CHAPTER XVIII.

VITAMINES—THE BIOLOGICAL ANALYSIS OF FOOD.

THE term "vitamine" was originated by Funk, an English scientist, about 1912. He was investigating the problem of beri-beri, the deficiency disease caused by a diet of polished rice or grains of similar food properties. Other investigators had learned that a similar disease could be caused by a polished rice diet fed to pigeons. They had also observed that the disease could be cured as in man, by feeding whole rice or other natural food substances. The English scientist attempted to isolate and analyze the chemical constituents of the missing food essential in the rice germ, or bran. He was not successful in determining the chemical composition of this mysterious substance, but he learned many of its properties, and that it existed in very minute quantities and was not a mineral salt. He termed the mysterious substance a "vitamine" and conceived the theory that vitamines were specific substances in food, the absence of which would cause specific diseases. The expectations of this investigator were that scurvy, pellagra, rickets and perhaps other diseases known to be caused by a deficient diet could be cured by the specific "vitamine" or missing food element, should it be discovered.

This theory that each food deficiency disease has its particular preventive vitamine has not been established by later investigations. But like many erroneous theories, the vitamine idea has proved of great importance in the stimulation of scientific research. Moreover, the publication of such scientific researches together with the use of the very suggestive term vitamine, turned the popular imagination toward the broad and general problem of the dangers of an artificial, denatured or deficient diet.

ANIMAL EXPERIMENTATION.—In this eager search for food vitamines the scientists have adopted a method of research comparatively new to food problems. It is that of animal experimentation or biological testing of foods as distinct from

the older method of chemical analysis. Animals, particularly small mammals that are easily kept in laboratories, such as guinea pigs, white rats and mice, had been extensively used by the bacteriologist in food experimentation as well as in testing the strength and effect of drugs, particularly those which could not be satisfactorily analyzed by chemical methods.

In this chapter will be given not only the facts regarding the unidentified food essentials popularly termed vitamines, but also a general review of methods and results achieved by this school of biological chemists who have investigated food problems by the method of animal experimentation. The general plan followed in such investigations is that of feeding a diet of foods the exact chemical properties of which were known, and to which may be added one or more foods the particular effects and properties of which the investigator wishes to discover.

There is considerable rivalry between this school of food experimenters and the old school of chemists, who confined food investigations to purely chemical analysis. However, it should be noted that it was the achievements of chemical science which enabled such diets composed of selected pure food elements to be prepared, which has made possible the biological researches.

Reference has already been made, in the chapters on protein and mineral salts, to results obtained with animal experimentation. Many of the earlier investigations in this field were with domestic animals and were conducted for the purpose of gaining information on animal nutrition. At the University of Wisconsin cows were fed diets derived wholly from the corn plant and compared with other cows fed wholly from wheat and from oats, in each case the food including not only grain but the fodder or straw. The cows were able to live on all three diets, though the corn-fed animals were the more thrifty. But particularly interesting were the results in the bearing of the young. The calves of corn-fed cows were healthy and normal, while the wheat-fed cows gave birth to their young prematurely, and the young were either born dead or died

within a few hours. Oat-fed cows gave birth to weak calves, many of which died at an early date. The corn-fed cows produced nearly three times as much milk as the wheat-fed animals.

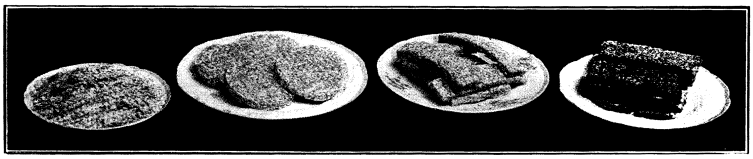
All this was exceedingly interesting and clearly demonstrated the insufficiency of the old food standards which were content to prescribe certain proportions of fats, carbohydrates and protein. The rations from the corn, wheat and oat plant had all answered the older chemical food standards. Here was a mystery that escaped the chemists. Here also was evidence that if food problems were to be solved, it was not sufficient to merely conduct experimentation for a few weeks or months with adult animals or even with the growing young, for the significant deficiencies were only revealed with the process of reproduction. The advantage of conducting such researches with an animal of brief generations, like the rat, is obvious. Moreover the rat is by nature omnivorous, hence the presumption that his dietetic needs are more nearly akin to man's than to those of a cow or dog.

It should be remarked at this point that the biological method of research has emphasized the fact that the fundamental chemical laws of nutrition apply pretty generally to all species, the chief differences between various species being in the mechanical or physical differences in the diet and the consequent adaptation of the digestive organs to various degrees of food bulkiness. Herbivorous animals have large digestive tracts for the digestion of bulky foods. Carnivorous animals occupy the other extreme, while omnivorous animals are intermediate. Some differences also exist as to the proportions of various food elements required, particularly as determined by the rate of growth of the young. But the essentiality of a particular element and the effects of its absence on the organism seems to apply generally to all warm-blooded species, and certainly to all mammals. Hence, while we cannot look upon experiments with pigeons or rats as absolutely applicable to the human species, we must accept the view that fundamental laws can be discovered in this manner. Experimentation re-

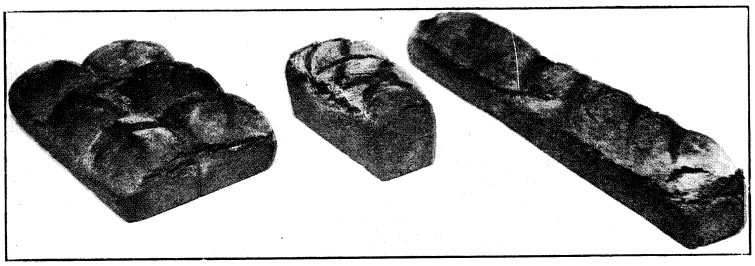
quiring feeding for a complete generation or for several generations when applied to humans would involve insurmountable difficulties.

DISCOVERIES BY MCCOLLUM.—The experiment in feeding cows, above referred to, led E. V. McCollum to undertake exhaustive experiments in systematic biological feeding tests that have resulted in materially furthering the world's knowledge of the science of nutrition. His first discovery that led to important results was that rats would not thrive on a diet of purified foodstuffs, though it included ample skim milk protein and mineral salts; but that normal health and growth could be secured if a small amount of butter was added to the diet. Since the rats were already getting ample fat from vegetable sources it was evident that it was not the added fat of the butter but some unknown substance existing in the butter in small amounts. The view that this newly discovered food essential was some material dissolved in fat was further proved by the fact that egg yolk was found to be efficient in the same way as the fat of butter; lard and vegetable oils failed utterly to support growth. It was thus proved that all fats were not of equal dietetic value, although the chemists had always reckoned them so.

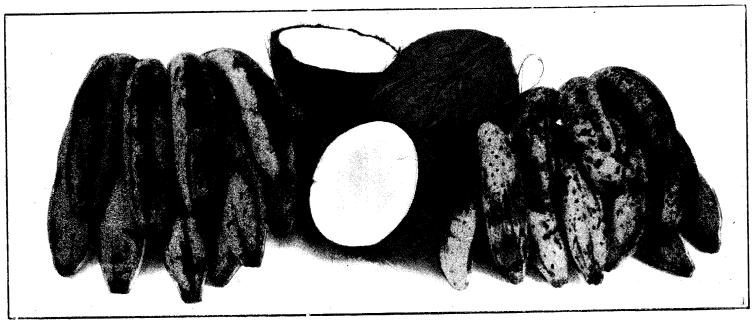
The first impression was that this unknown food essential or vitamine was the same as that discovered by Funk in the germ and bran of rice. But the diet upon which the rats were first fed and which was completed by the addition of butter fat was later found to contain the water soluble vitamine as an impurity in the milk sugar, for when the sugar was more carefully refined it was then found necessary to add the water soluble vitamine also before the diet would sustain life and growth. A further series of careful experiments revealed that there were two food essentials or vitamines of unknown composition, one of which was soluble in water and one of which was soluble in fat. Rejecting the term "vitamine" McCollum named these essential elements "water soluble A" and "fat soluble B." A mixture of refined foods containing carbohydrates, proteins, ordinary fats and mineral salts will not support



Some of the raw breads that are made from the whole grain of the wheat. First dish to the left, raw flaked wheat; second, round cakes of raw bread; third, another form of raw bread; fourth, a variety of raw bread largely composed of bran, especially valuable for remedying sluggishness of the bowels.



Examples of the delicious bread made from the whole meal of the wheat. Note its substantial appearance and rich brown color.



The banana and cocoanut constitute two extremely important factors in the nut and fruit diet.

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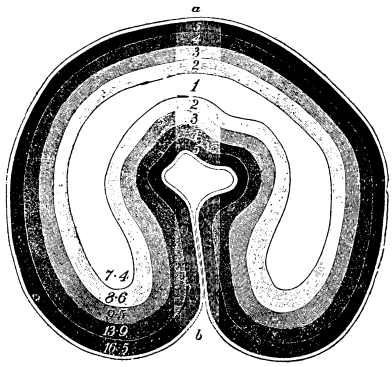
growth unless both of these vitamine food essentials are present.

The original vitamine theory that held that each deficiency disease was caused by the absence of a particular vitamine was thus disproven, as many such diseases were found to be curable by diets containing, in addition to ordinary fat, carbohydrates, suitable mixtures of protein, and salts, the water soluble vitamine, first discovered by Funk in rice polishings, and the fat soluble, first discovered by McCollum in butter fat

Since a diet may be deficient in the quantity of protein, carbohydrates or fats, and since it also may be deficient in the quality of proteins or in the quality or quantity of any of several mineral salts, and lastly in the quantity of either of the two vitamines, we readily see that the deficiencies in one or more of these varied essentials may cause various symptoms and diseases of mal-nutrition. The complexity of the problem seems to permit of a sufficient explanation of the numerous manifestations of food deficiency that have been observed.

A further important discovery made by McCollum relates to the value of grain or seeds in nutrition. He found, with numerous experiments, that no single grain or combinations of grains was sufficient to sustain normal growth in young rats. Further search of natural habits of animals and the records of feeding tests revealed the fact that no warm-blooded animals in nature or in the experi-



A GRAIN OF WHEAT.

Diagram of cross section of a grain of wheat of the Purple Straw type, showing the location of the five arbitrary "concentric" zones or layers of flour removed by hand. The "core" is shown white, and each successive zone is shown in a darker shade, the outermost zone being represented black. Outside the zones the bran is represented as a narrow white layer. The five zones are numbered 1, 2, 3, 4, 5, and are successively thinner toward the outside of the grain. The percentages of gluten found in the flour are marked on each zone. Zone 1, 7.4 per cent; zone 2, 8.6 per cent; zone 3, 9.5 per cent; zone 4, 13.9 per cent; zone 5, 16.5 per cent. The diagram is drawn to scale.

mental laboratory derived complete nutrition from seeds alone. Even seed-eating birds add insects, green leaves and sprouts and minerals taken in the form of "grit," to their diet.

Artificially milled and refined grain product were found to be deficient in the water soluble vitamine, but this deficiency is remedied when the whole grain is utilized. Most whole grains contain some of the fat soluble vitamine, though not enough for complete nourishment. Whole grains are therefore a far better source of nutrition than the denatured milled product. Pigeons when fed white flour bread died more quickly than those kept on an absolute fast. White flour is not a poison, but it is lacking in many food essentials. The birds fed the white flour starved to death for these essentials the more quickly because the added burden of digesting and metabolizing the white flour used up the bodily store of salts and vitamines. The fasting birds lived longer because the store of these elements was conserved. This experiment has been cited as a striking proof of the superiority of the whole wheat and the deficiency of white flour. But the new fact pointed out by McCollum is that the pigeon fed whole wheat will also succumb in the course of time, because even the whole grain, though vastly superior to the denatured product, is not a complete food. Wheat, he maintains, like other grains and seeds, has an insufficient quantity of the fat soluble vitamine and is also deficient in mineral salts, particularly calcium. Both of these faults are remedied by the addition of sufficient milk to the diet, as whole milk contains an ample quantity of calcium as well as both kinds of vitamines.

From McCollum's viewpoint, therefore, the statement that whole wheat bread is a complete food is incorrect, although his experiments show its food value is very much higher than white flour products even when these be combined with sugar, fats and meat.

By investigations of the relative value of natural foods McCollum discovered that the addition of any sort of edible leaves to a diet of grains or meat, or grain and meat, greatly

increased the growth sustaining power. A diet of sixty percent of any seed or grain with forty percent of alfalfa leaf flour was found to be greatly superior to any possible diet that could be made solely of grains, legumes, or other seeds. When the diet was composed of fifty percent corn, thirty percent alfalfa leaves and twenty percent peas, the experimental rats were able to complete their growth and reproduce their kind for several generations. This diet for the rat was the best diet of wholly vegetable origin discovered by McCollum. While the rats lived and reproduced upon it, they did not reach a maximum efficiency of growth and vitality. Out of many hundreds of vegetarian diets tried, none were found that would nourish the rat as completely as a diet including some foods of animal origin, particularly those diets that included milk.

ESSENTIAL "PROTECTIVE FOODS."—The same fact had been found to be true in the nutritive of pigs, which like rats are considered omnivorous in their habits. The statement applies equally to chickens and ducks. With all these domestic animals more profitable growth can be secured if some foods of animal origin are given, and with all of them the most efficient of all animal foods is milk. It is interesting to note that in all these species where animal foods are not available, the addition of leafy foods is a great help towards perfect nutrition. The practical observations of animal feeders bear out McCollum's contention of the superior value of milk and green leaves as the essential "protective foods." The addition of milk to a diet of grains makes possible growth and reproduction in all these species, and the same principle undoubtedly applies to man. Where milk is not available the best substitute is leafy foods. Thus we can explain the nutrition of the people of India, China and Japan in whose diets milk has small place, for these people use ample quantities of green vegetables. In practical application the use of both milk and green vegetables is found in animal feeding to give superior results to the use of either alone and the same conclusion we may safely apply to mankind.

McCollum points out the remarkable fact that these highly important discoveries in food science were utterly ignored by

the merely chemical consideration of foods as carbohydrates, proteins and fats, etc. He advises that practical dietetics be taught by grouping foods, in accordance with the purpose of the food in the economy of the plant or animal from which it is derived.

By this system milk unquestionably deserves a distinct place as a food of the highest order. Its function in nature is that of a food for the young mammal. No other food product used by man has such a complete natural function. The nearest approach is that of eggs, which are slightly inferior to milk for the following reasons: They contain no carbohydrates, as the chick growing within the shell needs little energy because it is inactive. Secondly, the edible portion of the egg is more deficient in calcium, as the chick obtains a portion of this element required for bone growth by dissolving the calcium carbonate from the egg shell. Lastly, the chick, not being a mammal, may on general principles be considered less closely akin in its nutritive needs to the human kind, than is the calf.

The second food group in McCollum's list is the leafy vegetables. Ample experimentation has proved leafy foods to contain the vitamines and minerals so likely to be deficient in the grain and meat products of a conventional diet.

The third food group in this system is that of seeds or grains. The place of the seed in nature is that of a storehouse of food energy, and this function explains why the seed is rich in carbohydrates, as in the case of grains, or in fats, as in the case of nuts and many other seeds. The seeds, therefore, can supply in economical form the energy requirements of man, but they must be supplemented by other foods rich in the lacking essentials. The bulk of the seed kernel is in the endosperm, which is rich either in starch or in oil. This portion of the seed is merely a storehouse of energy and is not composed of living cells containing the vitally active protoplasm. But the bran and germ of seeds is composed of cells and is a living portion of the plant, hence the use of whole grains is advantageous in the same way as is the use of leafy foods. White flour, polished rice, degerminated corn meal, vegetable oil or extracted sugar

are all derived from the plant's surplus store of food energy. None of these foods, nor any combination of them, is sufficient to support growth and reproduction. The use of the whole grain or product which contains the whole of these concentrated energy foods is much less dangerous than denatured foods, but even the use of these whole grain foods is not sufficient for the maximum efficiency in growth and nutrition unless supplemented by other foods.

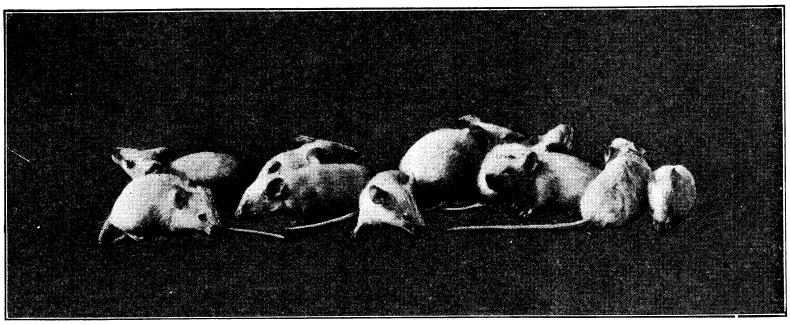
Milk, eggs and green vegetables used in the diet are the surest means of avoiding food deficiencies. With an ample use of these highly enriched and protective foods even a diet of denatured starches, oils and sugars may become safe. The logical and economical plan to follow is to use the grain and seed products in their natural and entire state and to add also the milk and greens. With such a diet the danger of food deficiency is indeed remote.

We have yet to consider certain further groups. Most vegetables, other than leafy greens, are tubers, roots or the thickened leaf bases, as in the case of cabbages, onions, chard and celery. Like seeds, the use of the roots and tubers in nature is that of a storehouse of energy for the next plant generation. This class of vegetables occupies an intermediate place in dietary value between leaves and seeds. If the vegetable is used in its entirety as in the case of potatoes, when the skin is eaten also, the value is likely to be superior to the grains. But if the raw potato be peeled with a knife, or if the sugar alone be extracted from the beet, we see again the denaturing process of extracting the energy food and discarding the vital cellular elements. Vegetables may also be "denatured" by the custom of boiling them and discarding the water, for many of the valuable elements are thus dissolved and wasted.

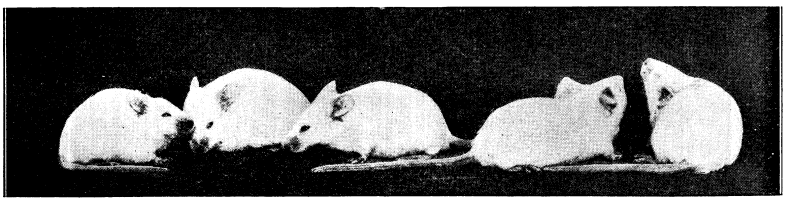
Many so-called vegetables, such as melons and tomatoes, are in truth fruit. Fruits may be given a dietary rank just below that of leaves. They are notably rich in minerals and presumably in vitamines, though at this writing they have not been experimentally tested for these elements. The chief value

of fruits, however, is in their natural sugars and organic acids, which present a variety of pleasing flavors. A diet might be entirely correct physiologically, and yet be psychologically deficient because of a lack of palatability. Fruits therefore rank especially high in the final dietetic reckoning.

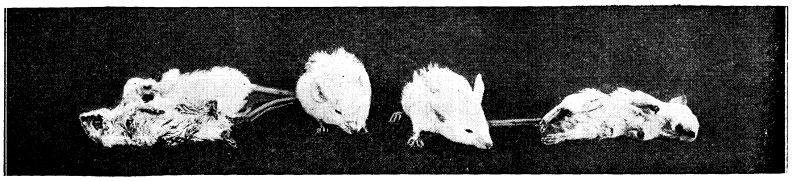
In McCollum's classification nuts are grouped with seeds because they are seeds in nature. In practical dietetics I would suggest that the nuts deserve a separate classification because of their higher fat content, and therefore of their capacity to improve, in that respect, a diet mainly derived from grains in which the energy food is in the form of starch.



Ten young mice at beginning of biological food test.



Five of the mice after a month's nourishment on natural foods.



Five of the mice after a month of devitalized food.

LOW RANKING FOR MEAT.—The greatest novelty of McCollum's system of food classification is in the dietetic ranking given to meat. This eminent scientist is not a vegetarian, and in fact rejects the vegetarian diet on the assumption that man is by nature omnivorous and that his dietetic necessities are analogous to those of the rats, pigs, and chickens. Neither does he take into consideration the objections to meat in the diet on the ground that it is a source of disease or that it contains the unexcreted waste products of the animal. Yet viewed wholly from the standpoint of its function in nature, McCollum ranks meat as of low dietetic value because meat as consumed is almost wholly made up of the functionally specialized tissue of muscle or stored fat. Neither sort of tissue is as rich in living cell protoplasm as are the active functional organs of the body. Fat meat is obviously a storehouse of food energy and as such is analogous to the stored fats in nuts and seeds. Lean meat is muscle and is composed of active cells. But these muscle cells are highly specialized for one function and hence may not be expected to be a source of complete nutrition for the entire physiological activity. In support of this unique view McCollum points out that carnivorous animals prefer the blood and the physiological active organs, such as the liver and kidneys, of their prey. Moreover, they also gnaw the bones.

Both the chemical analysis and the biological feeding tests seem to support this view of the dietetic insufficiency of meat products such as are consumed by man. Milk is a complete food and will support growth and reproduction in experimental animals. Meat, on the other hand, is a deficient, and requires to be supplemented by the protective foods much as does a diet of seeds.

The conventional diet of civilized man is dominantly one of seeds and meats, to which may be added refined sugar, and oils. If to this diet milk, leaves and fruits be added, nutrition is complete. Without such additions, especially when grains and vegetables are denatured in milling and cooking, the malnutrition and deficiency diseases of civilization result.

Such in brief are the conclusions of the most advanced authorities of the science of nutrition. These conclusions agree with the essential principle of physical culture dietetic teachings. When I began my work in food reform my views were freely ridiculed by physicians and by the food chemists of universities and government laboratories. Today the "natural" food system of dietetics, which I have advocated from the beginning, has been established by the research of highest authorities in those very scientific groups which formerly ridiculed my teachings. At the beginning of the twentieth century vegetarians were looked upon as unscientific cranks. Today the vegetarian diet, when it includes the use of milk and eggs, stands approved by scientists as the most efficient diet known to man. In regard to it McCollum says: "Lacto-vegetarianism, when the diet is properly planned, is the most highly satisfactory plan which can be adopted in the nutrition of man."