ingly soluble in the oils. Treated with alkalies at a high temperature and in the presence of water, the fats are decomposed into fatty acids and glycerine, the acids uniting with the bases to form soaps. Alkaline, mucilaginous, and some animal fluids—particularly the pancreatic juice—are capable of holding fat in a state of minute and permanent subdivision and suspension, forming what are known as emulsions.

The three varieties of fats usually recognized are stearine and palmitine, which are solid at the temperature of the body, and oleine, which is liquid. The formulæ for these varieties are the following:

Stearine (Tristearine), $C_{57}H_{110}O_6$

Palmitine (Tripalmitine), $C_{51}H_{98}O_6$

Oleine (Trioleine), $C_{57}H_{104}O_6$

It is noticeable that in the composition of fats, the hydrogen and oxygen do not exist in the proportions to form water, as they do in the carbohydrates, and that they are relatively poor in oxygen. One variety of fat can not be converted into another by chemical manipulation.

As alimentary substances, fats are undoubtedly of great importance. They are supposed by many to be particularly concerned in the production of animal heat. It has been proved by repeated experiments that fat, as a single article of diet, is insufficient for the purposes of nutrition.

Inorganic Alimentary Substances.—It has been shown that all the organs, tissues and fluids of the body contain inorganic matter in greater or less abundance. The same is true of vegetable products. All the organic nitrogenized matters contain mineral substances which can not be separated without incineration. When new organic matter is appropriated by the tissues to supply the place of that which has become effete, the mineral substances are deposited with them; and the organic matters, as they are transformed into excrementitious substances and discharged from the body, are always thrown off in connection with the mineral substances which enter into their composition. This constant discharge of inorganic matters, forming, as they do, an essential part of the organism, necessitates their introduction with the food, in order to maintain the normal constitution of the parts. As these matters are necessary to the proper constitution of the body, they must be regarded as alimentary substances.

Water.—This is one of the most important of the constituents of the organism, is found in every tissue and part without exception, is introduced with all kinds of food and is the basis of almost all drinks. As a rule it is taken in greater or less quantity in a nearly pure state. Although, as a drink, water should be colorless, odorless and tasteless, it always contains more or less saline and other matters in solution, with a certain quantity of air. The air and gases may be driven off by boiling or by removing the atmospheric pressure. The demand on the part of the system for water is regulated, to a certain extent, by the quantity discharged from the organism, and this is subject to great variations. The quantity taken as drink also depends very much on the constitution of the food as regards the water which enters into its composition.

Sodium Chloride.—Of all saline substances, sodium chloride is the one most widely distributed in the animal and the vegetable kingdoms. It exists in all varieties of food; but the quantity which is taken in combination with other matters is usually insufficient for the purposes of the economy, and common salt is generally added to certain articles of food, as a condiment, when it improves their flavor, promotes the secretion of certain of the digestive fluids and meets a nutritive demand on the part of the system. Experiments and observations have shown that a deficiency of sodium chloride in the food has an unfavorable influence on the general processes of nutrition.

Calcium Phosphate.—This is almost as common a constituent of vegetable and animal food as sodium chloride. It is seldom taken except in combination, particularly with nitrogenized alimentary matters. Its importance in alimentation has been experimentally demonstrated, it having been shown that in animals deprived as completely as possible of this salt, the nutrition of the body, particularly in parts which contain it in considerable quantity, as the bones, is seriously affected.

Iron.—Hæmaglobine, the coloring matter of the blood, contains, intimately united with organic matter, a certain proportion of iron. Examples of simple anæmia, which are frequently met with in practice and are almost always relieved in a short time by the administration of iron, are proof of the importance of this substance in alimentation. The quantity of iron which is discharged from the body is very slight, only a trace being discoverable in the urine. A small quantity of iron is frequently introduced in solution in the water taken as drink, and it is a constant constituent of milk and eggs. When its supply in the food is insufficient, it is necessary, in order to restore the normal processes of nutrition, to administer it in some form, until its proportion in the organism shall have reached the proper standard.

It is hardly necessary even to enumerate the other inorganic alimentary substances, as nearly all are in a state of such intimate combination with nitrogenized matters that they may be regarded as part of their substance. Suffice it to say, that all the inorganic matters which exist as constituents of the organism are found in the food. That these are essential to nutrition, can not be doubted; but it is evident that by themselves they are incapable of supporting life, as they can not be converted into either nitrogenized or non-nitrogenized organic matters.

Alcohol.—All distilled and fermented liquors and wines contain a greater or less proportion of alcohol. As these are so generally used as beverages, and as the effects of their excessive use are so serious, the influence of alcohol upon the organism has become one of the most important questions connected with alimentation. Some alcoholic beverages influence the functions solely through the alcohol which they contain; while others, as beer and porter, with a comparatively small proportion of alcohol, contain a considerable quantity of solid matter.

Alcohol (C_2H_6O), from its composition, is to be classed with the non-nitrogenized substances. It has already been stated that sugar and fat are essen-

tial to proper nutrition and that they undergo important changes in the organism. Alcohol is absorbed and taken into the blood; and it becomes a question of importance to determine whether it be consumed in the economy or whether it be discharged unchanged by the various emunctories.

Alcohol has long since been recognized in the expired air after it has been taken into the stomach; and late researches have confirmed the earlier observations with regard to its elimination in its original form, and have shown that after it has been taken in quantity, it exists in the blood and all the tissues and organs, particularly the liver and nervous system. Lallemand, Perrin and Duroy have stated, also, that there is a considerable elimination of alcohol by the lungs, skin and kidneys; but the accuracy of the experiments by which these results were arrived at has been questioned. The observations of Anstie and of Dupré have, indeed, thrown great doubt upon the chromic-acid test for alcohol, which was employed by the French observers above mentioned. Nevertheless, when alcohol has been taken in narcotic doses, there is some alcoholic elimination in the urine, as was shown long ago by Percy.

As the result of the final experiments of Anstie, it is certain that most of the alcohol which is taken in quantities not sufficient to produce alcoholic intoxication is consumed in the organism, and but a trivial quantity is thrown off, either in the urine, the fæces, the breath or the cutaneous transpiration. This question is of importance with regard to the moderate use of alcohol under normal conditions, and especially in its bearing upon the therapeutical action of the various alcoholic drinks administered in cases of disease.

Taken in moderate quantity, alcohol generally produces a certain degree of nervous exaltation which gradually passes off. In some individuals the mental faculties are sharpened by alcohol, while in others they are blunted. There is nothing, indeed, more variable than the immediate effects of alcohol on different persons. In large doses the effects are the well known phenomena of intoxication, delirum, more or less anæsthesia, coma, and sometimes, if the quantity be excessive, death. As a rule, the mental exaltation produced by alcohol is followed by reaction and depression, except in debilitated or exhausted conditions of the system, when the alcohol seems to supply a decided want.

The views of physiologists concerning the influence of a moderate quantity of alcohol on the nervous system are somewhat conflicting. That it may temporarily give tone and vigor to the system when the energies are unusually taxed, can not be doubted; but this effect is not produced in all individuals. The constant use of alcohol may create an apparent necessity for it, producing a condition of the system which must be regarded as pathological.

The immediate effects of the ingestion of a moderate quantity of alcohol, continued for a few days, are decided. It notably diminishes the exhalation of carbon dioxide and the discharge of other excrementitious matters, particularly urea. These facts have long since been experimentally demonstrated. Proper mental and physical exercise, tranquillity of the nervous system,

and all conditions which favor the vigorous nutrition and development of the organism physiologically increase, rather than diminish, the quantity of the excretions, correspondingly increase the demand for food, and if continued, are of permanent benefit. Alcohol, on the other hand, diminishes the activity of nutrition. If its use be long continued, the assimilative powers of the system become so weakened that the proper quantity of food can not be appropriated, and alcohol is craved to supply a self-engendered want. The organism may, in many instances, be restored to its physiological condition by discontinuing the use of alcohol; but it is generally some time before the nutritive powers become active, and alcohol, meanwhile, seems absolutely necessary to existence.

Under ordinary conditions, when the organism can be adequately supplied with food, alcohol is undoubtedly injurious. When the quantity of food is insufficient, alcohol may supply the want for a time and temporarily restore the powers of the body; but the effects of its continued use, conjoined with insufficient nourishment, show that it can not take the place of other assimilable matters. These effects are too well known to the physician, particularly in hospital-practice, to need farther comment. Notwithstanding these undoubted physiological facts, alcohol, in some form, is used by almost every people on the face of the earth, civilized or savage. Whether this be in order to meet some want occasionally felt by and peculiar to the human organism, is a question upon which physiologists have found it impossible to agree. That alcohol, at certain times, taken in moderation, soothes and tranquillizes the nervous system and relieves exhaustion dependent upon unusually severe mental or physical exertion, can not be doubted. It is by far too material a view to take of existence, to suppose that the highest condition of man is that in which the functions, possessed in common with the lower animals, are most perfectly performed. Inasmuch as temporary insufficiency of food, great exhaustion of the nervous system, and various conditions in which alcohol seems to be useful, must of necessity often occur, it is hardly proper that this agent should be absolutely condemned; but it is the article, *par excellence*, which is liable to abuse, and the effects of which on the mind and body, when taken constantly in excess, are most serious.

Although alcohol imparts a certain warmth when the system is suffering from excessive cold, it is not proved that it enables men to endure a very low temperature for a great length of time. This end can be effectually attained only by an increased quantity of food. The testimony of Dr. Hayes, the Arctic explorer, is very strong upon this point. He says: "While fresh animal food, and especially fat, is absolutely essential to the inhabitants and travellers in Arctic countries, alcohol is, in almost any shape, not only completely useless but positively injurious . . . . Circumstances may occur under which its administration seems necessary; such, for instance, as great prostration from long-continued exposure and exertion, or from getting wet; but then it should be avoided, if possible, for the succeeding reaction is always to be dreaded; and, if a place of safety is not near at hand, the immediate danger is only temporarily guarded against, and becomes, finally, greatly augmented

by reason of decreased vitality. If given at all, it should be in very small quantities frequently repeated, and continued until a place of safety is reached. I have known the most unpleasant consequences to result from the injudicious use of whiskey for the purpose of temporary stimulation, and have also known strong able-bodied men to have become utterly incapable of resisting cold in consequence of the long-continued use of alcoholic drinks." In a recent paper by General Greely (1887), is the following, which confirms the results of the experience of Hayes: "It seems to me to follow from these Arctic experiences that the regular use of spirits, even in moderation, under conditions of great physical hardship, continued and exhausting labor, or exposure to severe cold can not be too strongly deprecated, and that when used as a mental stimulus or as a physical luxury they should be taken in moderation. When habit or inclination induces the use of alcohol in the field, under conditions noted above, it should be taken only after the day's work is done, as a momentary stimulus while waiting for the preferable hot tea and food; or better, after the food, when going to bed, for then it may quickly induce sleep and its reaction pass unfelt."

It is not demonstrated that alcohol increases the capacity to endure severe and protracted bodily exertion. Its influence as a therapeutic agent, in promoting assimilation in certain conditions of defective nutrition, in relieving shock and nervous exhaustion, in sustaining the powers of life in acute diseases characterized by rapid emaciation and abnormally active disassimilation, etc., can hardly be doubted; but the consideration of these questions does not belong to physiology.

Coffee.—Coffee is an article consumed daily by many millions of human beings in all quarters of the globe. In armies it has been found almost indispensable, enabling men on moderate rations to perform an amount of labor which would otherwise be impossible. After exhausting efforts of any kind, there is no article which relieves the overpowering sense of fatigue so completely as coffee. Army-surgeons say that at night, after a severe march, the first desire of the soldier is for coffee, hot or cold, with or without sugar, the only essential being a sufficient quantity of the pure article. Almost every one can bear testimony from personal experience to the effects of coffee in relieving the sense of fatigue after mental or bodily exertion and in increasing the capacity for labor, especially mental work, by producing wakefulness and clearness of intellect. From these facts, the importance of coffee, either as an alimentary substance or as taking the place, to a certain extent, of aliment, is apparent.

Except in persons who, from idiosyncrasy, are unpleasantly affected by it, coffee, taken in moderate quantity and at proper times, produces an agreeable sense of tranquillity and comfort, with, however, no disinclination to exertion, either mental or physical. Its immediate influence upon the system, which is undoubtedly stimulant, is peculiar and is not followed by reaction or unpleasant after-effects. Habitual use renders coffee almost a necessity, even in those who are otherwise well nourished and subjected to no extraordinary mental or bodily strain. Taken in excessive quantity, or in those unaccustomed to its use, particularly when taken at night, it produces persistent wakefulness. These effects are so well known that it is often taken for the purpose of preventing sleep.

Experimental researches have shown that the use of coffee permits a reduction in the quantity of food, in workingmen especially, much below the standard which would otherwise be necessary to maintain the organism in proper condition. In the observations of De Gasparin upon the regimen of the Belgian miners, it was found that the addition of a quantity of coffee to the daily ration enabled them to perform their arduous labors on a diet which was even below that found necessary in prisons where this article was not used. Experiments have shown, also, that coffee diminishes the absolute quantity of urea discharged by the kidneys. In this respect, as far as has been ascertained, the action of coffee is like that of alcohol, and it may reasonably be supposed to retard disassimilation, with the important difference that it is followed by no unfavorable after-effects and can be used in moderation for an indefinite time with advantage.

A study of the composition of coffee shows a considerable proportion of what must be considered as alimentary matter. The following is the result of analyses by Payen:

Cellulose	34·000
Water (hygroscopic)	12·000
Fatty substances	10 to 13·000
Glucose, dextrine, indeterminate vegetable acid	15·500
Legumine, caseine etc.	10·000
Potassium chlorolignate and caffeine	3·5 to 5·000
Nitrogenized organic matter	3·000
Free caffeine	0·800
Concrete, insoluble essential oil	0·001
Aromatic essence, of agreeable odor, soluble in water	0·002
Mineral substances; potash, magnesia, lime, phosphoric, silicic, and sulphuric acid and chlorine	6·697
	100·000

The above is the composition of raw coffee, but the berry is seldom used in that form, being usually subjected to roasting before an infusion is made. During this process, the grains are considerably swollen, but they lose sixteen or seventeen per cent. in weight. A peculiar aromatic substance is also developed by roasting. If the torrefaction be pushed too far, much of the agreeable flavor of coffee is lost, and an acrid, empyreumatic substance is produced.

Tea.—An infusion of the dried and prepared leaves of the tea-plant is perhaps as common a beverage as coffee, and taking into consideration its large consumption in China and Japan, it is actually used by a greater number of persons. Its effects upon the system are similar to those of coffee, but they are generally not so marked. Ordinary tea, taken in moderate quantity, like coffee, relieves fatigue and increases mental activity, but does not usually produce such persistent wakefulness.

It is unnecessary to describe all the varieties of tea in common use. There are, however, certain varieties, called green teas, which present important differences, as regards composition and physiological effects, from the black teas, which latter are more commonly used. The following is a comparative analysis of these two varieties by Mulder:

CONSTITUENTS.	CHINESE TEA.		JAVANESE TEA.	
	Green.	Black.	Green.	Black.
Volatile oil	0·79	0·60	0·98	0·65
Chlorophyl	2·22	1·84	3·24	1·28
Wax	0·28	....	0·32	....
Resin	2·22	3·64	1·64	2·44
Gum	8·56	7·28	12·20	11·08
Tannin	17·80	12·88	17·56	14·80
Theine	0·43	0·46	0·60	0·65
Extractive	22·80	19·88	21·68	18·64
Apotheme	....	1·48	....	1·64
Extract obtained by hydrochloric acid	23·60	19·12	20·36	18·24
Albumin	3·00	2·80	3·64	1·28
Fibrous matter	17·08	28·32	18·20	27·00
	98·78	98·30	100·42	97·70
Salts included in the above	5·56	5·24	4·76	5·36

Both tea and coffee contain peculiar organic substances. The active principle of tea is called theine, and the active principle of coffee, caffeine. As they are supposed to be particularly efficient in producing the peculiar effects upon the nervous system which are characteristic of both tea and coffee, there is good reason to suppose that they are nearly identical in their physiological effects. Analyses more recent than the one quoted from Mulder (Stenhouse, Peligot) have shown that theine, or caffeine ($C_8H_{10}N_4O_2 + H_2O$), exists in greater proportion in tea than in coffee; but as a rule, a greater quantity of soluble matter is extracted in the preparation of coffee, which may account for its more marked effects upon the system. Some analyses have given as much as six per cent. as the proportion of theine in tea (Landois).

Chocolate.—Chocolate is made from the seeds of the cocoa-tree, roasted, deprived of their husks, and ground with warm rollers into a pasty mass with sugar, flavoring substances being sometimes added. It is then made into cakes, cut into small pieces or scraped to a powder, and boiled with milk or milk and water, when it forms a thick, gruel-like drink, which is highly nutritive and has some of the exhilarating properties of coffee or tea. Beside containing a large proportion of nitrogenized matter resembling albumen, the cocoa-seed is particularly rich in fatty matter, and contains a peculiar substance, theobromine ($C_7H_8N_4O_2$), analogous to caffeine and theine, which is supposed to possess similar physiological properties.

The following is an analysis by Payen of the cocoa-seeds freed from the husks but not roasted. Torrefaction has the effect of developing the peculiar aromatic principle, and of moderating the bitterness, which is always more or less marked:

Fatty matter (cocoa-butter)	48 to 50
Albumin, fibrin and other nitrogenized matter	21 " 20
Theobromine	4 " 2
Starch (with traces of saccharine matter)	11 " 10
Cellulose	3 " 2
Coloring matter, aromatic essence	Traces.
Mineral substances	3 to 4
Hygroscopic water	10 " 12
	100 100

It is evident, from the above table, that cocoa with milk and sugar, the ordinary form in which chocolate is taken, must form a very nutritious mixture. Its influence as a stimulant, supplying the place of matter which is directly assimilated, and retarding disassimilation, is dependent, if it exist at all, upon the theobromine; but its stimulating properties are slight as compared with those of coffee and tea.

Condiments and Flavoring Articles.—The refinements of cookery involve the use of many articles which can not be classed as alimentary substances. Pepper, capsicum, vinegar, mustard, spices and other articles of this class, which are so commonly used in various sauces, have no decided influence on nutrition, except in so far as they promote the secretion of the digestive fluids. Common salt, however, is very important, and this has been considered in connection with inorganic alimentary substances. The various flavoring seeds and leaves, truffles, mushrooms etc. have no physiological importance except as they render articles of food more palatable.

Quantity and Variety of Food necessary to Nutrition.—The inferior animals, especially those not subjected to the influence of man, regulate by instinct the quantity and kind of food which they consume. The same is true of man during the earliest periods of his existence; but later in life, the diet is variously modified by taste, habit, climate, and what may be termed artificial wants. It is usually a safe rule to follow the appetite with regard to quantity, and the tastes, when they are not manifestly vitiated or morbid, with regard to variety. The cravings of nature indicate when to change the form in which nutriment is taken; and that a sufficient quantity has been taken is manifested by a sense, not exactly of satiety, but of evident satisfaction of the demands of the system. During the first periods of life, the supply must be a little in excess of the actual loss, in order to furnish materials for growth; during the later periods, the quantity of nitrogenized matter assimilated is somewhat less than the loss; but in adult age, the system is maintained at a tolerably definite standard by the assimilation of matter about equal in quantity to that which is discharged in the form of excretions.

Although the loss of substance by disassimilation creates and regulates the demand for food, it is an important fact, never to be lost sight of, that the supply of food has a very great influence upon the quantity of the excretions. An illustration of this is the influence of food upon the exhalation of carbon dioxide; and this is but an example of what takes place with re-

gard to other excretions. The quantity of the excretions is even more strikingly modified by exercise, which, within physiological limits, increases the vigor of the system, provided the increased quantity of food required be supplied.

While a certain amount of waste of the system is inevitable, it is a conservative provision, that when the supply of new material is diminished, life is preserved—not, indeed, in all its vigor—by a corresponding reduction in the quantity of excretions; and in the same way, the forces are retained after complete deprivation of food much longer than if disassimilation proceeded always with the same activity.

As regards the quantity of food necessary to maintain the system in proper condition, it is evident that this must be greatly modified by habit, climate, the condition of the muscular system, age, sex etc., as well as by idiosyncrasies.

The daily loss of substance which must be supplied by matters introduced from without is very great. A large portion of this discharge takes place by the lungs, and a consideration of the mode of introduction of gases to supply part of this waste belongs to the subject of respiration. The most abundant discharge which is compensated by absorption from the alimentary canal is that of water, both in a liquid and vaporous condition. The entire quantity of water daily removed from the system has been estimated at about four and a half pounds (2,041 grammes), and it is probable that about the same quantity is introduced in the form of drink and as a constituent of the so-called solid articles of food. The quantity which is taken in the form of drink varies with the character of the food. When the solid articles contain a large proportion of water, the quantity of drink may be diminished; and it is possible, by taking a large quantity of the watery vegetables, to exist entirely without drink. There is no article more frequently taken than water, merely as a matter of habit, any excess being readily removed by the kidneys, skin and lungs. Dalton estimates the daily quantity necessary for a full-grown, healthy male, at fifty-four fluid ounces (1,530 grammes), or 3·38 pounds.

The quantity of solid food necessary to the proper nourishment of the body is shown by estimating the solid matter in the excretions; and the facts thus ascertained correspond very closely with the quantity of material which the system has been found to actually demand. The estimates of Payen, the quantity of carbon and of nitrogenized matter in a dry state being given, are generally quoted and adopted in works on physiology. According to this observer, the following are the daily losses of the organism:

Carbon (or its equivalent).	Respiration, 8·825 oz. (250 grammes) Excretions, 2·116 oz. (60 grammes)	10·941 oz. (310 grammes).
Nitrogenized substances (containing 308·64 grains, or 20 grammes of nitrogen)		4·586 oz. (130 grammes).
		15·527 oz. (440 grammes).

From this he estimates that the normal ration, supposing the food to consist of lean meat and bread, is as follows:

Bread	35·300 oz. (1,000 grammes).
Meat (without bones)	10·088 oz. (286 grammes).
	45·388 oz. (1,286 grammes).

	Nitrogenized substances.		Carbon.	
Bread contains	2·469 oz.	(70·00 grammes) and	10·582 oz.	(300·00 grammes).
Meat contains	2·125 oz.	(60·26 grammes) and	1·109 oz.	(31·46 grammes).
	4·594 oz.	(130·26 grammes) and	11·691 oz.	(331·46 grammes).

This daily ration, which is purely theoretical, is shown by actual observation to be nearly correct. Dalton says: "According to our own observations, a man in full health, taking active exercise in the open air, and restricted to a diet of bread, fresh meat, and butter, with water and coffee for drink, consumes the following quantities per day:

Meat	453	grammes, or about	16 oz.
Bread	540	" "	19 oz.
Butter or fat	100	" "	3·5 oz.
Water	1,530	" "	54 oz.

Bearing in mind the great variations in the nutritive demands of the system in different persons, it may be stated, in general terms, that in an adult male, ten to twelve ounces (282 to 340 grammes) of carbon and four to five ounces (113 to 142 grammes) of nitrogenized matter, estimated dry, are discharged from the organism and must be replaced by the ingesta; and this demands a daily consumption of between two and three pounds (907 and 1,361 grammes) of solid food, the quantity of food depending, of course, greatly on its proportion of solid, nutritive constituents.

It is undoubtedly true that the daily ration has frequently been diminished considerably below the physiological standard, in charitable institutions, prisons etc.; but when there is complete inactivity of body and mind, this produces no other effect than that of slightly diminishing the weight and strength. The system then becomes reduced without any actual disease, and there is simply a diminished capacity for labor; but in the alimentation of large bodies of men subjected to exposure and frequently called upon to perform severe labor, the question of food is of great importance, and the men collectively are like a powerful machine in which a certain quantity of material must be furnished in order to produce the required amount of force. This important physiological fact is strikingly exemplified in armies; and the history of the world presents few examples of warlike operations in which the efficiency of the men has not been impaired by insufficient food.

The influence of diet upon the capacity for labor was well illustrated by a comparison of the amount of work accomplished by English and French laborers, in 1841, on a railway from Paris to Rouen. The French laborers engaged on this work were able at first to perform only about two-thirds of the labor accomplished by the English. It was suspected that this was due to the more substantial diet of the English, which proved to be the fact; for when the French laborers were subjected to a similar regimen, they were able to accomplish an equal amount of work. In all observations of