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PATTERN OF CARIES IN RELATION TO THE PATTERN OF SOIL FERTILITY IN THE UNITED STATES*†

WM. A. ALBRECHT.**

While close correlations of phenomena are not necessarily proof of causal connection between them, they serve to stimulate search for such. The similarity between the relative numbers of caries per individual arranged by states for some sixty-nine thousand inductees into the U.S. Navy (1942) and the pattern of the soil fertility according to its climatic development is just such a stimulation. A combination map of these is presented (Fig. 1) for the suggestive value of it in our study of the soil fertility, i.e., the list of essential chemical elements coming from the soil in our foods, as this guarantees delivery of (a) the inorganic essentials in the ash—both major and trace elements—and, (b) the many required food compounds coming from the synthetic activities of plants and microbes.

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**Professor of Soils, University of Missouri.

THE GEOGRAPHY OF THE SOILS RATHER THAN AVAILABLE DENTAL SERVICES DETERMINES THE PATTERN OF CARIES.

During 1942 the Navy[1] took careful records of the dental condition of each of 69,584 inductees in relation to the economic conditions and the availability of dental services in the home territory. These data by geographical regions, as commonly used, were recalculated and rearranged to agree more closely with the climatic pattern of soil fertility (Fig. 1). This gave areas dividing the country into longitudinal belts, each approximately two states wide. The Mississippi River served well as one division line, since the belt of two states wide adjoining it on the west is also bisected by the still more helpful line separating the calcareous soils of the country (pedocals) on the west from the lime-deficient or acid soils (pedalfers) on the east.

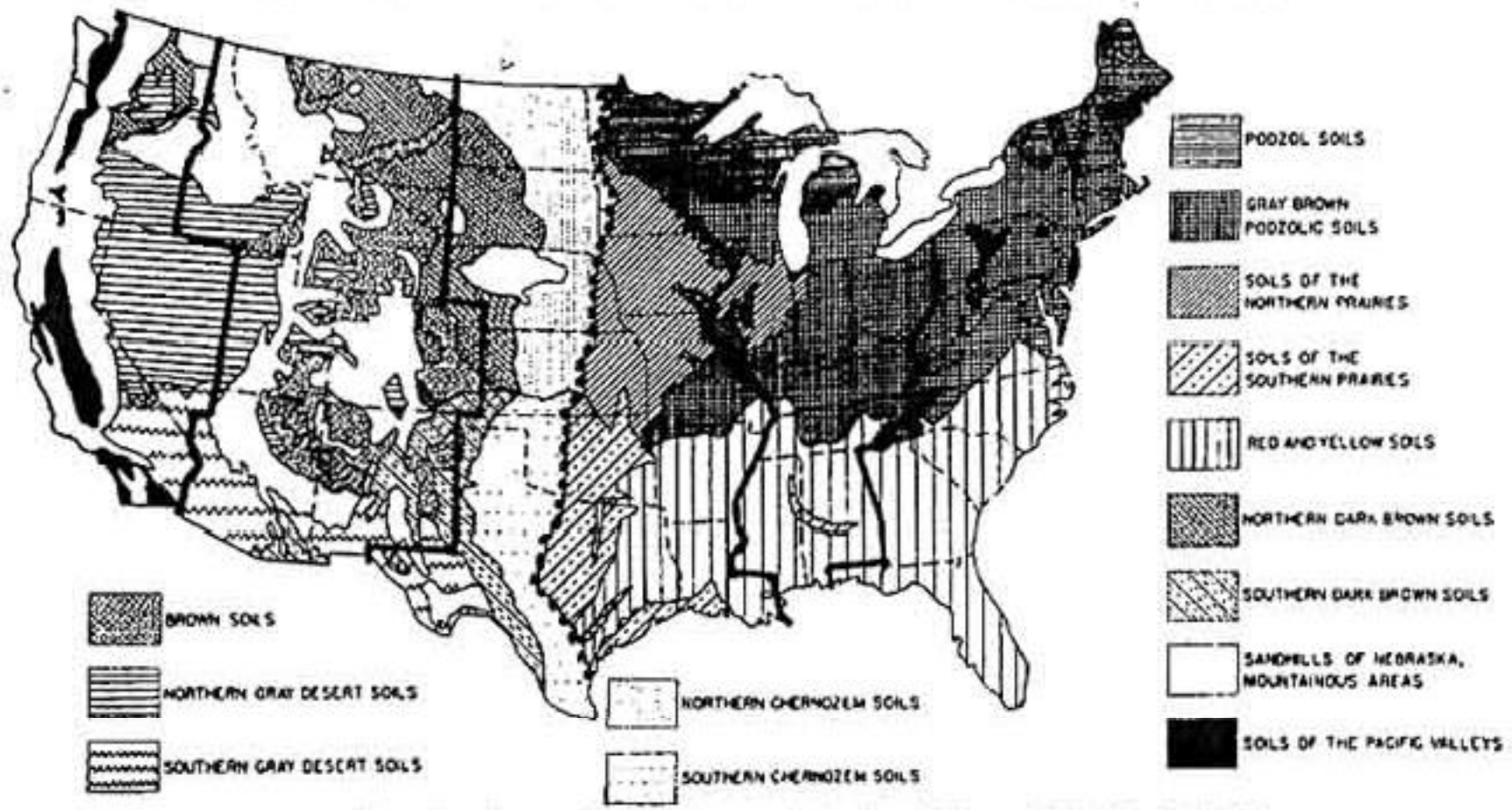
The data show that the minimum caries per mouth is in this soil belt of dominantly wind-moved materials, moderate rainfall, and of outstanding agricultural production by the chernozem and prairie soils. There is increasing caries on going either westward from this belt to decreasing annual rainfall, or eastward to increasing precipitation and more dentists (Fig. 2). The fact that the soils developed in the temperate zone by moderate rainfall support the better dental conditions warrants the hypothesis that the dental picture reflects the nutritional history of which the soil fertility is the significant foundation.

When the country is viewed for its pattern of the development of the soil, this also points out its belts of longitudinal arrangement, particularly in the western half. By starting with the very low rainfall of the west (omitting the Cascade Range on the extreme west) and going eastward (Fig. 2), these are belts of increasing rainfall. They represent increasing rock breakdown, more clay content of the soil, better soils with more fertility in available form absorbed on that clay, and more seasonal rainfall, all for growth of the crops of higher protein production and higher nutritional services to man and his herds. The most productive of these are in the midcontinental belt with the Mississippi River marking the western edge.

1. C. A, Schlack and J. E. Birren.-Influences on dental defects in navy personnel. Science, 104:259-262, 1946.

The relative number of caries per individual distribute themselves with the minimum figure in the mid-continental belt, bisected by the line separating the calcareous soils on the west from the lime-deficient soils on the east.

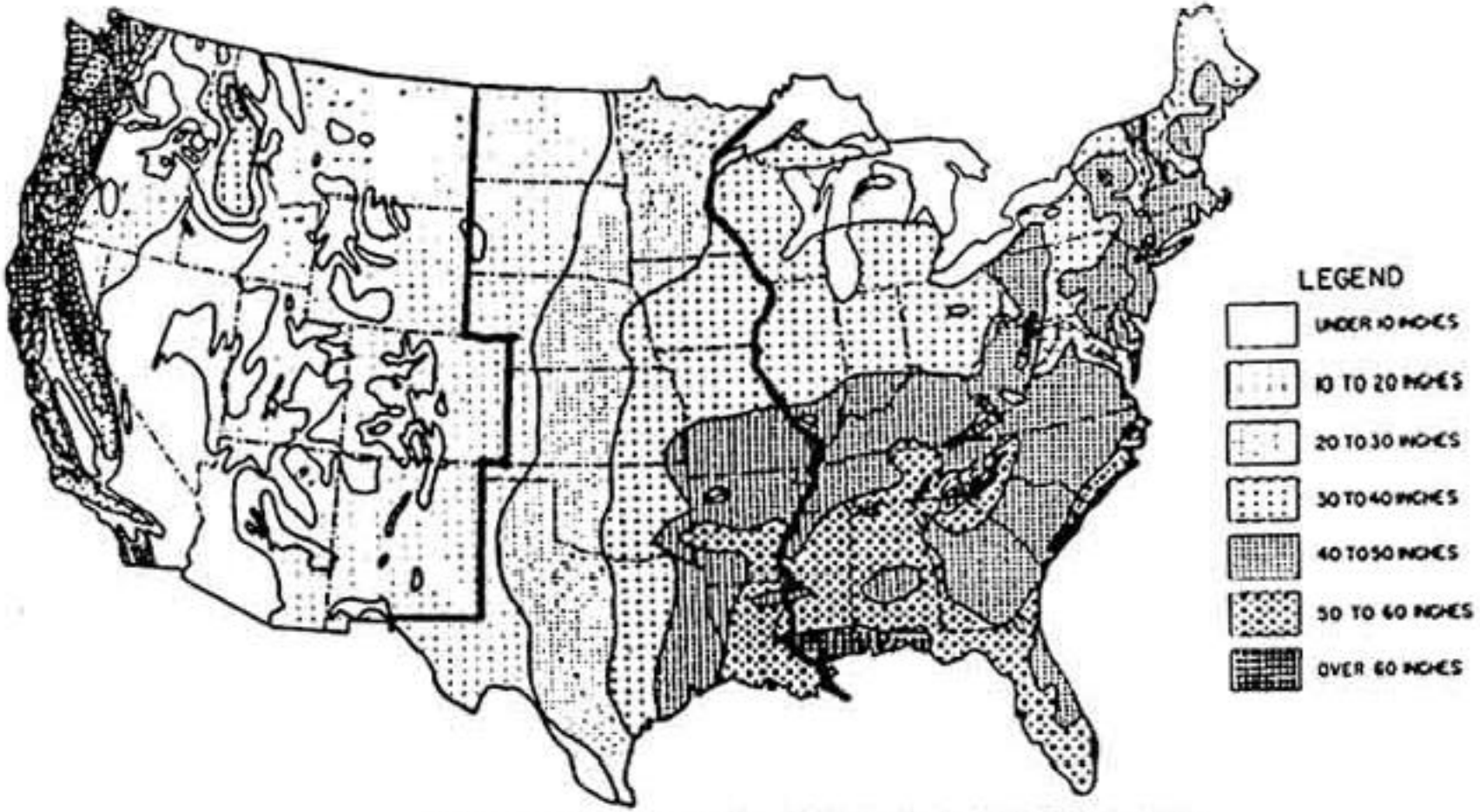
9.10	8.80	8.38	10.06	11.45	Cavities per person.
6.40	4.30	3.70	4.89	6.10	Fillings per person.
15.50	13.10	12.08	14.95	17.55	Total caries per person.



Climatic and vegetational soil groups of the United States. (*After Marbut*, 1935.)

Fig. 1.

Moderate rainfall in a longitudinal belt of the Mid-continent outlines the region of the lowest number of caries per mouth. Less rainfall and too little soil development to the West, and much higher rainfall and excessive soil development to the East, suggest the soil in control of the caries.



Distribution of mean annual precipitation in the United States (44).

Fig. 2.

On going eastward from the central belt, however, the increasing annual rainfall represents soil destruction rather than soil construction with reference to protein output in the crops. Higher rainfall has broken more rock down—and that more completely—to give soils of higher clay contents. Much rain has removed the lime from the soil. Many other elements of fertility, along with the calcium, have gone out to the sea. The processes of soil development, encouraged by decay of more organic matter grown there, have substituted hydrogen, or acidity, on the higher clay content of the soil. Such soils encourage a woody, protein-deficient and ash-deficient vegetation as represented by the forest primeval. Higher temperatures on going south accompanying still higher rainfall made still more, but a mineralogically different, clay. On this clay very little acidity and much less cations of nutritional values would be held. This is the climatic reason for the poor supplies of fertility under the virgin coniferous forests of the south, and thereby for the "poor" soils and "poor" people depending on the agriculture of that area today.

ONLY A PARTICULAR COMBINATION OF CLIMATIC FORCES DEVELOPS SOILS GIVING COMPLETE NUTRITION FOR ANIMALS AND MAN.

The differences in productivity of the soils according to their differences in climatic development suggest their responsibility for the differences demonstrated by the teeth as reflectors of complete or incomplete nutrition. The Midcontinental belt of lowest caries per mouth (twenty-four years of average age) originally contained the great herds of American bison. Within that territory this strictly herbivorous feeder migrated north in the summer and south in the winter. His wanderings eastward and westward seemed to have been limited, except for the fact that small numbers were native to the blue-grass region of Kentucky, made famous by the fine racehorses today. Also a few were native to some of the limestone valleys of Pennsylvania, widely known for the excellent farming by the thrifty agrarian Germans. This single case of wild animal array, a superimposition on the pattern of soil fertility, suggests that the latter must play a significant role rather than be just an accidental correlation. The physiology that builds proteins in the vegetation to undergird building of bone and brawn while favouring reproduction in numbers mounting to great herds suggests its support by the fertility of the soil. The virgin vegetation in this belt was not trees. Instead, it was prairie grasses, capable of surviving the summer droughts by temporary dormancy in the plants' growth processes. This was the bison's only feed. He purchased no protein supplements.

The limited rainfall did not weather those soils destructively. They are not leached into a highly acid condition. They are not deficient in the elements essential for good nutrition of plants (including the legumes) for high protein

production, and good reproduction by means of heavy yields of seed. The buffalo and his big muscular body reflected the nutritional qualities of the herbage coming from the responsible fertility in the soil. This was of wide diversity in elements because of windblown origins from extensive, less-weathered areas to the windward west. Here were soil fertility conditions pointing to carbohydrate production bringing with it also high protein output for growth and reproduction rather than to carbohydrate output only for mainly fattening effects.

The same soil area gave us more recently the slim, trim, but muscular body of the cowboy, championship basketball teams, and many of the selections of All-American football players. In livestock, it is the area of beef and literally the major Hereford belt. It grows the high-protein wheats. It provides the major output of that grain mounting one year to nearly three hundred million bushels in Kansas alone. That grain demonstrates increasing concentrations of its protein as one crosses this belt from the higher rainfall of nearly 40 inches along the eastern to less than 20 inches at the western side (Figs. 2 and 3). It is the area where the quality of the vegetative output is high in terms of protein as more nearly complete array of the essential amino-acids and of all the inorganic elements commonly associated with their production. In these facts there is the suggestion that the soil fertility pattern, not in terms of higher yields as bushels and tons per acre, but of quality output that guarantees growth and reproduction, deserves more consideration in looking at the health conditions of the teeth. By means of this broader pattern we would probably arrive at the suspicion, at least, that much that is now called “disease” should more properly be called deficiencies in nutrition because of low soil fertility.

STATISTICAL PATTERNS OP OTHER DISEASES SUPERIMPOSED ON THE SOIL FERTILITY PATTERN MAY BE SUGGESTIVE.

Perhaps if the statistical aspects of more diseases were mapped for the country as a whole and superimposed on the map of soils to be interpreted in their nutritional aspects, there might be suggestions regarding the deficiencies provoking the different ailments. Such results have not yet been demonstrated widely. However, recently a pronounced correlation between the decreasing percentage of reactors, both human and bovine, to the test for the infection by the fungus *Histoplasmin capsulatus* and the decreasing rainfall as it develops the soil less, or leaves more lime in the soil, was brought to attention by Sam E. Roberts, M.D., of Kansas City (Fig. 3). With the state divided into three sections, namely, East, Middle, and West, and with a rainfall reduction from 40 to 20 inches or less, in making that transition, the percentages of the tested student population reacting positively went down from

Human and bovine reactors to Histoplasmin tests as percentages of the samples according to the areas in Kansas producing different concentrations of protein in the wheat.

Percentages of Histoplasmin Reactors:

Among 3,600 students, lifetime residents of respective areas. (Solid Lines.)

Among cows in the three sections of the State. (Broken and Solid Lines.)

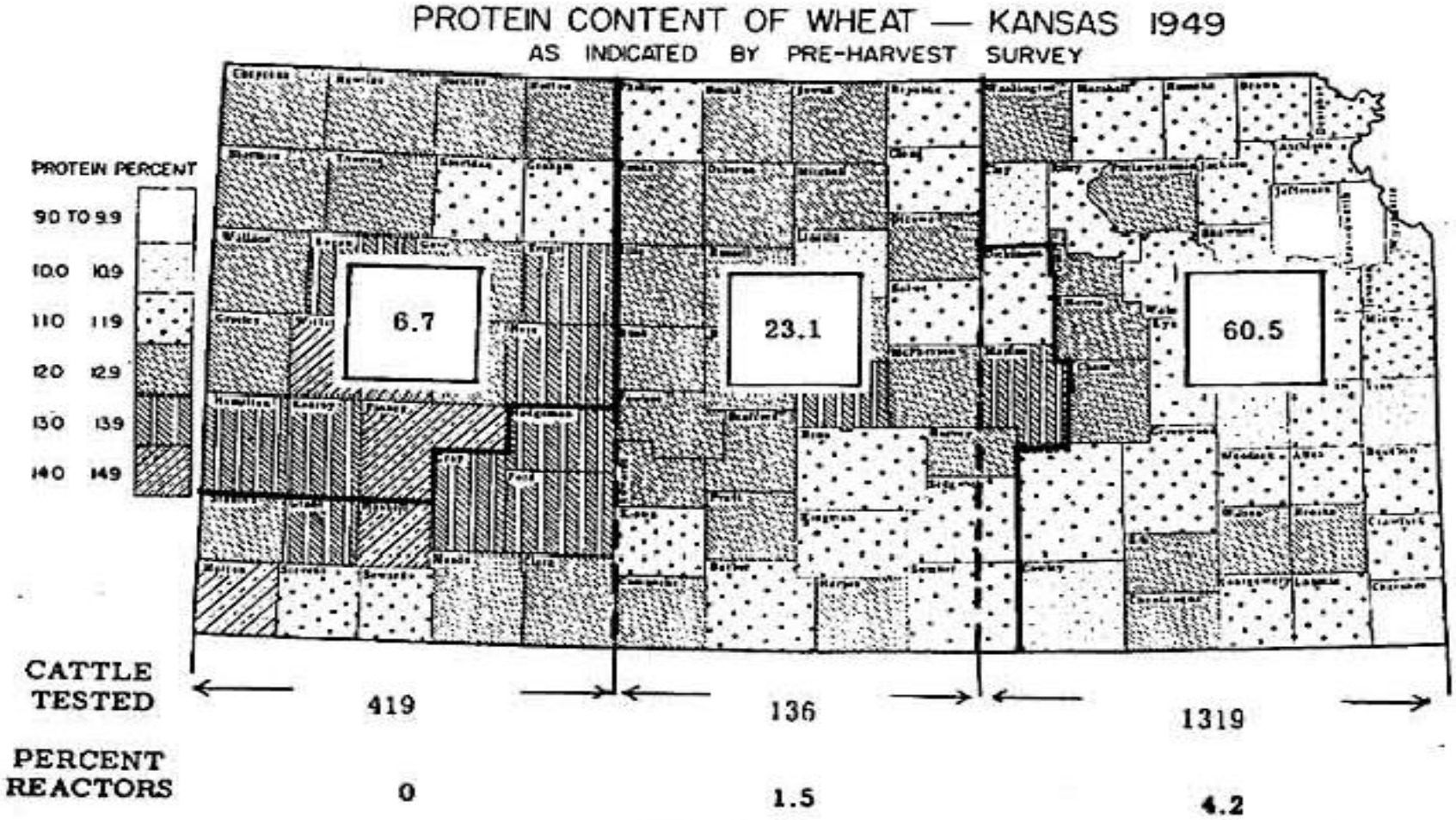


Fig. 3.

60.5 to 23.1 and then to 6.7. This represents a decided decline of infection by this fungus in going from the low-lime soils under higher degree of soil development westward to the high-lime soils under lower degrees of weathering and development. It is also a case of going from the area of low protein in the wheat to the area of high percentage of it in this food grain.

The agreement of this series of figures, in general principle, with the percentages for the cattle population in the same parts suggests that these animals with feeding habits more local to the soil, confirm the report by the student population. Here is a distinct correlation of disease pattern with the soil fertility pattern. Here is a significant one which awaits the establishment of possible causal connections. This is all the more challenging when with the higher lime content in the soil, and also with higher concentration of protein in the wheat grain in going across the state, there is also less infection in students and cattle by *Histoplasmin capsulatus* for which the human body manifests symptoms suggesting tuberculosis.

Equally as interesting for the State of Kansas is the statistical pattern of the rate of death by cancer. Here, again, the correlation between this and the other patterns already outlined as dependent on the soil fertility is so startling that it, too, adds its weight in suggesting that these degenerative behaviours of the human body may go back to deficiencies in nutrition and from there back to the soil fertility.

PROTEIN DEFICIENCIES ORIGINATING IN SOIL DEFICIENCIES MAY BE UNDERMINING THE BODY'S BIOCHEMICAL DEFENCES.

The suggestion that the soil and its deficiencies in the inorganic essentials for plants, animals, and man should set the disease pattern may seem farfetched. This concept will certainly be neither verified nor disproved as long as only the presence of microbes is taken as the direct cause of health troubles—particularly in the mouth and teeth—rather than the consideration of them as probably only another symptom of the body's weakened biochemical defence because of malnutrition. However, with more diseases being classified as degenerative, and with vitamins defined as "something that will kill you if you don't eat it," there is a growing admission that some folks are being killed gradually because of some things they don't eat. Diseases, then, may not need positive agencies. Their symptoms are bringing us to think of causation prefixed by a minus sign.

Shortages of protein, because of deficiencies in soil fertility to cause them, may come in for more consideration as "disease" provocation when we recall that, in measuring this conglomeration of essential amino-acids, we measure

no more accurately than by a method of ashing in sulphuric acid and multiplying the collected nitrogen by a mathematical factor established by common consent. Protein deficiencies, then, (a) in total because of economic conditions, and (b) in completeness of the required amino-acids, because of no greater refinement of our knowledge to lessen our ignorance of them in foods and of their possible relation to soil fertility, may well be a major factor in health degeneration.

That such thinking about the soil and proteins in relation to health deserves extension is suggested by our "cure" of tuberculosis. This is not brought about by the extermination of the microbes from the body through the use of pesticides, antiseptics, or antibiotics. Instead the "cure" is brought about by complete rest of the patient and his better nutrition under a generous, but high-protein, diet. Under such nutrition the microbes seemingly recognize their too hasty, or premature, entrance in anticipation of a task of disposal of a cadaver and move out. If our reasoning is sound about the high-protein diet driving them out. is it fallacious reasoning to believe that insufficient, or low-protein, diet and the malnutrition resulting invited them into the body? We may well raise the question "Were the microbes the cause or a symptom following the predisposing period of deficiencies of protein, *et altera,* in the nutrition?"

RESEARCH ON HEALTH CORRELATIONS WITH SOIL FERTILITY, OUGHT TO BE MORE CHALLENGING.

Since animals and man do not synthesize proteins from the elements but only assemble them from the amino-acids, and since the plants and the microbes alone can affect their syntheses and then only by the help of the more complete list of essentials in the fertility of the soil (both as major and trace elements), it seems reasonable that much could be learned about deficient health by correlating it with the soil fertility and corresponding nutrition. With more such correlations confronting us there ought to be encouragement for research under the belief that we may discover more causal connections. By such discoveries we may effect prevention of more bad health and the reciprocal of it, namely, the establishment of more good health in the body in general, and in the teeth—an exposed portion of its skeletal part—in particular. Through more diligent research we may eventually see the causal connections, as well as the correlations, between our soils and our teeth and, we hope, between our soils and ourselves.