in this issue . . . 1957

— REPORTS IN THIS ISSUE —

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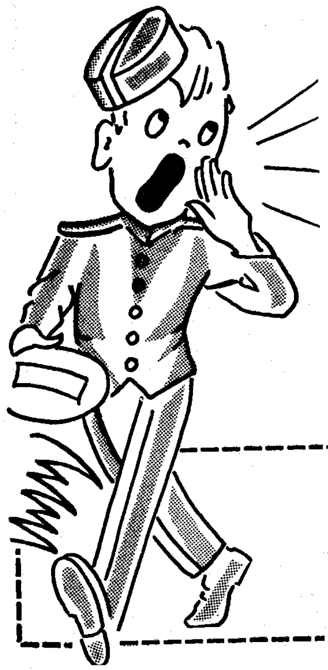

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SUPPLY, VIRGINIA

Soil Fertility and Animal Health

By W. A. ALBRECHT, Chairman,
Department of Soils, University of Missouri.

XI. The Problems of the Proteins

INTRODUCTION

The proper feeding of livestock to keep the animals healthy is mainly a problem of providing the extra essential proteins as supplements to the home-grown carbohydrate-rich crops. These energy-providers usually give good yield on humid soils but insufficient proteins and other essentials coming along in them. Those climatic areas of soils developed under higher rainfalls, and under fertility depletion by that natural part of the climate, have always had their problems of protein deficiency in their forages. Those areas have been the main reason for the commercial feed business. They gave us the whole problem of "purchased protein supplements." Consequently, the economics of getting those supplements is the major factor hindering the health of livestock.

In hoping to make "cheap gains" or "cheap gallons" we are not depending very much on managing our own soils to grow, or to create, the products bringing those gains and gallons for us. But rather, we are shifting to the hope of buying the health via the market's offerings of feed. We cannot, thereby, make our efforts dovetail into those put forth by the animals in their choices of feed and in their struggles for their own better health when they are grazing on mixed herbages of lush growth. That is what Nature offers in the wild during the spring season in which the births of the myriads of life forms are naturally scheduled. The purchases of supplements extends the protein life-lines from the soils which are deficient in growing this essential and all else, including both major and minor essential inorganic elements and special organic compounds of even medicinal services. Buying supplements lowers our view of the creation of domestic forms of animal life to the level of a simple economic transaction of costs and market prices, when for healthy animals it must be one of physiology, nutrition, health, reproduction and the creation of life by beginning with that potential in the soils which we cultivate supposedly for that high purpose.

We are apt to forget that agriculture is, first, a natural biological performance, and, second, a financial transaction in the market place with the death of those biotic products rather than with their health and the survival of their respective species in prospect. If we have lost sight of the life of agriculture in our management of it, should we not anticipate considerable bad health and disaster when we are concerned with only its economics and the technologies appied to it? Bringing the livestock from birth to the slaughter-house is a biological matter proceeding according to the laws of Mother Nature. It challenges our more careful study. Once the animal is slaughtered, and life eliminated, then it becomes an object of technology and economics which can be fitted readily into the demands of these two man-made controls and manipulations as we might choose them.

Definition of Proteins—A Problem of Confusion.

Just what all is included in the term "proteins" is not a clearly comprehended matter by even the sciences of organic chemistry and biochemistry. Proteins have always been characterized by the fact that they contain nitrogen combined with carbon, hydrogen, and oxygen. For that reason the nitrogen in many organic compounds has served to label them crudely as proteins. Unfortunately, this element, nitrogen, may take several chemical forms within the organic substances we grow as crops. As a truly protein form, it occurs as one atom of itself combined with two of hydrogen and this so-called "amino nitrogen" or protein-characterizing unit is combined with a particular carbon atom in an organic chain compound of more carbon, hydrogen and oxygen atoms. The measuring of this kind of nitrogen necessitates burning the carbon and hydrogen off to catch the nitrogen in the form of ammonia or in its combination with three, rather than two, atoms of hydrogen.

Other combinations of nitrogen, which are not chemically combined so specifically, and which do not serve in the processes of nutrition for growth, protection, and reproduction of life forms as the amino nitrogen does, are also converted into ammonia by ignition in this chemical determination. Since the different compounds supplying the amino nitrogen vary widely in their percentage of nitrogen; and since we have been content to say that proteins contain an average of 16 percent of this element; then any forms other than amino-nitrogen bring much error into the determination of the proteins. We are labelling as "protein" all the nitrogen regardless of whether it might be ammonia, nitrate, nitrite, and other forms which the growing plant takes from the soil and we trust will be converted into amino-nitrogen and function truly as a life-carrying protein. In feed analysis we have been selling organic and even inorganic nitrogen, but were believing we have thereby offered protein supplements.

The legume forages, and parts of the seeds such as milling remains, or seed cakes from which the oils have been extracted, were the pioneer concentrates as protein supplements to the hays and bulky carbohydrate matters of feeds. But these are no longer offered so extensively on the open market for economic transport to great distances, now that livestock production has become a more ambitious part of agriculture in most every farmed area. Proteins are a problem right at home on every farm. Milling products don't move very far from the mill. Those grown in Kansas formerly moved as wheat to the eastern mills. They were the protein supplements for the New York City mill-shed. They served in feeding operations near that metropolis for its meat supply. Now those milled products move as commercial feed in bags. Soybeans are also moving but short distances as protein supplements for livestock feed. They are moving away from animal into human consumption where the problem of protein supplements is rapidly shifting from one of animal products to vegetable forms. We are seeing the problem of even crude proteins confining its solution to the soil areas where the soil fertility grows the proteins more commonly. The acuteness of the problem is emphasizing the soil as the responsible factor under the crops.

Biochemsitry is removing some of this confusion as to what proteins really are. Research has shown that the body's needs for all that is included in the term "proteins" consists of the many demands for the separate components of proteins, namely for the amino acids. These are the units into which the proteins of foods are separated for their higher solubility, greater simplicity, and effective absorption by the processes of digestion. We are clearing away the confusion connected with the crude proteins measured by the amount of nitrogen multiplied by 6.25. We are now viewing the problem of the proteins as one of providing the specific amounts of each amino acid required to keep the body in balance so far as intake and out-go of nitrogen are concerned. These include ten for the white rat and eight for the human. Then also, the provision of many of the others in the two dozen, now known, is required for their contributions to body processes not yet tabulated even for only nitrogen balance. It is this knowledge built up by study of body physiology that is outlining this problem, not as one of only the crude protein supplements, but one of providing the essential amino acids. It is becoming necessary to know the kinds and the amounts of them in the feeds, and thereby the quality of the home grown and readily available protein in order to supplement it with those amino acids in which the array of those on hand is deficient. We are no longer concerned with the nutritional balance as simple as one of carbohydrates versus crude proteins. Instead we are concerned with nutrition balanced with respect to the required amino acids which those crude proteins provide in relation to the carbohydrates.

The Problem of Growing the Essential Amino Acids In What Crops.

The confusion resulting from our satisfaction with the crude protein contents of crops in certain ratios to the carbohydrates, as we make up our animal feeds, has allowed the declining soil fertility to bring more and more crops into use which may still have considerable nitrogen, but much of that may be in non-protein forms. Even much of what is protein may be deficient in two or three of the ten (or eight) essential amino acids. Mining our soils for larger yields of bushels and tons has consequently resulted in lower and lower quality of the forage and feed proteins with respect to their shortages in tryptophane, in methionine and in lysine. These are the three amino acids which we usually hope we get when we purchase protein supplements.

We have not been testing the feed crops on the farm for their contents of tryptophane, for example, which has a unique chemical structure. In its carbon-chain part there is one amino nitrogen unit, or the truly protein form of this element. The human body digests this chain section out of the amino acid and uses it when we eat tryptophane. Another part of this essential amino acid is a carbon-ring form. This ring contains another nitrogen atom but not an amino form in it. Unfortunately this entire ring remains undisturbed by digestion. The ring nitrogen is not used by the body. Instead, that nitrogen is just so much deception by one hundred percent when we measure its total in tryptophane and consider it all as protein or amino nitrogen. This much nitrogen of even an essential amino acid passes unchanged through the digestion to be excreted as part of either the compound indole or of the slightly more complex skatole, both giving the common fecal odor. When we measure crude proteins by ash analyses for the nitrogen as the index of proteins, then, we are not measuring even the true proteins correctly. Much less are we taking an inventory of the essential amino acids in the crops we grow. We add much confusion about what feed quality we are growing in our crops when we know no more than that about the proteins in the supplements we purchase, and then combine the crops and the supplements and believe we have solved the protein problem. By the increasing incidence of "disease" among our cattle resulting from that confusion, those poor beasts are paying for our ignorance of the nutritional values which our soils and crops are creating in terms of the essential amino acids in the proteins.

Methionine, as the second commonly deficient amino acid among those essential, serves to supply sulfur in the protein form. It is related to cysteine, also a sulfur-carrying protein, but not necessarily an essential amino acid. Unfortunately sulfur, which is no more prevalent and no less deficient in our soils, in general, than phosphorus, has had little attention as a fertility element. It has been included unwittingly in commercial fertilizers when sulfuric acid is applied to phosphatic rocks to make their phosphorus more soluble and active. Sulfur-containing crops, like rape and all those allied to the cabbages, and like garlic and others in the onion group, were once considered important feeds and animal medicines. The latter are taken by preference in animal choice, even the garlic in the spring time, to suggest the animal's verification of the medicinal values claimed for these pungent plants in connection with some baffling animal diseases, including Brucellosis. This commonly missing amino acid should cause our concern about sulfur in the soil's fertility store, particularly when experiments applying more sulfur have resulted in more methionine in some crops to suggest that these can be grown more nearly complete in protein by proper treatments to build soils accordingly.

Lysine, another commonly deficient amino acid, is not distinguished by any chemical structure widely different from most of the other amino acids, save that it has two amino nitrogen units. One is in the customary structural position while the other is at the end of the six carbon chain opposite the "acid" end. Like the tryptophane and the methionine, the lysine is deficient in the cereal grains. Fortunately all three are not so low in soybean meal or sesame meal, both of which represent possible concentrates for animal feed. They are all three much higher in certain fish, hence fish meal may be more significant for health than we realize for both humans and animals. Since fish must feed, in the last analysis, on the vegetative crop of the sea; and since they may need to eat the organic components which they assemble into their body proteins much the same as higher life forms must, there may be much value in putting some of the particular sea weeds into the animal diet. When the cattle in pastures along the sea coast wander to the beaches to search out and eat some of the vegetative inwash, they may be demonstrating their refined choice there as they do of herbages with different fertility treatments. They may be finding differences in quality of the proteins as well as differences in the amounts of iodine and other trace elements in the kelps and other marine vegetation to which we would give emphasis by this unique search.

Unfortunately in choosing the crops we grow, we have paid no attention to the quality of their proteins in such a great detail. We have appreciated legumes for their higher crude protein concentrations. But when they will not even grow on many soils, unless those are carefully fertilized, even the legumes are making up less and less of our home-grown feeds. We are not holding up the protein supply from that source. We are increasing the shortages of commonly deficient amino acids in the feeds. We have believed that legumes grown on most any soil were taking nitrogen from the air, when perhaps they were growing like a non-legume on the soil nitrogen or were even losing seed-nitrogen back to the soil. With our choices from a variety of crops merely to grow them, we may be magnifying the confusion relative to the quality of feed protein we are producing for animal health and animal reproduction.

Proteins Present a Problem of Balanced Soil Fertility For Particular Crops.

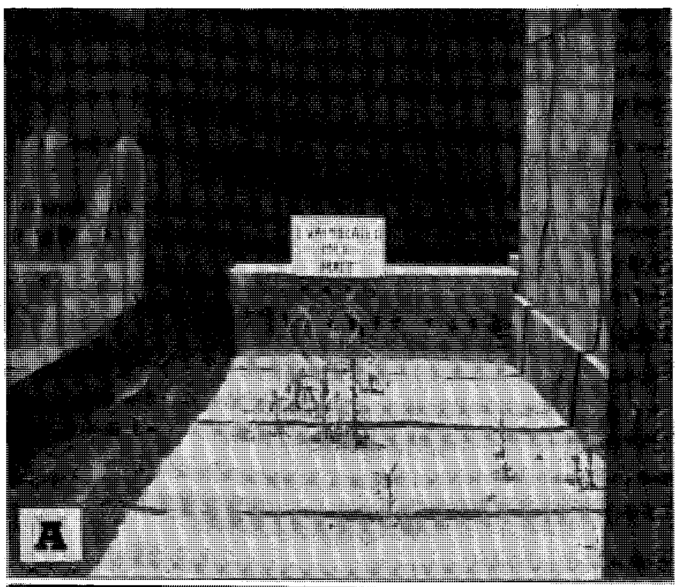
The words "soil fertility" represent more than you might believe from what is commonly reported as the contents of the fertilizer bag. That term includes all that comes from the soil to contribute in any way in the growth of plants. This divides itself into (a) the **inorganic** and (b) the **organic** parts. The inorganic divides itself further into (a) the major and (b) the minor or trace elements. Then each of these groups may be divided again into (a) the cations, of positive electric charges by which they are active and move toward the cathode or negative pole of a battery circuit, and (b) the anions, of negative electric charges by which they are active and move toward the anode or positive pole. In the services by the inorganic cations in plant nutrition, we visualize them weathered out of the rocks and minerals as soluble, active ions; then they are adsorbed on the clay which results simultaneously from the weathered rock; and while not taken from there by water, they can be exchanged from there by any other positively charged ions. For that, the hydrogen resulting from the carbon dioxide excreted into the moisture around the root serves as an exchanger. This non-nutrient then takes the place on the clay for the nutrients made active to move them into the root for plant nourishment. Thus we get a clear vision of the activities of cationic fertility elements like calcium, magnesium, potassium, ammonium, iron, copper, zinc, manganese and sodium in accordance with chemical laws. According to these, they may be held in the soil against loss from there in pure water percolating through the soil. But yet, they may be taken by the plant root using sunshine power to give the carbohydrates respired by that root into the carbonic acid surrounding it and activating the soil fertility into plant nutrition.

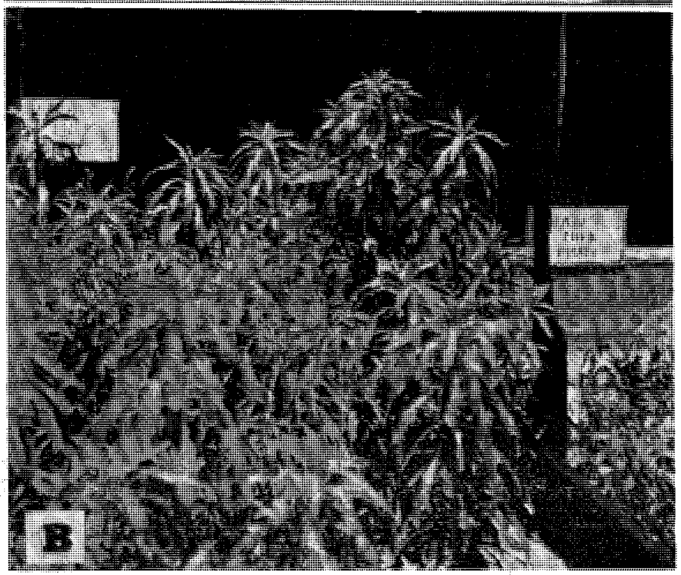
Unfortunately, however, while we envision the clay of the soil as the large sluggish, negative colloidal molecule holding and exchanging the above list of nutrient elements of positive charge, we do not comprehend too clearly just how the nutrient anions, like nitrate, chloride, iodine, sulfur, baron, phosphorus or molybdenum are held and exchanged into the plant root. Plausible theories concerning them have been formulated. Improved management of plant nutrition may result when they are fully established as the facts.

The organic fertility is another division of plant nutrition the services of which research has not yet elucidated clearly. Chemical science has been less specific in its interpretation of organic reactions than it has in its elucidation of those inorganic. As a consequence, much controversy has arisen regarding organic matter in soil and in fertilizers for its services in plant nutrition in contrast to services from chemical salts. The organic compounds taken up from soils by crop roots for plant nutrition are the seriously neglected other half of soil fertility. Their production and conversion by soil microbes for increased plant growth with the advance of the season may mean more in the final composition of the proteins in the crop than we appreciate.

When mushrooms, living almost wholly on decaying organic matter, are the most rapidly growing food crop we produce, should we not believe that crops might be more speedily grown if there were more organic matter in the soil serving in their nutrition? Would it not be plausible to postulate that compounds as complex as the amino acids would be more quickly synthesized by crops if those organic creators could take up from the soil some organic compounds like indole and proprionic acid, for example, the constituent parts of tryptophane, which is also called indoleproprionic acid, and thus synthesize this essential amino acid more speedily than if only the elements, carbon, hydrogen, oxygen and nitrogen are the starting materials offered by the soil, water and air?

The grazing cow taking grass, microbes, and soil all into her paunch, as a highly active and fermenting mass, suggests the important role microbes play in converting organic matter from a chemically stable compound, like cellulose, into digestible food values for either the plant root or the cow's alimentary canal. The cow's paunch suggests her literally direct connection thereby with what resembles the soil and the organic matter of its production under microbial transformation at body temperature. It suggests the preparation for later digestion along the alimentary tract for introduction into the liquid protein stream which her blood represents in nutrient balance with the entire body protein. Should it be a dangerous stretch of the imagination to visualize the cow's blood as the combined organic and inorganic chemical expression by that warm-blooded body of what a protein potential for animal life





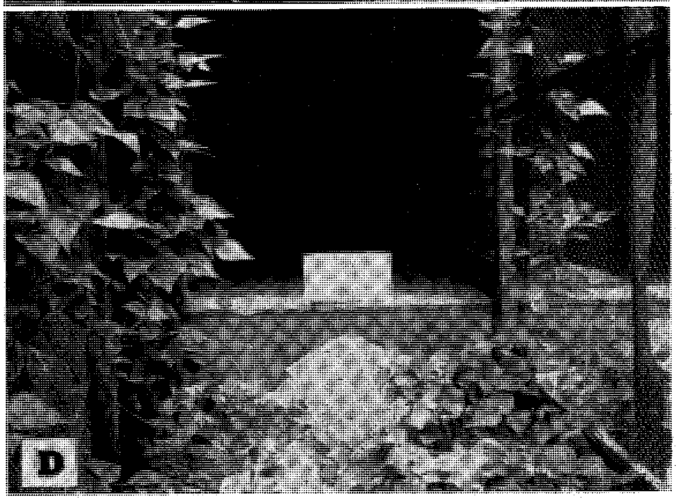


Figure 1-XI. Dung buried in the sand by cats reflects its differing manurial values under the volunteer weed crops according as the male cats were fed evaporated milk (A) or unpasteurized (raw) milk (B). The manurial values under dwarf beans from evaporated milk (C) were less startling than those from unpasteurized (raw) milk (D) which changed the plant growth characters from "dwarf" to "pole" bean, regardless of the same pedigree of all the seed.

the soil fertility growing her grazing really is? We have been slow to believe that the critical chemical testing of the levels of organic and inorganic essentials in the cow's blood might give helpful suggestions on soil treatments ministering more directly to good animal health via preventions of diseases than drugs and potions do when they are aimed at the cure of health deficiencies. That soil treatments for growing more nutritious feeds can be surmised from analyses of the blood for improvement of animal health and for even prevention of diseases has already been demonstrated both abroad and in the United States.

Proteins as the body's protective agents against disease can be grown and chosen by, or administered to, the grazing animal as its medicine in the form of nutritious feed only when the fertility of the soil is balanced for the particular crops by which those protein requirements result from their biosynthetic activities. Such proteins are problems of the proper choice of the crops and the proper choice of the fertility treatments on the soil. They are problems of all this good judgment coupled with the maximum help the animal can give by its behaviors to our critical study of even its blood stream or other body properties as they give suggestions about good health via complete nutrition for it.

For too long a time have we had a fear of microbes. We have shunned the changed organic products resulting from the many microbial digestive activities. We forget that the cow's paunch is an outstanding case of her use of the many changed organic products the microbes can bring about within that voluminous organ. As a result she, quite different from the non-ruminating pig and chicken following her and requiring so-called "animal proteins" in their rations, can live wholly by vegetarian principles. She does not require animal proteins.

We forget that microbial activities also in our foods contribute to their preservation and even improvement in nutritional values in terms of vitamins, and other special compounds when we use fermentations for preparation and preservation of sauerkraut, wines, beer, sauerturnips, sour milk, cheese, and other foods with distinct flavors. Microbes in the soil have even come into recognition for the antibiotics they make. We have not yet appreciated the microbial flora and fauna of the soil for their services in transforming crop residues, plowed under, into not only organic fragments serving directly as organic nutrition of the crop, but into also the chelating agents for moving the inorganic fertility into the crop for more effective plant growth. All of these services emphasize the microbial connection with the plant's production of the proteins. Nitrogen connects itself with the protein production of plants by coming even from the gaseous supply of it through the help of legume bacteria. But that occurs only when all inorganic elements of fertility are completely assembled and in proper ratios. Proteins are a problem in our health program because even organic fertility must be balanced too if we are to grow this food component which has not yet become a product which the industrial assembly line can put out.

Biosynthesis of Proteins by Crops Via Soil's Organic Remnants of Digested Proteins.

The synthesis of the more commonly deficient amino acids, like tryptophane, or of the plant hormones like indole-acetic acid, for example, may require that the plant take up from the soil some organic molecules of larger dimensions excreted by animals from their digestion of amino acids. This was suggested by observations of the varied growth behaviors of Michigan dwarf bean plants. Dr. Frances M. Pottenger, of Monrovia, California grew these ordinary navy bean plants in some abandoned cat pens as a second phase in his experimental studies of the differing nutritional values of (a) condensed, (b) evaporated, (c) pasteurized and (d) raw milks for cats during two years. These were combined with a constant allotment of cooked food as the diets for all of the cats.

The pens had been filled with an infertile, well-washed, nearly-pure quartz sand. This was fertilized by only the urine and cat dung buried by them during the two years of these critical studies of cat nutrition. The pens were arranged according to the one variable in the test, namely, the kind of milk fed the cats. They were separated, however, according to male and female sex of them.

After the nutritional phase of the study of the cats was completed, the pens were left abandoned for a time. They were observed, then, the tremendous differences in the volunteer weed crops of a single species according to the different treatments of the milk represented in the feed for the cats. All the urine and dung from the condensed, evaporated and pasteurized milks apparently did not put into the sand enough fertility even to invite weed growths, save for the pasteurized milk through the males. The raw milk, of the same composition as the original of the pasteurized, had put so much back, even after feeding the cats better in terms of physical vigor and persistent reproduction, that the weed growth filled the pens completely. (Figure 1-XI).

In order to observe these matters more closely, the weeds were removed and the pens planted each with two rows of beans. The first significant fact demonstrated was the different growth behaviors of the bean plants, even if all represented the same lot of seed. Wherever the cats' diets contained the heated milks, the plant growth characters were those which one would call the "bush" or "dwarf" kind of bean. Where the buried dung from the cats fed the raw milk was the fertilizer, the plants were like "pole" beans with vines climbing the screened sides as high as six feet. Here were decided differences in the growth behaviors of the plants, not because of the claims of the plant breeder, but contrary to them and because of heat treatment of the feed (in some not to exceed 140°F. for half hour) going into the animals making the manure, which fertilized the soil growing them.

Still more significant was the observation of the fecal odor in the bean seeds harvested from the "bush" type of plant growth in the pens of cats fed on heated milks. There was no such odor detectable from the seeds harvested where the buried dung was from cats consuming the raw milk or where the plant growth was of the "pole" bean type.

Since indole and skatole are the common urinary and fecal excretions resulting from digestive changes of tryptophane, one of the essential amino acids, it would seem mere hallucination to believe these powerfully odoriferous compounds to have resulted from the plants' regular creation of them from customary soil fertility elements. It is more logical to believe that some of the excretory organic compounds from the cat's digestive, or from the microbial, transformations were taken up by the plants—after burial in the soil—and were transmitted into the seed without enough analytic or synthetic change to remove the odor. With the odor so characteristic to suggest no breakdown of the ring combination of the indole or skatole, there is much reason to believe that this is the correct route of travel of the organic compounds of protein potential undergoing little change as these self-announcers reported to the nose at the outset and the finish of their apparent journey from the dung in the soil to the seed or the beans' reproductive part.

The chemical stability of indole and skatole, because they are ring compounds of carbon including nitrogen, is more reason to believe in their movement within the soil, into the plant, and into its seed without chemical change. Few if any common microbes can break down the indole and skatole ring. Microbes or digestion may break the carbon side chain off from the ring when the combination of these is tryptophane. One needs only to be reminded that indole-acetic acid, that is, the indole ring with an acetic acid side chain, is the common plant hormone giving pronounced growth of roots and of shoots extended into vines. This change in type of plant characters would not occur unless this larger molecular structure is absorbed into the plant cell. Indole taken up from the soil may became this hormone, that is, the indole-acetic acid, through but little chemical change, represented by the addition of a two-carbon chain to the indole ring. With not much more change through the addition of amino-proprionic acid, a three-carbon chain with the amino nitrogen, it becomes tryptophane.

If this is the plant's performance of starting its tryptophane resynthesis by using the indole going into the cat dung from the digestion of tryptophane, it suggests that indole might be the starter organic compound also for the plant's synthesis of the in-