equivalent to a little over two parts of either protein or of carbohydrates. The mineral matters make up a large part of the bones and teeth, small proportions are contained in the other tissues, and they are necessary for nutrition in various other ways.

It is a fundamental principle of food economy that the diet should contain nutritive material adapted to the wants of the consumer. A great deal of experimenting and observation have been devoted to the determination of the quantities of protein, fats, and carbohydrates needed for the daily nourishment of individuals of different age and sex, at work or at rest, and subject to the varied conditions of life. In Germany, where the subject has been most thoroughly studied, it has come to be commonly accepted that about 4.2 ounces of protein, 2 ounces of fats, and 17.6 ounces of carbohydrates will make a fair daily ration for a laboring man of average weight and doing moderate work. Of course he can get on with less of one if he has more of the others. But there is a minimum below which he cannot go without injury, and his amount of protein should not fall much below the 4.2 ounces per day, though protein, as we shall see later on, is by far the costliest of the nutrients. In animal foods, furthermore, it is usually associated with the so-called extractives, which have a peculiarly agreeable flavor. In accordance with one of those universal processes of natural selection which science is gradually helping us to understand, the food of the poor is apt to contain too little protein and that of the rich too much.

The flesh of codfish contains, aside from water, little else than protein, butter is almost wholly fat, and sugar and starch are carbohydrates. The lean meats are similar to codfish; fat pork resembles butter, and the chief nutrient of potatoes and rice is starch. Each of these materials is unfit by itself for nourishment. Milk, on the other hand, abounds in all the nutrients and is more nearly a "perfect food," for those with whom it agrees, than any other animal food material. While meats and fish are rich in protein, and most meats and some fish abound in fats, the vegetable foods generally lack protein and fats but have an excess of carbohydrates, of which the meats and fish have none. Beans and pease, however, have a good deal of protein.

We have here a very simple chemical explanation of a usage which, under the promptings of experience or instinct, mankind has almost everywhere come to adopt,— that of supplementing wheat and corn and rice and potatoes with meats and fish, or, when these are lacking, by beans, pease, or other vegetables rich in protein. There is a sound reason in the Hindu's practice of eating pulse with rice, in the Irishman's use of skimmed milk with his potatoes, in the Scotchman's

*The following is from the late report of the Dairy Commissioner of Connecticut, which comes to hand just as this is being written:

"As a protection to consumers the national law is a failure, and the present tax is too small to benefit our dairies to any appreciable extent; a ten cent tax might more nearly have accomplished what the national law was intended to accomplish, but as matters now stand the national law is simply a source of revenue to the national government, and practically levies a tax on poor people who can ill afford to bear it."

partiality for oatmeal, haddock, and herring, and in the frugal New England diet of codfish and potatoes and pork and beans.

Reserving further consideration of these subjects for future articles, I may briefly recapitulate some of the main points already considered.

First. Our bodies and our foods consist of essentially the same kinds of materials.

Second. The actually nutritive ingredients of our food may be divided into four classes: protein, fats, carbohydrates, and mineral matters. Leaving water out of account, lean meat, white of egg, casein (curd) of milk, and gluten of wheat consist mainly of protein compounds. Butter and lard are mostly fats. Sugar and starch are carbohydrates.

Third. The nutrients of animal foods consist mainly of protein and fats. Those of the vegetable foods are largely carbohydrates. The fatter kinds of meat and some species of fish, as salmon, shad, and mackerel, contain considerable quantities of fat. The lean kinds of meat and such fish as cod and haddock contain very little fat. Beans, pease, oatmeal, and some other vegetable foods contain considerable quantities of protein.

Fourth. The different nutrients have different offices to perform in the nutrition of the body. The demands of different people for nourishment vary with age, sex, occupation, and other conditions of life. Health and pecuniary economy alike require that the diet should contain nutrients proportioned to the wants of the user.

W. O. Atwater.

IF.

IF he had known that when her proud fair face
Turned from him calm and slow
Beneath its cold indifference had place
A passionate, deep woe.

If he had known that when her hand lay still,
Pulseless so near his own,
It was because pain's bitter, bitter chill
Changed her to very stone.

If he had known that she had borne so much
For sake of the sweet past,
That mere despair said, "This cold look and touch
Must be the cruel last."

If he had known her eyes so cold and bright,
Watching the sunset's red,
Held back within their deeps of purple light
A storm of tears unshed.

If he had known the keenly barbéd jest
With such hard lightness thrown
Cut through the hot proud heart within her breast
Before it pierced his own.

If she had known that when her calm glance swept
Him as she passed him by
His blood was fire, his pulses madly leapt
Beneath her careless eye.

If she had known that when he touched her hand
And felt it still and cold
There closed round his wrung heart the iron band
Of misery untold.

If she had known that when her laughter rang
In scorn of sweet past days
His very soul shook with a deadly pang
Before her light dispraise.

If she had known that every poisoned dart —
If she had understood
That each sunk to the depths of his man's heart
And drew the burning blood.

If she had known that when in the wide west
The sun sank gold and red
He whispered bitterly, "'Tis like the rest;
The warmth and light have fled."

If she had known the longing and the pain,
If she had only guessed,—
One look — one word — and she perhaps had lain
Silent upon his breast.

If she had known how oft when their eyes met
And his so fiercely shone,
But for man's shame and pride they had been wet —
Ah! if she had but known!

If they had known the wastes lost love must cross,—
The wastes of unlit lands,—
If they had known what seas of salt tears toss
Between the barren strands.

If they had known how lost love prays for death
And makes low, ceaseless moan,
Yet never fails his sad, sweet, wearying breath —
Ah! if they had but known.

Frances Hodgson Burnett.