Plants—Protected by Fertile Soil

William A. Albrecht

Plant pests and diseases, much like the size of the crop yield, were once considered purely a matter of chance. But we know now that the crop yields demand the management of the fertility of the soil for maximum use of the rainfall, the air and the sunshine.

We are also overcoming the plant diseases and the insects, in some measure, by special efforts in combatting them with poisons. We have not yet, however, given much thought to the possible prevention of their damage as a by-product of managing the soil for bigger yields; for crops of better feeding qualities for our animals and ourselves; and for plants growing their own immunity and self-protection.

Only properly nourished microbes can defend themselves by making antibiotics.

Since we now know that microbes make the antibiotics by which they protect themselves; and which are also nutritional helps to those higher animals fed them; or are even helpful to us when we get them into our blood stream by other less natural means than the digestive tract; it is dawning on us that the life of the microbes and the compounds they create are a matter of the soil and the level of its fertility for the nourishment of these lowly life forms.

Since the men of the research laboratories have isolated these antibiotics and suggested their chemical formulae, we have discovered that the creation of them within the microbial cell is determined by specific nutrition. Only according as the proper food permits, can the microbe make the chemical compounds by which it keeps other microbes from consuming it. On finding these chemical protectors against microbial attack also serving for improved nutrition of pigs, we see the fertile soil as the food for the microbe, or as the food responsible for making the protection possible for this single-celled plant.

The soil fertility is also the food for protection of the single cell like the root hair. It is thus in control of the creation of the chemical substances by which this underground part of the plant—and the entire plant—grows and simultaneously protects itself from microbes. Thus, with the root hairs and the roots pushing themselves into the fertile soil, their good nutrition, which means good growth, (not necessarily measured by size) is also good health and good protection against microbes at the same time. Now that we know that antibiotics are some of the compounds giving growth and protection all in one, we need no longer consider the microbes a case of one fighting the other with this special equipment; rather, we may consider it a case of each microbe feeding itself for proper nutrition and growth. Along with that good nutrition comes protection from attacks by other microbes, and against what is commonly considered microbial "Diseases." For the microbe it is true that "To be well fed is to be healthy" or to be well fed is to take no bacterial "diseases."

Plants also have their antibiotics for protection against bacteria and fungi even as early as the germinating seeds.

We have also discovered that germinating seeds produce antibiotic compounds. The chemists have isolated them and tested their effectiveness. When the mother plant lays down the seed, she gives the potential offspring not only its life via compounds of food value, but also by those same nutritional values guaranteeing life and growth, she is guaranteeing protection against the young plant's troubles with bacterial "diseases." The radicle of the germinating seed protects itself because it is growing. It is growing because proper nutrition was packed into the seed by the mother plant getting her help from a fertile soil. While the root gathers its nutrition, it builds protection against microbial attack for the new plant. Thus, by means of proper nutrition more than weapons for interspecies warfare, Nature has given us the surviving species.

Animals knowing their own nutrition and medicines make autibiotics which protect us as well as themselves.

Much like the plants, our animals have already been making their own antibiotics too. Microbes and plants were making theirs long before we discovered these compounds. We could not have discovered them if they had not been there before. Animals must know their nutrition, or what to eat to make theirs. Wild animals certainly know their "medicines" to have survived all these ages in the absence of what we would administer as drugs and veterinarian depraved services. The so-called "depraved" appetite of the goat is certainly not bad etiquette in good goat society. The "filthy" chicken and the "dirty" hog running for the fecal droppings of the cattle are animal behaviors shown recently by the scientists to be animal wisdom of high order regarding proper animal nutrition. Those supposedly "filthy" animals know their vitamins, in this instance vitamin B_{12}, and did so long before we know ours, especially this one among the last to be discovered. It was because they knew theirs that we discovered them. The animals have demonstrated refinements in their chemistry much beyond ours in the laboratory.

These animals are apparently not worried about fighting microbes in order to be healthy. They consume millions of microbes. They scratch for them and root up the soil for them. They waged no struggles against microbes by means of chlorinated and sulfonated carbon-ring compounds as the deadly weapons. Instead they went about their business of feeding themselves properly by their own instincts. The prevention of microbial invasions or "diseases" has been a resulting by-product. Good feed has always been the animals' own "medicine." If now new "diseases" are rampant, shall we not begin to consider the possiblities that too many poisons scattered so freely about, too low quality of feed, and too much of its production on the more infertile soils, may have some causal connection?

Our animals have been making antibiotics not only for themselves but also for us. The horse can be given our typhoid bacteria or our typhoid fever and by no other feed than what is customarily good grazing or good horse feed, it can create the protein compounds in its blood to be transferred to our blood stream as protection against the typhoid bacteria. The cow can take small pox and generate protection for us, yet both these animals live through these diseases and services of providing antibiotics for us as protection against microbial and virus invasions.

Virgin vegetation grew its own immunity to diseases when the fertility was annually put back on the soil rather than hauled off to the market.

If these various life forms below man in the biotic pyramid, namely the microbe, the plant, and the animal were all once able to protect themselves; and if our crop plants were not wiped out by diseases, as their evolutionary survivial indicates; why don't they protect themselves more effectively today? Have the "genes" of protection, or of resistance, been lost in the many generations? The answer is in the negative if subjecting the plants to rigid situations should make them grow stronger and develop the necessary characters. The many plants destroyed by fungi and insects tell us that if subjecting our crops to "harsh" or "tough" situations ought to "breed" a resistance to, or a toleration of, disease and insects, then our plants really ought to have come through as "toughies."

But in spite of the belief by some folks that we can select or breed legume plants, for example, to **tolerate** soil acidity, and wheat to **resist** smut, such beliefs rest on fallacious logic. It will not stand the common test of **reducto ad absurdum.** If that reasoning is carried to its final conclusion, then we should be able to breed plants to tolerate starvation. An experiment aiming at that objective would carry the plants no farther than one generation. It would go no farther, than one aiming to develop a race of men immune and resistant to women, or a race of bachelors. That immunity, and resistance, (or what have you) to diseases and insects are something the plant gets by way of its genetic potential we breed into it may perhaps be a belief to which you hold. But the plant's survival by evolution tells us that it always had that potential and therefore it cannot now be introduced by the plant breeder's art or science. The plants may be failing to demonstrate the presence of those characters because we have not permitted them to be nourished well enough, when growing as they are, on soils much lower in fertility than were the virgin soils in the course of the plant's evolution.

Under virgin conditions each crop dropped itself, its contents coming from the soil, and its own organic creations, resulting from air, water, and sunshine, back to the soil in place. Its ash or inorganic elements increased those in the surface soil by the extras brought up annually from the lower soil strata. Its organic residues kept much of nutrient value in the less soluble but microbiologically active condition in that surface soil layer. More inorganic nutrients were being broken out of the mineral reserves by the acidity of the roots and of the respiratory carbonic acid from the soil microbes decaying the abundant organic matter. After the many generations of the same plant species had worked over the minerals and the organic matter and had dropped them back, the soil was offering better nutrition in consequence of the generations of nutritional heritages collected there. This secondary assembly line of rotating organic matter, in addition to the primary one of breaking out the inorganic elements from the rock minerals, made big healthy growth of virgin crops possible.

Here Nature was putting back into the soil not only a rotating, balanced diet of the plant's inorganic needs, but She was also building up a bigger supply of the plant's organic needs. Plants of higher order making more complex compounds for their own nutrition—and for better animal nutrition too—use organic compounds from the soil. Virgin crops were putting these organic compounds back into the soil regularly for the next plant generation. Can it be possible that immunity to diseases and insects was greater when the higher content of organic matter of the soil offered more organic compounds as nutrition for the crops to build their "resistance" to these troubles?

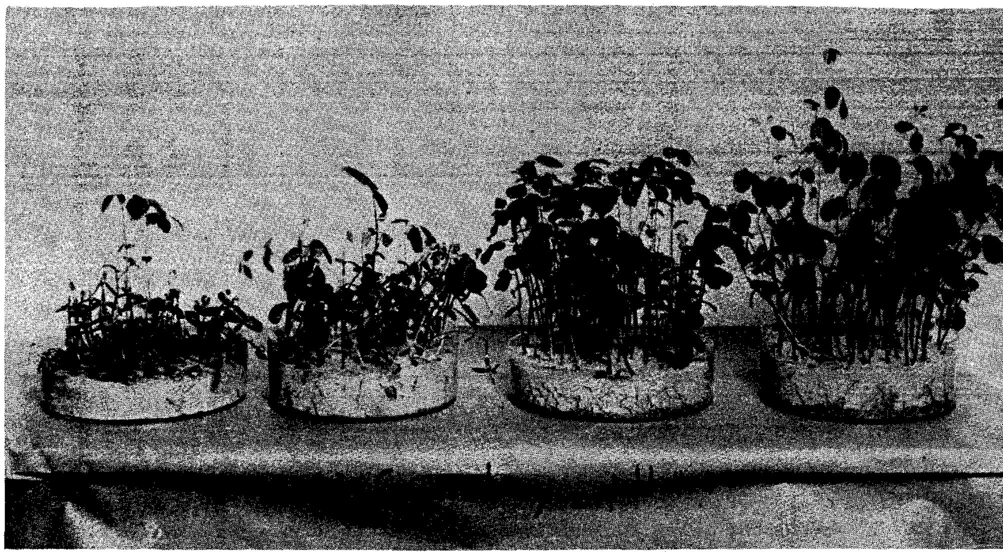
Experiments demonstrated plants' immunity to fungus "disease" when ample inorganic fertility was put into the soil.

That even a soil more fertile in more inorganic elements alone is better plant nutrition to build immunity to disease was demonstrated in some soils research as far back as 1936. Colloidal clay was freed of its active nutrients by electodialysis. It was then given calcium to the extent of about twentv-five per cent of its adsorption capacity. This left the clay extremely acid, with a pH of 4.4, when the figure pH 3.6 represented its complete saturation with hydrogen or acidity, and the figure of pH 7.0 represented the absence of acidity. By merely putting increasing amounts of this acid clay into sterile quartz sand, soybean plants growing in it were protected to an increasing degree against a fungus attrack that resembled what is commonly called "damping off." (See Illustration No. 1)

Here was a legume crop taking its nitrogen from the air. It was carrying enough of the inorganic elements (both major and trace except calcium) in the larger seeds. It was carrying there also enough of the organic reserves for the physiological mechanisms that would build a root system which, if given contact with more calcium clay, would ward off the fungus attack or the "damping off" disease. More calcium in the soil meant more good growth and more immunity, if we view it with "disease" in mind.

Increasing plant "diseases" result from lowered soil fertility bringing on poor plant nutrition.

Reasoning in the converse then, if virgin plants could build antibiotics on higher fertility levels in the soil, shall we not believe that the increase in present plant diseases is premised on declining inorganic and organic fertility, and failure of nourishment of plants to produce antibiotics? Should we not



No. 1

Soybean plants were increasingly "immune" to a fungus attack (suggesting "damping off" disease) as the quartz sand was given more clay (more of it settled out to the bottom of the glass container, left to right) even if this was a very acid one. These plants (on the right) were healthy because they were well fed with more calcium as help to these legumes in making more of their necessary protective proteins.

test this hypothesis by making our soils more fertile in every possible way to see if that would not help our plants ward off diseases and insects? In test of that hypothesis it would be necessary to fertilize not only with nitrogen, phosphorus and potassium, but there should be included calcium, too, long applied erroneously for its companion carbonate ion in limestone as a neutralizer of soil acidity. We should consider sulfur as necessary. It has been unwittingly applied for many years with phosphate, made more soluble by treating the pulverized phosphate rock with equal quantities of sulfuric acid. We should add magnesium, and the host of so-called "trace" elements, including boron, manganese, copper, zinc, molybdenum and possibly others not yet even listed as needed in "trace" amounts.

In testing the hypothesis whether we cannot ward off diseases and insects from plants by soil fertility treatments, we should apply organic compounds as fertilizer too. Suggestions are coming that if our bodies provide proteins and other similar complexities equally as valuable in their effects for self-defense as those by the antibiotics of fungal origin, then it may be the proteins and protein-like compounds which the plants synthesize and which serve for the protection against these enemies. Horse serum, as a protein brought up to the higher life level of man for the latter's protection, is a protein. It is not a fat suspension that protects. Nor is it a carbohydrate. It is proteins that we put into our blood streams as protection against the invading foreign proteins which we call "diseases."

Fertile soils building more plant proteins help to ward off insects too.

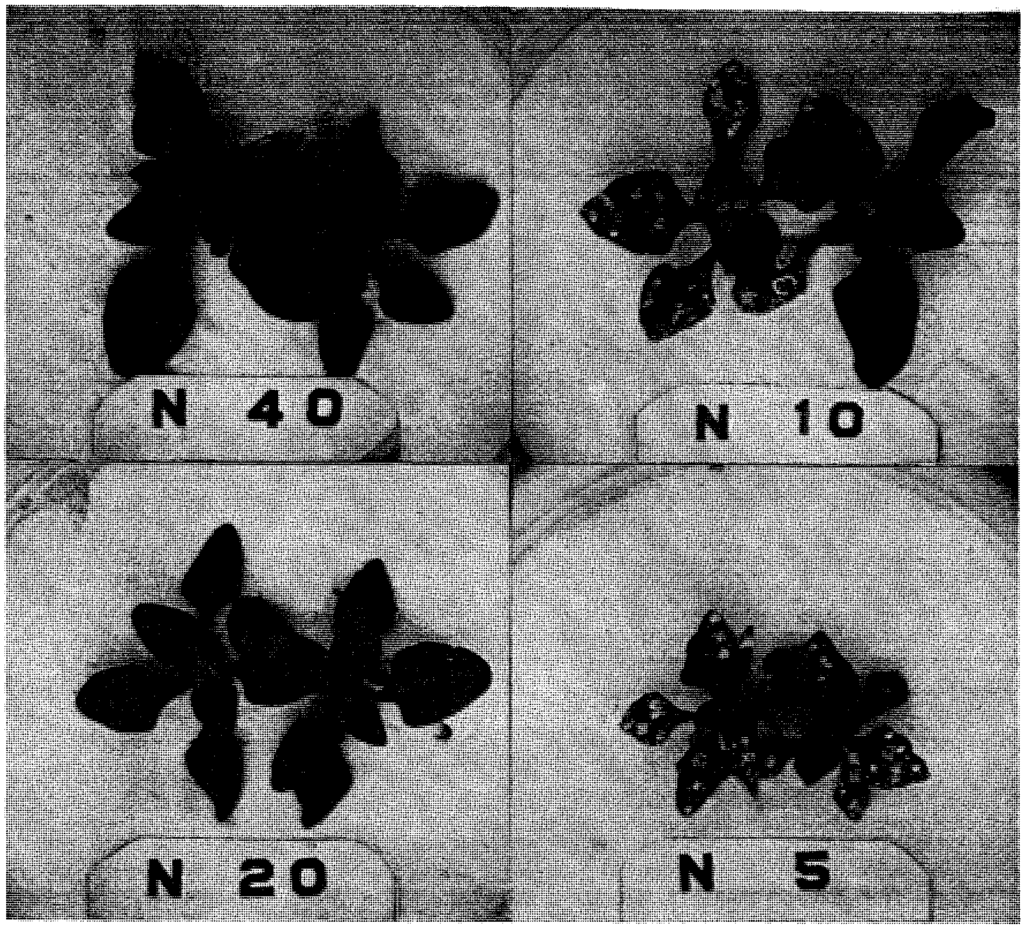
That soils of higher fertility are protection for plants against insects as well as against diseases was also demonstrated by the Missouri Agricultural Experiment Station. Spinach was grown in the glasshouse. Again there was a very delicate control of the variation in the fertility by means of colloidal clay, which was mixed into highly pure quartz sand. Only two nutrient elements were varied in the amounts offered each plant. These were nitrogen, and calcium adsorbed on the clay. Nitrogen is naturally the common symbol of protein. Calcium is readily connected with the synthesis of proteins by legume plants. It is also the element serving closely with the non-legume plants' efficient utilization of nitrogen from the soil. Nitrogen and calcium were each used in amounts ranging through 5, 10, 20 and 40 milligram equivalents per plant in the many possible combinations of the two elements used in these amounts.

While we do not ordinarily spray spinach plants to ward off insects, and do not expect insect attacks on this plant regularly, it happened that the thrips insects invaded this experimental arrangement. But strangely enough, they attacked only those plants given no more than 5 and 10 milligram equivalents of nitrogen. These were attacks on only those plants of low protein contents because of limited nitrogen as fertility for protein synthesis. Still more strangely, however, even in their attacks on the plants on these soils less fertile in nitrogen, the increasing amounts of calcium accompanying either of the lower amounts of nitrogen, served to give decreasing attacks by the insects. (See Illustrations No. 2 and No. 3)

Here was the suggestion that the soil given more nitrogen for more protein production by the plants gave them immunity against the insects eating the leaves. Likewise, giving the soil more calcium for more protein registered a similar effect. These results suggest that we would not be correct in believing that it is the element nitrogen per se, or the element calcium per se, that protects the plant. It seems much more nearly correct to believe that the plant carries on its biosynthetic activities more effectively, through the extra nitrogen and calcium, in making those proteins by which it is protected against microbial invasion or insect attack. It suggests that the nitrogen and the calcium are doing more than hitch-hiking. They are help, seemingly, in the plants' creative services by which it makes the proteins supporting its own life and growth with the protection as an incidental. By those same helps it makes the many kinds of proteins that nourish us and our farm animals. It is the fertile soil, then, by means of which we can hope to make our plants immune.

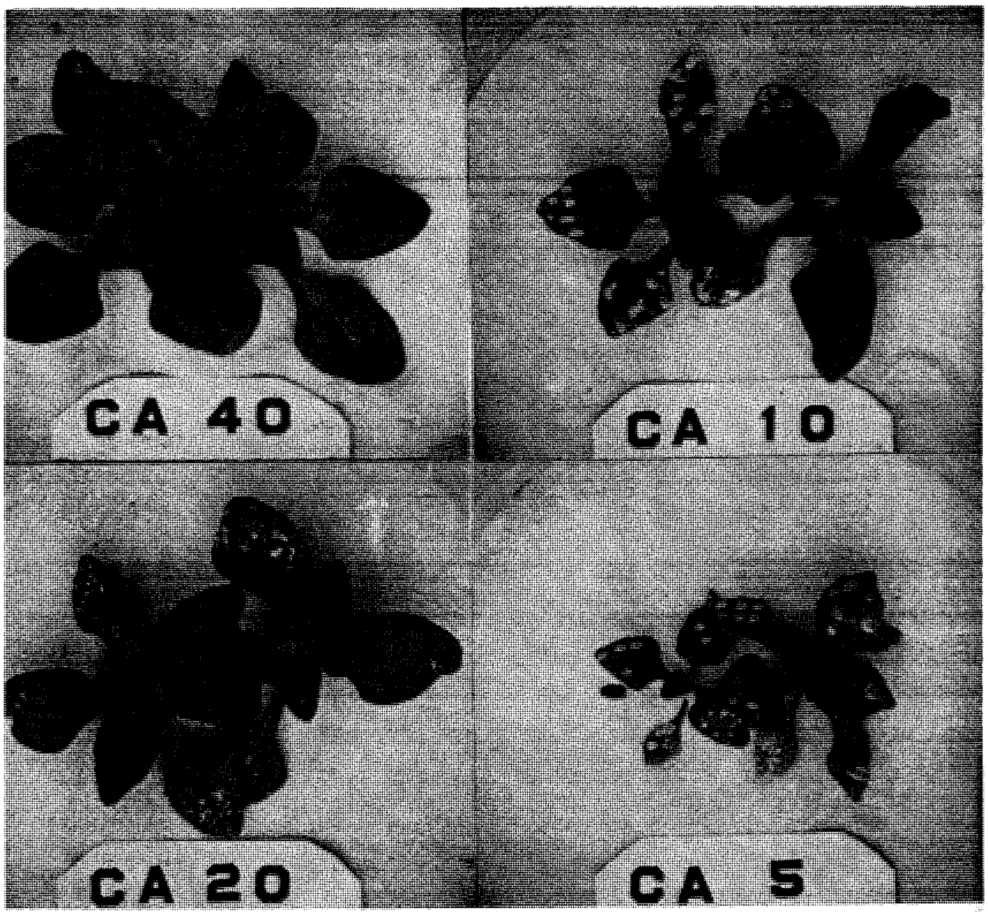
Use soil treatments for prevention; insecticides for relief.

While insecticides are a help in the fight on the insects once these destroyers are present, or may be the "cure" for the invasion by them, it is the better



No. 2

The smaller or larger amounts of nitrogen put into the soil as nutrition for the spinach plants made them either VICTIMS OF (right two photos) or VICTORS OVER (left two photos), the leaf-eating (Heliothrips haemorrhoidalis) insects. Apparently, the nitrogen undergirded the plants in making their own protective antibiotics. Insects took those plants which were struggling for their proteins but disregarded those producing more of this growth substance by the help from this extra soil treatment. Photo by Mo. Agr. Expt. Station.



No. 3

Spinach plants suffering under the attacks by leaf-eating insects (Heliothrips haemorrhoidalis) because of insufficient nitrogen from the soil to nourish these plants, were making better growth and suffering less from the insects as this smaller amount of applied nitrogen was combined with increasing amounts of active calcium in the soil. (Lower to top photo, Ca = calcium as milligram—equivalents per plant combined with N = 10 see other photos). Photo by Mo. Agr. Expt. Station.

plant nutrition via better soil fertility supplies which comes in for prevention. At the same time, the more fertile soil is insurance for a crop of bigger yield and of better quality. Since we grow crops for their earnings determined by yields and by nutritional qualities contributed according to the fertility, then if the soil is improved by treatments to bring about these two customarily desired objectives, we may obtain the protection against plant diseases and insects at the same time as a by-product. By this procedure we need little special knowledge about insects and plant diseases, and little special effort with special expense for a "fight" on these two commonly listed enemies of our food and feed crops.

Our knowledge about soils and their fertility management extends over many more years of experience than our knowledge about the myriads of different insects to plague us and all the unheard-of and unnameable chemical poisons coming forth regularly with their claims as ammunition to fight microbes and bugs. In using the extra soil fertility for prevention, we will also move forward much more effectively in feed and food production than we shall by dependence on poisons to save crops that are already of low yield and low nutritional values even if saved by victory in a war on the bugs and microbes. We are slow to believe that much of what we call "disease" originates at the cellular level because of deficiencies, malnutrition, dysfunction, etc., and that the microbial invasion is a symptom of, and a sequel to, but not necessarily the cause of it.

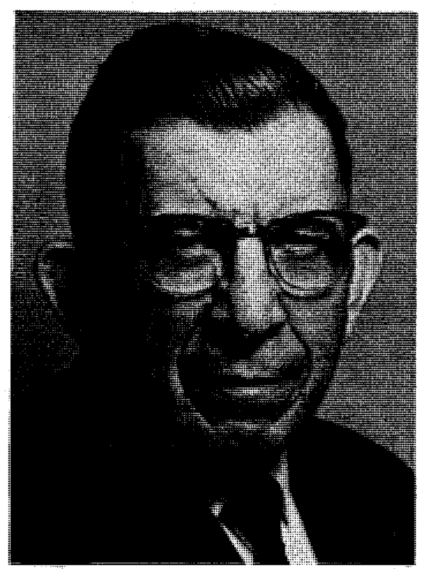
With the serious hazards to our own health in using the poisons so extensively, to say nothing of hazards to crops in some combinations of them, shall we not try to avoid all these risks if the non-poisonous fertility additions to the soil may be the way to escape all the poisons? Working from the ground up in this case is prevention, of which an ounce is worth a pound of cure. If we are to solve the insect and disease problems most wisely for the plants, animals and ourselves, it is not going to be by a call on only the insecticides and the drugs. Rather it will be by also rebuilding our soils in their fertility. By that means we shall starve the insects but feed our livestock and ourselves just that much better. Plant diseases and insects should be less as the fertile soils become more, and as we demonstrate for plants the age-old truth which says that "To be well-fed is to be healthy."

BIOGRAPHY

William A. Albrecht, Ph.D.

Professor Emeritus of Soils

University of Missouri



Dr. William A. Albrecht, Emeritus Professor of Soils and former chairman of the department of soils at the Univerisity of Missouri College of Agriculture, has been a member of the Missouri staff since 1916. He holds four degrees, A.B., B.S., M.S., and Ph.D., from the University of Illinois. He has traveled and studied soils in Great Britain, on the European continent, and in Australia.

Born on a farm in central Illinois, in an area of highly fertile soil typical of the Cornbelt, and educated in his native state, Dr. Albrecht grew up with an intense interest in the soil and all things agricultural. These were approached, however, through the avenues of the basic sciences and liberal arts and not primarily through applied practices, and their economics. Some teaching experience after completing the liberal arts course, with some thought of the medical profession, as well as an assistantship in botany, gave an early vision of the inter-relationships that enrich the facts acquired in various fields when viewed as parts of a master design.

These experiences led him into additional undergraduate and graduate work, that was encouraged by scholarships and fellowships until he received his doctor's degree in 1919. During the meantime, he joined the research and teaching staff at the University of Missouri.

Both as a writer and speaker, Dr. Albrecht serves tirelessly as an interpreter of scientific truth to inquiring minds.