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Some Means of Improving Human Life by Increasing the Vitamin Content of Milk and Its Products

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OUTLINE:

a. Some Reasons Why Civilizations Have Been Built Around the Dairy Cow and Suffer From Her Feed, Climate and Other Limitations.
b. Why Milk is the Only Complete Food.
c. Evidence of a Need for Creating More Vitamins in Milk.
d. The Seasonal Rise and Fall in Health and Disease.
e. A Study of the Seasonal Rise and Fall in Milk Vitamins in Five Hundred Places Throughout the World.
f. The Danger to National Health and Life From the Declining Minerals and Vitamins in Cattle Foods.

The complete dependence of infant life of the human species on milk and milk products for the sustenance of life is shared by all Mammalia. That so large a group of animal life is included in this restriction establishes the fundamental importance and value of milk as a food product. It is of particular interest and significance that the higher mammalian forms are dependent for a longer period upon milk as the food of infancy than the lower forms. For this reason the burden of human motherhood has had to be lifted by the utilization of foster mothers which have consisted almost entirely of some other animal and for this a very wide range of contemporary mammals have been used, including the cow, goat, sheep, horse, pig, reindeer, camel, llama, buffalo, water buffalo and yak. It is significant that all of these are grazing animals. It is for this reason that the people of the United States maintain approximately 25 million dairy cows, or one for every five of the inhabitants. That the mammary gland product of so large a variety of animals could be used as a source of milk to substitute for or augment that produced by the human mothers demonstrates the similarity of the chemical content of milk from various sources, the difference being largely in the concentration of various factors. This remarkable similarity is disclosed in Table 1.

It is of particular interest that in those countries where climatic conditions do not permit the maintenance of some animal to act as a foster mother, as in Greenland and many other countries, the human mothers are compelled to suckle their young to three, four, five and even six years of age. This suggests that milk must contain some factors that are very essential to human life that cannot readily be obtained from other sources. Conditions, therefore, which determine the value of a district for the comfortable and healthful maintenance of large human groups must of necessity be, in large part, influenced and even controlled by the capacity of the area to maintain in good health grazing animals that can function as foster mothers, and as we shall see later human welfare is tremendously dependent upon the availability of adequate nutritional food for such grazing animals which factors readily become quite rigidly fixed limitations for human progress and expansion.

Milk is the only single food known that is able to maintain life with continued growth, which means that it must contain not only the energy producing factors, but also those essential for the maintenance and repair of body tissues and for sustaining organ function. During a couple of decades

preceding the present one food values have been expressed largely in terms of energy production, hence their equivalent in calories. This was based on the oxygen that would be consumed in their burning, it having been established that the energy factor was the same whether determined on the basis of oxidation in the tissues for heat and energy production or when burned with oxygen in a confined chamber. It was found, however, that the purer the synthetic food product the shorter was the period of time that it could maintain animal life.

The great contribution of the last few years which constitutes an epoch in man's history has been the discovery of a group of substances called activators, some of which have been sufficiently identified to be labeled as vitamins A, B, C, etc. It is because in order for a food to be adequate for growth and the maintenance of life it must contain these activators as well as the energy producing factors, namely, the minerals and other chemicals needed for tissue building and repair, hence milk stands supreme and alone in importance as the only food which may contain all these substances in adequate quantity. Whenever milk fails to contain these essential activating substances in adequate quantity, mammalian life, whether human or other animals, cannot develop with maximum physical form and most efficient function.

The physical stress of gestation and lactation has been a very great factor in the multiplication and growth of animals of all the mammalian species and especially so of the human species. This is, in large part, because nature

	Water	Fat	Sugar	Casein	Albumin	Ash
	%	%	%	%	%	%
Cow	87.32	3.75	4.75	3.00	0.40	0.75
Goat	86.04	4.63	4.22	3.49	0.86	0.76
Ewe	79.46	8.63	4.28	5.23	1.45	0.97
Buffalo	82.34	7.57	4.96	3.62	0.60	0.84
Woman	88.5	3.3	6.8	0.9	0.4	0.20
Mare	89.80	1.17	6.89	1.84		0.30
Ass	90.12	1.26	6.50	1.32	0.34	0.46
Mule	91.50	1.59	4.80	1.64		0.38
Bitch	75.44	9.57	3.09	6.10	5.05	0.73
Cat	81.63	3.33	4.91	3.12	5.96	0.58
Rabbit	69.50	10.45	1.95	15.54		2.56
Llama	86.55	3.15	5.60	3.00	0.90	0.80
Camel	86.57	3.07	5.59	4.00		0.77
Elephant	67.85	19.57	8.84	3.09		0.65
Sow	84.04	4.55	3.13	7.23		1.05
Porpoise	41.11	48.50	1.33	11.19		0.57
Whale	48.67	43.67	7.11			0.46
Cow (mountain)	87.08	3.95	4.84	2.85	0.56	0.72
Cow (plains)	87.97	3.25	4.78	2.78	0.51	0.71
Sheep	82.82	6.12	4.73	4.46	0.98	0.89
Reindeer	65.40	19.05	4.05	8.48	1.56	1.46

Fig. 1 Composition of Mammalian Milk. Milks of the different mammals differ chiefly in the water and fat content.

has so constituted maternal units that in case of shortage in the food of the various products essential for making complete milk the mother will take these substances from the tissues of her own body for the nourishment of her developing embryo or nursing infant. There are many evidences of the seriousness of this overdraft. It has, for example, been found that practically every language has an expression equivalent to our own "A Tooth for Every Child," thus expressiug tbe acknowledgment that dental caries was particularly rampant at tbe time of pregnancy and lactation and associated with child bearing. This condition bas been produced in various lactating animals under nutritional stress. It has further been demonstrated and abundantly so, that if the milk product was produced by an individual, human or other animal, that was on a diet sufficiently deficient so that the maternal body could not supply the deficiencies very marked disturbances would develop in the young being nourished by tbat milk supply. These deficiencies bave not been chiefly due to the absence of such minerals as calcium and phosphorus, the chief constituents of bones and teeth, but primarily to the absence of the activating substances which though essential may be present only in very minute proportion and quantity to the total volume of the milk.

Macy and her associates[1] have shown that the absence of the water soluble vitamin B group is chiefly responsible for death in childhood in the Philippines. It has long been koown that one of the serious results of war consisted in the increase in rickets and other children's deficiency diseases.

With the progressive appreciation of the value of milk as a food product there has, of necessity, been an increase in demand which could only be supplied by increasing the individual production of the cows making up the dairy herds. This has been associated with a progressive decrease in the physical strength and resistance to disease of the offspring, such that it often happens that the calves of tbe most valued cows on the basis of capacity for milk production are the hardest calves to raise and are often required to be taken from their own mothers and placed on the milk of a cow that has raised a strong calf in order that they may be adequately nourished to normal development. This has not been caused by the cow not having received an adequate quantity of food or food incapable of enabling the cow to produce a large quantity of milk, but because that food did not provide to the cow the essentials for providing in addition to the energy producing factors and minerals an adequate supply of the activating substances, some of which are the known vitamins.

In order to more easily visualize the route of tbe mineral elements from the soil through to the human or other animal body by way of milk as a food product, we will consider some characteristics of the foods of plants and animals. First, we must remember that animals are dependent upon plants directly or indirectly for their food. Plants, whether grasses or trees, utilize binary water-soluble products. These include mineral salts such as, calcium, phosphorus, magnesium, potassium, oxygen, nitrogen and carbon from the soil and air. Plants through photosynthesis, by way of chloropbyll in the leaves make these into organic compounds containing three or more elements. These are available for building blocks for various forms of animal life which are, in the higher forms, almost completely incapable of utilizing the inorganic products utilized by the plant. The structure of the animal's body contains the same chemical elements as those producing the plant tissue, but largely in a different form.

The complete depeudence of plant

[1] Macy, Icie G.: and Outhouse, Julia: The Vitamin Content of Milk Used in Infant Feeding: Am. J. Dis. Children; Vol. 37, No. 2, Feb., 1929.

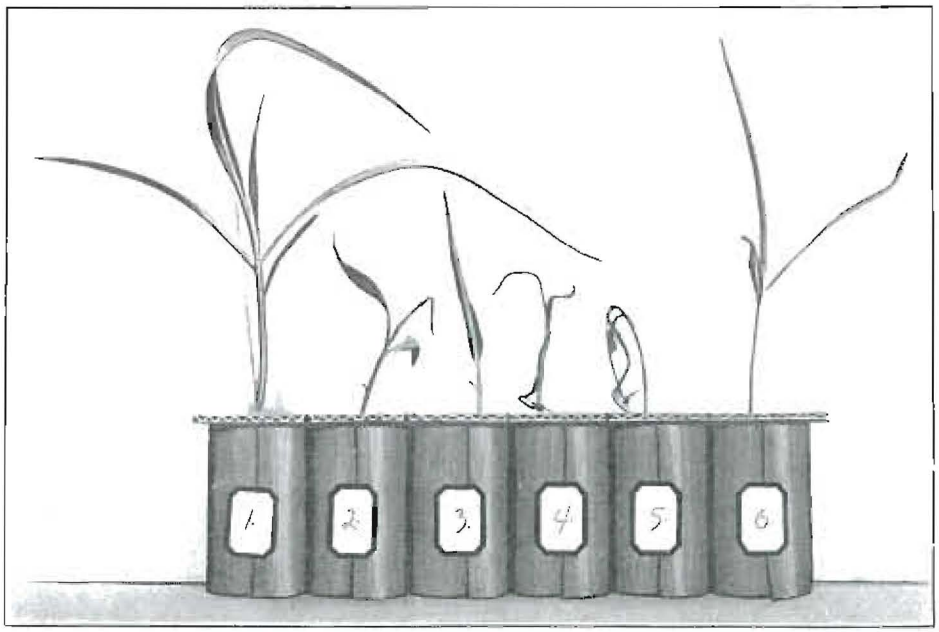


FIGURE 2.

These six corn plants are growing in distilled water plus five mineral salts as follows: calcium nitrate, potassium nitrate, potassium sulphate, magnesium sulphate, and ferrous phosphate. No. 1 contains all five. No. 2 lacks calcium nitrate. No. 3 lacks potassium nitrate. No. 4 lacks potassium sulphate. No. 5 lacks magnesium sulphate. No. 6 lacks ferrous phosphate.

life on the chemical constituents and physical characteristics of the soil and environmental factors can be easily demonstrated in many ways as can also the difference in the chemical requirements of different plants. In Figure 2 will be seen approximately ten days' growth of corn, grown in solution of mineral salts. In No. 1 all five are present and in the succeeding numbers all but the one salt indicated are present. No. 1 shows the amount of growth of the plant in a solution containing the following salts in distilled water per 1,000 c.c.: calcium nitrate two grams, potassium nitrate 0.5 of a gram, potassium sulphate 0.5 of a gram, magnesium sulphate 0.5 of a gram and ferrous phosphate 0.4 of a gram. Plant No. 2 lacks the calcium nitrate; No. 3 lacks potassium nitrate; 4 lacks potassium sulphate, 5 lacks magnesium sulphate and 6 lacks the ferrous phosphate. It will at once be seen that the corn has its most vigorous growth in the complete solution, is greatly stunted in No. 2 lacking calcium nitrate, only a slight growth in No. 3 lacking potassium nitrate and depressed growth in each Nos. 4 and 5 lacking respectively potassium sulphate and magnesium sulphate, and has its second best growth in No. 6, which lacks the ferrous phosphate. It must be kept in mind that large seeds have a potential reserve of minerals which tides the plant over the early periods of growth under conditions where not all of the minerals are deficient in proportion to the storage. The stored minerals feed the plant until its rootlets are formed and functioning. Similarly many other plants might be shown

These results have to do with the direct influence on early plant growth of those minerals and salts which form the largest part of the ash. Minute

quantities of certain other minerals are needed in addition by certain plants. One part in 20 thousand of some of the above and of some other minerals exert a very marked effect. For example, some plants including tomatoes seem to require copper in minute amounts, while others require baron, zinc or aluminum. The absence of minerals in the soil reduces the growth of plant lift and resultant ability of the plant to store those minerals, hence grazing animals are handicapped in their ability to obtain these minerals.

This is demonstrated in a series of studies I have been conducting on soils and grasses from an area in Texas (and also from many other places) in which a nutritional disturbance iu cattle has been troublesome, known locally as loin disease or creeps. Through the kindness of Dr. H. Schmidt, veterinarian, Texas Agricultural Experiment Station, College Station, Texas, I have been provided with bloods of experimental animals and samples of grasses and soils. I will present here in brief detail results of six different types of determinations that have been made in a stndy of the causative factors of organ and tissue degenerations, due primarily to nutritional disturbances. In a more extended communication I am discussing the evidence of breakdown in one or more organs or tissue in domestic and wild animals in many countries throughout the world. While some of these including loin disease have an associated infection factor, the fundamental lesion or disturbance is brought about by chemical deficiencies, chiefly mineral. Such disturbances in domestic animals are usually associated with an abnormal craving, particularly for bones, and treatment in many countries has as one, and usually the chief factor, the feeding of ground sterile bone. Animals may be so afflicted with a craving for the minerals that they will eat even putrid bones and by so doing may obtain toxic material and bacterial infection from organisms like bacillus botulinus and death may consequently be produced by the toxic products of the bacterial invasion. In many countries, however, members of this group of organisms are not available in the soil and although the animals do not get this organism large numbers die or are greatly reduced in efficiency. I have made these studies to throw light upon the human nutritional disturbances as well as those of the dairy cow. In figure 3 I have presented five phases for stndy:

I. Soils, the total and available plant food of calcium, phosphorus and potassium in three soils A1, A2 and B.

II. A comparison of 2 of the grasses A1 and A2 growing in the loin disease district with an average lawn grass taken from my front lawn, B.

III. The average calcium, phosphorus and potassium levels of the blood of 3 cows in the loin disease area and the average for 15 normal cows

IV. The milk-fat vitamins for cows in the loin disease district and in comparison my data for that entire latitude zone III.

V. The dairy requirements of a thousand pound cow are shown for each metabolism and milk.

The chemical analysis of the soils beneath the grasses analyzed gives important information bearing directly upon factors controlling the quality of the grass. This is shown in Group I of Figure 3. The chemicals are shown in one form only, namely, that available, for each of three minerals. Most of the minerals are in a chemical form not available for plants. The calcium, phosphorus and potassium are all low in both Texas soils, the phosphorus and potassium being exceedingly low; in fact, with no other information, in the light of our present knowledge, we would know that these soils could not continue to maintain stock on the pasture they could grow. The levels shown here for available plant food phosphorus at 0.0007 and 0.0008 are only a fraction of that provided by a typically

Study of a Texas Cattle Disease Area on a Mineral and Vitamin Basis, Considering Grasses, Cows' Blood, Milk-Fat-Vitamins and Cows' Mineral Requirements.

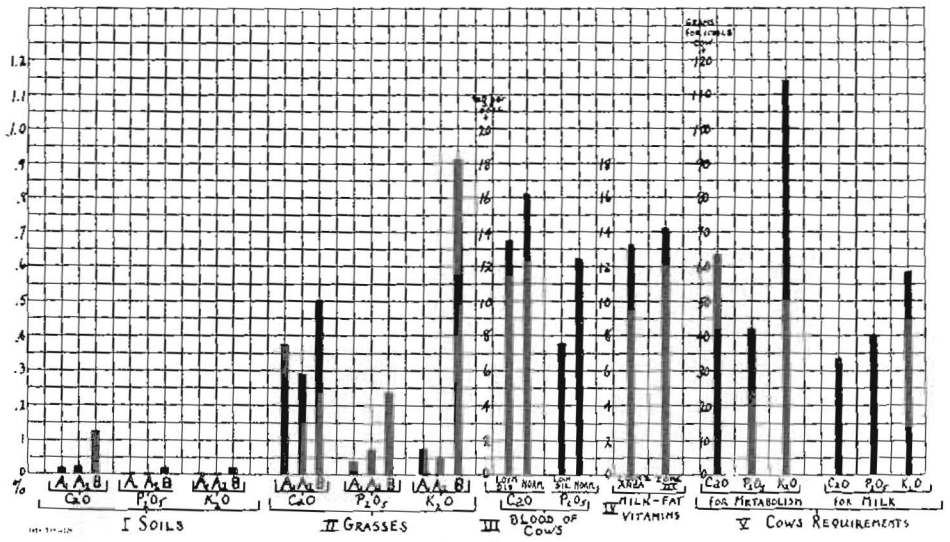


FIGURE 3

In Groups I. and II. A1 and A2, in each soils and grasses, are associated with a loin disease area in Texas. B represents a lawn grass and its soil for comparison for each calcium, phosphorus, and potassium. In Group III comparison is made of the calcium, and phosphorus of the bloods of cows of the loin disease area. Group IV shows a comparison of milk-fat vitamins. Group V shows a cow's requirements for these three minerals for metabolism and for milk.

good soil and the available potassium at 0.0004 and 0.0003 are likewise far below the minimum requirements for a good soil. In Group I A1 and A2 are the soils beneath the two Texas grasses and B is the soil beneath my lawn grass.

In Group II will be seen the chemical content of the grasses. It will be seen that the calcium of the grass marked A1 is about one-third that found in my lawn grass B which itself is low in calcium. Grass A2 is about one-quarter that of my lawn grass. As we shall see later even this low level of calcium is not the great embarrassment. The phosphorus contents of these two grasses are respectively 0.04 per cent and 0.07 per cent of the dry grass or one-twenty-eighth and one-sixteenth respectively the quantity in my lawn grass. The potassium fares still worse. The quantity in grass A1 is 0.07 per cent of the dry grass and in A2, 0.05 per cent of the dry grass. That in my lawn grass is 0.49, seven times that in grass A1 and approximately 10 times that in grass A2. We will see shortly the results that must be produced from the use of such fodders.

Since the blood of cows as well as the efficiency of the body will, of necessity, be dependent upon the food elements available we obtain important information from an analysis of the blood for the level of various chemical elements, only three of which are presented in this chart. In all of these studies, including soils, grasses, bloods, milks, etc., a large number of chemical elements were determined which space does not permit of presenting here. It is of great importance that the controlling mechanisms of the body are able to maintain relatively constant levels for most of the chemical constituents, due to a remarkable system of temporary borrowing from depots of storage with-

in the body. When disturbances appear in the mineral content of the blood or body tissues they usually indicate a very marked stress in which the body is not able to compensate by processes of readjustment and borrowing. The tissues, therefore, must suffer and function be impaired. Notwithstanding this remarkable compensatory capacity bloods sent to me for analysis of cows living on the pasturage of the loin disease area show very definite evidence of embarrassment. In Group III of Figure 3 I have presented the levels of calcium, phosphorus and potassium in the bloods of 15 normal cows as controls and the average levels for 3 cows from the loin disease area. It is of great importance that all of these 3 cows whose blood chemical content is shown here have had bloods so seriously deficient in spite of the fact that each was receiving 3 ounces of bone meal per day, which if it were all available would go far to compensate for an ordinarily deficient pasture grass. The average calcium level in the serum of a normal cow in my series has been shown to be 11.5. The average for these 3 cows in the loin disease area is 9.7. The inorganic phosphorus of the bloods of my series of normal cows has an average of 5.5 and in these 3 it is 3.3. It has been known by the cattlemen of the affected districts that simply moving the affected cattle to another district for a few weeks or months would not only cure the disease, but permit them to return to the same pasturage and frequently not break again for months. This demonstrates nature's remarkable capacity to replace depleted minerals in the normal storage depots of the body. One cattleman writes me that just moving his cattle across the road cured the disease.

An additional group of data are available from a study of the requirements of the body for metabolism and for milk production. These data are shown in Group V, Figure 3. The daily requirements of a normal cow weighting 1,000 pounds for metabolism will be 42 grams of phosphorus, 63 grams of calcium and 114 grams of potassium, estimated as their oxides. It has been estimated that a normal cow weighing 1,000 pounds can eat daily 56 pounds of fresh grass. The water content of the green grass making the difference between green and dry grass is usually estimated at 70 per cent. From the analysis of the grass shown in Group II, marked A1, which expresses the minerals in the percentage of dry grass, we see that, that quantity of this grass would only furnish a total of 19 grams which would be the limit of available phosphorus from that source for one day. We see by this that each day this cow would have to borrow from her storage depots, the tissues of her body, chiefly the skeleton, 23 grams of phosphorus. Her requirements for calcium would be 63 grams and the amount available in grass A1 would be 199 grams. There would, therefore, be 136 grams more than she would need for the daily requirements for metabolism. The needs of the body for potassium are very great. This 1,000 pound cow would require 114 grams every day. Grass A1 could only furnish her 11 grams and her need would, of necessity, become very great. Were this cow milking and producing five gallons of milk per day, which would not be a large amount for a good producer, she would require 46 grams of phosphorus for that purpose in addition to that required for metabolism. Of calcium she would require 34 grams and of potassium 58 grams for the milk alone. In other words, there would be a combined demand for both metabolism and milk production of 82 grams for phosphorus, 97 for calcium and 172 for potassium. These are all computed as their oxides. On a ration of grass A1 alone the daily overdraft for phosphorus would be 63 grams and for potassium 161 grams. The calcium demand would be satisfied with 102 grams unused. About one-fifth of normal bone structure is phosphorus, one-

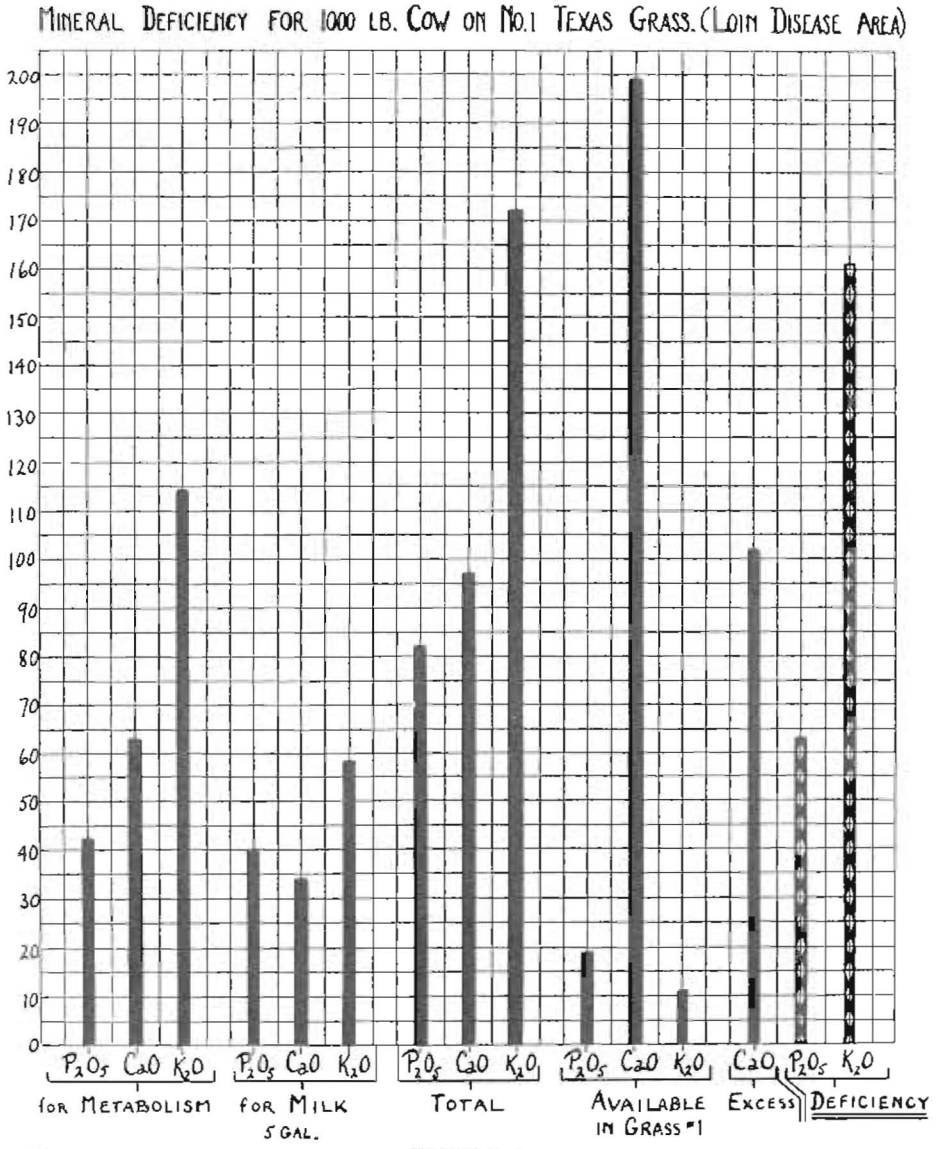


FIGURE 4.

This shows the metabolism and milk demands of a cow for minerals and the amount of these minerals available in a 56 lb. daily ration of the Texas A1 grass. There is enough calcium and some to spare, but a large deficiency of both phosphorus and potassium.

third calcium, one-fiftieth magnesium and the balance organic material. The three ounces of bone meal would only provide about 18 grams of phosphorus even if all were utilized, which is probably never possible.

In Figure 4 is shown graphically this daily mineral shortage for phosphorus and potassium if only grass A1 were used. In this chart there are also shown graphically the mineral requirements of a 1,000 pound cow for each metabolism and milk production. The total daily requirements of a cow for each metabol-

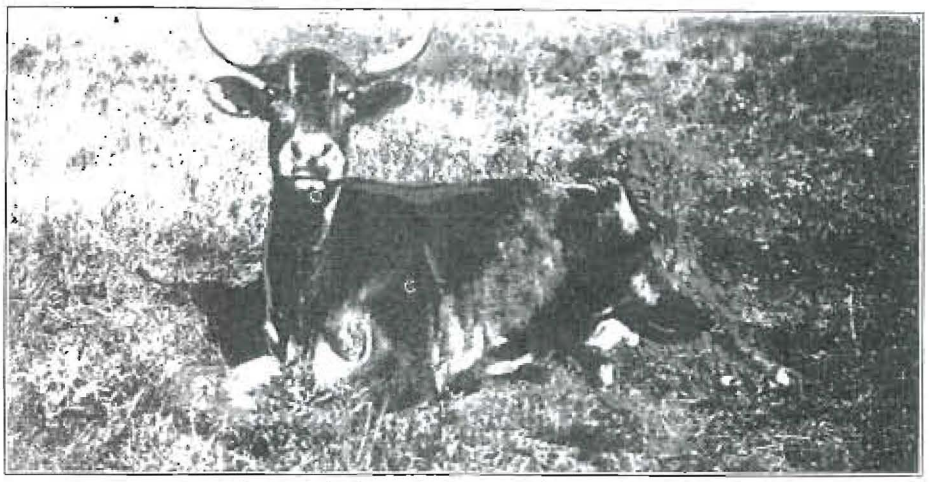
ism and milk are shown in solid columns for three factors, phosphorus, potassium and calcium. It will be seen that the phosphorus requirement for five gallons of milk is almost as great as the cow's own daily requirements. The calcium and potassium are both a little over half as much as metabolism requirements. The sum total of these two is shown in the third group of these solid columns and in the fourth group of three columns the amounts of thes three minerals available in grass No. 1 are shown graphically for a day's ration. In the last group of three it will he seen that there is an excess of calcium which is indicated in the solid column, but a large shortage of each phosphorus and potassium both shown in the open work column. These represent the daily deficiency of a 1,000 pound cow on this particular grass.

In Figure 5 will be seen two views of cows that are down with loin disease. Through the kindness of Dr. Schmidt I am permitted to use these typical illustrations of this disturbance. Cows with loin disease at times go insane and attack those who are trying to help them. They often linger for days, dragging their paralyzed parts in an effort to maintain nutrition. Somewhat similar deficiency diseases have created great havoc in many countries of the world. Expressions of deficiency diseases are generally a little different in one country than in another, due primarily to differences in the mineral deficiencies of the soil. In some countries these conditions become so severe that when cattle and lambs are allowed to run together the cattle will kill and completely eat the lambs. Workers on biological problems involving deficiency diets frequently find that where animals are together, one after another members of the group in the cage will be missing, having been entirely eaten by their associates. This, of course, requires that in such tests animals must be in separate cages.

The emphasis of recent years has been almost entirely upon the role of infecting organisms without due consideration for either the mineral content of the food ingested and the mineral needs of the body or the role that these deficiencies play in establishing a condition of susceptibility to attack from infecting organisms. When we recognize that humans are also chemical machines like the cows and are dependent upon the food intake for the maintenance of the structural units of the body, we realize at once that there is great possibility that imbalances will develop from inadequate diets. It is very easy for us to place practically all the stress upon the mineral intake together with the energy producing food factors with too little attention upon the activators. While the activators include the known vitamins they also include many substances not already identified or classified.

A most interesting incident happened in connection with the cows whose bloods we have just been studying with regard to loin disease in the coastal counties of Texas. According to Dr. Schmidt within about a week nearly all of the cows affected "went off bone meal." In other words, they suddenly lost their bone craving. This occurred with the rapid growth of the young grass and lasted for about six weeks, when a most remarkable incident happened. Within about four or five days practically all of the animals again acquired the craving for bones. The usual method for testing for this condition (though often it will be immediately observable by the fact that the cows will eat pieces of wood, cloth, or even dirt when bones are not available) is to place two grades of bones before the cattle to be tested and to note the percentage that try to eat them. The very severe cravers are determined by the fact that they not only will eat the clean bones, but will eat the putrid bones. Usually two kinds of bones are used; some that are clean and white, free from all objectionable

Animal making an effort to rise after it had been down with loin disease for ten hours



Animal suffering from loin disease just found on the prairie

FIGURE 5.
Some typical expressions of loin disease, which is primarily a mineral deficiency disturbance with toxic poisoning from the eating of infected bones.

odors, and some putrid bones. Why did the cattle acquire the craving so suddenly? Dr. Theiler, working in South Africa where there has been a great deal of trouble with this affection, has presented data from which I have made a graph shown in Figure 6. By following the results outlined by Dr. Theiler as shown in the graph which I have developed from his data to more easily visualize them, it will be seen at once that the intensity of the hunger is not related directly to either sunshine or rain alone or even together. A note of caution is probably justified, in that, individuals living in a particular latitude in either the northern or southern hemisphere will be in danger of thinking of seasons in terms of their expression in their geographic and physical

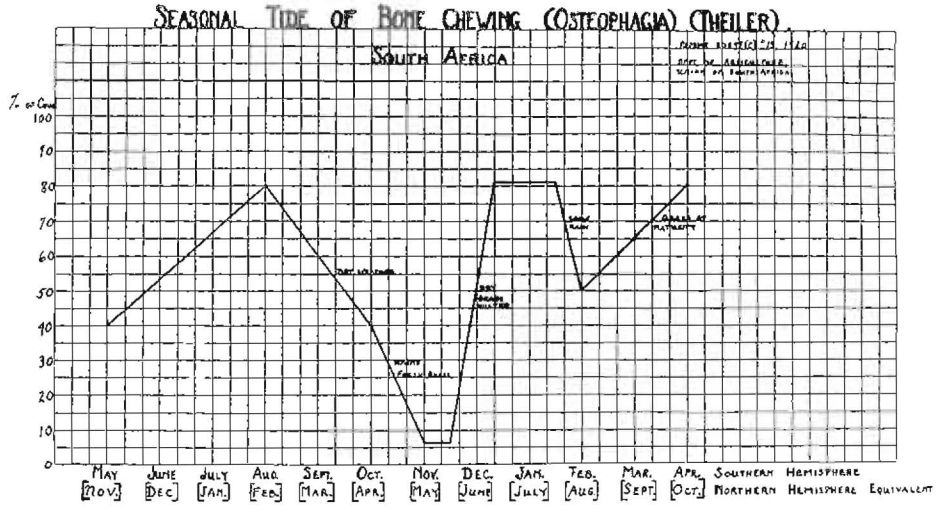


FIGURE 6.

This shows the seasonal tide in the bone craving produced by mineral deficiencies, which is a common and serious disturbance in some grazing animals in many countries of the world.

location, whereas, quite different factors will obtain with regard to the period of growth as related to sunshine, maximum heat and cold periods, seasonal rainfall, etc. The latitude in which Dr. Theiler's work was done was approximately 40 degrees South. During the period commencing with the beginning of the winter season, which is not a cold season in that latitude, and progressing through May to August (our winter, November to February) there was a continual increase in bone-chewing. Note that at this point 80 per cent of all the cattle ate rotten bones. During the time from August 5, to October 27, there was a continual diminution of the curve, at which time it had fallen to 40 per cent. Note that during this period Dr. Theiler states: "the weather had been continuously dry, but as it grew warmer the spring vegetation began to appear, and this is regarded as responsible for the diminution in pica bone-chewing." At this time rains began and lasted for a fortnight, with the result that "the young vegetation became almost luxuriant, and by the middle of November the craving had rapidly fallen to 6 per cent." We see then an association so far with the rapidly growing grass. A number of important factors are recorded after a fortnight of rainless weather; the young grass wilted and although the craving remained at the low level of 6 per cent for two weeks, in the next three weeks it increased to the high level of 82 per cent, the highest recorded, and around which figure it oscillated for the next two months of summer drought. Clearly, something had happened to the grass so that in its present state it could not supply to the animals that which they needed so acutely to prevent the abnormal craving. As Dr. Theiler has emphasized, we have the record that the craving increased while the cattle were eating the old dry grass of the preceding year, prior to the beginning of the growth of new grass in August (their mid-winter, equivalent to our February) and that again during the period of dry weather when the grass was wilted in their summer, December and January (our June and July) the craving was acute. He reports that in the middle of January "the drought broke, the pasture recovered, and it was naturally thought that the craving would

again disappear. The unexpected happened, however, and notwithstanding the ample supply of good green grass and the absence of wilting, the craving did not fall to the previous 6 per cent, but only to 50 per cent." He states further that "by the end of March (the end of their summer) the craving again stood at 80 per cent." It is of particular interest that Dr. Theiler relates these phenomena directly to the phosphorus content of the growing vegetation.

It is very evident from many sources of information that the utilization of minerals in food is often directly dependent upon not only a sufficient quantity of the particular minerals in available form, but also that there shall be present in adequate quantity, certain activators, some of which are the known vitamins. For the cow these must be available in the grass which she eats. If she can obtain sufficient of each of the minerals and activators for the needs of her own body she will without depletion of her skeleton provide them for either lactation or gestation. Nature, however, has provided that in case of shortage the mother's body will be depleted. This depletion may be restored and under normal conditions the restoration is completely accomplished during the period of rest after the stress. The nature of the activators, whether the known vitamins, including both the water soluble and fat-soluble, or those regarding which but little is known, would seem to be almost dependent upon several factors; namely, the character of the plant, the soil on which it grows, the available moisture and temperature, and the radiant energy with regard to both the kind and quantity which nourishes and develops it.

We have naturally thought of grass such as cows eat as being a similar thing wherever found. It looks green and has many physical factors in common. In Figure 7 I have shown in groups for comparison, grasses that I have studied from the chemical standpoint and for their vitamin content.

Comparison of Mineral Content of Pasture Grasses

1. Pennsylvania Knoll Grass.
2. Ohio Lawn Grass.
3. Arizona Johnson Grass.
4. Arizona Crowfoot Grass.
5. Texas Loin District Grass No. 1.
6. Texas Loin District Grass No 2.
7. Pennsylvania Iron Weed.
8. British Columbia Land Kale Plant.

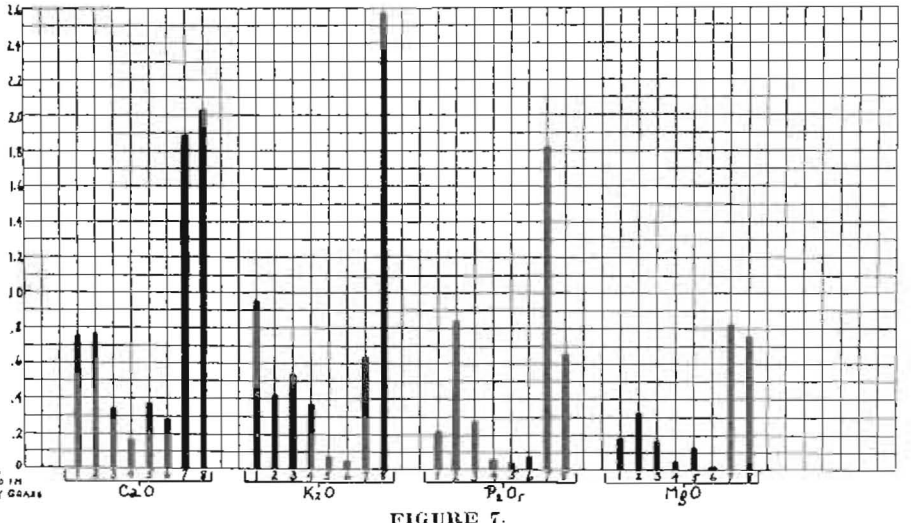


FIGURE 7.

The difference in the chemical content of different pasturages from different places indicates an almost unbelievable difference in the mineral content that is possible and demonstrates readily the tragic stress that deficient grasses must produce in animals.

These grasses selected are from eight different sources and have been studied chiefly for their minerals, four only of which are shown, namely, calcium, potassium, phosphorus and magnesium. They are numbered from 1 to 8 successively for each of the four chemicals. No. 1, is a Pennsylvania knoll grass which I obtained while searching for the causes of high vitamins being produced by a particular herd feeding on this farm. No. 2, is an Ohio lawn grass growing on the front lawn at my office. No. 3 and No. 4, called Johnson and Crowfoot grass respectively, were from an Arizona district that showed evidence of nutritional disturbances. Nos. 5 and 6 are two Texas loin district grasses, the first of which we have just been studying. No. 7 is a plant that the cows were eating with great avidity on the farm in Pennsylvania. This plant is locally called Iron Weed. No. 8 is a pasturage shrub eaten liberally by the stock in British Columbia and called land kale. A glance at this chart reveals a remarkable difference in the quantity of the minerals in the grasses grown in different places. For example, the variation in calcium is from 0.17 per cent of the dry grass in Arizona, Crowfoot grass, to 1.9 per cent in the Pennsylvania Iron Weed and to 2.0 per cent in the British Columbia land kale, the last two having ten times as much available calcium as the most deficient grass. The variation in potassium is seen to be very great, that in No. 8 being over fifty times that in No. 6. The variations in phosphorus are also very great, that in the Texas loin district grass (No. 1) that we have just been studying being only one-forty-sixth that in the Pennsylvania Iron Weed. Similarly, the variation in magnesium is about 60 times as great in the Pennsylvania Iron Weed, which was being eaten ravenously by the cows, as that in the grass No 2 from Texas. From this chart we see at once where we might go for some grass or fodder to reenforce that which is found to be so deficient both from clinical experience and from chemical analyses.

The experience of dairymen engaged with large production herds is that they frequently, if not usually, produce weaker calves than cows not being fed for high production. This strongly emphasizes the absence of some factors during one or both the gestation and lactation periods. In discussing this matter recently with a dairyman who announced that a means had been discovered for conserving and providing the growth and development for these weak calves, he stated that his new practice was to remove the calves from the mother's milk within twenty-four hours when they were found to be abnormally weak and place them on the milk of a cow that had been known to give birth to and rear a vigorous calf. These calves are valuable because of the large production capacity of their mothers. I asked him what was done with that cow's milk, whether it was bottled up and sold at an extra price for babies. "By jove, that's a hard one" he said, "but that is precisely what we are doing."

In the light of my researches the deficiency in cow's milk is largely the absence of the vitalizing or vitamin factors and not the mineral content. With the increase in the density of population of particular areas of the United States there has been, of necessity, a change of balance in values which have affected pasture lands and besides have greatly reduced the ratio of pasture land to that required for all the various uses associated with the densely populated district. This has also, of necessity, enormously increased the demand for dairy products for given areas. New York City, for example, is reported to use approximately three million quarts of milk per day besides cream and butter. Notwithstanding the increased facilities for long distance hauling this constitutes a very exacting physical limitation and requires the transportation of fodder to dairy herds maintained near large centers of population. This

also carries with it the requirement of a relatively even distribution of the milk supply throughout the various months of the year in order to provide the needs of human nutrition. This also places a burden upon the cropped land from which the cattle food products are shipped through the continued shipping off the land of the farm products. Probably few of the problems concerning the coming generations are more exacting and difficult to meet than the problem of reduction in the mineral and other chemical content of the soil through this process of depletion together with erosion by wind and rain due to the reducing vigor and covering capacity of the vegetation.

I have before me communications recently received from the majority of the states in the Union in reply to my inquiry as to whether there was evidence of a reduction in carrying capacity of the soils of their state that might be traceable directly to the cropping and pasturage. The data received indicate that there is generally recognized to be a marked reduction ascribed to a group of causes associated with the cropping and shipping from the soil of plant products. The data I am obtaining from my studies strongly suggest that the vitamin content of dairy products is largely dependent upon the utilization by the cow of either a rapidly growing fresh grass that has developed on a soil amply provided with mineral requirements of the plant to provide to the cow not only these minerals, but activating substances which are not produced in adequate quantity in the absence of an adequate supply of the minerals. That this shortage is not limited to the cropped, tilled land, but also obtains over many pasture ranges is strongly suggested by the marked reduction in calf crop in many of the cattle range areas of our country. According to data provided by state and national bureaus this factor has become quite serious in many places. There is a phase of this problem that seems not to have been sufficiently a part of the general consideration of the best health interests from the standpoint of the health of the masses. Indeed, we have looked upon health as a normal and constantly present state except in the presence of disease. We have, accordingly, spent much effort, and wisely so, both to eliminate infectious and the so-called degenerative diseases.

Humanity's greatest quest is for health. The struggle to maintain life constitutes much of the energy of all forms of animal life. As chemical machines we require not only energy-producing foods, but also those that can be utilized by the body tissues for growth and repair. We have thought of the building blocks of the body in terms of minerals and other chemicals constituting the hard and soft tissues, protoplasm and fluids of the body. With the newer knowledge of life the activators, including the known vitamins, take the place as the fundamental requisite both for the maintenance of life and for growth. Rapidly during very recent years a group of physical disturbances discussed and considered as diseases have come to be recognized as embarrassments of certain tissues of the body due to an inadequate supply of certain of the activating substances. In this group will be considered the rickets of childhood which is a disturbance in bone development and related to an inadequate supply of vitamin D; beri-beri, a severe disfunction of the nervous system associated with paralysis in humans and other animals and related to a deficiency in the diet of vitamin B1; scurvy, for centuries a curse to sailors, and associated with the absence of vitamin C; xeropthalmia, an acute eye infection, and abscesses at the base of the tongue and general susceptibility to infections due to a deficiency of vitamin A; pellagra, a marked nutritional disturbance associated with the absence of vitamin B2 or G; and disturbances in reproduction, particularly gestation due primarily to an absence of vitamin E. These vitamins have already been sufficiently rec-

ognized to be given identifying characters as letters of the alphabet. That there are many other activators not yet so well understood has been abundantly demonstrated. Their association, however, with specific bodily disfunctions or tissue degenerations has not been sufficiently elucidated. The very nature of the vitamins is not yet sufficiently understood to permit of relating substances of somewhat similar effects. For example, vitamin A is known to be associated with the development and function of many tissues of the body, particularly the epithelial structures and certain structure of the nerves. The retina of the eye is rich in vitamin A. It has, however, been found that carotin, the coloring matter of carrots and found in many other plants, will prevent infections in practically the same minute dilutions as will vitamin A. It will also cure xerophthalmia, an acute eye disease, quite as readily as will vitamin A and yet this substance does not respond to the tests for vitamin A and is not recognized as vitamin A. This fact suggests that vitamin A (as at present understood) produces its characteristic effect because of a specific atomic formula. The utilization of minerals and probably of other chemicals seems to be largely dependent upon the presence in the food or in the system of both of these specific activating substances, and disease or disturbed health is now seen to be, in many cases, due to the absence of certain of these activating substances.

It is of particular interest that diseases are generally divided into two main groups, those due to invasion of the system by microorganisms which include the infectious diseases, some of which are contagious or readily transmissible. These have included the epidemic diseases which in the past have taken such large tolls of human life. Many, perhaps most, of the epidemic contagious diseases have been brought under control by isolation, prophylaxis and specific treatment. A few like influenza are still unconquered. Another large group of physical ailments is spoken of as the degenerative diseases. Many of these are associated with localized infection, chiefly by serophytic organisms. This group of disturbances causes a large part of the natural deaths today. Some of the so-called degenerative diseases are apparently on the increase in many localities. An important characteristic has to do with seasonal cycle as a rise and fall in their incidence in severity. It is for this reason that our hospitals have a marked increase in medical cases in the winter and spring with a reduction in the summer and autumn.

While very many diseases have a rise and fall in incidence in various months of the year we will take three or four representative but different types of disturbances showing the seasonal incidence. Figure 8 for New York City presents the number of cases by months for scarlet fever, and the number of deaths by months for each organic heart disease, pneumonia and disease of the arteries. It will readily be seen that, in general, the peak is reached in March with a progressive decline to August, then a progressive rise again to March. In this chart we have the average for these diseases for the six years, 1923 to 1928, inclusive. We are concerned at this point to know why these diseases have a similar incidence of severity for different months and why so many of them have their peaks and low points at the particular times of the year that they do. If it were due to some mysterious energy factor from the sun acting directly why do the extremes not follow the curves for hours of sunshine? When these factors are studied for various countries some very interesting factors are brought out. This is splendidly demonstrated in Figure 9 in which the incidence by months for pneumonia and heart disease is shown for each the United States of America, England and Wales and New South Wales, Australia. It will be seen at a glance that the curves for deaths from heart disease and pneumonia for each of these three countries shown in

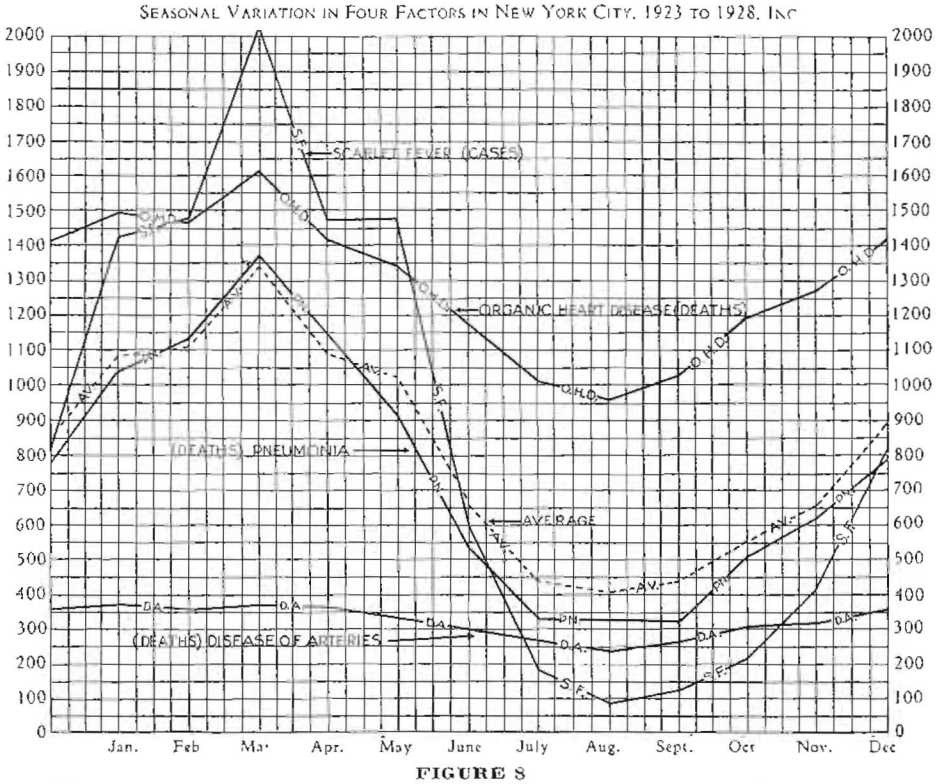


FIGURE 8

The means for several morbidity and mortality curves for 6 years in New York City follow the same general configuration by months. This is shown as being typical of these diseases for many other cities.

the top row in groups A, B and C have a most remarkable similarity on the basis of season, the southern hemisphere curve for Australia being transposed a half year for this comparisou to bring it into the same phase. In the second row it will be seen in group D that the curve for pneumonia shown for the United States in the solid line and for England and Wales in the broken line are exceedingly similar. Likewise in Group E the heart disease curve for these two countries is seen to be very similar. In Group G in the third row the three countries are shown for pneumonia and in Group H for heart disease. These curves are also seeu to be strikingly similar. A combination of the two curves; namely, heart disease and pneumouia for each the northern and southern hemisphere, is shown in the seasonal relationsbip in I, the last group in the second row. Similarly, these are shown for calendar relationship in Group F, the last group in the third row.

It would seem to be very clear that factors that have so constant an expression in different parts of the world must have similar causes. However, exceedingly little seems to be known regarding the nature of these causative factors. It would seem that just as they have been known to be associated with the seasons which themselves are iuevitable, just so, these calamities have been accepted as inevitable. Owing to the apparently very great importance of throwing light upon the causative factors for the rise and fall in the incidence of human disease I have directed intensive effort toward a study of pos-

Comparison of the Mortality Rates by Months for the United States of America, England and Wales and Australia.

Pneumonia U. S. A., Jan., 1923, to Dec., 1927; Eng. and W., Oct., 1923, to Sept., 1928; Austr., Jan., 1924, to Dec., 1929.
Heart U. S. A., Jan., 1925, to Dec., 1927; Eng. and W., Oct., 1923, to Sept., 1928; Austr., Jan., 1928, to Dec., 1929.

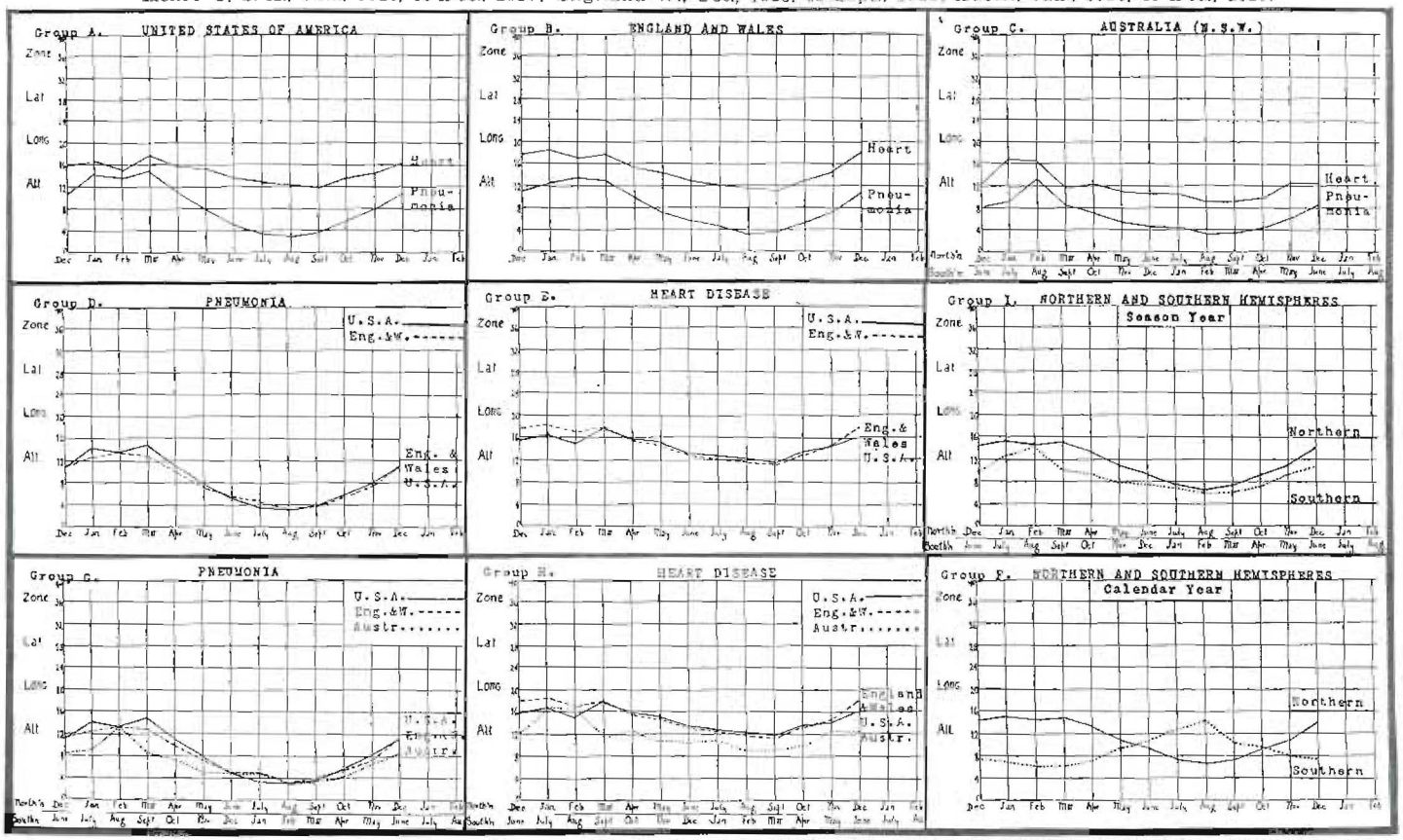


FIGURE 9. The mortality curves for these different countries from both hemispheres show remarkable similarities. The controlling factors have a seasonal relationship yet do not correspond with possible hours of sunshine.

sible contributing factors and for which I have considered the most hopeful field the new realm made possible through the newer knowledge of activating substances and their fundamental relationship to life and health. Since these vitalizing factors can only be found naturally in food substances as a result of plant and animal synthesis it would seem most logical to make a search of variations in the levels of these factors of some of the most important foods and for this it has seemed very logical to put an important emphasis on the characteristics of milk and its products, since milk is the only known food that is capable of providing nutritional elements for life and growth not only for the human species, but for all of the Mammalia, it being the chief or only food of infancy for this very large portion of animal life. Since the activators can be divided, in general, into two classes, the water-soluble and the fat-soluble, and because the water-soluble vitamins, in most instances, are much more readily obtained than the fat-soluble, the emphasis in these studies has been placed upon the fat-soluble. Group A of these fat-soluble vitamins is particularly important because of the part it plays both in the structure of the tissues and the ability of the body to maintain and build defense against infections, and group D, which is important because of its influence in the utilization of calcium and phosphorus both for the building of hard structures and the various tissues of the body for the mineral metabolism, in general.

Among the means available for evaluating the amount of these various activators present in foods a biologic or animal feeding procedure will perhaps usually be considered the most important. Several workers have pointed out the lack of exactness of this procedure. McCollum and Adams[2] after using the biologic method for the study of cod liver oils state in part as follows:

> . . . "The data obtained in this investigation do not bear out the anticipated possibility of determining the anti-rachitic potency of cod liver oils by following changes in bone composition." . . .

Another method, namely the color reaction for vitamin D as developed by Yoder[3] has value, but it too must be deemed to contain probable error which perhaps by both methods should be expected to be as great as 10 per cent. This method because of its being so much more available for use with large numbers of samples is the method that has been chiefly used in these studies.

For the determination of vitamin A I have used the antimony trichloride method of Carr and Price[4] which is a modification of the arsenic chloride method of Rosenheim and Drummond. This has been shown by Drummond[5] to have an accuracy well within the range of animal feeding tests.

Since the fat-soluble vitamins of milk are in the butterfat, a commercial product that is developed as a matter of commerce in many parts of the world it has been relatively convenient to carry on a far-reaching investigation of the activators by having samples of butterfat sent in small glass tubes provided in mailing blocks for this purpose. Through the very great kindness of individuals acting both in official capacity for states and provinces and as individual producers, it has been possible to obtain samples of butter and cream from many hundred places every two or four weeks. This is demonstrated in Figure 10, which is a map of the world with pins placed in those areas from which samples are being provided for these studies. This it will be noted includes: Australia, New Zealand, Islands of the Pacific, including the Philippines, Japan and Hawaii, Alaska, Canada, United States, Mexico, Cuba, Porto Rico, South America including Brazil, Argentine and Ecuador, Ireland, Scotland, Eng-

[2] McCollum, E. V., and Adams, G.: J. of Biol. Chem., 78,495 (July) 1928.

[3] Yoder, L.: J. Biol. Chem., 70-297 (Oct.) 1926.

[4] Carr, F. H., and Price, E. A.: Biochem J., 20:497-501, 1928.

[5] Biochem J. 23-785, 1929.

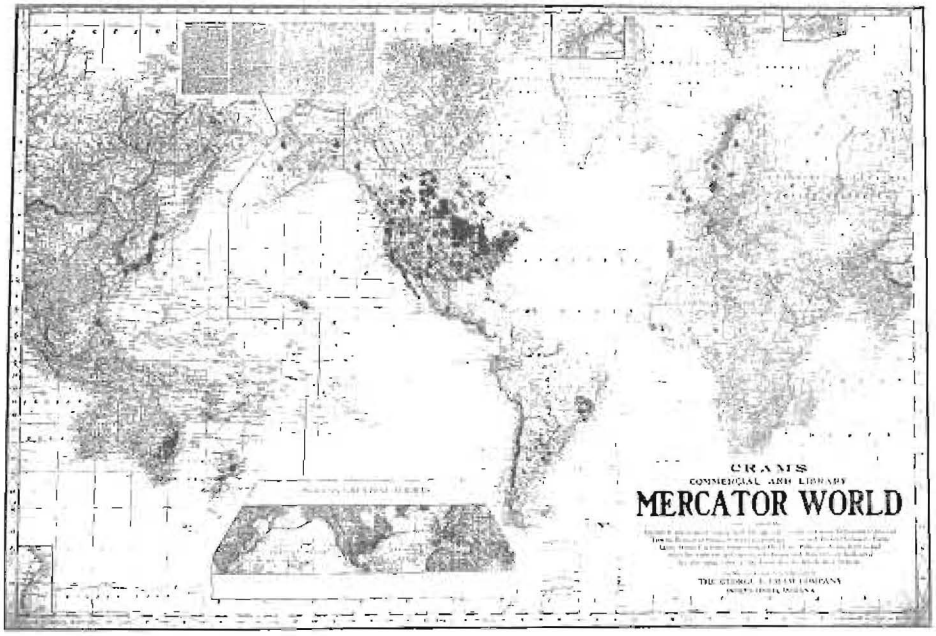


FIGURE 10.
The several hundred places throughout the world from which butter and cream samples are received regularly for chemical analysis are shown by colored pins.

land, Wales, Northern and Southern Norway, Sweden, Denmark and arrangements have been made for samples to be received from India. These studies have been in progress for about four years and curves are now nearly completed for three years for a five-state area and for two years for North America.

In Figure 11 will be seen a comparison of the vitamin A and D curves by months for the three years 1928, 1929 and 1930. It will be seen that, in general, the vitamin A curve for the three years (shown in the dotted line) and the vitamin D curve (shown in the solid line) have remarkable similarities in general trend and distribution. Vitamin D tends to be low from November to April, rising in May and June, falling in mid-summer, sometimes rising in the early autumn with a rapid decline in the fall and early winter. It is of special interest to observe that the general curve for 1929 to September was a little higher than that for 1928 and particularly that 1930 not only was higher during the spring months, but had a spring rise much earlier than did 1928 and 1929 and that it also dropped greatly in the heat of the summer. As data were being developed in the spring of 1930 the prophecy was evident that an early and hot summer was impending. Whether these curves will be found to have significance as units of a larger cycle which in turn may have direct or indirect association with such solar phenomena as sun spots is a matter of conjecture and passing interest.

The question is often asked whether the vitamins of butterfat are preserved in storage butter. This is a matter of profound importance for if it be true that there is a tide in these precious life-giving substances it need only be a matter of general knowledge in order that it may be a part of intelligent procedure. In order to study this factor and also the relative proportions of different vitamin levels in the total number of samples of a given time and area we will see that in Figure 12 data which indicate for the year 1928 for a five-

state area four levels of vitamin D from month to month in fresh products as obtained and similarly the levels in storage products of the previous June as obtained from month to month during the following year. It is of particular interest and perhaps grave significance that 90 per cent of the products tested, shown in the lowest of the four solid lines, are found to be so low as compared with the best 10 per cent or the best one per cent shown in the two highest solid lines. The average of all samples is shown in the second line from the bottom. At the extreme right in the solid lines I have shown the results of analysis of storage butter and it will at once be seen that 90 per cent of the storage products of the June before are at approximately the same level for vitamin D as 90 per cent of the products during the June of 1928 and similarly the level of the highest 10 per cent and the highest one per cent are all found to be, in general, at corresponding levels with fresh products. This would seem to suggest that a storage product maintains its value and since I wish to demonstrate that the high vitamin product is very much more valuable than the low vitamin product, it would seem to be a part of logic and wisdom not only that butter should be stored at the time of its greatest abundance, nature's harvest time, but, particularly, that it should be stored at the time of its highest vitamin and life-giving content and, further, that every means possible should be fostered to make such a product available without handicap for the greatest good to humanity. This would seem to indicate the need for modification of such laws, statutes and practices as put an embargo upon or prejudice against the high vitamin June butter that will be sold in the winter months.

One of our chief concerns is to obtain knowledge relative to the forces that are at work in determining the levels of the vitamins in plant life. If, for example, they were due to constantly operating forces which repeat themselves in cycles their degree for a given time and period for succeeding years would be similar. The lack of similarity in the curves, therefore, presents an opportunity for observing the possible contributing causative factors. When, therefore, we take a set of three groups of curves for the years 1928, 1929 and 1930 we have a possible source for suggestions as to causative factors. This is shown in Figure 13. From this study it is easily seen that the early summer of 1930 showed all the factors to be in advance of 1928 and 1929. There is also disclosed a very marked depression in July, August and September as a result of the dry, hot weather, the drop in 1930 coming earlier than in 1928 and 1929. It will be of interest to note whether October provides a sharp rise as did both 1928 and 1929.

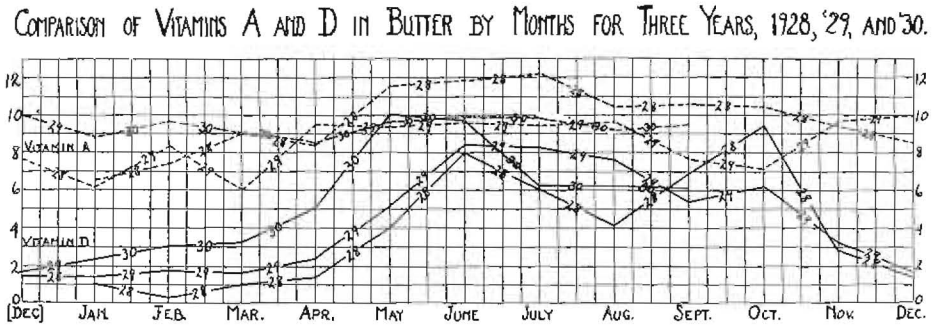


FIGURE 11.

In comparing the 1928, 1929, and 1930 vitamin D curves by months, it is of interest that 1929 is higher than 1928 for the spring and early summer. 1930 is much higher than either with an earlier spring rise.

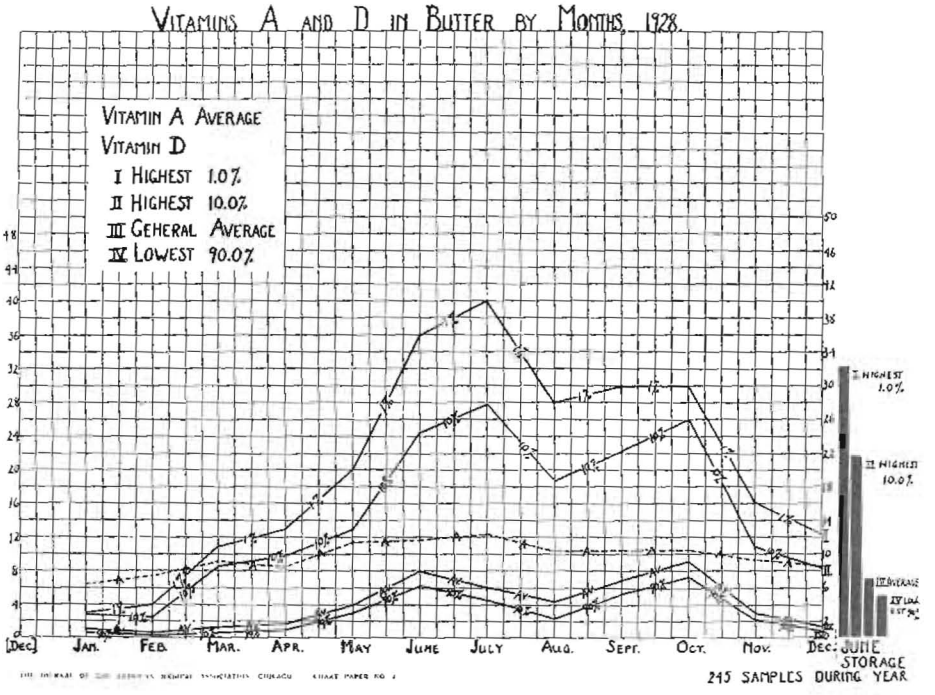


FIGURE 12.

These graphs show the monthly levels of vitamins A and D in the butter samples received from 5 states during 1928. D is in 4 percentages. At the extreme right are shown the same values for vitamin D for the June storage butter of the year before (1927).

In the last three groups of data we have studied, first, in Figure 4 the seasonal variations in vitamins as expressed monthly for a five-state area for three years; second, in Figure 5 the levels of four phases of vitamin D and the general average of vitamin A for the five-state area for 1928 and in Figure 6 we have studied these four factors for the same area for three years.

It has been exceedingly important that data be obtained from many different districts and even different countries in order to study the nature of the forces which are chiefly responsible for determining these levels. In order to do this I have divided the United States and Canada into 16 districts and have arranged them in relation to each other according to geographic position. This makes possible a study of the influence of latitiude, altitude, precipitation, temperature, soil characteristics, relation to densities of population, relation to number of decades the soils have been tilled or pastured, cloud and sunshine, etc. These data are shown in graphic form in Figure 14. Fortunately, I am able to present data for the two consecutive years 1929 and 1930. As a basis for these studies all over the world I have divided the areas north and south of the equator into ten degree latitude zones; five degrees above and below the equator being the equator zone; zone I being 5 to 15 deg.; zone II, 15 to 25; zone III, 25 to 35; zone IV, 35 to 45; zone V, 45 to 55; zone VI, 55 to 65. The latitude zones are marked on the side of each of these cards showing individual groups of states and provinces. A general survey of the entire area divided up into these 16 districts of many thousand square miles demonstrates that each reveals a general similarity in

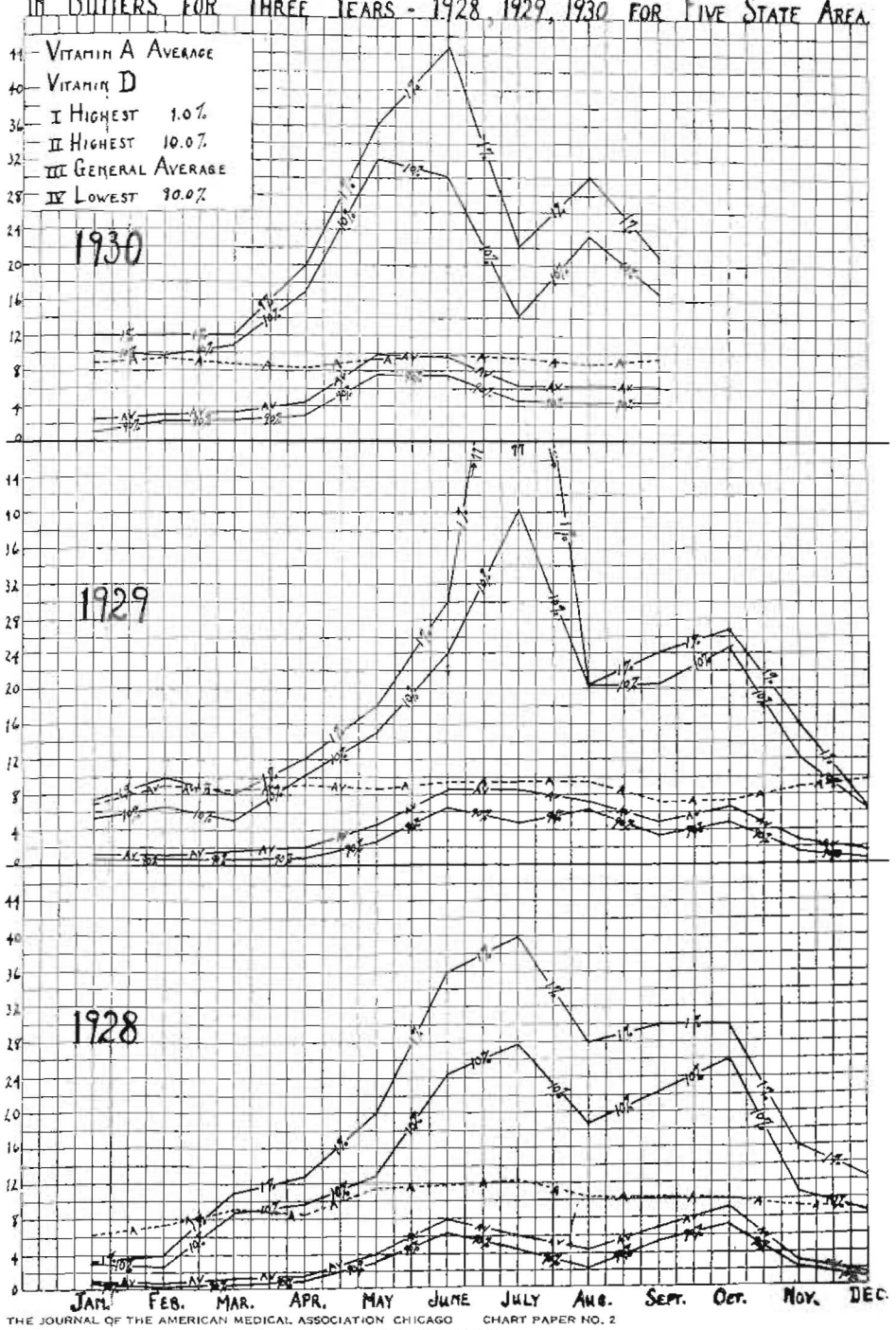


FIGURE 13.

The four values for vitamin D for each of three years 1928, 1929, and 1930 show remarkable similarities but with detailed differences.

Comparison of 1929 and 1930 Vitamins **A** and **D** Curves for 16 Districts Covering the United States and Canada.

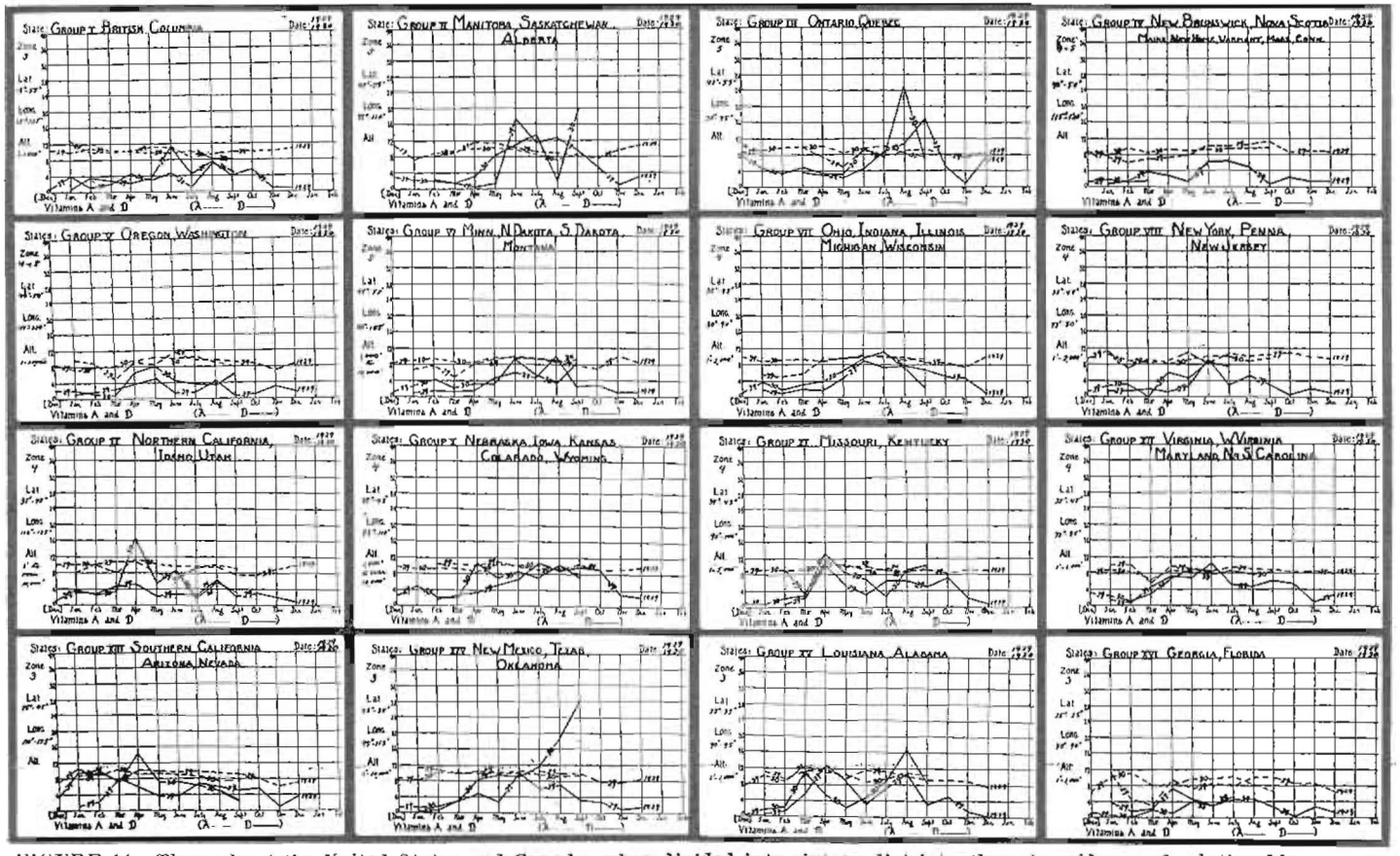


FIGURE 14. Throughout the United States and Canada, when divided into sixteen districts, there is evidence of relationship.

the curves for the two years for these areas with the general characteristics that the 1930 series of curves tends to be higher in the spring months and shows an earlier drop for the summer depression in those districts which suffered most from the severe drouth and extreme heat of 1930, the summer depression in vitamin D being much greater than in 1929.

The data presented in these various readings strongly suggest that the vitamin levels as recorded by these tests are not established by any of the following alone: Total possible hours of sunshine, temperature, latitude, altitude, or precipitation, but appear to be directly related to the state of growth and type of fodder being eaten by the cows. In general, my interpretation of these and many other data (which space does not permit me to present here) is that a rapidly growing young grass regardless of latitude, altitude, precipitation, etc., is capable of producing high vitamin levels in dairy products. I do not say that only fresh rapidly growing grass or the same dried without injury will be the only means of accomplishing this. I believe, however, they are determining factors of the products available at this time.

Another very important lesson that one gets from looking at this chart is to note the higher levels reached in the northern latitudes although the rise occurs later than in the more southerly latitudes. If a rapidly growing grass is is an important factor it is of interest that the hours of sunshine are increasingly longer as we go northward in the spring and summer. Three months in northerly latitudes will have as many actual hours of sunshine as four months in more southerly latitudes. I have discussed the probable bearing of this in another communication. In this last study I have included most of the populated areas of the United States and Canada. If there are clearly defined relationships found in other countries it should throw much additional light on our general problem as to the nature and source of activating substances or vitamins in foods. My data as obtained from many countries (as indicated in Figure 10) make possible a study of characteristics of widely divergent conditions and geographic positions. These are presented in Figure 15 in which graphs will be seen for the following groups: Zones V, IV and III in North America; Norway, Sweden and Denmark; the British Isles; and Mexico, Porto Rico and Cuba, all in the northern hemisphere and in the southern hemisphere, Brazil, Argentina; and Australia and New Zealand. There are two ways we might express the available data for making comparative studies for countries in the northern and southern hemispheres. One, on the basis of the calendar year and the other on the basis of seasons. Inasmuch as this meeting is the convention of the International Association of Milk Dealers and, therefore, represents the southern hemisphere as well as the northern, it seems quite as important that we use as a unit the calendar year which, of course, makes the curves for the southern hemisphere the reverse of those in the northern hemisphere. These data are shown in Figure 15. While a study of this chart reveals the same seasonal tides disclosed in the southern hemisphere as in the northern, it is of particular interest to note that some districts throughout the world are shown by these studies to have distinctly higher levels than others at the time of their maximum levels. For example, Denmark, Norway and Sweden which are in the same zone as considerable of Alaska and, therefore, are much more northerly located than the United States and Canada, reach very high levels, indeed, some of the highest obtained in the northern hemisphere. We do not and clearly cannot have readings for the southern hemisphere as far south of the equator as these countries are north of the equator. It is very interesting, however, to observe the splendid readings that are obtained from samples of butter coming regularly from

Butter Vitamin Curves by Months for Several Countries Throughout the World.

North America by Zones. Northern Hemisphere. Southern Hemisphere.

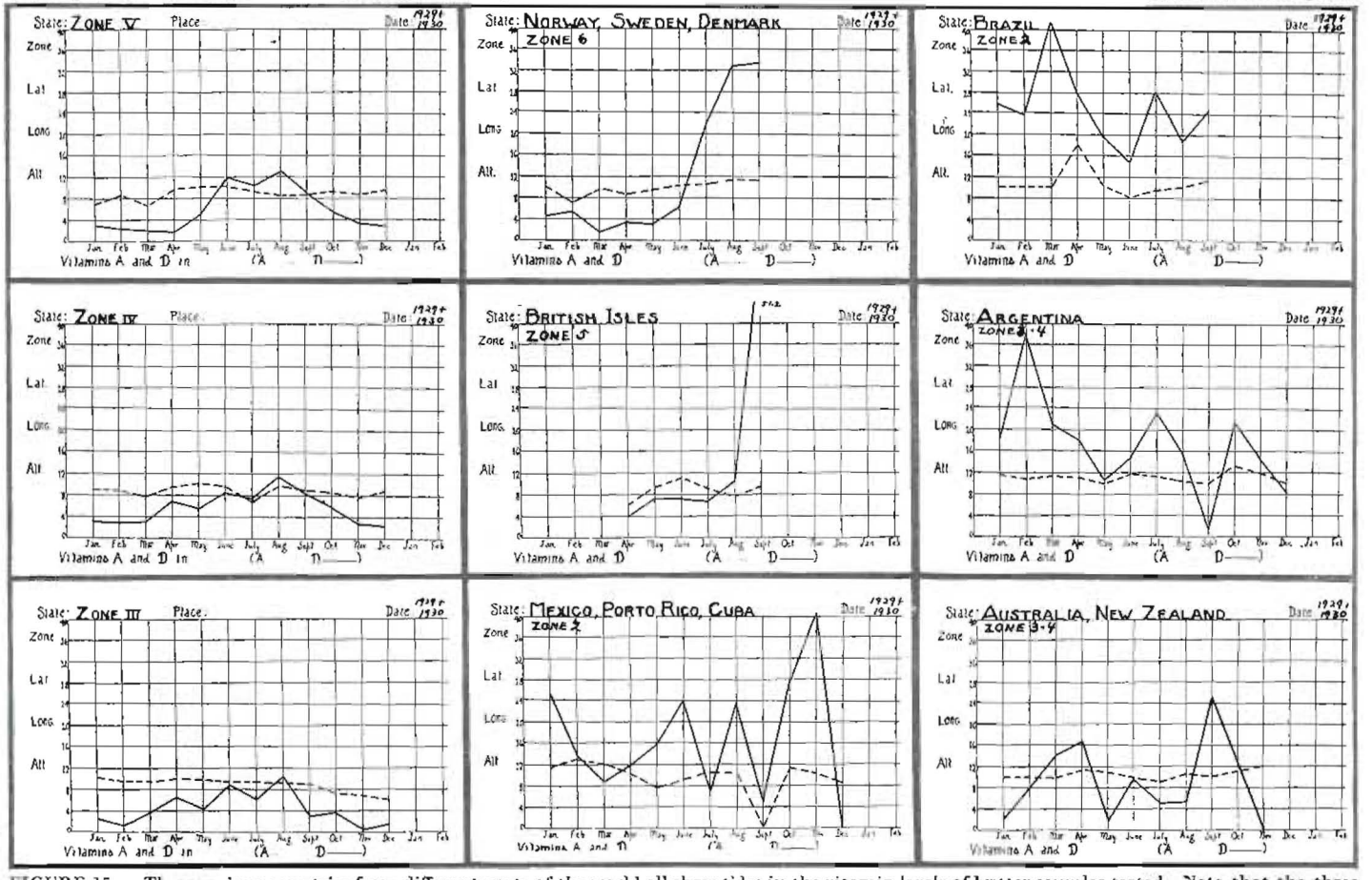


FIGURE 15 — These various countries from different parts of the world all show tides in the vitamin levels of butter samples tested. Note that the three peaks seen in 10° latitude zone III and IV of the North American continent show the same variations. Zone V being farther north does not show the April rise.

New South Wales, Australia and from New Zealand in the Orient, and Argentina in the Occident. Since altitude plays so important a part in determining temperature and other growth factors, it is of special interest to note that the data obtained from samples being received from the province of Minas Geraes in Brazil with an altitude of about 2,000 to 5,000 feet apparently provides plant growth conditions that are exceedingly favorable for vitamin development. The altitude would seem to prevent the extreme rise in temperature that might be expected in that latitude which is about 20 degrees south.

Since our fundamental problem is a search for means of bettering health and thereby increasing the total of human efficieney and happiness, and to which end we are especially studying milk and its products, it is important that we relate the data that I have presented on seasonal vitamin tides to morbidity and mortality; to do this I am presenting in Figure 16 a comparison of the death rate curve for pneumonia for each of the four cities in a central area with the curve for milk fat vitamins I have found to obtain in that district. The cities included are Cleveland, Chicago, Indianapolis, and Detroit. For this I have added together the figures for the level of vitamins A and D by months. Two things are immediately apparent: First, the remarkable similarity in the death rate curves for these four cities, and the other, the striking evidence that those factors are in opposite phase with the vitamin level curve shown by the dotted line. It is exceedingly important that great care should be taken at this stage of these investigations in making an interpretation of the significance of these relationships. If it shall be that the relationship shown in this district shall be found to maintain in various other areas and particularly, if there should be modifications in either of these curves which is reproduced in the other, it will throw important and suggestive light on our problem. I am accordingly presenting in Figure 17 a graph showing the relationship of deaths from pneumonia to the vitamin curves of sixteen different districts, obtained by dividing the United States and the pop-

RELATION OF DEATHS FROM PNEUMONIA IN FOUR CITIES TO LEVEL OF VITAMINS A PLUS D BY MONTHS.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN.

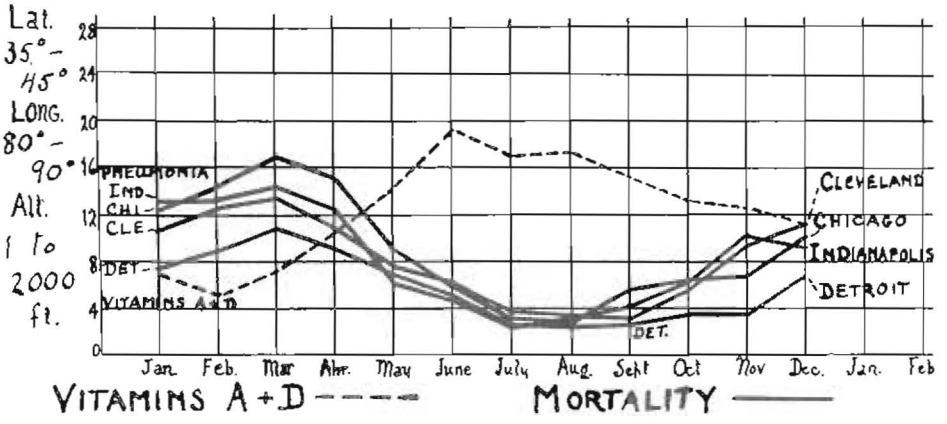


FIGURE 16.

Note the similarity in the monthly incidents of deaths from pneumonia in these four cities shown in the solid line. Also note that these curves are the opposite of the vitamin curves as determined.

Relation of Deaths from **PNEUMONIA** to Level of Vitamins **A** + **D** by Months.
United States of America and Canada by Geographical Districts.

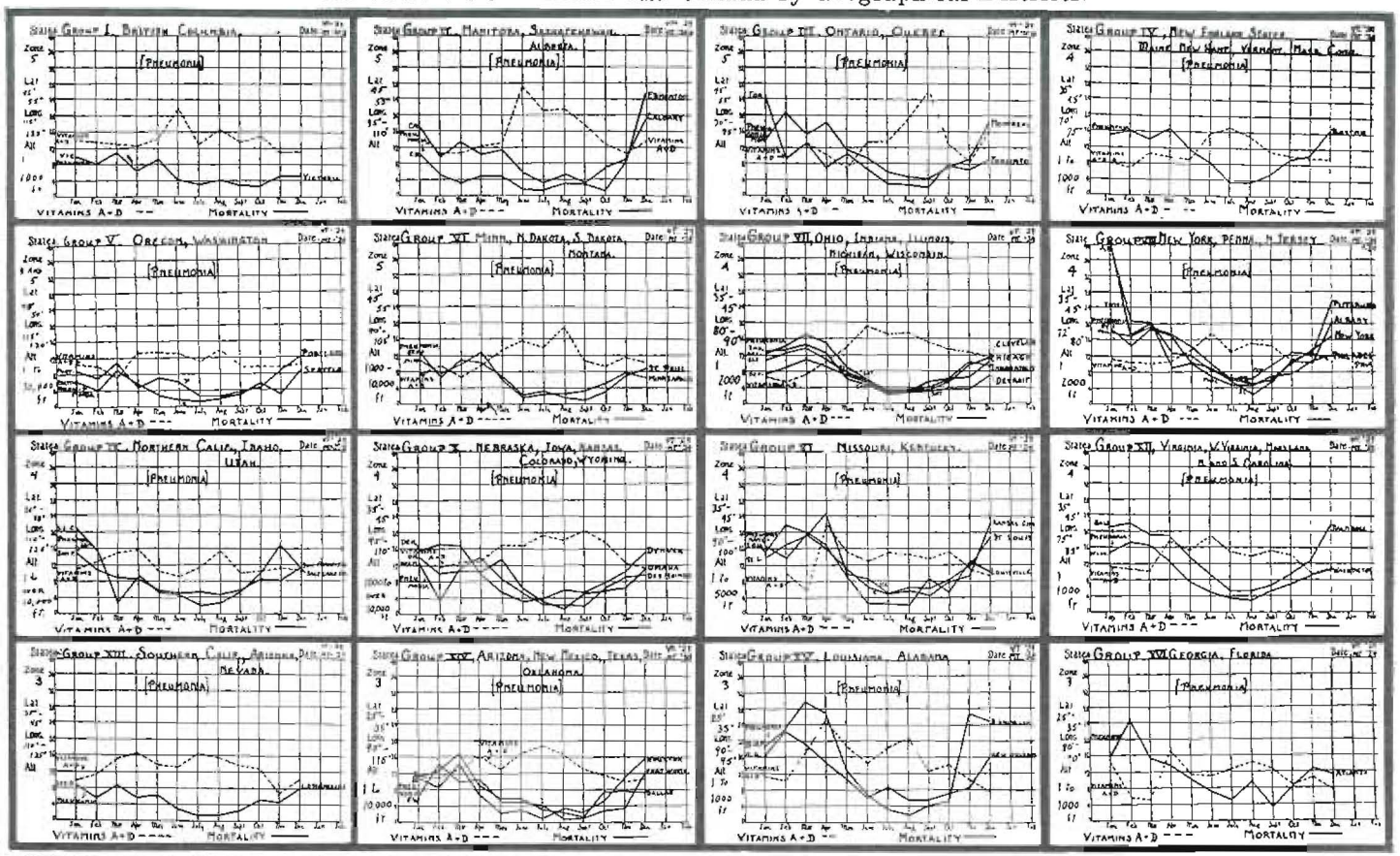


FIGURE 17. A comparison of the 1929 combined curves for vitamins A and D with the curves for deaths from Pneumonia for sixteen large districts of the United States and Canada shows not only an apparent relationship, but unique characteristics for different areas.

ulated parts of Canada into geographically related districts. The death rates for pneumonia are included for large cities. Each of these districts cover thousands of square miles. It is very snggestive that we find not only reverse phases in these two curves, but evidence of intensity at different monthly periods, represented in both curves for different latitudes. I have discussed this in much more extended detail in others of my communications, which space does not permit of my doing in this bird's eye view.

In the light of the limited data available, which are entirely inadequate for making final deductions, we see need for continuance of these investigations and broadening their scope with a view to establishing sources for high vitamin products for reenforcing vitality levels of humans of all ages, but particularly of infants. Some of this group will also appreciate the necessity for the reenforcement of vital factors in the offspring of very valuable dairy cows which so often are weak and are raised with difficulty, a factor which seems to be directly related though in inverse proportion to the volume capacity for milk production of the cow.

If milk fat has important differences in levels at different seasons of the year for the same places or different places at the same time it should readily be possible to disclose these differences by human and other animal feeding tests by selecting the butterfat by the means outlined above as being used in these studies for grading butter on the basis of its vitamin content. The following experiment illustrates such a test. Twenty-five young chicks were placed in three groups. All had the same deficiency diet (McCollum's 3143) low in phosphorus, but adequate in calcium and also low in vitamins. Group I received butter high in both vitamin A and D. Group II, high in A and low in D, and Group III received butter low in both vitamins A and D. In 19 days the deaths were as follows: In group I, 24 per cent had died; group II, 53 per cent: and Group III, 72 per cent. It was observed that notwithstanding the similarity in odor and taste being so great that humans could not detect any difference the chickens receiving the high vitamin product ate more of their butter than the others. Whether this was due to some physical factor and not a matter of individual selection was a matter of importance to be ascertained. Accordingly, 40 other chickens were placed in a large brooder and three separate dishes were placed in the brooder, each dish being of the same size and shape and containing the same quantity of butter, but differing in that the same three grades of butter were used as in the last test and the dishes were refilled every day. The positions of the dishes were changed from day to day. This quickly disclosed that the chickens ate, by selection, more of the high vitamin product. Butters were carefully weighed at the beginning and and of each day's feed and at the end of 57 days when the experiment was terminated it was found that during that time there had been placed before the chickens 800 grams of each of the three grades of butter and that the chickens had eaten during this extended period 415 grams of butter high in both vitamins A and D, 289 grams high in A and low in D, and 209 grams low in both A and D. In other words, on the basis of butter low in both vitamins A and D they ate of the butter that was high in A and low in D 36 per cent more and of the butter high in both A and D they ate 98 per cent more than of the butter which was low in both. This would seem to indicate clearly the ability of the chickens to select a food that was higher in vitamins in accordauce with their needs. The butters used in this test were composites made from the unused portions of a large number of samples received for tests from various parts of the world. It has been known that many animals have the ability to select the foods that will benefit them most. All grazing animals when pasturing seem by instinct to go from one

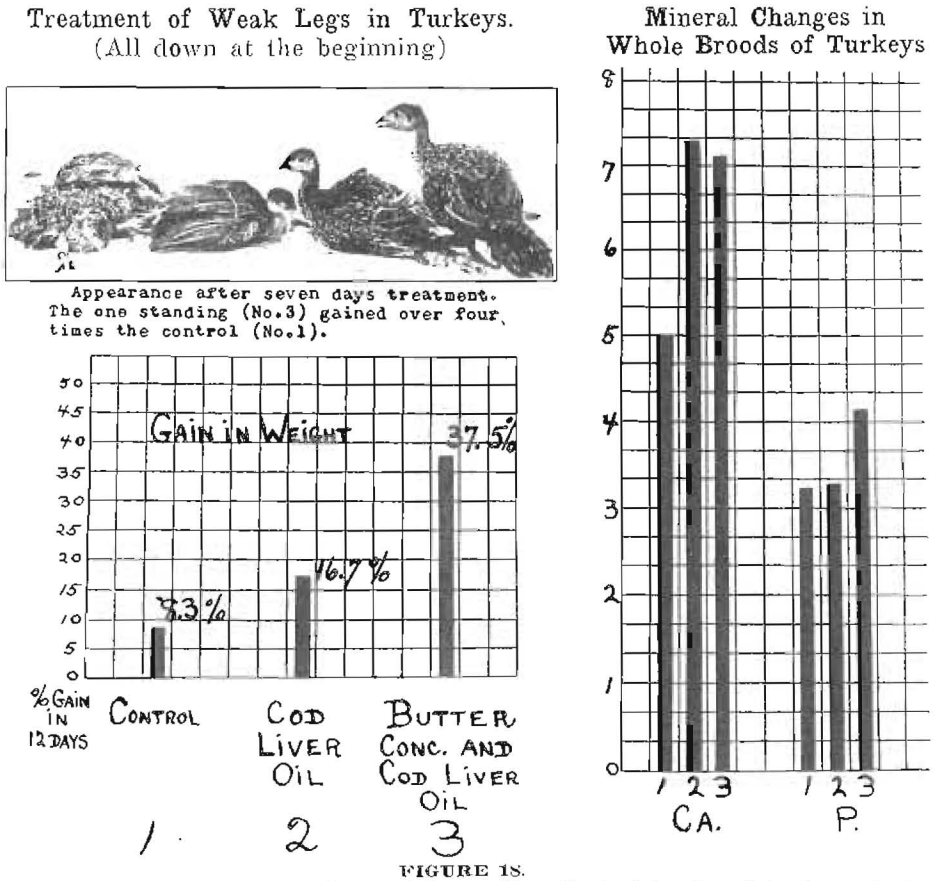


FIGURE 18.

Six turkeys were down with weak legs. The effect of treatment is shown to be greatly in favor of a mixture of the activators as concentrated from a high vitamin butter, with a high vitamin cod liver oil over cod liver oil alone. The turkey standing, gained over four times that of the control and over twice that of the one on cod liver oil.

tuft of grass to another to select that which contains the factors they desire. This is probably one of the principal reasons why animals allowed to find their own food so long as it is available will often be in better condition than those which are pen fed.

It is very unfortunate that most people think of vitamins and food activators in much too limited a sense. Mineral utilization, for example, is presumed to be dependent upon vitamin D because vitamin D is known to cure rickets. Adult humans, as also all forms of animal life, require minerals for all metabolic purposes. Calcium and phosphorus, for example, are constituents of practically all the fluids in the body as well as the tissues. Adults do not have rickets, which is a disease associated with growth. Even growing animals including humans require an adequate supply of minerals for metabolism. This confusion probably arises in large part from the fact that the difference between calcification and lack of calcification is readily discernible roentgenographically or physically whereas factors which modify the diffusibility of the minerals in body fluids are not so readily identified or demonstrated. Important light, therefore, is being thrown upon these processes in larger and larger volume as methods

are developed for the chemical analysis of body fluids. In the writer's clinical work blood chemical and microscopic analyses constitute an important part of the study, over 150 determinations being made routinely on the blood, saliva, and urine of which over 90 are on the blood. This procedure is also carried on extensively in animal experimentations. These studies include about 1,900 on patients.

An illustration of some of the qualities of high vitamin butter will be seen in Figure 18 which shows several turkeys. In this flock of young turkeys it was observed that quite suddenly a number of them began losing the power to stand on their legs, a condition in fowls usually spoken of as "weak legs." It is of interest that these turkeys were being fed a stock chick-food understood to contain not only the necessary minerals and other chemicals, but also an adequate quantity of cod liver oil. In spite of this they were going down. Some of the young turkeys were placed on different feeds as follows: Group I were controls and continued to receive the same stock diet as previously. Group II received the same stock diet plus a small quantity of high vitamin cod liver oil, and Group III received the same as Group II, but in addition the vitamin concentrate obtained from butter. The

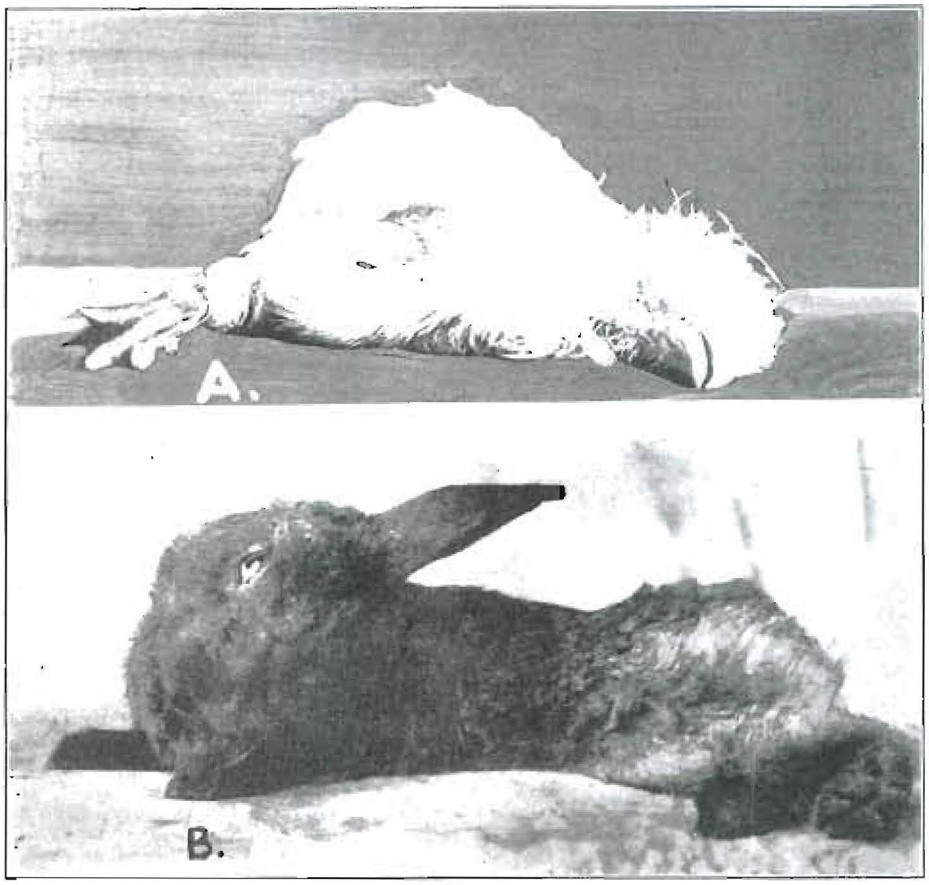
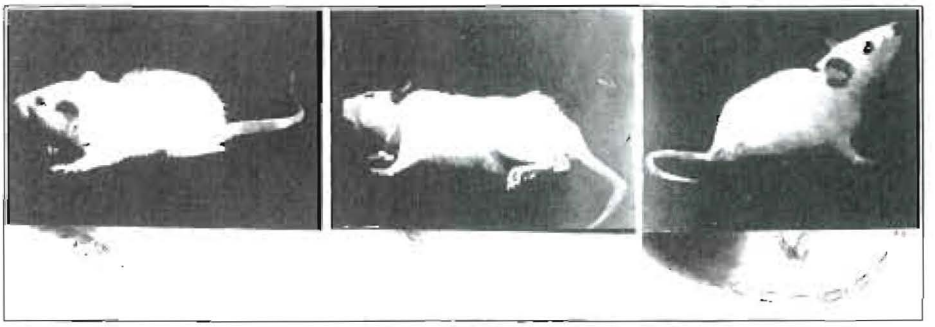


FIGURE 19.

Progressive paralysis produced in a chicken A and a rabbit B apparently by an overdose of cod liver oil. The daily quantity per body weight was approximately that often advocated for children.



I	II	III
Diet Deficient in Phos. (Steenbock 2965)	**Diet** Deficient in Phos. (Steenbock 2965) Plus 2½% Cod Liver Oil.	**Diet** Deficient in Phos. (Steenbock 2965) Plus 2½% Cod Liver Oil. 2½% Butter Concentrate.
Calcification Deficient. Marked rickets.	**Calcification** Improved. Healing + +.	**Calcification** Excellent. Healing + + + +.
Clinical Inactive.	**Clinical** Progressive paralysis.	**Clinical** Normally active.

FIGURE 26.
This is a study of the relative beneficial effect of cod liver oil alone and cod liver oil plus butter vitamin concentrate.

gain in weight in Group I was 8.3 per cent in 12 days. Those in Group II receiving an addition of cod liver oil gained in that period 16.7 per cent and those in Group III receiving both the cod liver oil and the butter concentrates gained 37.5 per cent. The calcium and phosphorus changes in bloods are also shown in this chart. It will at once be seen that the calcium was much higher in both Groups II and III than in Group I and that the phosphorus was higher in only Group III. The same preparation as was given to Group III was then given to the entire flock as an addition to the ration they had been using previously with the result that not a single additional case of weak legs developed.

It is important in a study of the value of milk and its products that it be kept clearly in mind that there are only two abundant sources of some of the fat-soluble vitamins; namely, the fat of some dairy products and some fish oils. It is very honestly considered by many that cod liver oil is a universal source of vitamins A and D and adaptable to all conditions. For those who are concerned to acquaint themselves with some of the important new data I refer you to the important work of Adughr[6] in which he has reported very extensive studies on the toxic effects produced in animals by the administration of cod liver oil. In figure 19, I have shown a chicken and a rabbit with progressive paralysis apparently produced by an overdose of cod liver oil, yet the quantity for body weight is approximately that often advocated for children. These animals are not dead, but helpless with progressive paralysis. In order to further study this phase of the problem I fed rats different combinations, an illustration of which will be seen in Figure 20. These three rats all received the same deficiency diet; namely, Steenbock's 2965. Rat number 1 has developed the typical languidness found with this ration. It has a very marked deficiency of calcification as shown by the tail bones. Rat number

[6] Erik Adughr. Vols. VIII, IX, X Acta Paediatrica.

2 received the same diet plus 2½ per cent cod liver oil. The calcification is improved as shown by the narrowing of the interspace between the epiphyses and the diaphyses. This rat has, however, developed progressive paralysis, which can be judged by the attitude. Rat number 3 received the same deficiency diet and the same quantity of the same cod liver oil, but with it received 2½ per cent of butter vitamin concentrate. It will at once be seen that there is much more complete healing of the rickets, and the animal is clinically vigorous and very active. I have made a large number of studies designed to throw light upon the relative value of the activators from cod liver oil and those from various butter products on both animals and humans. It is very clear that products can be obtained from butter that have a decidedly greater beneficial effect with the experimental animals used and also with humans. The effect of cod liver oil alone is illustrated by the turkeys in figure 18 and the last illustration, figure 20. Even though this paper has already exceeded a reasonable length, it seems very important to add some of the results with humans.

Since dental caries is the most universal disease in the world, and because it indicates a disturbance in the metabolism which not only relates to the well-being of the hard tissues of the teeth and bones, but also to the functioning of practically all the tissues of the body, we will discuss the importance of providing the proper activators in a form that will be available for assimilation. In figure 21, I have shown the effect of activator treatment on the reduction of dental caries. The first two columns represent a group of forty-nine individuals who received no special treatment to prevent dental caries in the years 1928 and 1929. It will be seen that

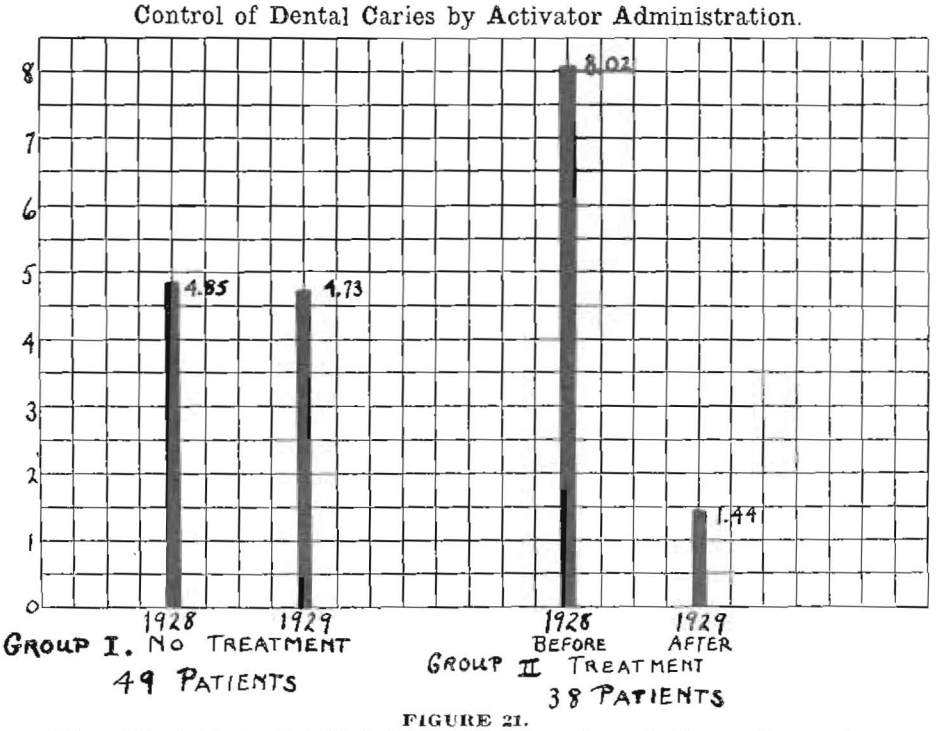


FIGURE 21.

These data indicate that dental caries is primarily a deficiency disease due to a lack of vitamins, chiefly D, and influenced by low mineral foods.

Effect of Vitamin Capsules on Dental Caries by 10 Year Age Groups.

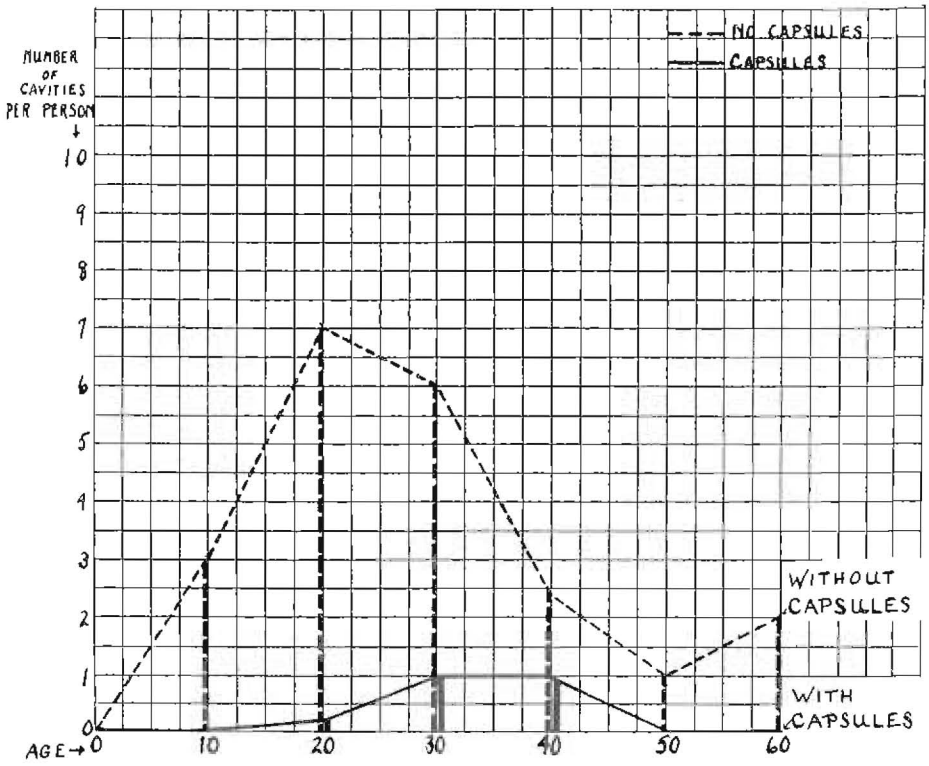


FIGURE 22.

The progresss in the control of dental caries is shown by the difference in the number of cavities which have developed per individual in the group receiving special activators as compared with those in the group not receiving them. For all ages this difference is 1 to 10 and for the teen ages 1 to 40.

the average number of cavities was 4.85 in 1928 and 4.73 in 1929. The individuals with an excessive amount of dental caries, averaging eight cavities per person, were given additional activators in capsule form during the year 1929, and it will be seen that the caries decreased to 1.44 cavities per person, much lower than those less susceptible ones who received no treatment. During 1929 two groups of one hundred each were checked critically, an effort being made to keep comparable individuals in each group. These are shown in figure 22, divided into age groups of 10 years each. The average number of cavities per individual in the group not receiving additional activators is shown in the broken line, and those receiving additional activators in the solid line. There are approximately 10 times as many cavities in the group not receiving the additional activators than in the group receiving them. In the teen ages the differences is still greater.

There are many clinical phases of this problem that should be discussed if space permitted, such for example as the healing of ununited fractures, following the administration of activators, the frequent breakage of bones in elderly people and some adults, which is often chiefly related to the fact that the individual was in a condition of negative mineral balance for months or even for a year at a time, under which condition the individual borrowed the material from the storage depots to

meet the daily needs for metabolism. This is, in a sense, like burning your furniture to keep warm, since the tissue of every organ of the body must have new minerals supplied to them continually. These individuals cannot readily heal a broken bone because they do not have the material available. They can often be made available by means of additional activators to the food, thereby changing progressive degeneration and beginning death to rejuvenation and repair. Figure 23 shows a case of a woman 74 years of age, with an ununited intracapsular fracture of the neck of the femur, which in A had been nine months without union. Note the absence of a cortical layer on the shaft of the femur. In B will be seen the results of the administration of activators in capsule form in three months time. Note the marked building on of the cortical layer on to the shaft of the femur, also on the surfaces of the fractured bone. The results have been most gratifying. In addition to the improvement of the hip, there has been a very marked improvement in the general physical condition. This woman's mother died at 70 years of age, a year after her hip was broken.

Spontaneous fractures and fractures occurring with very little physical force are often associated with or followed by physical overloads, one of the most important of which is the additional stress of pregnancy and extended lactation. High production cows are particularly susceptible and for the same reasons that it so often affects humans.

This problem of distributed mineral utilization may be associated with disturbances chiefly characterized by local or general excessive depositions of minerals. This is particularly true of joint tissues and is often associated with streptococcal infections reaching the joint tissues, from the teeth, the tonsils, or other foci by what is called metastasis. Even after the sources of

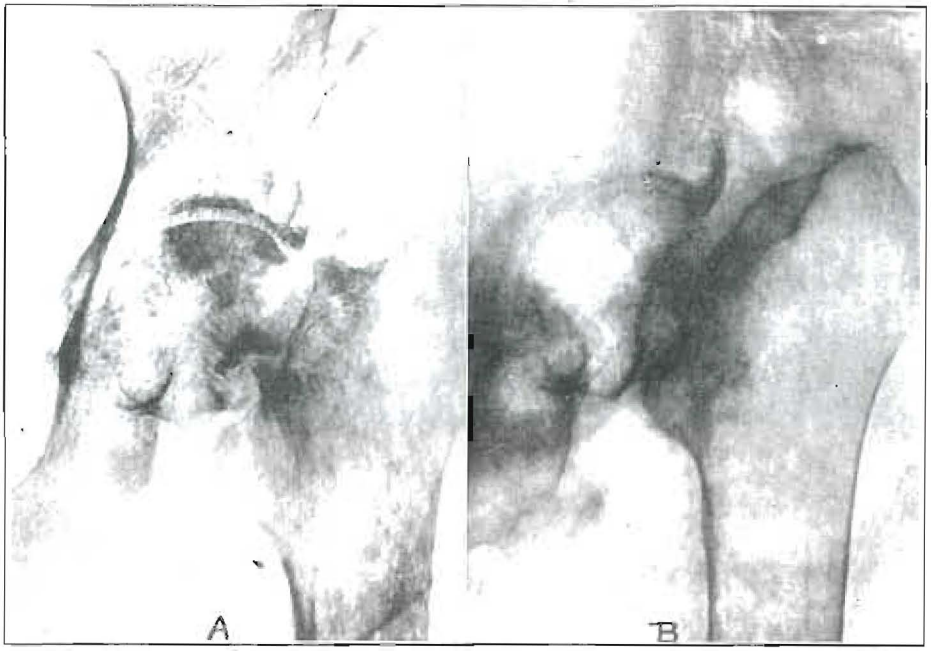


FIGURE 23.
The healing of an ununited fracture of nine months' standing, as shown after three months' treatment. Note the additions to the cortical layer of practically all surfaces. Final union was complete.

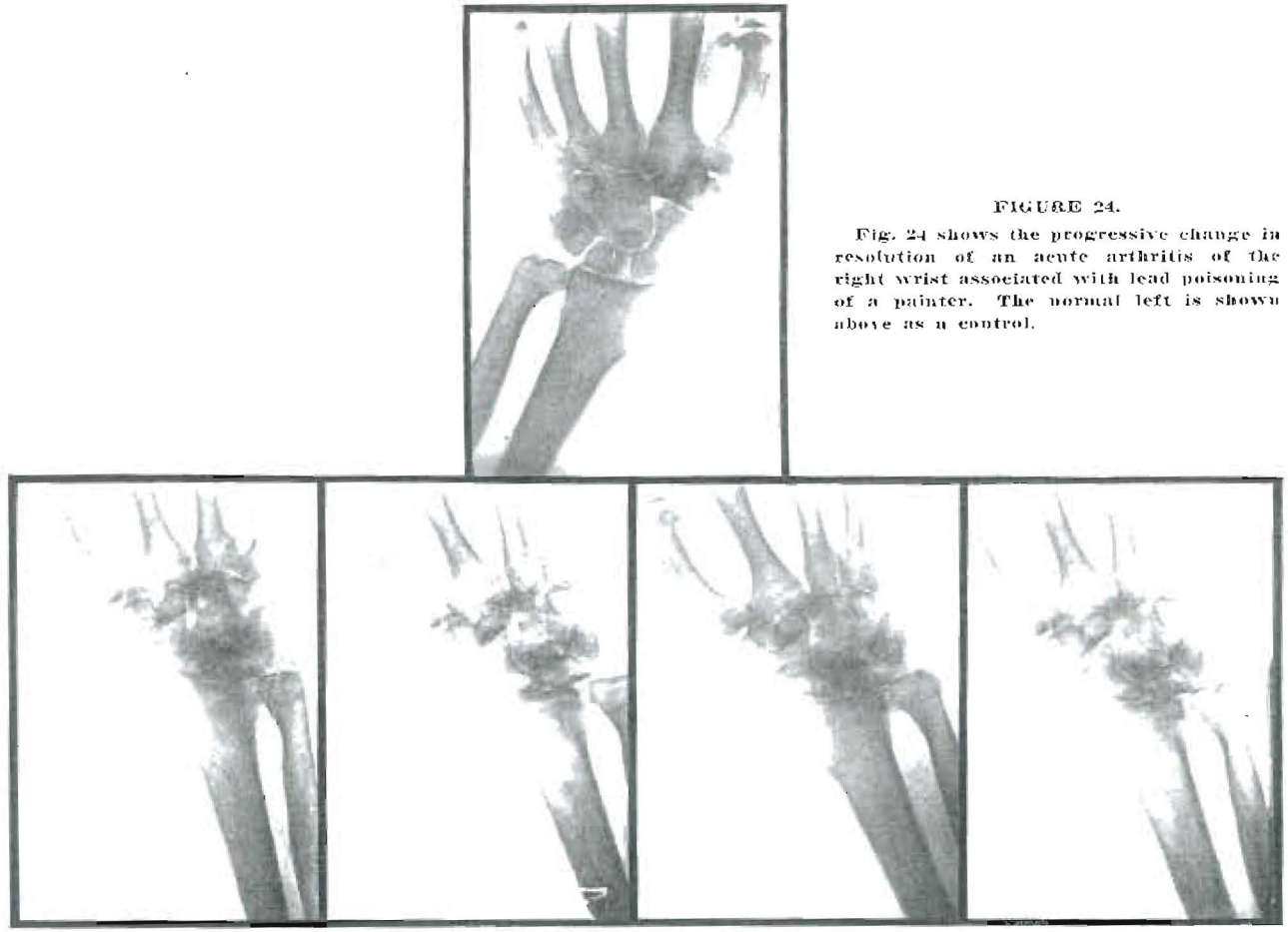


FIGURE 24.

Fig. 24 shows the progressive change in resolution of an acute arthritis of the right wrist associated with lead poisoning of a painter. The normal left is shown above as a control.

infection are removed, this condition frequently goes on from bad to worse. This is usually a form of arthritis. It may produce a marked deformity of a few or usually several joints of the body. The rapidly accumulating evidences from these researches suggest that the role of these activators is an exceedingly important contributing or controlling factor in these cases. I will illustrate in one case shown in figure 24. This shows the progressive change in deposits which cement the bones of the right hand together with a typical arthritis. In the upper picture will be seen the normal left hand. Note the spaces between the bones of the wrist. In the lower series of four pictures we see the progressive changes in the right hand during which time the swelling, pain, and extreme tenderness disappeared. These pictures were taken approximately three months apart and extended over a period of one year. Other joints of his body were affected and were similarly greatly improved. The individual thus regained the use of the hand, walked erect instead of stooped, and had free movement of all the joints. This was a case of lead poisoning arthritis in a painter. The treatment was with butter vitamins and high vitamin cod liver oil.

I interpret my data as indicating that some of the essential substances of life and health can be found chiefly in rapidly growing plants, whether the microscopic plant life of the ocean or the pasturage plants of the land. The fundamental characteristics of all the Mammalia is their dependence upon milk as a food in infancy which must be provided by a foster mother if that of the natural mother is not available. Life requires these same activators for its adult forms, but the individuals develop a capacity for obtaining most of the essential food factors from the available plant food directly for themselves. Probably one of the most universal stresses of life is produced by the difficulty in obtaining the fat-soluble activators essential for mineral utilization. There are only two considerable sources for the factors, namely the butter fats of milk and some of the fish oils. The Mammalia are so constituted physically that they are able to utilize these products from milk fat much more readily than from fish fats. Accordingly all the civilizations of the past and present were built around these two sources of fat-soluble activators. It is probable that in the past the difficulty in obtaining the fat-soluble activators has constituted one of the most exacting limitations in the development of mankind. We are probably much more dependent upon the cow as a foster mother than we realize. It would not be strange if our growing appreciation of her service to us would rapidly result in providing her with the most available facilities in environment and food to best enable her to manufacture these precious vitamins, along with the mineral and energy producing factors, which up to this time have been almost the only measure used in evaluating her efficiency. This paper is only intended to be a bird's eye view chiefly as indicated by my researches in this field. A much more extended discussion of this problem and its relation to the associated health and economic factors is in preparation to be available in book form in order to aid those who are concerned with the various phases of the application of these newer data. Many technical phases cannot be discussed in this type of paper. Several of them are discussed in some of my research reports, a bibliography of which I am attaching to this paper.

It is my hope in presenting this matter at this time that I may in this way aid you in some of your problems, the most important of which I deem to be the betterment of mankind and particularly child life by providing milk and milk products of excellent activator content. I congratulate you upon your opportunity for service.

DISCUSSION

QUESTION: Under average similar conditions, have you found that any one breed of dairy cattle were better manufacturers, so to speak, of the vitamin and could transfer it to their milk in a better manner than other dairy breeds of cattle?

DR. PRICE: In general, we have found that the different breeds on the same rations, or same pasturage, produce pretty much the same level of vitamins. There is a difference in individual cows in a herd of the same breed.

QUESTION: Is there any difference between the torrid zone and the temperate zone in this same field? All your charts appareutly show the temperate zone.

DR. PRICE: The torrid zone has not provided us with samples of milk for comparison. If you think of the countries that lie close to the equator, they are not dairy product producers so we are not able to get a check.

We might, however, take an observatiou like this: As we go down the second district, which would be from latitude 15° north of the eqnator to 25° north of the equator, that would include Mexico, Cuba, Porto Rico—we seem to find periods of the year in which they are higher than we get them in these northern zones and there will be periods when it is lower.

Right there is an important suggestion and some of you dairy men should follow this cue. As we have tried to trace it back, it has seemed to be true that the plant foods that they were giving these cattle when they were high in vitamin was in some instances chopped up sugar cane and it may he that some plant food will be available in those countries that could be shipped for you to feed to your cattle in these uorthern zones.

QUESTION: What substitutes can be used for the capsules?

DR. PRICE: The substitute for the capsules would perhaps be to go to the drug store and buy cod liver oil, and just as soon as your child gets so he hates it, stop using it because when he or she does, it is a pretty sure sign that it is doing more harm than good.

QUESTION: How about sunshine?

DR. PRICE: That is an important question. I might have shown you, for example, three chickens—one about one-fifth of the size of one of the others. It had been exposed to tou much ultra-violet light. The little one had ultra-violet light from a mercury qnartz lamp.

The largest chicken got the sunshine, and something else. It ran around outdoors and picked up little pieces of food that it wanted, pieces of grass and green stnff that had been rapidly growing with vitamins in it, and what else? Little grubs and bugs and beetles and all those litile things were little capsules of vitamins. That is why the one running arouud in the sunshine was able to get tbese activating substances that it could store and put into its body.

QUESTION: Sun lamps are not good?

DR. PRICE: I would say that if you use an artificial source of light, be careful to cut off the spectrum where the sun cuts it off. Why do you suppose it is necessary to do that? If we look at it from one standpoint alone, we'd say, "Since we are the product of the environment of this earth, the sunshine, the water, the soil, the air, etc., we'd better, until we know better, keep close to the formula that made us—sunshine." Sunshine doesn't furnish radiation shorter than 2900 A. U.

Enzymes are broken up hy radiatrous shorter than 2750 bnt not by anything that can come from tbe sun. So if you are going to use an artificial source of

light, get a piece of helio-glass or a piece of vita-glass and put it in front of the source of light and make it cut off the rays of light at the point that will make it more like sunlight.

QUESTION: Are the grown-ups using codliver oil as well? Are you recommending that?

DR. PRICE: I went into a meat shop in Boston a year ago last summer to make an observation of what people were buying. Every fifth person who came in to buy fish bought a can of codliver oil of some size because of propaganda, and whether it's doing a lot of good, it is doing some good and I have no doubt it is doing some harm.

Most of my patients get two capsules containing six-tenths of a gram of a mixture which is approximately either a little above or below fifty-fifty concentrate of the vitamins made from butter and a high vitamin codliver oil, just a fresh, normal, raw codliver oil that is very high in vitamins. So that makes in that capsule of six-tenths of a gram three-tenths of a gram of codliver oil and three-tenths of a gram of high vitamin butter concentrate.

That gives enough product so that the vitalizing quality is sufficient to reinforce people and carry their energy factors to a higher level—more pep, more zeal—just what it did to those calves it does to boys and girls if they get the right quantity. But they will often defeat the purpose if they get too much.

QUESTION: What is your opinion of the radiated ergosterol?

DR. PRICE: I am glad you asked that question. What do I think of radiated ergosterol?

One of the representatives of one of the larger manufacturers was at my office within a week and told me frankly that they were greatly disappointed in the results from activated ergosterol, which is precisely what I found earlier and reported in my paper earlier on "The Effects of Giving Activated Ergosterol."

You and I do not have rickets. Adults are not dependent on reaction in the body that will be chiefly expressed in deposit of calcium and phosphorus. We may need to have mineral go into solution. We may need the calcium to be made more diffusible, which activated ergosterol does not accomplish.

If I would answer it still further, I would say that this man told me, as a number of others have told me direct from the manufacturers and from internists, that the medical profession and dental profession have been very greatly disappointed in the effect on their patients. An internist recently said, in answer to my question, "How much activated ergosterol are you giving now in the form of viosterol or any other preparation—reinforced codliver oil?" "Not to a single patient."

I said, "Why have you changed?"

"Why," he said, "I found my patients getting nervous and they were getting effects that I didn't want at all and on clinical bases entirely I had to stop."

We can't get very far away from the original formula. We are mammalia. We are designed to get certain mineral elements from certain foods, one of which is milk. We are designed to get our vitamins from certain of the plant foods and from certain of the fat-carrying foods like the milk fat of milk, and we can often best get some of our activators including vitamin D from a milk product that is high in vitamins.

In practically every instance where we find the milk fat vitamin high, we have found that that cow was getting a plant food that grew rapidly, generally young grass just growing, and all those curves went up just as soon as the spring growth of grass came out. We can tell almost to a certainty when they start to feed the concentrates because the vitamin drops.

So one answer is instead of using activated ergosterol, find a good source of vitamins in a stored high vitamin butter.

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