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The Address of the President: Old Wine in New Bottles

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The Address of the President

OLD WINE IN NEW BOTTLES

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Fungi, such as mushrooms, plant pathogens, molds, and mildews have been known from the time man began to take an interest in his natural surroundings. The plant pathologists cite the Bible for their early records, and we know that mushrooms were a source of inspiration to ancient Roman architects in the adornment of buildings. Their sudden appearance in unexpected places gives them an aura of mystery that enfolds them like a mantle and lends interest to them even today. When we add to these attributes their great diversity of form and color, their beauty and their repulsiveness, their uses and their destructiveness, it is strange that the fungi have not been the subject of wider investigations than is the case. In fact, the secretary of the National Research Coouncil, in his plea for a closer integration between science and the public, pointed out that in the war emergency requiring a knowledge of fungi, not enough persons could be found who were qualified o undertake the necessary investigations. This problem, however, was but one of many that are today occupying the attention of scientists in many fields. It is my purpose to review briefly the new activity that has been aroused concerning that ancient race, the fungi.

Before discussing the present-day problems in mycology, a short review of the nature of fungi should clarify our understanding. Fungi are comparatively simple organisms whose assimilative bodies are made up of a system of branching tubes, called the mycelium. In some cases this system is reduced to a single cell, as in yeasts; in others it may be a wide-spread mat of interwoven threads which ultimately produces the complicated fruit that is known as a mushroom. Between these extremes is a great diversity of forms, a discussion of which is precluded by the limitations of time. Mere mention of blue molds, mildew, rusts, smuts, stink-horns, coral-fungi, bracket fungi, cup-fungi, mushrooms, and puff-balls is sufficient to recall the diversity of commonly encountered types. Yet with all these differences fungi are unified by a single character that is of great significance to an understanding of their qualities. That character is the lack of chrlorophyll, that green pigment that enables plants to manufacture their energy-supplying food.

This lack of chlorophyll determines the habitats in which fungi occur. Like other living organisms, they require water, oxygen and minerals, but also energy-supplying substances such as carbohydrates or fats. Therefore, they are most commonly found where an abundance of organic material is available; such material may be either living or dead, for the fungi may be parasites or saprobes, but can-not live in the absence of such food. This fact determines the importance of the fungi. They cause disease in plants and animals; they are destructive agents in stored foods and other materials; they are, as well, significant wreckers of elaborated carbon and nitrogen compounds, breaking these down into simpler structures that are again available as food for plants and animals. The study of these processes has led to remarkable progress in the field of mycology, a review of which is the purpose of this discussion.

DESTRUCTIVENESS OF FUNGI

Primarily fungi are important as destructive agents, both as parasites attacking crop plants or man and other animals, and as saprobes tearing down food, timber, fabrics, and plastics. To say that one or the other of these activities has the greater significance is very difficult, for, as parasites or as saprobes, fungi cause enormous economic losses; but in both cases a knowledge of the fungi has led to important advances toward their control. A few selected instances illustrate the situation.

In plant pathology, beginning with the demonstration of parasitism in fungi by De Bary in 1853, a long series of advances was initiated which culminated in the development of varieties of oats resistant to such parasites as stem-rust, leaf rust, and smuts, and insured a profitable crop even in years when weather conditions favor growth of the parasite. In this achievement Dr. H. C. Murphy of our Academy was a leader. Similarly, knowledge of parasitism led to seed-treatments for the smut-fungi in cereals and onions, and for protection against other soil-borne fungi that attack seedlings as they emerge from the seed or parasites that live on roots of cultivated plants. Advances in this field have led to the establishment of a great fungicide industry among chemists, developing better chemicals for the protection of plants. A parallel development is emerging in the field of spraying for control of parasitic fungi. Until recently spraying and dusting were primarily protectant in character, that is, the spray was a means of spreading a protective chemical cover over a plant so that it could not be reached by the fungus against which the spray was applied. Such a procedure necessitated a delicate balance between concentrations of the toxic materials that would not injure the plant but still were strong enough to kill or inhibit the fungus. The working limits of such a program were often very narrow. An attempt to overcome this obstacle led to the development of so-called eradicant sprays applied to the fungus in those stages which are passed on follen leaves or soil. The procedure here is to apply the controlling chemical to the soil area beneath the plant in such concentrations that the fungi of the upper soil layer or on the surface will be destroyed. Hence the name *eradicant* sprays. Their development is still in its infancy, but better knowledge of the fungi and a great range of new chemical compounds for use in this way opens a promising field for further investigation.

So much for the field of plant pathology which rests on a background of mycology. A parallel field ,though of less importance until recently, is that of medical mycology. This field has been stimulated by the awakened interest in the tropics both militarily and commercially; for many of the skin infections, such as athletes' foot, jungle-foot, etc., are of fungous origin and are aggravated by the conditions of the tropics. Emmons in his able review of this field has postulated the idea that in these diseases a conditioning of the subject precedes infection. He likens the situation to the allergies, and we do know that many fungi by their spores alone have caused allergic reactions in individuals. Air-borne spores of rusts, particularly grass rusts, and smuts have been shown as casual agents. The well-known house dust asthma has been attributed in part at least to common molds of the *Penicillium* and *Aspergillus* types. Smith is of the opinion that certain types of mushroom poisoning are similar allergic responses and thus accounts for cases of mushroom poisoning caused by species usually considered edible. Such an explanation might well account for the type of poisoning caused by *Lepiota morgani,* the green gilled parasol, in which certain individuals are severely affected while others are not. It does not seem probable, however, that this explanation applies in cases where a definite alkaloid has been isolated, such as *Amanita muscaria* or *Amanita phalloides.* Here a specific poison with a definite syndrome, differing one from the other, is evident. To return to the skin diseases of fungous origin, some such idea as that of allergic conditioning seems necessary to account for the peculiarities of communicability encountered in cases of this kind. A person may be exposed to infection many times before succumbing to the attack of the fungus.

Only part of the destructiveness of fungi is caused by parasites; the saprobes also play an important role in bringing about deterioration of materials and structures. They cause weakening of tensile strength, discoloration, odors, and loss of usefulness in manufactured articles. The wood-decaying fungi destroy 15 per cent of standing timber annually. This loss is increased greatly by the destruction of lumber, structures, etc., which defies estimation. The total annual destruction is greater than the harvest. In times of wooden ships, with masts and spars of wood as well, the fungi played an important role in history. Lord Nelson at Trafalgar had an active ally in the fungi which had wrought havoc in the French and Spanish fleet. Perhaps less known but of greater interest to Americans was the part played by fungi in the American Revolution. In this case reinforcements for Cornwallis at Yorktown were delayed by a storm which so crippled the British fleet carrying them that they were unable to arrive in time to prevent defeat. Wood-rotting fungi had so weakened masts and spars that the British fleet was forced to put in at New York to refit. Today, with steel ships and metal replacing wood, it would seem that fungi would not be a factor, yet in the war just concluded the fungi found a vulnerable spot at which to strike. I quote from a report made at the recent St. Louis meetings of the Mycological Society of America by Dr. W. N. Ezekiel:

"Modern fighting ships use electrical systems not only for communications and navigation, but also for locating hostile forces and for directing guns, rockets, or torpedoes. . . Moisture and fungus growth may prevent continued accurate operation of electrical units. Battle telephone systems, transfer switches, gun directors, and gun power drives are among items seen with fungus growth." The source of the difficulty lay in the materials used for insulation. In general, they were rubber or cellulosic fibers or plastics which under proper moisture conditions could be favorable substrates for fungus growth, causing disarrangement of the currents which they carried. The fungus strands themselves, being 80 to 90 per cent water, often afforded a path for electrical current to pass from one wire to another seriously impairing operation. The problem of control is not a new one fundamentally, but the surroundings have changed. Industrial firms, particularly those that are expanding into the tropics, are facing similar problems. Fungicides that can be incorporated into or coat the products, fungistatic materials to replace those liable to attack, as well as new designs that prevent entrance of molds to susceptible parts, are all being actively investigated.

In addition to electrical equipment, fabrics, both cotton and wool, leather, rubber, and optical instruments are all subject to fungus attack, particularly in climates of high humidities and temperatures.

Progress in preventing mold growth has been made; new fungicides constantly are being developed, new materials such as silicones, which are immune from attack, are replacing susceptible materials, but the fungi are and probably always will be a force to be considered.

In the field of foods, fungi annually take their toll. Grain in bins and elevators, fruits, vegetables, and cereals in transit, and meats in refrigerators are all susceptible to destruction by these pests. Fungicides, because of their poisonous properties and their disagreeable or distasteful qualities, such as color and odor, are usually unavailable, economically. Hence industry has turned to the more expensive practices of refrigeration, canning, and drying with practical but not complete success. When the public locker systems for food preservation were first introduced, the control of mold on the stored products was a primary concern of the proprietors. Recognition of the cause with better control of temperatures has largely solved that problem.

Thus far the destructiveness of the fungi has been emphasized. There is, however, another side to the picture. Fungi also have their uses.

Usefulness of the Fungi

On the constructive side the most obvious use to which fungi are put is the mushroom as a source of food. Although mushrooms are a minor dietary item, the industry of growing market mushrooms is of considerable importance. Mushroom culture is exacting, and commercially hazardous because of the rapid deterioration of the product. It is, therefore, not to be undertaken lightly nor with the idea of large returns from slight labor. Near large markets, particularly the cities, successful culture of the field mushroom, (*Agaricus campestris*) and its varieties has become widespread. In this connection the truffle industry of Europe should be mentioned. Truffles are underground fruiting bodies of certain Ascomycetes usually, and are found associated with the roots of trees. They are sown in proper groves and are harvested by animals, chiefly pigs and dogs that find them and dig them out for the grower. Before World War I the industry was estimated to be worth $15,000,000, a sizeable sum when the epicurean character of the truffle is considered.

The large and fleshy fungi are not the only sources of food, however. Recently yeasts as well have been cultivated for this purpose. On the island of Trinidad the waste products of sugar mills have been used as a substrate for growing yeasts in enormous amounts to supplement the protein diets of the people of the Island, and Anheuser-Busch received considerable publicity on their project of using this important group of fungi as protein substitutes to replace meat during the shortages caused by war.

Fungi serve also as indirect influences in food production. The use of pure cultures of *Penicillium* to replace natural inoculation in the cheese industry has been particularly successful in the development of Iowa Blue Cheese, which approaches the Roquefort type of European manufacture. Other types using similar methods are under way.

In the fields other than foods, fungi also have made important contributions. In fermentation, species of Aspergillus are used particularly for converting sugars into organic acids. The citric acid industry is an example. Members of the genera *Penicillium, Rhizopus,* and *Mucor* are being used to produce alcohol and organic acids such as gluconic acid and itaconic acid. Molds are sources of amylase which changes starch to sugar preceding alcoholic fermentation by yeasts. The list is incomplete but indicates the importance of molds to industry.

In the field of medicine the production of penicillin, an antibiotic substance that prevents the growth of many types of pathogenic bacteria, has recently caught the public eye. The fact of antibiosis has been known for almost as long as the pure culture has been used, but the stimulation of war accelerated its application. Penicillin was a product of the growth of *Penicillium notatum*. Other fungi also produce other antibiotics which are being investigated. The most promising of these latter is streptomycin produced by a species of Streptomyces, one of the fungi common in soil and variously classified as bacterial or fungal. The field is very active; I note that our own joint symposium with the Iowa Medical Society will discuss this subject this afternoon.

Another fungus important in medicine is *Claviceps purpurea,* the cause of ergot in rye. Extracts from the horny bodies produced on invaded rye plants contain an alkaloid, ergotin, which stimulates smooth muscle contraction and is used in cases of child-birth. Before the war the supply of this material was largely imported from Spain. Today by new methods of inoculation, fields of rye are artificially infected to supply this market. The process is still in an experimental stage, but the idea of growing a cereal crop for the disease organism it carries is certainly new.

Finally fungi are lending themselves to scientific techniques .Because of ease of handling, and delicacy of reaction, fungi are being used as indicators in vitamin assays and in studies of protein synthesis. In the latter case Beadle, Tatum, and their co-workers have found strains of Neurospora that can synthesize certain aminoacids and not others. By arranging these acids in series with the strains that can use them, they are able to postulate the manner in which the more complex molecules are built up. With the geneticist, biochemist, and mycologist working together, new knowledge in many baffling fields seems imminent.

In this brief summary I have tried to give you a picture of the importance of the fungi as they touch our lives and our science. They, like the poor, are always with us, and even the Bible promises no surcease in the hereafter, for in the sixth chapter of Matthew, the twentieth verse says:

"Lay up for yourselves treasures in Heaven where neither moth nor rust doth corrupt." I would have you note that insects and corrosion are absent but no mention is made of the fungi.

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