

VITAMINS

in human and animal nutrition



UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
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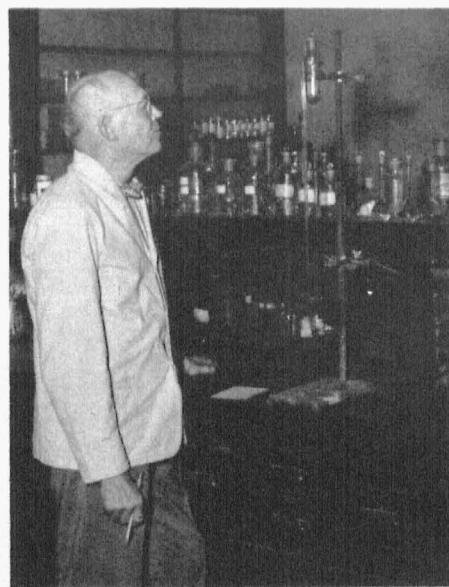
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Dr. Albert G. Hogan (pictured), author of this bulletin, retired recently from his work as chairman of our Department of Agricultural Chemistry with a distinguished record in the field of nutritional research. He was a co-discoverer of the vitamin, folic acid. Hogan and members of his group at the University of Missouri Agricultural Experiment Station also did some of the original work in demonstrating that "Vitamin B" was a complex of vitamins.

Much of our knowledge of human nutrition stems from experiments with animals. As a result, work with animals done by the agricultural experiment stations of our nation's land grant colleges figures in many of the discoveries. Agricultural colleges have made the major contributions to the discovery of at least 8 of the 15 recognized vitamins.—Ed.

COVER PICTURE



This Bulletin Reports on Department of Agricultural Chemistry Research Projects 137, "Poultry Nutrition" and 151, "Nutrients."

VITAMINS

A. G. HOGAN

The "Big Things" In Nutrition

Unless directed otherwise the feed chemist usually makes six determinations on each sample:

Water	Crude protein	Nitrogen-free extract
Ash	Crude fat	Crude fiber

Anyone of these constituents may be present in relatively large amounts, and everyone is more or less familiar with each of them. It was supposed for many years that these were the only constituents of feeds that were of any significance. Chemists were of course aware that feedstuffs contained what seemed to be insignificant amounts of other organic substances. These unidentified substances were present though in many excellent feeds in such minute quantities that it seemed unthinkable they could have any significance as constituents of a ration. However, as time went on investigators found that it was necessary in many types of investigations to use rations made up of relatively pure nutrients, protein, carbohydrates, fats, and minerals, from which the unidentified substances previously mentioned were rigidly excluded. All investigators

in this field, whatever their original problem, had in one respect the same experience. Animals that were limited to these purified rations not only failed to thrive, they even failed to survive if the investigations were continued for any length of time. It was taken for granted at first that these failures were due to the fact that rations of this type were unpalatable, and animals failed to consume them because they were monotonous. Many attempts were made to overcome this difficulty, but every expedient failed and chemists were slowly convinced that the nutrients mentioned were not the only essential ones. There must be others, required in such minute amounts that they are ignored completely in the usual type of chemical analysis, they decided. Eventually this conviction was justified, and in recent years a considerable number of these obscure nutrients have been identified. They are now known as vitamins. The six substances commonly determined by chemical analysis are known as the "big things" in nutrition. The vitamins are the "little things."

The "Little Things" In Nutrition

We describe the "big things" in parts per hundred, or percent; but we describe the "little things" in parts per million. For example, 1,000,000 lbs. of whole wheat contain approximately 5 lb. or 0.0005 percent, of thiamine (vitamin B₁). The older chemical methods fall far too short in sensitivity to detect such minute quantities. The newer chemical methods can measure this substance with a reasonable degree of accuracy.

The rapid increase in our knowledge of vitamins has brought about a striking shift in emphasis on nutritional problems. Forty years ago students of nutrition were chiefly concerned with the quality and quantity of protein and minerals, and with problems in energy metabolism. The emphasis on these nutrients has not diminished, but the emphasis on vitamins has vastly increased. It is realized now that many of the important problems in the nutrition of men and animals are due to the fact that under certain systems of feeding, the supply of vitamins is insufficient. By ordinary standards the amounts required are exceedingly minute but, although only small quantities of the vitamins are required, their importance cannot be exaggerated. If man or animals receive none at all they soon perish. If they receive insufficient amounts the

health is impaired. It should be mentioned that in practice mild deficiencies probably cause higher total losses than do severe deficiencies. It is relatively uncommon for a diet, or ration, to contain so little of a vitamin that obvious symptoms of a deficiency occur. It is reasonable to suppose that when one such case occurs there must be several cases that are too mild to produce characteristic symptoms, but which are sufficiently severe to lower the state of health. Ordinarily we think of people or livestock as being either healthy or sick. It is well recognized now that there is no sharp dividing line between health and disease. There are individuals who have not a single characteristic symptom of any disease, and yet do not possess the degree of health they are capable of achieving. The proportion of such individuals is a matter of controversy. Some authorities believe it is small, others with equal experience and training believe it is large. Recent reports of medical examiners on the proportion of young men rejected for military service contain weighty evidence that the latter group is more nearly correct. Some of us can never have perfect health, but many of us could attain better health than we have now.

The Number of Vitamins

According to the classification followed in this bulletin there are 15 vitamins. The newest discovery among these is vitamin B₁₂, which was isolated in 1948. A list of the vitamins now recognized appears below.

Of the total of 15 compounds in the list, 14 can be synthesized in a chemical laboratory. It is not yet possible to synthesize vitamin B₁₂. Its commercial preparations are isolated from some of the waste by-products of the fermentation industries.

VITAMINS WHOSE EXISTENCE IS UNDISPUTED

Of practical importance because many foods contain insufficient amounts.

A (carotene)
B₁, thiamine
B₂, G, riboflavin
C, ascorbic acid
nicotinic acid (niacin)
D

Of less practical importance because most diets or rations contain adequate amounts.

E
K
B₆, pyridoxine
pantothenic acid
choline
biotin
folic acid
vitamin B₁₂
inositol

Notes On Individual Vitamins

Vitamins that may be deficient under practical conditions

Vitamin A.—Vitamin A is almost, if not entirely, an animal product. There is little or none in plants. Some commercial vitamin A preparations are processed from certain fish liver oils, as the cod, halibut, shark, or sardine. Others are synthesized in chemical laboratories. Since all animals require vitamin A it is obvious that plants contain some substance that can be transformed by the animal body into vitamin A. This substance is carotene, an orange or golden pigment. The color of the carrot is due to carotene, and this substance is present in all green leaves that have been investigated. The yellow vegetables such as the rutabaga and sweet potato, also contain carotene. Green leaves are preeminent as a source. When consumed by an animal a portion is transformed into vitamin A and, presumably, it is only this transformation product that can be used. Carotene is not identical with vitamin A, but since it is the raw material that is converted into vitamin A, the terms carotene and vitamin A are often used interchangeably.

Symptoms of a deficiency: In man, cattle, sheep, and horses, night blindness, or poor vision in dim light, is the most easily recognized symptom; in later stages the eyelids are swollen and a sticky discharge flows from the eyes. In poultry, swollen eyelids, and white patches in the oesophagus are characteristic signs.

In swine, weakness in the hind quarters ending in paralysis, nerve degeneration, and blindness are typical symptoms.

The fundamental defect in vitamin A deficiency is impairment of epithelial tissues.

Stability: Carotene and vitamin A are destroyed fairly rapidly at high temperatures, especially when exposed to light and air. Average alfalfa hay contains about 25 to 35 percent of the original amount of carotene. Low grade hay may retain only 10 percent. If cod



Symptoms of a deficiency of vitamin A in a chick.

liver oil is mixed with ground feed as a source of vitamin A, practically all of the vitamin may be destroyed in 2 or 3 weeks. Feed that contains cod liver oil as a source of vitamin A should be used up within a few weeks after mixing, unless stored at a low temperature.

Sources: Milk, cheese, eggs, and liver are excellent sources. Most vegetables are at least good sources and the leafy vegetables, such as spinach or kale, are excellent. Of the cereals, only yellow corn is a good source. The best sources for livestock are fresh green forage and the legume hays.

Vitamin B₁ or Thiamine.—*Symptoms of a deficiency:* Weakness, impairment of nerve function, with various manifestations of paralysis in different animals, poor appetite and digestive disturbances. In practice, the importance of this vitamin is most emphasized in human nutrition, though it is required by all animals with one stomach. This vitamin is synthesized by the microorganisms in the rumen, so it is not required by mature cattle, goats, or sheep. In fact all of the water-soluble vitamins, except vitamin C, are manufactured in this way and they are not feed essentials for ruminants. Most of them are feed essentials for these species early in life though, before the rumen begins to function.

Stability: Is not readily destroyed under ordinary conditions. It is destroyed by prolonged moist heat. It is destroyed by alkali, especially if heated. Vitamin B₁ is fairly stable in acid solution.

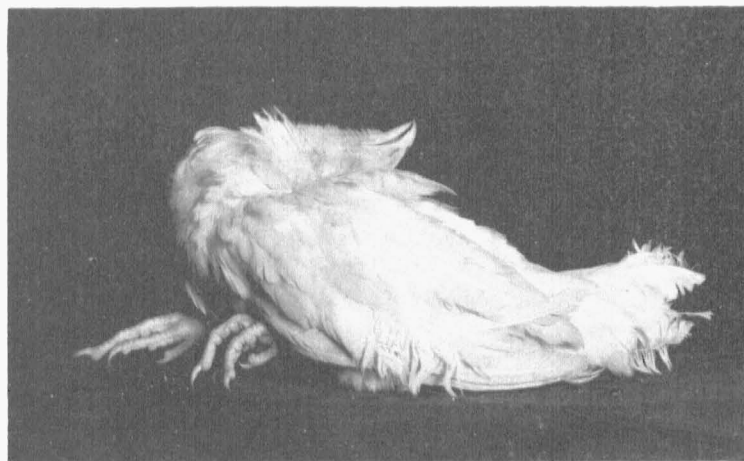
Sources: Milk, eggs, liver, and fresh fruit or vegetables are good sources. Lean pork, and most seeds such as corn, wheat, and soybeans, are excellent or good. High quality forage is a dependable source. A deficiency in the ration of livestock is improbable, but because of poor food habits the diet of man often contains less than the optimum amount.

Vitamin B₂, (G), riboflavin.—There are well authenticated reports that man does at times consume diets that are deficient in riboflavin. In every such case, however, it seems that the diet is also deficient in at least one more vitamin. This means that certain vitamins accompany each other, and if one is deficient it is probable that more than one is deficient. Riboflavin belongs in this group.

Symptoms of a deficiency. In man, fissures or cracks at the corners of the mouth.

In the rat, thinning of the hair and appearance of premature old age, cataract.

In the chick, curled toe paralysis; low hatchability of eggs.



Symptoms of a deficiency of thiamine in a chick.

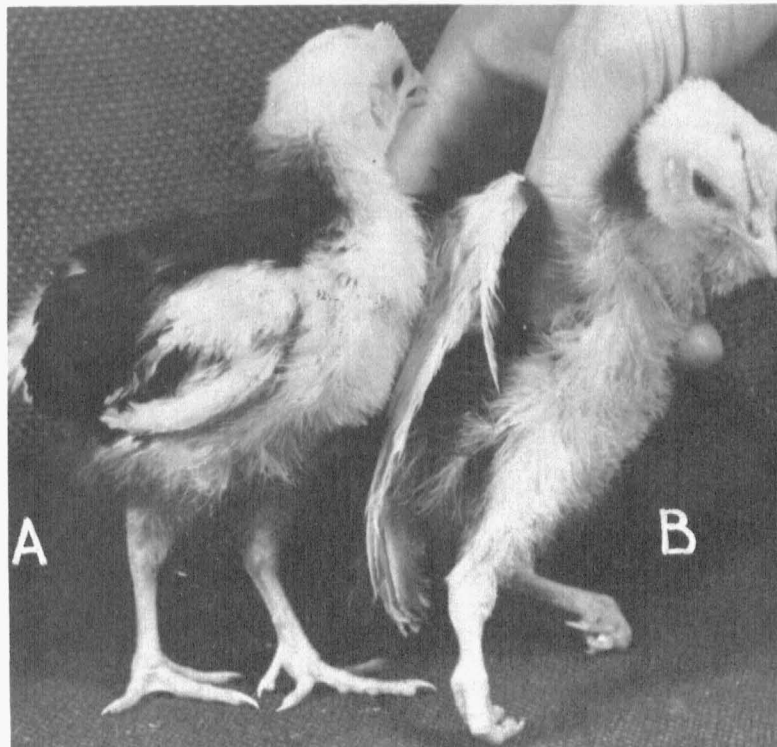
In the dog, sudden collapse.

In swine, slight deformities in the feet, and lameness; diarrhea; during a long continued deficiency the skin becomes scaly and ulcerated.

In horses, there is some evidence that moon blindness or periodic ophthalmia, is the result of a deficiency of riboflavin.

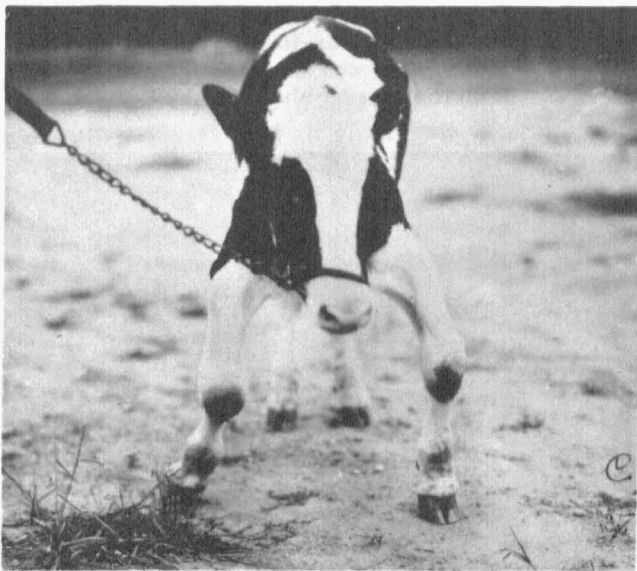
Stability: Riboflavin is relatively stable and a reduction in potency by destruction is not a major problem. It is destroyed by exposure to strong light, especially if the vitamin is in an alkaline solution during the exposure.

Illustrates riboflavin deficiency. When first observed both chicks had curled-toe paralysis. Chick A received 100 micrograms of riboflavin daily for 4 days, when this photograph was taken, and recovered completely. 400 micrograms are about 1/70,000 ounce.





Rickets in children is prevented by vitamin D or exposure to sunlight. (Courtesy of H. R. Sandstead, M. D., National Institutes of Health, Bethesda, Md.)



Rickets in a calf. (Courtesy of Prof. C. F. Huffman, Michigan State College.)

Sources: Milk, cheese, eggs, and lean meat are excellent sources. Liver is one of the best. Practically all fruits and vegetables are good sources, though the leafy vegetables are preeminent.

Of the common feeds, forages with a high proportion of leaf are the most reliable source. Alfalfa meal is a good source and skim milk is one of the best. As a rule the cereal grains and milling by-products, such as wheat bran or middlings, are poor sources. Yellow corn contains a fair amount. If an abundance of green pasture is provided, both swine and poultry will receive all they need.

Vitamin C.—A deficiency of this vitamin produces the disease known as scurvy. None of our domestic animals is susceptible, but man is subject to this disease. The only animals known to develop it are guinea pigs and monkeys.

Symptoms of a deficiency: Swollen, bleeding gums, and loose teeth; tender, swollen joints; fragile bones; weakened blood capillaries, with a tendency to “bruise” easily.

Stability: This vitamin is readily destroyed by oxygen, and the destruction is accelerated by an alkaline reaction, and by certain metals, especially copper. The oxidizing enzymes of plants, after harvesting, are also destructive, and the vitamin C content of many vegetables falls markedly during storage, even in a refrigerator. This applies especially to the leafy vegetables. An acid reaction retards the destruction.

Sources: Dry seeds and foods, unless extraordinary precautions are taken, are practically devoid of vitamin C. Fresh fruits and vegetables are reliable sources if not stored too long. The importance of fresh leafy vegetables should receive special emphasis. Eggs contain practically none of this vitamin and cow’s milk is undependable. Among meats only the glandular tissues such as liver are reliable sources.

Vitamin D.—The disease caused by a deficiency of vitamin D is known as rickets, therefore the preventive agent is often described as the antirachitic vitamin. Presumably, adult animals require vitamin D, but the requirement of adults has been studied very little and we have little knowledge of the amount they need. Rickets is a disease of youth, at the time when the bones are growing. If the supply of the vitamin is inadequate the amount of calcium phosphate deposited in the bones will be reduced. The result is structural weakness, which leads to the deformities that are characteristic of the disease.

Many infants and young children receive vitamin D in the form of a fish liver oil. Older children, and

most young animals, obtain very little of the vitamin D they require from the food they consume. Vitamin D is exceptional in at least one respect, for the required amount is assured by exposure to sunshine, or skyshine, and to artificial ultraviolet rays. The explanation is that just beneath the superficial layer of the skin of animals there is widely dispersed in the tissues a substance which is converted into vitamin D by exposure to ultraviolet rays. A similar substance occurs in plants. This substance, in its normal state, has no vitamin D activity, but it is readily converted into vitamin D. Sunlight that has passed through glass is unable to bring about this conversion, because glass absorbs the ultraviolet rays. Artificial irradiation is a widely used commercial method of increasing the vitamin D content of human food. Some of the commercial vitamin D concentrates used in poultry feeds are prepared in a similar way. In this connection it should be mentioned that there is more than one vitamin D, though chemically they are very similar. For example, the vitamin D of irradiated yeast is an effective source of the antirachitic vitamin for man and for some animals at least, but it is very ineffective for poultry. If irradiated products are supplied to poultry the raw material should be obtained from animal and not from plant sources.

Symptoms of a deficiency: Enlarged joints; soft, porous bones, with more or less pronounced deformities.

Stability: This vitamin is not readily destroyed, and losses in storage are usually negligible.

Sources: Egg yolk and liver usually contain an abundant supply. None of the other common foods or feeds is an excellent source, and few are reliable sources. Sun-cured hay of good quality contains a fair amount. The more common concentrated feeds contain practically none. Fish liver oils are the most widely used commercial sources. A type of vitamin D concentrate called "activated animal sterol" is now on the market, prepared by ultraviolet irradiation of suitable raw materials of animal origin.

Nicotinic Acid (niacin).—The disease, pellagra, has long been prevalent in the Southeastern part of the United States. As has been known for about 35 years, it is due to an inadequate diet. Some medical men believe the disease diagnosed as pellagra is often due to a multiple deficiency, that is to a deficiency of two or more vitamins at the same time. It is the general opinion, however, that the more characteristic symptoms of the disease are due to a deficiency of nicotinic acid. The other vitamins most likely to be defi-

cient, along with nicotinic acid, are thiamine and riboflavin.

Unfortunately, the term nicotinic acid is sometimes confused with nicotine, and this confusion has led to some prejudice against the use of the vitamin. The two substances are not identical, either chemically or physiologically and the name nicotinic acid is a historical accident.

Symptoms of a deficiency: In man, the most characteristic feature is an "eruption" or dermatitis on the backs of the hands, feet, and forearms. A burning sensation in the mouth, and reddened tongue are frequently reported also. A long list of other symptoms has been reported as present in some cases.

In the dog, characteristic symptoms are reddening of the mucus membrane of the lip, cheeks, and floor of the mouth. Within a very few days the reddened areas become necrotic, with an exceedingly foul odor, accompanied by drooling of a stringy secretion from the mouth. This disease in dogs is known as black-tongue.

In swine, the symptoms are unhealthy skins with scabby patches; diarrhea; inflammation and necrotic areas in the intestines.

In poultry, leg deformities develop if the supply of nicotinic acid is inadequate. Under some circumstances chicks develop perosis; goslings are highly susceptible. Ducklings develop bowed legs when this vitamin is deficient; turkey poult develop enlarged hocks.

Stability: Nicotinic acid is quite stable.

Sources: This vitamin is so widely distributed that only poor food habits or poor feeding practices would explain a deficiency. Human beings who contract pellagra in the United States are said to subsist largely on corn bread, salt pork, and molasses. If, however, such a diet were re-enforced by diversified garden products, pellagra would disappear. Vegetables, fruits, and most seed foods, such as wheat, peas, and beans are reliable sources. Green leaves, such as turnip tops or spinach are especially dependable.

Niacin is unique in some respects for the amount required depends largely on the biological value of the protein consumed. The amino acid tryptophan can be converted into niacin by most animals, including man. In addition, niacin is synthesized by bacteria in the intestinal tract, and a portion of this vitamin is recovered by the host. Because of these complications there is great variability in estimates of the required amount. Some animals require none if the amino acids are supplied in suitable proportions.

Considerable information has been accumulated concerning the other known vitamins, but this is still largely restricted to experimental laboratories. Except for isolated examples, there is no reason to believe they are likely to be deficient and, in that sense, they are of limited importance. Needless to say, they are just as important to the animal that requires them as are those that are less widely distributed.

Vitamins that Are Not Deficient Under Practical Conditions

Further study may show that some of these should be transferred to the previous group.

Vitamine E.—It was observed over 30 years ago that on certain diets rats, of both sexes, became sterile. Later it was shown that the sterility was due to the lack of a certain vitamin, later known as vitamin E. It was also shown that if hens received insufficient vitamin E their eggs would not hatch. The protective substance came to be commonly known as the anti-sterility vitamin, though as it developed later the term was unfortunate. Vitamin E has other functions than that of preventing sterility. In time it became known that under certain conditions rats became paralyzed if deprived of vitamin E for a sufficiently long period of time. Under certain conditions guinea pigs and rabbits may also develop paralysis if their rations do not contain this vitamin.

Symptoms of a deficiency: In the rat, sterility and paralysis.

In the chick, paralysis; uncommon under practical conditions.

In the rabbit and guinea pig, paralysis, especially if cod liver oil is present in the diet.

In the lamb, stiffness. The disease was reported when the ration of the ewes consisted of cull beans and alfalfa. Presumably a considerable proportion of the vitamin in the feeds had been destroyed.

In cattle, degenerative changes in the heart muscle, and death; probably rare.

Stability: This vitamin is destroyed readily by oxidation, especially in the presence of rancid fat. Under practical conditions of feed storage it is usually preserved for months.

Sources: Green forage and many vegetable oils, such as oils of corn, cottonseed, and soybeans. Deficiencies have been reported but they are not common.

Vitamin K.—Although this vitamin is placed in the list of those that are unlikely to be deficient, it is known that pathological conditions may occur that are remedied by administration of vitamin K. New

born babies sometimes develop a defect in the blood-coagulation mechanism and die of hemorrhage. This is one of the more common causes of infant mortality, but it is easily controlled by administering the vitamin. Cattle, also rabbits, sometimes develop a similar defect, caused by consuming spoiled sweet clover hay. In severe cases the animals die from internal hemorrhage. Recent experimental work indicates that the disease can be cured by treatment with vitamin K. It is possible to produce this same bleeding abnormality in chicks by supplying them with experimental rations from which the vitamin is rigidly excluded, but the preparation of such a diet requires elaborate precautions, and considerable skill. It is reported that after some types of medication poultry develop a hemorrhagic condition, which is controlled by vitamin K.

Symptoms of a deficiency: In man and in chicks, hemorrhage due to a defect in the blood-coagulation mechanism.

Stability: The vitamin is not readily destroyed.

Sources: It is probably present in all practical feeds. Alfalfa is an excellent source and probably all forages contain liberal amounts.

Vitamin B₆, or Pyridoxine.—*Symptoms of a deficiency:* In the rat, reddened, inflamed paws, muzzle; swollen eyelids; fits. In the chick, jerky, abnormal gait; collapse.

In the pig, fits.

In the pigeon, anemia; dermatitis of the legs and feet; poor feathering.

In the dog, anemia; convulsive fits.

Stability: Pyridoxine is not readily destroyed.

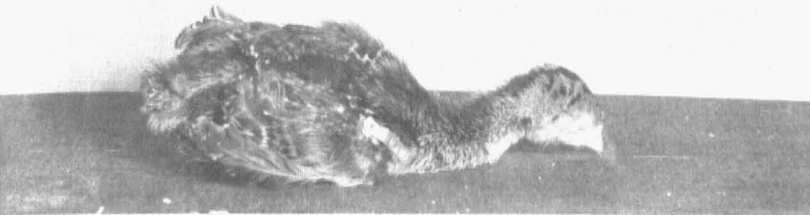
Sources: Is widely distributed in all natural food-stuffs and a deficiency is improbable.

Pantothenic Acid.—*Symptoms of a deficiency:* In the rat, reddened inflamed paws, muzzle; swollen eyelids; necrosis of the adrenal glands; black haired rats turn gray.

In the chick encrusted skin at angle of mouth, rough skin on legs and feet; cracks in the skin occur around the mouth and on the toes and feet.

In the pig, loss of hair; diarrhoea; inflammation of stomach and intestines; abnormal gait (goose-step) has been observed, and this deficiency is of some practical importance. This abnormality does not develop in pigs that have unlimited access to pasture of good quality.

It has been asserted that gray hair of man can be restored to its natural color by the administration of pantothenic acid, but this sounds improbable, and this method of restoring natural color to gray hair is not recommended.



Photograph at the left shows symptoms of a deficiency of pantothenic acid in a turkey poult. The

Stability: Pantothenic acid is not readily destroyed by the ordinary manipulations of preparing food or feeds. It is destroyed by either strong acid or alkali.

Sources: It is widely distributed and deficiencies are not common. Corn and tankage, if they are the only sources of pantothenic acid, do not contain enough to meet the requirements of swine.

Choline.—*Symptoms of a deficiency:* In rats, fatty livers; hemorrhagic kidneys; retarded growth.

In the chicken, fatty livers; interference with egg laying; perosis in the baby chick and turkey poult.

Stability: Choline is not readily destroyed.

Sources: Little information is now available, but the supply of choline is probably not an important problem. There is reason to believe that the inclusion of soybean oil meal in the ration of growing poultry will supply the choline required to prevent perosis.

The amount of choline required by the rat and chick is much larger than the amount of any other vitamin they require. For that reason some students of nutrition feel that although choline is an essential nutrient it should not be classified as a vitamin.

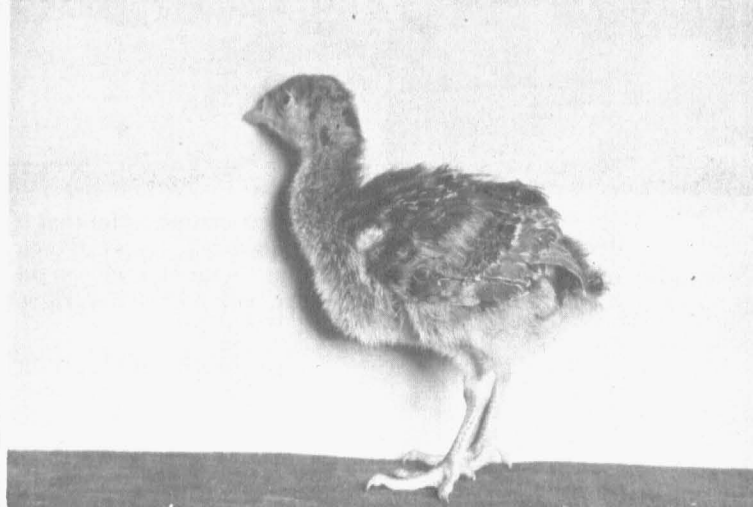
Biotin.—*Symptoms of a deficiency:* In the rat, awkward gait, humped back; loss of hair, closed eyelids; dark, roughened skin.

In the chick, redness and encrustation around eyes and corners of the mouth; legs and feet scaly and rough; perosis.

The amount of biotin that is required is very small, and it is difficult to remove biotin from a diet with sufficient completeness to permit a deficiency to develop. If uncooked egg white is included in the diet it makes this biotin unavailable to the animal and a deficiency is developed with ease. This observation supports the commonly held opinion that egg white should be cooked before it is consumed.

Stability: Biotin is quite stable.

Sources: It is widely distributed and a deficiency is improbable.



same poult is shown at the right as it appeared three days later, after it had been supplied with pantothenic acid.

Inositol.—*Symptoms of a deficiency:* In the mouse, failure to grow; almost complete loss of hair.

In the hamster, abnormal development of embryos.

Investigations of the nutritional function of inositol are several years old, and should be repeated with modern techniques.

Stability: Inositol is quite stable.

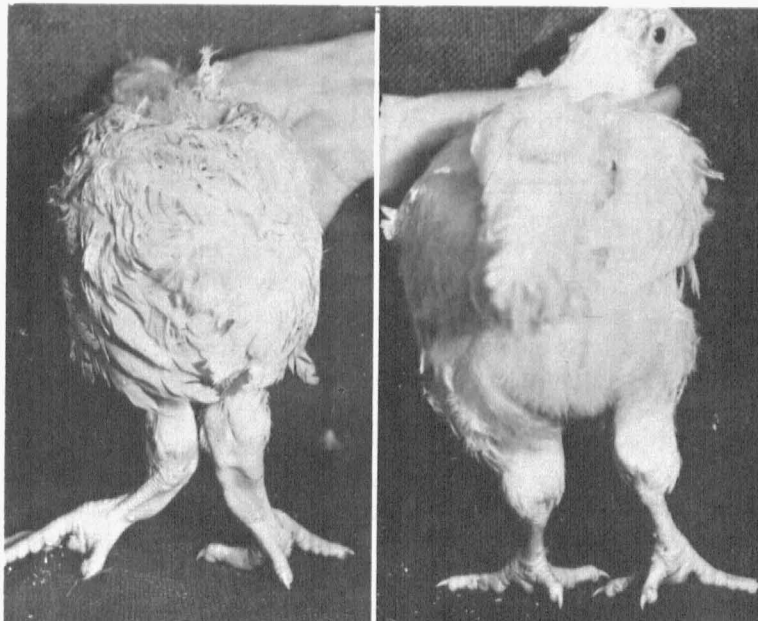
Sources: It is widely distributed and a deficiency is improbable. There is no reason now to believe this substance is of any practical importance.

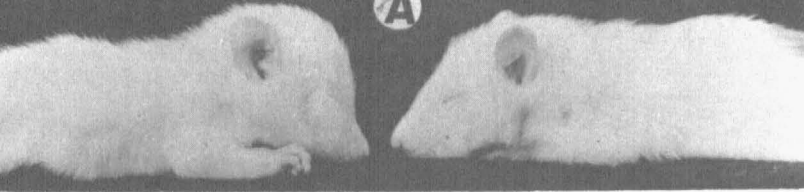
Folic Acid.—*Symptoms of a deficiency:* In the chick, anemia, weakness, quivering wings, body tremors and paralysis.

In the turkey, head thrust straight forward, commonly called "straight neck" paralysis.

In the rat, about 1.5 percent of the young are born with hydrocephalus (big-head, or water-on-the-brain).

Perosis (hock-disease or slipped tendon), left, is caused by a nutritional deficiency. Chick at right is normal.





When female rats consume a diet that is deficient in either folic acid or vitamin B₁₂, some of their offspring develop hydrocephalus (bighead, water on the brain). Compare affected rat, left, with normal one, right.

In the guinea pig, a high death rate, specific symptoms not reported.

In the monkey, anemia.

In man, anemia develops in cases of sprue. Folic acid relieves anemia, in pernicious anemia of man, but does not prevent mental deterioration.

Stability: Folic acid is not readily destroyed.

Sources: Is abundant in leafy vegetables and liver.

Most of the other green vegetables are good sources. Milk, most meats, cereals, and vegetables with little green color do not contain large amounts of the vitamin. Turkeys have an unusually high requirement for folic acid. It is possible to prepare a practical ration that does not supply enough folic acid for either chicks or turkey poults, but such a deficiency in the state of Missouri does not seem probable.

Vitamin B₁₂.—*Symptoms of a deficiency:* In the chicken, low hatchability of eggs; retarded rate of growth.

In the pig, reduced food consumption, irritability, weakness and inability to stand, slow growth, and mild reduction in number of red blood corpuscles.

In the rat, retarded rate of growth. A high mortality rate in the young shortly after birth. A high incidence (20%) of hydrocephalus in the new born young.

In man, pernicious anemia due to a functional derangement, is controlled with vitamin B₁₂. Presumably all normal human beings require the vitamin, but that fact has not been demonstrated.

Stability: Vitamin B₁₂ is quite stable.

Sources: Most fermentation by-products, fish solubles, good quality fish meal, milk and milk by-products. Of the human foods, meat (especially liver and kidney), eggs and milk are reliable sources. Plants contain no vitamin B₁₂, and ruminants (presumably all herbivora) obtain the needed vitamin B₁₂ from synthesis in the alimentary tract by microorganisms.

Unrecognized Vitamins

Fifteen different compounds have been described that are commonly accepted as vitamins. Students of nutrition would like to know whether or not there are any more but at present the answer is uncertain. Some investigators are convinced of the existence of two or three more vitamins that are now unrecognized. Other investigators are of the opinion that we do not have satisfactory evidence for the existence of even one more. The last vitamin to be discovered was vitamin B₁₂, the isolation of which was announced in 1948. That was practically seven years ago, and this is a longer period than has ever elapsed between the discovery of two vitamins, at least since thiamine was isolated in the year 1926. At the present time it is possible to rear swine, rats, guinea pigs, and chicks on synthetic diets with a considerable degree of success. It is true that diets of natural foodstuffs are often superior to these synthetic diets in some respects, but one can not be sure that the less favorable response is due to nutritional inadequacy. There is always the possibility that the physical texture of the synthetic diet is unsuitable in some way, or it may be that some constituent, when included in the diet of young animals, is objectionable in some respect. If unrecognized vitamins do exist it is difficult to demonstrate the fact, and any vitamin not yet discovered is probably of little practical importance.

If an unrecognized vitamin, or vitamins, does exist, it seems quite certain that we know how it can be supplied. It is certainly present in adequate amount in fresh growing grass, and whenever possible this kind of feed should be supplied in abundance to all types of livestock. If this is done there is convincing reason to believe that there will be no serious deficiency of vitamins. The provision of high quality pasture would solve many difficult nutritional problems. There are equally convincing reasons to believe that vegetables, especially the leafy vegetables, would vastly improve the diet of many human beings. If there are any unrecognized vitamins, concerning which we have little information, we are confident that we know how all of them may be supplied. It should be emphasized that food is the proper source of vitamins, and proper dietary habits will supply them. Pure vitamins and vitamin mixtures have their proper place, if taken under the guidance of a dietitian or physician. They may be helpful to many individuals with bad food habits, but they are not a substitute for proper food and they can not be depended on to maintain optimum health.

One finds a wide variety of attitudes toward the precautions that should be taken to secure an adequate vitamin supply. At one extreme is the individual who is completely indifferent and gives the problem no

thought at all. At the other extreme is the individual who is too much concerned, and almost makes a profession of counting vitamin units. Other publications should be consulted by those seeking assistance in planning diets, but a few remarks may be helpful to those who make a burdensome task of their personal vitamin supply.

It is not necessary that each meal should provide its mathematical quota of any vitamin. In fact it is not necessary that any three meals should do so. The body carries some reserve of every vitamin, though there are enormous differences between vitamins in the amounts that may be accumulated, and in the tenacity with which they are retained in the body. Presumably the body can retain enough of each of the fat soluble vitamins, A, D, E, and K, to tide it over a long period of scarcity, certainly for several weeks. Apparently one of the water soluble vitamins, vita-

min B₁₂, can also be stored for long periods. It is commonly assumed that the amounts of the other water soluble vitamins in the body can not be greatly increased over the normal level and that reserves are retained for comparatively short periods. Though our information on this point is very meager, it seems certain that if the vitamin supply has been generous previously, it would do no harm if, for three or four days at least, the diet were completely devoid of any specific vitamin. Such periods of deprivation are ordinarily unnecessary and should be avoided, but the fact that they are not attended with detectable injury demonstrates that constant preoccupation with the vitamin supply is a useless waste of time. Either extreme, then, is to be avoided. A more reasonable attitude is to adopt a flexible but consistent daily dietary regimen that includes approved quantities of the protective foods.