DISEASE IN PLANTS—A COMPARISON WITH HUMAN DISEASE.

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Although Phytopathology as a separate branch of study in our universities is a comparatively recent acquisition, the history of the study of plant diseases takes us back through the days of superstitious and religious beliefs to the very beginning of man's civilization. With his very earliest attempts at growing plants for his own use, man must have observed the appearance of disturbances in their growth and productivity for the very earliest writings mention the visitation of various plagues. These were considered to be sent by the gods and early offerings were made to the gods to propitiate them and get them to protect the crops.

The Bible makes mention of such maladies as blightings, rusts, mildews, and blastings and considers that they were laid down, like the boils of Job, as an expression of the wrath or disfavor of the Deity.

Among the greatest of ancient botanists was Theophrastus (372-287? B. C.) of Greece, a pupil of Aristotle. He accurately observed in his *Historia Plantarum* that cultivated plants were more subject to disease than wild ones. "As to diseases," says he, "they say that wild trees are not liable to diseases which destroy them. Cultivated kinds, however, are subject to various diseases, some of which are, one may say, common to all or to most, while others are special to many kinds. General diseases are those of being worm-eaten, of being sun-scorched, and rot.

"The olive in addition to having worms (which destroy the fig, too, by breeding in it) produces also a knot (which some call a fungus and others a bark blister) and it resembles the effect of sun scorch. The fig is also liable to scab. Moreover, there are certain affections due to season or situation which are likely to destroy the plant, but which one would not call diseases; I mean such affections as freezing and what some call 'scorching.' As to diseases of seeds—some are common to all, as rust, some are peculiar to certain kinds." Theophrastus seems to have made rather a careful study of the epiphytotics of rust as they occurred in Greece.

The true etiology of disease in plants in these ancient days was, for the most part, buried deep in the mystery and superstition from which it was a long time in being extricated. Legends were evolved to explain the maladies and diseases were dedicated to special gods, such as the Roman rust gods, Rubigus and Rubigo, in whose honor annual festivals of propitiation were held.

From 476 A. D. to the beginning of the seventeenth century, which includes the "Dark Ages," was a dark age for Phytopathology too, but interest was revived in the seventeenth century, this time among the farmers and agriculturists, whereas previously it was the philosopher who speculated on the cause of disease while the superstitious farmer offered up libations to the gods. (We still have some farmers who plant certain crops by the dark of the moon.) It was during this century that the first law, so far as record shows, was enacted for the express purpose of controlling a plant disease. In Rouen, France, in 1660, a decree was passed directing the digging up and destroying of all barberry plants. The barberry was thought to bear some mysterious relation to the wheat-rust epiphytotics. It is a striking thing how often the observations and, one might almost say, "hunches," of these early observers came very near hitting the truth, as was the case in this first "barberry eradication campaign."

The eighteenth century was a period devoted to taxonomy-attempts to name and classify the diseases on a symptomologic basis. The names were fashioned after or copied from those used for supposedly similar human diseases. Thus we have plant cancers, tumors, fevers and so forth. Johann B. Zallinger in his book on plant diseases, 1773, divided plant diseases into (1) Phlegmasiae or inflammatory diseases, (2) Paralysis or debility, (3) Discharges or draining, (4) Cachexia or bad constitution, and (5) Chief defects of different organs.

It must be remembered that all during this time any fungi found associated with disease lesions were considered not as causes of the disease but as abnormal structures resulting from the disease—that is, morbid plant tissues. Although more emphasis was now laid on the causal nature of such environmental factors as droughts and freezing, the etiology of plant diseases was still largely assigned to supernatural forces. There was an occasional leaning toward the autogenetic theory of disease, the plant being considered to have within it a disposition to disease. Unger (1833), a strong advocate of the autogenetic theory, believed that fungi originated from the diseased host tissues but still he recognized them as distinct organisms worthy of names and classification. He believed diseases were brought about through internal disorganization of the nutrition processes, having their origin in a lack of certain chemical constituents of the sap. The fungi, or entophytes as he called them, were the transformed sap of these diseased tissues, the morbid sap being exuded into the intercellular spaces and there converted under the influence of the still living cells of the host into fungus structures.

During the latter part of the eighteenth century and the early part of the nineteenth, further studies on the part of the growing school of mycologists resulted in the recognition of the independent nature of the entophytic fungi which were found to propagate their kind by means of the spore-like structures or reproductive bodies. It then followed that the organisms must be the causes of the diseased conditions with which they were associated rather than the result. The theory was upheld by such men as De Candolle, Link and Tulasne, but there was up to this time no carefully checked infection experiments to prove it. The first positive proof of the causal relation of an organism to a plant disease was brought out by a young German botanist, Anton de Bary, who was trained in medicine but after practicing two years gave up medicine for research in Botany.

In 1853, just seven years before Louis Pasteur presented to the Academy of Science his first work upsetting the spontaneous generation theory, De Bary published his classical work, "Die Brand Pilze," establishing unquestionably the causal nature of the fungi found associated with rust and smut diseases. Previous to this time, 1844-45, the eyes of everyone were turned upon the economic importance of plant diseases through the widespread and disastrous epiphytotic of the Phytophthora late blight which devastated the potato fields of Europe resulting in famine in some regions. De Bary worked out and published in 1861, the nature of the late blight and the causal relation of Phytophthora infestans.

Just previous to this, in 1858, the farmer scientist, Julius Kuhn, published his famous phytopathologic text—the first to appear based on the remarkable discoveries and researches of De Bary, Pasteur and the others of that school.

It is an interesting little side line, that an appendix in the book was entitled, "The Microscope as a household utensil for the farmer."

Perhaps the last great stage in the development of phytopathology as an independent field of work was ushered in by the discovery of Bordeaux mixture in 1883, and the subsequent emphasis placed upon the economic features of plant pathology. Like Dr. Arno B. Luckhardt's discovery of the anaesthetic property of ethylene gas, and many other discoveries far reaching in their effects, the fungicidal properties of Bordeaux mixture were learned quite by accident. Millardet, a young Frenchman was another physician who abandoned medicine for the pursuit of botany. While attempting to devise control measures with which to combat the devastating spread among the wine grapes of an introduced American fungus causing mildew, he accidentally observed the prophylactic effects of a mixture of copper sulfate and lime which had been sprinkled on grapevines near the road to prevent stealing of the fruit. He at once undertook the investigation of copper as a fungicide and developed the Bordeaux mixture which has been so efficiently and universally used since.

The most important event in the rise and development of phytopathology in this country was the establishment in 1885 of a section of Mycology of the Botanical Division of the United States Department of Agriculture. F. Lamson Scribner was appointed as mycologist and the following year Erwin F. Smith, later so well known for his work on Plant Cancer, was called to be his assistant. Since their work had mostly to do with diseases in plants the name of this section was changed in 1887, to that of Vegetable

Pathology. From a union of this section with four other divisions arose the present Bureau of Plant Industry.

Such has been the history of Plant Pathology, slower in its earlier development than the history of medicine, but rather quickly springing to maturity after the world became convinced of its practical nature in meeting the needs of plant-eating, wearing, and sheltered man.

And of practical value it surely is, for there is not a cultivated plant which is not subject to several diseases, nor does one find that the wild plants are immune to all the rusts, smuts, leaf spots, and pests in general that prey upon plant tissues. Just what is a plant disease and do they have diseases just like humans? is a question a plant pathologist is often called upon to answer. Perhaps the hardest part of the answer comes in the question "what is disease?" for the line between disease and health is sometimes a very narrow one, especially when nothing more is involved than some slight change in function.

It is evident that the concept, "disease," cannot mean just the same to the medical doctor as it does to a phytopathologist for the very reason that man sets himself up as a judge of what health in plants shall consist of. When the medical doctor visits the bedside of another human who claims to be sick, the patient considers that he is himself the best judge of whether or not he is in good health. Unfortunately, for its own complete life functions sometimes, the plant is not able to state its views on the matter. We do not consider that the lovely white bordered coleus leaves are diseased, yet further loss of the same green pigment has reduced some plants to parasitism, and when such light areas show up in mosaicked potato-plants we are immediately alarmed. In both cases the nutritional processes of the plant have been diminished. The farmer has learned to know how beneficial to him is the presence on the roots of his clover and alfalfa of the little tubercles inhabited by nitrogen-fixing bacteria and would probably laugh to scorn any suggestion that the roots were diseased. Yet a hand as warty as the alfalfa roots is certainly considered pathological.

The cauliflower developed under cultivation has its normal flower shoots compacted and aborted and so enlarged that they form a fleshy edible mass whose normal function of producing seed is completely interfered with. A quite different looking plant, this horticultural variety, from its ancestral plant Brassica oleraceae, variety sylvestris, still growing wild on the seashores of western and southern England and Europe. The ancestor at beholding the cauliflower or those other wayward brothers,—the Brussels sprouts with its multiple heads, and the kohlrabe with his goiterous neck—would probably (were it given the power of expression) throw up its branches and exclaim in holy horror, "Look what the association with these wicked men in cities has done for my poor children! Why didn't they stay at home on the seashores of the old country as any self respecting Brassica plant should do?" One might well regard the changes which have taken place in the cauliflower under cultivation as pathological. Certainly from the plant's point of view they are. However, any tendency in the cauliflower to revert back to its ancestral type and function correctly would be viewed with concern and considered pathological from the view-point of man. A plant disease is usually considered, then, as any marked deviation from the normal functions or structure of the plant as it *now* exists, whether wild or greatly modified by cultivation—any deviation which involves death or impairs the life or economic value of the plant.

Various factors are responsible for a difference in the nature of disease in plants and animals. A closed circulatory system and an intricate nervous system in animals results in more systemic diseases. The nearest approach to the circulatory system in plants is the vascular system which is not a connected system of veins offering free circulation to all parts of the plant body as in the case of the human circulatory system. There is no demonstrable nervous system, the most nearly comparable thing being the very fine cytoplasmic strands passing from one cell to another. Hence diseases in plants are more apt to be local as in Nailhead spot of tomatoes, than systemic as in loose smut of grains. In loose smut of grains the organism (Ustilago) gains entry to the young seed and penetrating the ovary wall lies dormant in the embryo. When the seed germinates the resulting dwarfed plant harbors the parasite which keeps pace with the growing point till time for flowering and is therefore in the new seed which becomes a mass of loose smut spores scattering to new plants.

Plants are more at the mercy of the environment than humans are, which again affects the nature of disease in the two. Man being a warm blooded animal is not submitted to the vast temperature range to which plants are exposed. A circulating blood stream, respiratory activities with the giving off of heat in warmed air, involuntary muscular reactions such as shivering, and the giving off of sweat from the body surface all combine with the radiation from the skin itself to keep uniform the bodily temperature of man, even were he not able to move to new environment or to put on or remove clothing at will. Plants on the other hand are fixed in their environment, and are able only by transpiration and radiation to cut down the temperature in summer and by a slow chemico-physical process to harden themselves to extreme temperatures in winter. With a weather as fluctuating as that in Chicago where there can be a daily range of over 40° between maximum and minimum, it is not surprising that the plants are often caught with a lowered resistance. Non-parasitic diseases due to hot winds, freezing temperatures, or excessively high temperatures, unfavorable light relations, and unfavorable soil and atmospheric water relations are very common in the plant world as may be evidenced by the common appearance of sun scalds, sun burns, blastings, waterloggings and like symptoms, as contrasted with the occasional sun stroke, heat-exhaustion and frosted ear occurring among humans.

Plants also lack the elaborate defense mechanism against the invasion of organisms. The lacunae of the tonsils are veritable culture basins for numerous streptococci and other bacteria, but these are kept at bay not only by the epithelium but by an army of bacteria-destroying-leucocytes which constantly stream out from the lymphoid tissue. A plant has no such army for self protection. If the skin of the leg or arm is broken through accident and the injured area becomes infected with streptococcus or staphylococcus, a protective mechanism is at once activated to keep it local. An acute inflammation occurs with dilatation of the blood vessels, increased blood flow, exudation of serum and leucocytes and increased local heat. A wall of leucocytes about the inflamed area limits the spread of the infection. If, on the other hand, the plant loses its protecting cutinized layer by trauma and the parasite gains entrance there is no resultant releasing of a host of little bacteria-digesters, no production of a hostile temperature.

If the plant does not succeed in laying down a corky protective layer and forming wound tissue, and if its protoplasm does not contain a substance toxic to the invading organism, it has no further recourse. Cells may die over a large enough local area to check further advance by starving out the invader.

This leads us rather nicely to a comparison of immunity in plants and animals. Humans may possess a natural immunity, as is true of the most of us in the case of tuberculosis, or an acquired immunity as in the case of those people who have once had scarlet fever and are therefore free from its infection. Plants have natural immunity only. There are some few reported cases of acquired immunity in plants, but none of them have held up under tests. Immunity in plants is mostly a matter of genera, one genus being free from a disease while another is susceptible. Much use of this fact has been made in the breeding of disease resistant strains. Resistant strains are the only hope to the farmer in the case of such diseases as cotton and melon wilt which are caused by species of Fusarium, an almost ubiquitous soil parasite. Pioneer work in the breeding of disease resistant strains was done by W. A. Orton of the Bureau of Plant Industry and great steps are being made along these lines at the present time.

Some of the essential differences in principle between diseases of plants and those of man have been brought out, but in many essentials diseases in the two are very similar.

The response of plant cells to a pathological stimulus is in many ways like that of the cells of the human body. There may be a qualitative change in the cell or the response may be of a quantitative nature such as decreased photosynthetic activity or increased mitotic activity. The response of the cells may be one of hypoplasia, as in nanism, the cells becoming smaller or failing to reach their normal number. Such a response is exhibited by pot bound plants and is made use of economically by florists in producing small evergreens for decorative purposes.

Or the cells may be stimulated to excessive division resulting in hyperplasia. This may or may not be accompanied by hypertrophy, or the enlargement of cells already present. Both symptoms are exhibited in peach leaf curl which is one of the most serious diseases affecting fruits in cooler climates. The physiological pathology involves hypertrophy and hyperplasia, chlorosis, necrosis and dropping of the leaves with subsequent loss of vitality due to defoliation and development of new leaves.

Metaplasia such as is exhibited in the bronchi of the human lungs when the high columnar epithelium cells are changed to stratified squamous cells, is seldom if at all exhibited in plants. The nearest phenomenon is the stimulation of the cambium to form cortical tissue instead of phloëm as in club root of cabbage. Finally, the stimulus may result directly in morphological, physical or chemical disorganization with local or total necrosis. Most of the leaf spot and fruit spot disease are examples of local necrosis.

The effect of the parasite on the host is accomplished by toxins as in some Fusarium wilts, enzymes as in slimy soft rot of vegetables, or less frequently by mechanical trauma, as in Albugo which causes excessive contortion of its host as well as loss of food. The parasite may interfere directly with the food supply of the plant much as the tapeworm does in man, or it may fill the vessels as in Fusarium wilt and thus cut off the transfer of water and soil solutes.

As in animals, so in plants physiological predisposition seems to play a certain part in the development of disease. Just as in tuberculosis, race is an important influence, the disease seeming to be particularly fatal to negroes, so there is a racial predisposition in plants. Black rot, caused by Pseudomonas campestre, is confined entirely to plants of the mustard family. Age is also an important factor, onion smut occurring only in young tissues. There are some fungi which are known definitely as seedling blights.

Sex influence is demonstrated in the limiting of ergot of rye to the ovary. In man certain diseases may be confined to one system or even to a part of one system, as in the confinement of Tabes dorsalis at onset to the sensory tract of the nervous system. Similarly diseases in plants may be confined to one system or to one organ. Potato wart attacks only the tuber of the potato.

As to the *causes* of plant disease—one might divide plant diseases much as Osler does in his text book, into (1) specific infectious diseases, (2) diseases due to physical agents, (3) intoxications, (4) deficiency diseases, (5) diseases of metabolism.

In the case of plants most emphasis would be laid on the first of these, a great deal more emphasis laid on the second than in the case of animals, and least emphasis put on intoxications. Apple scald may be considered as an intoxication. It occurs on apples in storage and seems due to the accumulation in the air surrounding the apples of the odorous substances given off by the apples in their respiration (amyl esters of formic, acetic and caproic acids). It is prevented by wrapping in oiled papers which absorb these odorous substances.

More specific infectious diseases of plants are caused by fungi than by any other group of parasites. Practically every taxonomic group is represented among the disease formers. Some fungi are strictly parasitic as in the case of the wheat-rust, some are either parasitic or saprophytic which is true of that widely known soil fungus and decay producer—Fusarium. Some of the fungous diseases have reached national importance, for instance, the chestnut blight and the white pine blister rust which have spread rapidly with serious effects.

There are many cases of plant injury due to metazoan parasites. Common among these are the nematode disease of roots of various plants (root-knot caused by Heterodera radicicola), and bulb and stem infections due to species of Tylenchus. The oriental fruit moth causes injury in peaches and apples and the codling moth is responsible for an injury to apples. The striped cucumber beetle and his little friend of the polka dotted uniform, Diabrotica duodecipunctata, feed upon the leaves and young stems and cause much damage to the cucumber vine. Plants like humans are subject to lice, though lice are a little more prevalent among the plant aristocrats such as the Rose family than is true of man.

There is no proven case of protozoan infection in a plant though the connection of amoebae with the disease known as mosaic has caused considerable discussion in the past few years. Holmes of the Boyce Thompson Institute has definitely proven the existence of Flagellates in the latex tissue of Euphorbia. Living protozoans have been isolated from tobacco plants showing mosaic symptoms but the tendency of investigators now is to discount any causal relationship of the protozoans found to the mosaic disease. Mosaic seems doomed to be classed with measles and smallpox as a virus disease of doubtful or unknown etiology for yet some time.

Through the relative importance of bacterial diseases and fungous diseases is reversed in plants as compared with animals still some of the most interesting and very important plant diseases are due to bacteria.

An American, Thomas Jonathan Burrill, working at the University of Illinois deserves the credit for the discovery of bacteria as a causal agent in plant disease. Burrill was working on fireblight of apples and pears. The causal organism, Bacillus amylovorus, which is motile by peritrichiate flagella, first destroys the blossoms, green fruits and young shoots but passes quickly downward by way of the bark parenchyma into the larger branches and trunk often girdling and killing them.

The common symptoms are wilting and blackening or browning of the blighted twigs or branches, the dead persistent leaves of which look as if they had been scorched thus giving rise to the common name for the disease—fireblight. The death of so many twigs results in a forcing of adventitious buds to form new shoots. The fruit becomes water soaked and later the tissues darken and become soft at the center with yellow honey-like horns, oozing out thru the lenticels. As the inner bark of the shoots becomes firm in late summer, the blight seems to spread, and the organism usually dies off over winter. But in some cases "hold-over-cankers" are formed from which, with increased sap flow in the spring, ooze out living and virulent bacteria.

It is an interesting fact that the role insects may play in the transmission of disease was first clearly proved in connection with fire blight though the connection of mosquitoes with malarial fever was an old story suggested as far back as Roman times. Merton B. Waite's first report on the role of insects as a carrier of the fireblight organism was made to the American Association and published in the Botanical Gazette in 1891, two years before Smith and Kilborne showed that the cattle tick acted as an intermediate host in the case of Texas cattle fever and several years before Ross' work (1895-7) on the connection of mosquitoes with avian malaria. This latter work stimulated the investigations which resulted in the discovery of the relation the Anopheles mosquito bore to malarial fever.

Waite found that insects carried the bacteria from the amber fluid extruded from the hold-over cankers in the spring to the flowers where a short incubation followed, the bacteria multiplying rapidly. Infection occurs by penetration of the nectary, and from here the bacteria work their way thru the fruit spur at whose base a small canker may form. The secondary cycle is the one most responsible for serious damage. The infected nectaries act as sources of inoculum from which the nectary visiting insects such as bees carry the bacterium from one flower to another. The disease may also be carried by sucking insects such as the aphid and leaf hopper, these latter being responsible for infection of many of the new and succulent shoots formed from adventitious buds.

Fire blight is one of the few plant diseases in which therapeutic measures may be taken since eradication of the cankers by tree surgery and systematic cutting out of blighted twigs is as necessary as the removal of a gangrenous area in humans. Most of the diseases of plants must be fought with prophylactic measures.

In concluding we may say that while plant diseases are, by virtue of the difference in nature of the human body and that of the plant, different in some ways, there are the same general types of response to the presence of a parasite, and plants are subject to the same types of pests. As to whether the same organism can create disease in plants and in animals little is known. J. R. Johnson working in Smith's laboratory found an organism causing coconut bud rot in the West Indies which was indistinguishable from Bacillus coli. Cross inoculation studies have been made with plant parasites in animals and animal parasites in plants but the results may be summed up as being doubtful or negative. However, M. Downin recently reported an interesting case of food poisoning in Russia. Rye grains infected with Fusarium roseum. Lk. are responsible for what he calls "inebriant bread". People who ate it suffered from weakness, vertigo, headache, nausea and vomition. He also isolated a species of Fusarium from the flax which was used in making "inebriant" linseed oil in Ukraine. This furnished the same symptoms as the rye.

Literature Cited.

1. de Bary, Anton: Untersuchungen über die Brandpilze und die durch sie verursachten Krankheiten der Pflanzen, mit Rucksicht auf das Getreide und andere Nutzpflanzen, pp. I-VII-1-44, Berlin, 1853.
2. ——— ——— Die gegenwartig herrschende Kartoffelkrankheit, ihre Ursache und ihre Verhütung, pp. 75, Leipzig, 1861.
3. Burrill, Thomas J.: Series of papers presented before the Illinois Horticultural Society, 1878-84. For complete list see bibliography in New York (Cornell) Agr. Exp. Sta. Bul. 329:369, 1913.
4. Dounin, M.: The fusariosis of cereal crops in European Russia in 1923. Phytopathology, Vol. 16, No. 4, 305-8, 1926.
5. Hort, Sir Arthur: Theophrastus' enquiry into plants. 1:I-XXVIII, 391-413; 2:I-IX—201-209, 1916.
6. Holmes, F. O.: A flagellate infection of milkweed in Maryland. Abstract, Phytopath. Vol. 14, No. 1, p. 54, 1924.
7. Johnston, J. R.: Coconut budrot of the West Indies, Phytopath. Vol. 1, No. 3, 1911.
8. Kuhn, J.: Die Krankheiten die Kulturgewachse, ihre Ursachen und ihre Verhütung, pp. I-XXII-1-312, Berlin, 1858.
9. Luckhardt, A. B. and J. B. Carter: The physiologic effects of ethylene. A new gas anesthetic. Journ. Amer. Med. Assoc., Vol. 80, pp. 765-770, 1923.
10. Millardet, P. M. A.: Annales de la Societe d'Agriculture de la Gironde, 1885, p. 73.
11. Osler and McCrae: The principles and practice of medicine. D. Appleton & Co., N. York, 1923.
12. Orton, W. A.: Plant breeding as a factor in controlling plant diseases. Amer. Breeders' Assoc., 1:69-72, 1905.
13. ——— ——— The development of disease-resistant varieties of plants, IV Conférence Internat. de génétique, Paris, 1911 et al.
14. Ross, R.: The Role of the mosquito in the evolution of the malarial parasite. The Lancet, Vol. II, p. 488, 1898.
15. Smith, E. F.: Bacteria in relation to plant diseases, Carnegie Inst. Publication, Wash. D. C., Vol. I, 1905; Vol. II, 1911; Vol. III, 1914.
16. ——— ——— Crown gall of plants, its cause and remedy, U. S. D. A. Bu. Pl. Ind. Bul. 213, 1911.
17. ——— ——— Crown gall and sarcoma, U. S. D. A. Bu. Pl. Ind. Circ. 85, 1911.

18. ——— ——— Embryomas in plants (produced by bacterial inoculations). The Johns Hopkins Hospital Bull. 28:276-294, Sept., 1917 et al.
19. Smith, T., and F. L. Kilborne: Investigations into the nature, causation and prevention of Southern cattle fever, Bur. of Animal Ind. Rept. 177-304, 1893.
20. Vallery-Radot, R.: Life of Pasteur, Doubleday Page and Co., 1923.
21. Waite, M. B.: Fire Blight of Pears, Proc. Amer. Assoc., 1891, p. 315 & Bot. Gaz., 1891, p. 259, under Bot. Papers at the A. A. A. S.
22. Whetzel, H. H.: An outline of the history of phytopathology, W. B. Saunders, 1918.
23. Zallinger, J. B.: De morbis plantarum cognoscendis et curandis dissertatio exphaenomensis deducta, 1773, German trans. by J. G. von Auersberg under title Abhandlung über die Krankheiten der Pflanzen, ihrer Kenntniss und Heilung; aus dem Lateinischen ubersetzt, pp. I-VI-1-143, Augsburg, 1779.