

CHAPTER XVII.

MINERAL ELEMENTS IN FOOD.

THE composition of the human body as given by the physiological chemists contain fifteen chemical elements. These are present approximately in the following percentages:

Oxygen .....	.65	per cent.	Chlorin .....	.22	per cent.
Carbohydrates .....	.18	"	Sodium .....	.15	"
Hydrogen .....	.10	"	Magnesium .....	.05	"
Nitrogen .....	.3	"	Iron .....	.004	"
Calcium .....	.2	"	Iodine	Trace	
Phosphorus .....	.1	"	Flourine	"	
Potassium .....	.35	"	Silicon	"	
Sulphur .....	.25	"			

The first four elements variously combined form the common food substance known as carbohydrates, fats and protein. These are the organic or non-mineral elements. The remaining eleven elements are minerals or inorganic elements. When food materials are burned these minerals are left in the ash, though in the ash they do not exist as the same chemical combinations as they do when combined with the organic material in food or in the body.

ASH CONTENT OF FOOD.—The older school of food chemistry left all these inorganic elements, or "ash" from the burning of food samples grouped together in the tables of food composition as "mineral salts" or "ash." Such method of food analysis was very incomplete and uncertain and, as recent scientific progress has shown, such lumping together of chemical elements vitally important in nutrition failed to tell us the whole necessary truth. In a vague way the chemists realized that the ash content of food was of great importance and in some particular instances the specific purpose and use of these elements was known to the chemists. The followers of the natural school of dietetics, deriving their knowledge from practical observation of the effects of various diets, emphasized the supreme importance of the mineral elements in foods.

A diet of artificial foods as white flour, polished rice, sugar,

glucose, fats and meat may contain correct proportions of carbohydrates, fats and proteins, yet fail to properly nourish the body. On the other hand the natural foods such as milk, eggs, fruits, nuts, entire grain products, and particularly the leafy or salad vegetables, were observed to be highly beneficial in normal diet and particularly useful in the diet of children, and as corrective elements for those suffering from ill health due to the deficiencies of the more artificial and conventional diet.

Of recent years not only has the testimony of the benefit of the such foods which are rich in the mineral elements been repeatedly demonstrated in practice but the laboratory investigations of the physiological and biological chemist have produced an interesting and conclusive fund of knowledge which explains why such benefits have been attained. This knowledge not only teaches us the importance of the mineral content of food considered as a whole, but points out the particular physiological harm that may result from such deficiencies.

Much of the past argument regarding food minerals has centered about the question of their availability to the human body in inorganic form. Because these mineral elements are found in nature or may be manufactured in the laboratory without the aid of the life processes of plants and animals, there was a general belief among the old school of medical scientists, that mineral elements might be supplied to the body in the form of inorganic or artificial salts. On the other hand, the dietitians belonging to the natural food school held that while the chemical elements of food minerals could exist in inorganic combinations, they were not available to the use of the human body. Neither of these early views was entirely correct.

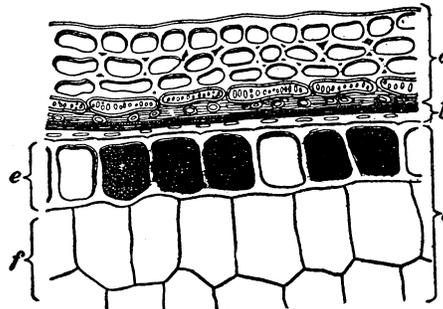
There are some mineral elements, as the sodium and chlorin of common salt, that can be utilized by the body in the simpler inorganic forms. But the more rare and hence more vitally important elements exist for the most part in complex combination with the organic elements of food, hence deficiencies in such elements can not be made good by purely mineral or artificial products.

Of the eleven mineral elements in the human body, iodine, fluorine, silicon, exist in such small quantities that they can be chemically detected by qualitative analysis only, hence any detailed study of their functions is impractical. However, as these elements exist more abundantly in many plant tissues than in the human body it is not likely, with a varied diet supplying the other minerals, that any of these will be deficient, hence we need not consider them further in the present discussion.

This leaves eight elements for further consideration. Two of these, sodium and chlorine, are the components of common salt and are available to the body in that simple form. With conventional man's present custom of liberally salting his food there is no danger of these elements being deficient. In fact, salt requires consideration because of the possible ill effects that may come from the over eating of this common mineral.

The carnivorous animal secures an ample quantity of salt from his diet, for flesh, and particularly blood, is distinctly salty. Many herbivorous animals, both in a wild and domestic state, crave salt. As this is practically the only case in nature in which animals seek food in a mineral form, scientists have searched to find some logical explanation of the phenomena. One view holds that sodium chloride (salt) is craved by animals existing on a vegetable diet because of the over abundance of

potassium or potash salts in vegetable substances. That potash is a highly important element in the composition of plants will be recognized by those who recall its great importance to the fertilizer industry and the role played in the world war by



Section of outer coverings of a grain of wheat. a, outer bran; b, inner bran; d, edible portion, consisting of: e, aleuron layer, rich in protein and salts; f, interior starch.

the isolation of the German potash mines. Potatoes are particularly rich in potash, and if the chemists be correct that may be a reason why we crave salt upon potatoes.

COOKING DESTROYS SALTS.—Unfortunately our modern methods of life have so changed our diet from the normal that few people know what a natural diet is, and the result is they do not get in their food a sufficient supply of these natural salts to build up the body to the most perfect vigor. Cooking also removes much of the organized salts, and to complete the cooking processes satisfactorily and make the food taste as it should mineral salt must be added. Where foods are boiled and the natural salts are leached out into the water and then poured away, as is so often the case, the foods do not contain the salts they should, and the body craves those elements in the foods of which cooking has robbed them.

Hence, in the majority of cases, there is an unsatisfied feeling if salt is absent, which most people proceed to satisfy by a too liberal use of an *artificial substitute* for that of which Nature originally gave an abundant supply. This seems to me to be the most rational explanation of the universal desire for mineral salt.

Common salt is unquestionably of supreme importance in the physiological processes. The adult human body normally contains about 100 grams, or one-fourth pound. The presence of salt in the body fluids is essential to the solution of protein. The relation of salt to the solution of protein may be clearly demonstrated with an experiment which any one can perform in the kitchen. Take a small quantity of the white of egg. Place it in a tumbler of water and the albumen will be precipitated showing a milky whiteness. If salt now be slowly added to the water, the albumen will presently be dissolved and the liquid become quite clear. Different concentrations of various salts effect the solubility of many proteins according to the strength of the salt solutions. The normal workings of the body process unquestionably depend upon the proper content not only of sodium chloride but of other mineral salts in the fluids of the body.

Should a perfectly salt free diet be fed to any person, death would be inevitable. But the essentiality of common salt in the diet does not justify its excessive use. When an excess is taken it is quickly excreted, but if the excess be too great it will result in the overstimulation of the digestive secretions and the interference of food assimilation. Excessive salt is also thought to have an unfavorable effect on protein metabolism. In the case of a long fast the salt excreted for the first ten days of fasting was fourteen grams, for the second ten days two grams, for the third ten days one-half gram. Thus between ten and twenty percent of the salt content of the body is rapidly excreted when we cease to take it in the food, while the remainder is husbanded very carefully. This would seem to indicate that we use too much salt.

Salt in connection with flesh gives rise to scurvy, salt-rheum, kidney trouble and other cutaneous and constitutional disorders. Salt is the cause of inflammation under the breasts, in the armpits and under the nose.

Those who habitually live as near to the natural diet as possible experience great discomfort from thirst if what would be regarded as an ordinary supply of salt meat or salt fish is given them at a meal. It should need no argument to prove that the excessive thirst produced is Nature's protest against a too liberal use of salty food.

Salt, in liberal quantities, as used frequently, is as directly blinding to the sense of taste as the direct rays of the sun shining in the eyes are blinding to the sense of sight. After a continued liberal use of salt the sense of taste becomes so blunted to the natural and finer flavors of food that nothing "tastes good" unless salted to the requirements of the eater.

Hence I would recommend a reasonable caution in the use of mineral salt. Do not allow the taste buds to become so blunted that foods are not satisfactory to you unless heavily salted. Use enough to satisfy the demands of a reasonably normal appetite and there will then be little danger of your being injured by its over use.

POTASSIUM.—The potassium salts are chemically similar to those of sodium, the most abundant form being potassium chloride. This we do not need to add to the food for the reason that it is abundant in all natural diets and therefore there is no danger of potassium deficiency where other mineral essentials of the food are provided for.

SULPHUR.—Sulphur is distinct from the elements just considered, in that food sulphur is taken wholly in an organic combination. Mineral sulphur has no place in the diet and when administered as a drug passes through the alimentary canal as an entirely foreign substance. Sulphur, while a mineral, exists in food in combination with the nitrogen of protein, and in that sense may be considered as part of the organic foods. The amount of sulphur varies slightly with the different forms of protein, but on the average proteins contain about one per cent of sulphur. The sulphur while taken into the body and utilized in organic compounds is reduced in the process of metabolism to inorganic forms and is eliminated chiefly through the kidneys as mineral sulphates.

As proof that the sulphur in the body exists as a constituent of protein, and not in the simpler forms, we note that in the case of fasting, sulphur is excreted from the body at a rate proportionate to the excretion of nitrogen, both resulting from the destruction of the protein compounds. In the process

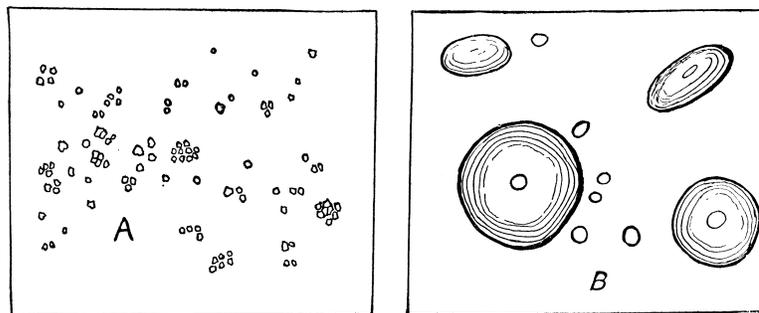


Figure A, starch granules of rice; figure B, starch granules of wheat. Drawings show comparative formation and size. Vol. 1—25

of this destruction sulphuric acid is developed and must be neutralized into sulphur salts or sulphates. This aspect of the metabolism of sulphur will be considered again under the question of the acidity and alkalinity of the fluids of the body. As a practical dietetic consideration, sulphur need not be considered separately from the question of the protein because it will vary in direct proportion and if the protein needs are taken care of, the needs for sulphur will be automatically regulated.

Sulphur also appears in the decomposition of proteins in the intestinal tract giving rise to organic sulphates and to hydrogen sulphide.

PHOSPHORUS.—The utilization of phosphorus in the physiological processes is highly complex. It enters into the composition of the cell nucleus and all cellular structure. Combined with calcium, it forms the chief mineral substance of the bones. It is a highly important element of milk. It exists in the sexual secretions and in the nerves and brain. From the early discovery of the presence of phosphorus in the brain came the saying of the scientists, "No phosphorus, no thought"; and from this same discovery came also the erroneous impression that fish was a brain food.

Functionally, phosphorus is involved in the process of cell multiplication, in the action of digestive and other enzymes, in the neutrality of the blood and body fluids, in the conduct of nerve stimulæ, in the maintenance of osmotic pressure, surface tension and the circulation of body fluids, with the multiplication of cells and with the processes of absorption and secretion.

In fasting, phosphorus is secreted at a steady rate showing that it is part of the living tissue being metabolized and not merely an excess of salt, as is the sodium chloride. The rate of phosphorus secretion in fasting also reveals the fact that bone tissue is being actually metabolized. The distribution of phosphorus in the body is that of 600 parts in the skeleton, 56 in the muscles and 5 in the brain and nerves. The rate of phosphorus secretion in fasting is such that all the phosphorus excreted

could not possibly be derived elsewhere than from the phosphorus in the bones. Hence in fasting, or when phosphorus is absent from the diet, the store in the bones is drawn upon for other physiological needs, in which service the phosphorus is rendered valueless for further body use, hence it is excreted.

It has been shown that milk cows and nursing mothers, on diets deficient in phosphorus, draw upon the supply in the bones, with a resulting weakness of the skeleton. Pigs at the Kansas Experiment Station were fed a diet deficient in mineral ash, and their bones were found to be only one-half as strong as those in normally developed swine.

In the complete diet this element exists in three organic forms, besides the mineral form of phosphorus. The first of these is the phosphorus-containing proteins, notably milk, casein, and ovovitellin of egg yolk. Phosphorous proteins exist in the nuclei of all cells, hence in the proteins of all flesh foods.

The second kind of organic phosphorus is that of phosphorized fats, chief of which is lecithin, a highly important substance found abundantly in the brain and in the yolk of eggs.

Phosphorus also exists in food in combination with carbohydrates. A very surprising recent chemical discovery is that phosphorus in a very small quantity is an essential element in starch.

Experimentation leads us to the belief that phosphorus for bone growth can be absorbed from the simpler mineral forms, but for other bodily uses the phosphorus must be derived from the more highly organized forms. As evidence of this we find that the mineral phosphorus in the milk of different species is in proportion to the rate of growth of the young, and therefore cow's milk is richer in pure phosphorus than human milk, but there is as much phosphorus combined with fat in the form of lecithin in the human milk as there is in the milk of the cow. This may be one of the reasons why cow's milk, when modified, is still not as perfect a food for the human infant as the mother's milk.

A number of experiments have been conducted in an effort to solve this problem of the comparative dietetic worth of food phosphorus in organic and inorganic forms. The results are somewhat contradictory and the scientists are not fully agreed in the matter. Much of the experimental evidence indicates the distinct superiority of the organic forms of food phosphorus, while in no cases does the pure mineral salt show any advantage. The safe course, therefore, is to secure a high phosphorus content in its organic combinations in natural foods.

Efforts to exploit mineral salts as dietetic accessories are frequent not only in human medicine but in the nutrition of domestic animals. A few years ago a grit for chickens composed of rock phosphates was very much advertised. Careful tests by experiment stations proved that such phosphorus rock was of no more value to the chickens than any other form of gritty substance, which the chicken uses for grinding food in the gizzard, and that the rock phosphate would not supply the food phosphorus which the poultryman usually secures from ground bones.

Like sulphur, phosphorus is broken down in the vital processes and is excreted from the body in the form of simple mineral phosphates. The amount of phosphorus needed in human nutrition is at least a gram per day. A study of many diets reveals that the phosphorus content is likely to be below this minimum need particularly when the diet is composed largely of white flour, polished rice, sugar and other demineralized foods. The safest correctives of the phosphorus-lacking diet is milk and eggs.

The following table gives the amount of phosphorus, calcium and iron in selected foods that are particularly rich or particularly deficient in these three most essential minerals. The amounts are not given per pound of the food but for 2,500 calories (1.5 wheat pounds), which is the food requirement of a man for a day. This means that if a man lived wholly on lean beef he would secure five times as much phosphorus as needed, but would secure but one-third the necessary calcium. While if he lived on oranges, he would secure but one-tenth the phos-

phorus needed but four times more calcium than the body requires, etc.

QUANTITY OF ESSENTIAL MINERALS SUPPLIED BY 2500
CALORIES OF VARIOUS FOODS.

	Grams of Phosphorus	Grams of Calcium	Milligrams of Iron
Spinach	5.40	6.54	375
Lettuce	4.72	4.38	156
Lean beef	4.21	.15	81
Cheese	4.02	5.40	9
Beans	3.61	1.17	49
Milk	3.34	4.35	8
Eggs	3.58	1.35	47
Turnips	3.12	3.97	32
Whole wheat	3.34	.33	35
Carrots	2.51	2.80	42
Oatmeal	2.38	.41	21
Cabbage	2.34	3.55	86
Beets	2.13	1.60	32
Peanuts	1.93	.33	9
Almonds	1.78	.89	15
Potatoes	1.71	.43	35
Walnuts	1.34	.33	7
Oranges	1.06	2.17	10
Prunes .....	.83	.43	25
Bananas .....	.71	.22	15
Polished rice .....	.68	.03	5
White flour .....	.61	.15	12
Apples .....	.55	.30	8

CALCIUM AND MAGNESIUM.—Calcium and magnesium are chemical elements of somewhat similar properties. Both occur combined with phosphorus in the bones. Egg shells are composed of calcium carbonate, and the similarity to magnesium is revealed by the fact that hens fed a diet deficient in calcium but rich in magnesium will lay eggs with the shells composed of magnesium carbonate. But in more complex physiological needs, even these related elements cannot be so readily substituted for each other.

The calcium salts in the blood are intimately related to its power of coagulation. The balance between calcium salts on the one hand and those of sodium potassium on the other is thought to be the chemical basis of the control of the heart beat. The calcium salts seem to stimulate the contraction of the muscles, and an excess of calcium causes what is known as calcium rigor of the heart. This statement will show the high importance of the mineral salts in sustaining and regulating the life processes and the actual dangers of possible deficiencies—

for while the body may find ways to rid itself of an over supply, if the elements are not present in the diet it cannot be created in the body if there is an under supply.

As a practical dietetic problem magnesium needs no separate consideration because the quantity required is relatively small and because it is usually associated with calcium in such quantities that if the calcium supply be sufficient the needs for magnesium will be taken care of.

The total weight of calcium in the body is the greatest of any mineral, and, like phosphorus, it is unevenly distributed, being by far the most abundant in the bones. Calcium is also quite irregularly distributed in foods, and hence an ill selected diet creates a danger of a calcium shortage. A study of the usual diets of various groups of people indicates that calcium is the food element most frequently deficient. Many of the cases of malnutrition, especially among children, that were formerly considered to be due to a lack in protein are now known to be caused by a lack of calcium. As in the case of phosphorus, milk so rich in these two elements essential to bone growth, is the article to be first relied upon in guaranteeing against calcium deficiency.

Meat, when free from bones, is not sufficiently rich in calcium to nourish the young of carnivorous animals. The failure of lions to bring forth healthy young in captivity has been found to be due to the habit of feeding them upon meat from which the bones have been removed. Puppies fed pure meat and fat have suffered a check in their growth which has been remedied by giving them bones to gnaw. Pigeons fed food deficient in calcium give an outward appearance of maintaining health, but upon being killed and examined it was found that the bones had suffered degeneration even to the extent of the perforation of the skull.

Earlier scientific investigators failed to realize the full extent of the calcium needs of the body, due to the fact that they assumed that all of the calcium was excreted by way of the kidneys and that the calcium in the feces was an indication that much calcium in the food was not digested. It has now

been discovered that the calcium in the food is absorbed and again excreted by way of the intestines, hence the erroneous reasoning which led to underestimating the calcium needs. The body requires at least one-half gram of calcium per day, and a larger amount is a safe estimate because there is greater danger from deficiency and little danger from a moderate excess.

Growing boys from six to ten years of age were found to accumulate calcium in the body from the rate of four-tenths grams per day, which does not account for that required in the various physiological processes and again excreted. An ample calcium supply is highly essential to the pregnant and nursing mother, for if either phosphorus or calcium be lacking in the diet the supply in the bones will be drawn upon to meet the demands of milk secretions.

IRON.—Of all those chemical elements which exist in the body in measurable quantity iron is the rarest. The total quantity in the human body is hardly more than one-tenth of an ounce, or but one part in 25,000 of the weight of the body. But small as is this quantity, it is absolutely necessary to life. Iron in highly organic combination is essential to the composition of the hemoglobin of the red blood corpuscles, the substance which gives them their peculiar power to carry oxygen from the lungs to the tissues. Lack of iron produces anemia, a very prevalent disease symptom due to the decrease in the red corpuscles.

This function of iron has been known to the medical world for many years, and mineral iron in inorganic form was the classic prescription for the cure of anemia. The modern biological chemists have attempted to investigate this problem with a view of determining whether such mineral iron was effective or whether its use was merely a fallacy reasoned from the chemical knowledge of the presence of iron in the blood corpuscles. As in the case of the phosphorus problem, much argument has been waged as to the conclusion to be drawn from this experimentation. Formerly favorable results have been reported from the use of medicinal iron, but the results were not conclusive. The modern view seems to be that the mineral iron is not available for this highly important physi-

ological function, and that such favorable results as have been reported from its use were either due to other causes or that the normal usefulness of mineral iron was merely to spare in some way the destruction of the true food iron. For instance, iron combines with hydrogen sulphide in the intestines, and perhaps the presence of mineral iron may in this manner prevent undue destruction of the true food iron.

The best scientific opinion today concedes that with iron, as with other highly complex mineral food substances, it is a dangerous expedient to attempt to rely on the artificial products of the chemist, as substitutes for the natural organic combination of minerals with food substances evolved in plant life, from which source the human and the animal body under natural conditions secured the mineral elements of nutrition.

Food iron is absorbed from the small intestines and deposited in the pancreas, liver and marrow of the bones, where the red blood corpuscles are formed. The minimum body requirement of iron is about ten milograms a day, which in a normal diet furnishes iron in about the same proportion that it is present in milk. Compared with human needs, iron is more rare in milk than are other essential food minerals. The probable explanation is that the iron of milk exists in a chemical form highly adapted for physiological use without waste, whereas iron in other food substances may be only partly available to the physiological needs. The shortage of iron in milk is explained by some scientists by the reputed presence of a store of iron in the body of the child at birth. It is stated that the young of such animals as have short nursing periods show no such store of organic iron. While this theory does not seem altogether plausible, the fact is clearly established that the iron content of milk is no more than a safe minimum, and that may also have a practical bearing on the poor nutritive value of a diet for the human infant that consists in diluted cow's milk or diet of milk supplemented only with cereal substance and sugar. The use of fruit and vegetable juices to supplement such artificial feeding of children is found in practice to prove a safeguard against malnutrition, which fact may be related to this problem of the supply of organic iron.

The iron content of meat is chiefly in the blood contained in the meat tissues. Moreover, it is doubtful if this eating of the spent blood corpuscles of other animals gives a suitable supply of iron for forming new blood corpuscles.

Wheat is robbed of its iron supply in the milling of white flour, which contains only one-sixth as much iron as whole wheat. In a carefully conducted experiment two groups of young rats were fed white bread and bran bread. The rats fed bran bread gained about four times as much in weight as the white bread rats. They were killed and an estimate made of the red blood corpuscles. Only two-thirds as many of these oxygen-bearing messengers were found in the white bread rats as were found in their bran bread brothers.

ACIDITY AND ALKALINITY.—Acidosis is an abnormal condition of the body due to a reduction of the normal alkalinity of the blood and body fluids. It results, among other things, in a strongly acid urine and a failure to absorb uric acid. This problem of the balance of acids and alkalies in the human body is a very complex one, the full theoretical discussion of which cannot be given here. The condition of acidosis may be temporarily and artificially corrected by the administration of common soda. But this, like many medical measures, is in no sense a true and permanent remedy. Soda may be used, however, in diagnosis of this abnormal condition. The urine is normally slightly acid, but a dose of from five to ten grams of soda will result in causing it to give an alkaline reaction to litmus paper. But if the blood be abnormally acid, this amount of soda will fail to turn the litmus paper blue and a condition is indicated which can only be permanently remedied by a correctly balanced diet.

Many chemical substances contribute to the total contents of acid and alkaline elements of the blood. The absorbed carbon dioxide is slightly acid, while the majority of the mineral salts in the blood are alkaline. The true balance gives a mildly alkaline reaction, but the normal blood condition is so near the marginal line of neutrality that the failure of the alkaline yielding salts or an increase of foods that form acids in their

metabolism will result in an increase of the acid elements. When body proteins are finally destroyed in the various vital processes, the sulphur content in them is oxydized to the highly powerful sulphuric acid. If this acid remained unneutralized it would prove exceedingly poisonous and destructive to cellular life. In practice sulphuric acid never exists in the body as such in any measurable quantity, but it is constantly being formed and as quickly being neutralized by the alkaline minerals.

Phosphorus plays an important part in this neutralization of the sulphuric acid. But these alkaline salts in neutralizing the acid lose their alkalinity, hence the danger of acidosis when there is too much acid to be taken care of. As a chief source of the acid is from protein, particularly meat proteins—neither meats, fats, sugars, or starches, bear alkaline salts—the natural correctives are the vegetables, rich in the alkaline salts.

The above statements in reference to the danger of acidosis bears no relation to such foods as acid fruits, or sour milk. These acids are composed of oxygen, hydrogen and carbon and are much more closely related to fruit sugars than they are to the mineral acids. These purely organic acid fruits do not appear in the blood as acids at all, but are neutralized in digestion and assimilated and burned in the body much as are sugar, starches and other neutral foods.