Vitamins and Vital Elements *

Suggesting a Possible Chemical Basis for Vitamin Activity

BY JOHN E. RUTZLER, JR.

IT is the writer's belief that the *action of the vitamins may be* due, within certain limits, to their *inorganic constituents*. The limiting factor is that the metallic, or the non-metallic element shall be present in an available form. This means that the organic radical, if it is at all necessary for availability, may be any one of a number of different ones. For example, sodium xanthate may just as well make the sodium available as may sodium acetate, sodium oxalate, or sodium cholesterate.

From this point on, in order to attempt to get away from the mystery of the word 'vitamin' let us call these substances nutritional factors. Then, nutritional factor number 1 will correspond to vitamin A, and so on.

An explanation of the action of these nutritional factors on the basis of their elemental inorganic composition involves the consideration of salt ratios, body colloids, the permeability of body membranes, catalysis, mineral frothing agents, solubilities, and other biologic phenomena.

Elements Associated with Vitamins

Let us proceed to assign to each of the five nutritional factors, in an arbitrary manner, a given element, or elements. Then let us try to hold these elements responsible for the actions of our nutritional factors. To factor number one we will assign iron, to number two, manganese, to number three, zinc, to number four, calcium and phosphorus, and to number five, iodine.

Before attempting to justify these assignments, it is of interest to consider these and other vital elements in the light of the periodic table. Ignoring carbon, hydrogen, nitrogen, and oxygen, for the reason that they do not have vitamin action, in the atomic form, it is fairly generally conceded that the most important elements to normal body function are: sodium, magnesium, phosphorus, calcium, zinc, manganese, iron, potassium, and iodine. Of these elements, sodium, magnesium, and phosphorus are in the third period of Mendeléef's Periodic Table, whereas potassium, calcium, zinc, manganese, and iron, are in the fourth period. Iodine alone does not fall in either of these two periods, being in the fifth period. Fig. 1 shows the grouping of these elements in the Periodic Table. There are two distinct groups of such elements. It is interesting to note that in the right hand group we have two very versatile elements, namely manganese and iodine. Of all the metals manganese has the greatest range of valence, while among the non-metals, iodine leads in this respect. Another notable fact is that the elements in the left group have only one valence each. In contradistinction, of

* Continued from the September issue.

those in the right group each has more than one valence.

There are several reasons for the assumption that the active principle of nutritional factor number one is iron. First of all, it was mentioned, under the discussion of vitamin A, that there is a relation between pigmentation and vitamin content. As was stated, it has been found that the more yellow a foodstuff is, the higher the vitamin A content. This may indicate iron, since iron is indispensable to plant life, and its tri-valent ion and many of its salts are yellow in color. Further, its oxide hydrosol can be got in a deep yellow form. Also, it has been found in spinach, the green color of which masks a strong yellow pigmentation. Coupling these things with the fact that spinach is rich in this nutritional factor, we have further evidence that iron is the important thing here, admitting at the same time that the major portion of the yellow color in the spinach is due to the presence of xanthophyll.

It is known that iron, in extremely small quantities, acts as a true catalyst in oxidation reactions, both within the body, and in entirely inorganic reactions.

Eminent physiologists believe that iron exists in the human body in the form of the ferric oxide hydrosol, $Fe_2O_3.3H_2O$. This is equivalent to two molecules of $Fe(OH)_3$.

Na	Mg			P			
K	Ca Zn					Mn	Fe
						I	

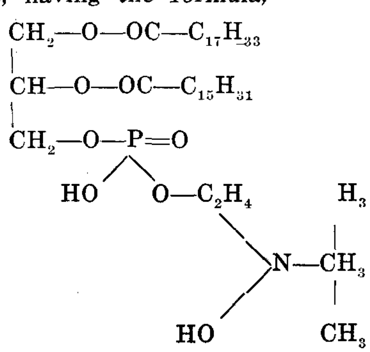
Fig. 1

With these facts in mind we will attempt to show, on the basis of its iron content, why nutritional factor number one is beneficial to body growth. The process of oxidation, which is vital to living cells, depends in no small measure upon a substance which acts upon peroxides to liberate oxygen. This substance, which was thought to be an enzyme, is called peroxidase. Iron acts upon the cell peroxides just as does peroxidase. Pursuing this idea further, experimenters have found that peroxidases are exceptionally active forms of the metal iron, and in some cases of manganese. Also, it has been shown that in order to so function, the metal must have at least two valences. This situation is found in the right hand group of the table shown in Fig. 1. Iron oxide hydrosol is protected from coalescing by stable albumin colloids in some parts of the body[15].

In summary, it has been shown that iron is necessary for normal cellular functions, due to its catalytic action, and the subsequent production of oxygen. Therefore, normal body functions, since they depend on normal cellular functions, must also depend upon the iron taken into the body. Since the evidence is in favor of the existence of iron in foodstuffs which are supposed to be rich in vitamin A, it can now readily be seen how iron could well be responsible for the growth-promoting action of factor one.

It is known that hæmoglobin contains iron. The amount of oxygen taken up by the hæmoglobin corresponds exactly to the calculated amount necessary to convert into FeO_2 all of the iron which is present. No such compound of iron is known. There are compounds of iron present, and they take up oxygen also. The important thing here is that there is a constant ratio of oxygen to iron.

To make this theory of value we must in some way show how iron may possibly be of assistance in the prevention and cure of xerophthalmia. We have seen that this disease is characterized by dryness and irritation of the eye. There is a cell membrane constituent called lecithin. It is closely related to the lipoids. It is a phospholipine, having the formula,



This substance is generally colloidal. In this form it is permeable to water and moderately dilute salt solutions. It has been found that flocculated lecithin is not permeable to water. The oxidation of lipoid films is catalyzed by iron salts. According to Mott, the electric potential of body cells is produced by the oxidation of lipoid films surrounding the globules.

Iron in Xerophthalmia

It is known that pathogenic bacteria cause xerophthalmia. The question which must be answered, is, "How does iron prevent and cure this disease?" For the normal function of the optic system a certain electric potential must be maintained therein. The iron sol may be precipitated due to the decreased potential which is caused by bacterial action. We make the assumption that the colloidal iron oxide is not protected by albumin in the optic system. The coagulated iron sol will then catalyze the oxidation of the lecithin in the cell membranes. As a result of this oxidation the H-ion concentration of the cells will rise, due to the formation of acids, and the electric potential will be restored to normal. The hydrogen ions present will then peptize the iron oxide back into solution.[16]. The oxidation of the lecithin will also provide the carbohydrates which are necessary for normal cell functions[15]. The oxidized lecithin will then be replaced by a new supply. Thus, we have shown how the disease may be prevented by the presence of iron.

When the bacteria are present and the ferric oxide hydrosol is not, the lecithin will probably be flocculated, due to the bacterial action. It then becomes impermeable to water, and the symptom of dryness appears. When iron is added in the form of nutritional factor number one, it proceeds to *oxidize the lecithin*. This causes the normal optic functions to reappear, due to the train of reactions discussed above.

We have assumed that iron is the controlling element in nutritional factor number one, and on that basis we have shown how iron could have the nutritional and anti-conjunctivitic properties that vitamin A is known to possess.

Manganese and Vitamin "B"

The case for manganese, as the controlling factor in nutritional factor two seems quite clear. It has been shown that manganese is as widespread in plant life as is iron, and further, that it is necessary for the normal growth of plants containing chlorophyll[18]. The element is therefore an essential part of the green things that are so abundant in our normal diet. Plants are a rich source of vitamin B.

There is another argument for the relation of manganese to vitamin B. Polished rice causes beri-beri when it is the main source of nutrition, whereas the polishings contain the curative and preventive substance for this disease. Now, it has been found that the polishings are rich in manganese, while the rest of the kernel has a low manganese content. This seems to be a significant fact. The effects of feeding manganese to prevent beri-beri, to the writer's knowledge, have not been thoroughly investigated.

Manganese acts in the body oxidation processes as does iron. It behaves similarly to the peroxidase mentioned under the discussion of iron. It may be that the oxidations which are catalyzed by manganese are those which occur in the nerve cells. This would explain how this element might act in preventing polyneuritis, and in promoting general good health.

The starch and sugar contents of leaves that have become chlorotic because of lack of manganese, are much lower than those of the normal plant[18]. This is in accord with the fact that carbohydrates are formed in body oxidations catalyzed by manganese.

Another striking fact is that seed germs, which are so rich in vitamin B, are abundant sources of manganese[18].

The facts brought out above suggest that this versatile element is the contolling one in nutritional factor two.

Zinc Analogy Weak

The case for zinc as the responsible agent in nutritional factor three is not as strong as that for the other elements. There are only a few facts to support it. First of all, zinc is commonly found in plant life. It is known that zinc is helpful in the growth of an organism known as aspergillis. In the summer, cow's milk contains zinc, and milk is known to be a fairly good source of vitamin C. Acids protect this nutritional factor and alkalies destroy it. This is just what would be expected because of the amphoteric nature of zinc. To support the theory herein proposed those vital elements which are metals must occur in the basic-combining form. Thus, in the presence of acids the zinc would act as a metal and form compounds of the general formula ZnR_2. In the presence of alkalies compounds such as Na_2ZnO_2 would form, destroying vitamin potency.

At this point it is well to mention the fact that manganese is amphoteric, and that alkalies destroy nutritional factor two more readily than do acids. This would be predicted in the light of this theory.

Nutritional factor four is next to be considered. To this factor we have assigned calcium and phosphorus.

Salt ratios seem to be of prime importance in connection with the action of calcium and phosphorus in factor four. Salts of calcium promote the formation of a membrane which is too impermeable for the performance of normal vital functions. Salts of sodium exert the opposite effect. They prevent the growth of the membrane, or else make it too permeable to resist normal vital functions. "Balanced solutions like mammalian blood appear to be those in which the antagonistic electrolytes are in such proportions that the protoplasmic membrane formed possesses that measure of permeability most favorable to cell life"[19] Thus, when the Ca/Na ratio is not correct the permeability of the membrane is altered and the bones do not ossify normally.

The Role of Phosphorus

Phosphorus plays the role of keeping the ratio between itself and calcium correct.

When the Ca/P ratio is high it is possible that the Ca/Na ratio is thrown off by the excess of calcium which would then be present in the system. This would result in a higher than the normal amount of calcium, and the membrane permeability would then be such that normal vital functions would not proceed. Thus we see that phosphorus may be indirectly responsible for the maintenance of the proper Ca/Na ratio.

When the body is deficient in calcium it is possible that it may be supplied with that element in the form of nutritional factor four from vitamin D.

Ultra-Violet Reaction

The action of ultra-violet light in connection with factor four can be explained in two ways, either or both of which may be responsible. The calcium may emit electrons and become activated by exposure to ultra-violet light. In this way it could become more available in foodstuffs, or in the human system. Also, the most available form of phosphorus may be the colloidal form. It seems likely that ultra-violet light will peptize phosphorus.

Let us now examine the facts that are known about the fourth vitamin, and see how they fit in with the theory of action proposed above. Rachitis is caused by the failure of the bones to take in the necessary amounts of calcium and phosphorus. If the salt ratios in the body are not proper, membrane permeability will be such as to prevent the passage of these two elements into the bones. This would cause rickets.

Though cod liver oil contains very little mineral matter, it probably contains enough phosphorus to balance the Ca/P ratio in the body. Thus it may be of much use in the prevention and cure of rachitis.

The absence of the proper Ca/P ratio would make the body unable to use its own rich calcium deposits due to the resulting impermeability of certain cell membranes. Thus, when vitamin D is absent rachitis will develop.

The action of ultra-violet light has already been accounted for in connection with this vitamin. There is another possible way that these rays may act. They may catalyze a photochemical reaction, the product of which is phosphorus in an available form.

The fact that upon saponifying cod liver oil and removing the soap, the cholesterol which is left behind contains almost all of the vitamin content of the oil, can be explained. The explanation does not assume that the vitamin and cholesterol are closely related, but rather calcium cholesterate, and cholesterol phosphate form which results in these two elements losing their availability.

Vitamin "E" and Iodine

This brings us to the consideration of the anti-sterility factor. This nutritional factor is assumed herein to be responsible for its conduct to the element iodine. The important thing in connection with this vitamin is indirectly that within themselves all of the endocrine glands act alike.

At this point we will summarize some of the facts concerning iodine and the human system. Iodine increases the electrical conductivity of the tissues. Feeble quantities of energy are sufficient to make iodine pass from the state of a positive catalyst to that of a negative catalyst. When a thyroidectomy has been performed the response to stimulation ceases, and only sufficient electricity is generated for the processes essential to life. When iodized thyroid extract is injected into the system, sensitivity, and the power to do work return to normal. Iodine in the body increases membrane permeability and electrical conductance. Due to these two effects it increases metabolism.

Thus, it has been shown that iodine has profound physiological effects upon at least one of the endocrine glands. Since the organs of reproduction are part of the endocrine system of glands, and since within themselves all of these glands act alike, iodine probably exerts an effect on these organs. Thus, we see that iodine may be of prime importance to the normal reproductive functions.

Without iodine the thyroid and the rest of the endocrine glands cannot function properly. Therefore, it does not seem amiss to attribute to iodine the power to prevent and cure sterility. Conversely, the lack of iodine may be the prime cause of sterility.

Vitamin E is soluble in many fats. This fits in with the hypothesis that iodine is responsible for the anti-sterility action of nutritional factor five because many fats absorb iodine.

Summary

We have now shown how each of the elements assigned to the five nutritional factors may be responsible for the action that the five vitamins have on the human being and on animals, the case for zinc admittedly being weak. We have also shown that many of the chemical and physical properties known to be possessed by the vitamins are in accord with this theory.

This theory can be substantiated or disproved by the use of the too little utilized spectrograph. A brief outline of the procedure for doing this follows. The methods for all of the vitamins are identical, so an outline for one of them is given. A great many of the foodstuffs, known to be sources of vitamin A, should be examined. Spectrograms should be made of each of these foodstuffs in turn, using a spectroscope capable of photographing spectra in the ultra-violet region. According to this theory all of the spectrograms should show the presence of iron. Those materials rich in vitamin A should show a higher iron content than those low in A content. This can be determined from the spectrograms. Next many foodstuffs known to be lacking in vitamin A should have their spectra examined in the above manner. This set of spectrograms should show little or no iron, if this theory is correct. If the theory is not correct, the foodstuffs devoid of vitamin A might show the presence of appreciable amounts of iron upon spectrographic examination. One should always be on the lookout for some element other than iron which may be common to all of the spectrograms of vitamin-A-containing substances; for the vitamin action might not be due to iron but to another element. Provided the spectrograms show what is predicted by the theory, another step is necessary before it can be called entirely valid. Animals suffering from conjunctivitis should be fed compounds of iron, and the effect noted. In this part of the procedure animals of the same kind but not diseased, should be used as controls. Both inorganic and organic iron compounds should be tried, also ferrous and ferric compounds. It might be necessary to intravenously inject these compounds into the animals. Colloidal iron and colloidal ferric oxide should be fed or injected. Provided these tests come out positive, this theory is entirely substantiated. If another element is found to be common to the vitamin-A foods as a result of the spectrographic examination, it should be fed as outlined above.

This procedure should be followed in the case of each of the vitamins, in order to obtain comprehensive supporting data.

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