DR. BARTON: No. As far as dry storage is concerned, the viability of the seed will be maintained but dormancy will not be overcome.

MR PINNEY: What is your opinion of indoor versus natural stratification out-of-doors?

DR. BARTON: If you have sufficient cold weather out doors, stratification is just as good as indoors. The only exception to that would be if seed require only one month of low temperature, germination may occur and the seedlings killed by cold weather.

MR. C. H. HENNING (Niagara Falls Park Commission, Niagara Falls, Ontario): With alpines and conifers, does a snow cover have any influence on germination?

DR. BARTON: Snow cover is very good because it keeps the ground from freezing and thawing, thereby giving the seeds the low temperature needed to insure germination.

PRESIDENT SCANLON: Thank you, Doctor Barton, for coming to Cleveland to tell our members of your interesting and useful work on the problems of dormancy in seeds We hope that the meeting has been of interest to you

I am sorry to announce that our next speaker, Dr. Wendall Camp of the University of Connecticut, has been unable to come to our meeting today. Dr. Camp is now Head of the Department of Botany at Connecticut. He has had an illustrious career in botany and horticulture and is eminently qualified on the subject of Soil Mirco-Organisms. Louis Vanderbrook, our Vice-President and Program Chairman, is well acquainted with Dr. Camp and has graciously consented to read his paper.

Mr Louis Vanderbrook read Dr. Camp's paper, entitled "Mirco-organisms in Soils and Their Action on Plants." (Applause).

MICRO-ORGANISMS IN SOILS AND THEIR ACTION ON PLANTS

DR. WENDELL H CAMP
Head, Department of Botany
University of Connecticut, Storrs, Connecticut

When your amiable Vice-President some time ago asked me to talk to you about certain items which he had heard me discuss previously I agreed to do so with the understanding that I would not be restricted by the title, but would be permitted to explore certain other things pertaining to the general field of plant propagation and nursery production which would lead into my general topic.

In certain circles there is a growing feeling that the responsibility of the plant propagator ends when he has produced roots on the base of a cutting, gotten the seedling out of its seeds coats, or achieved some sort of union between stock and scion. It is encouraging to note from the program before me that this group still feels it important to get the material established in the field for, when one considers the whole problem, a plant cannot be said to have been successfully propagated until it is established in soil under something approaching natural condtions.

Soil organisms. A single ounce of good garden soil usually contains about 10 billion living organisms. Of these about 6 billion will be bacteria, with the remaining 4 billion scattered among the protoza (one celled animals), the algae (one celled plants), the fungi, and a wide variety of small multicellular forms in the animal and vegetable kingdoms which, to be here named, would add little but length to this general list. Fortunately for those of us who grow plants, relatively few of those 10 billion living organisms in every ounce of good garden soil can be classed as pathologically dangerous. The bulk are friends Were it not so, life as we understand it, would long ago have ceased to exist in our world.

It is only within comparatively recent years that man has become aware of the teeming life in good soils, yet since Adam gardeners unknowingly have evolved practices which favored a healthy and abundant soil flora and fauna, for only by so doing can the gardener achieve the success he deires with the plants he really is interested in cultivating

About twenty-five years ago many of our experimental scientists were so chemically minded that fertilizers consisted only of inorganic materials However, the good gardener, seemingly stubborn and set in his ways, wasn't easily stampeded and so still believed in old fashioned manures. Then there was a period when a group, mainly amateurs, swung their fertilizer pendulum over to what has been called the "organic phase" — and soon discovered that, under intensive cultivation, organic fertilizers some how were not enough. And now we are again back at the place where good gardeners long have been — to an ample supply of some sort of organic material, plus the requisite amount and balance of inorganic substances. And by so doing we have again established proper conditions for the healthy growth of soil micro-organisms, requisite to the good growth of our garden plants. As will be noted later there are evidences from the plant-fossil record, which goes back well over 500 million years, that this system has been in the natural scheme of things for a very long time; and it is not likely soon to change scheme of things for a very long time, and it is not likely soon to change, no matter how much more soil and plant chemistry we come to know.

Conditions for propagation: It would be a waste of time to discuss before this group the basic factors in propagation, for they are too well known to all of you. However, I should like to review a few to see if we can shed any light on certain practices. We all are now fully familiar with the fact that roots don't "just grow" on the bottom of a cutting, for there are root-inducing auxins or hormones responsible for this specialized plant reaction. The fact that these now can artificially be supplied has made the work of the propagator much easier. However, we still have problems where cuttings are concerned.

One of the problems always has been that of keeping the cutting from wilting until it has formed its own absorbing roots. We have sometimes tried sweat-boxes, but here conditions were such that certain pathogenic fungi sometimes got the upper hand. The surface appearance or feel of the rooting medium in a propagating bed often is misleading so that the right amount of water is not always available in the lower layers. To correct this situation tight benches with constant water levels have been tried, but this has not been much of a success under most conditions I have analyzed some of these set-ups and discovered several items, either of which dooms them to ultimate failure for all but a few types of material. In the first place the water level was usually maintained by an automatic device which added additional water as it was evaported from the bed itself and from the plants This water of evaporation was pure water, while that constantly being added contained the usual salts of our water supplies. The result was an increasing salt content of the water at the base of the plant so that is osmoic value was such that no self-respecting root primordium would develop, save under continual physiological protest and then only with difficulty. But, worse yet, the oxygen content of the static water in these beds fell far below the point where the basic physiological process of respiration was sufficient for what it should be for good growth, for respiration requires abundant oxygen The result generally was tardy and usually very poor root development.

I have tried a modification of this with considerable success in several of my pilot experiments This is to have a constant water level, controlled by a simple over-flow mechanism, but with the water always moving through the bottom of the bed, being injected at one end from a cock with needle-valve control In one such bed there was an especially fine root development of a variety of materials In analyzing the situation the most obvious thing was that the cock had been placed too high and its valve-seat not ground perfectly, so that instead of delivering a thin stream of water directly into the bed it was more like a fine spray falling about 18 inches into the collecting receptacle at the end of the bench, from there to trickle under the cuttings. The only difference betwen this set-up and the others was that the water, being in a fine mist and also falling through the air before entering the bench, was fully aerated In brief, while at a constant level, the water in this bench never suffered salt accumulation and always was full of oxygen. To reduce water loss from the cuttings, all series were covered with sheets of plastic on frames. But to me the really important factor leading to success in this particular bench was that the bases of the cuttings were supplied at all times with ample amounts of both water and oxygen

This basic principle was later applied to a much larger propagating unit with the same sort of success and with a much wider variety of cuttings. It does not require a large amount of water, but it must be fully aerated and anybody with the spirit of experimentation can devise some simple appartus for mixing the oxygen of air with the water used in such a propagating bed by agitation, bubbling, or some other means. I have long felt that the success some have had with propagation under mist lay not only in the high humidity of the air about the exposed tops of the cuttings but in the fact that the water trickling through such beds first had fallen as a fine mist and so was fully oxygenated. The relation of oxygen content of soils to root growth in crops plants has long been known Why it has not been more widely studied in relation to the formation and growth of roots on cuttings in propagating beds is something of a mystery. I do not here imply that oxygen can take the place of root-inducing hormones, but once their primordia are initiated the success of root growth depends largely on the speed of respiration, and this process is governed by the oxygen supply and is further regulated by temperature (bottom heat), so long as the cutting has ample available food.

Although we often proceed by rule-of-thumb in many of our cutting practices the food reserves in the cutting, or its ability to synthesize further amounts, often spells the difference between success or failure. To reduce water loss we often have resorted to dense shade over the cuttings. By so doing we did reduce water loss, but we often were starving the cuttings by reducing the light beyond the point where they could manufacture sufficient food to keep themselves going. Another factor pointing to the success of propagation under mist is that the house need not be shaded to the extent we usually thought necessary, thereby speeding up the synthesis of food in the cutting itself.

Plastic-covered propagating units: The basic food manufacturing process in plants — photosynthesis — does not occur in just any sort of light and sunlight is a mixture of various wave lengths of energy. Experimental evidence indicates that photosynthesis is most rapid in the blue-violet and red ends of the spectrum, and that it proceeds at a low rate or not at all in other wave lengths. And, as we all know, ordinary greenhouse glass is notable in excluding large percentages of the short rays at the violet end of the spectrum, and almost entirely cuts off the ultra-violet end of sunlight. Thus, on the basis of straight photosynthesis, ordinary glass is not the theoretically ideal covering for a greenhouse. Furthermore, there now are indications that there is an increased synthesis of natural plant hormones under the stimulation of ultra-violet light and, as noted, this our greenhouse glass almost entirely excludes. Therefore, no matter how one looks at it, our propagating processes always are somewhat behind the proverbial 8-ball when done under glass. This as much as anything has stimulated the search for glass substitutes for our greenhouses and propagating structures, that is, for substances which would have the insulating quality of glass but have a better light transmission factor, especially in the blue end of the spectrum. And I think, at long last, we are on the right track.

Much has recently been written and discussed regarding plastic-covered greenhouses. And, as always with a new topic, extravagant claims have been made for something new — perhaps only because it is new. Now there are plastics, and there are plastics. But so far in our tests only one type begins to meet the requirements which we would wish for both light transmission and durability, and this is Polyflex 230, supplied by the Plax Coropation, Box 1019, Hartford, Connecticut. Others of a similar formulation doubtless soon will be available from other firms At present it is furnished in rolls 42 in. wide and of different weights, from 5 thousandths to 20 thousandths inch thick. The thinnest seems to be too thin for general use, and I would recommend either the 10 or 15 thousandth inch thickness. One important thing, however, must be remembered. So far, in the first year of its use, it has been applied to structures of almost standard greenhouse design which, basically, have been designed for glass. The ultimate success of this plastic will depending on evolving a new type of greenhouse fitted not only for good growing conditions but also to the material. The application and fastening of the material has presented problems, but these will not be solved by trying to fit it into our concepts of traditional greenhouse construction. Here is where our imaginations will have to come into play.

For a propagating unit there is no point in constructing special chambers using this plastic inside a regular glass-enclosed unit, for by so doing we have defeated the basic function of this material — its special light-energy transmission qualities. We will have to start with a specially designed propagating unit, if we are using it for propagating, and in northern climates probably use two thicknesses with an air space between, for the heat loss appears to be somewhat greater than with ordinary glass when used only one layer thick. Plants grown under this particular plastic have a deep rich green color and a firm texture which one does not find in those grown under glass. But, I repeat, success with this type of plastic will come only when we have done a rather thorough job of redesigning our greenhouses and propagating units We can't put a 200 horsepower engine into an old surrey with fringe on top and think that we have achieved the ideal in automotive design.

As this is being written I am in the process of building (by commercial standards) a very small experimental propagating unit, old-style, with glass enclosure. But on my drawing board are the beginnings of a completely unorthedox design for a small, experimental propagating house, started from the beginning with the idea of using plastic. And, except for the slanting roof, it doesn't look very much like anything that any of us have ever seen in a propagating unit. But the point is, in the house using plastic I will be getting the short-ray end of the spectrum which I can't get under glass. The plants grown under this plastic are not leggy. They are compact and, having already been exposed to ultra-violet light, can be set directly into outdoor beds without "shock" once the weather is warm enough, thus eliminating an extra move which, under commercial conditions, can be a costly one. I predict that within a few years most of us will be using some form of plastic-covered propagating unit

Seed beds for trees with heavy tap roots: All of us who have propagated trees from seed have experienced the problem of transplanting, especially when they are sorts prone to the production of heavy tap roots with almost no laterals the first several years. Your Vice-President especially requested that I pass a special method of handling such materials on to you for, although I picked it up years ago from a forester, it seems not to have been widely circulated in the nursery trade.

There is nothing complicated about it for the whole set-up looks very much like an ordinary cold frame. There are, however, a few important modifications The pit or trench is dug to the necessary depth with the sides of the frame placed as usual. The necessary bottom drainage is supplied as always. Then ordinary copper window screen is unrolled and tacked along the bottom of the frame inside, forming a floor for the whole unit. Obviously, in constructing the frame it is best to adjust its width to the width of the copper screen available so that piecing is not necessary. A frame 3 inches narrower than the screen is ample, giving an inch and a half margin for turning up and tacking. To finish it off so as to be sure it is tight and rodent proof at the bottom, narrow battens can be nailed over the edges of the screen. The copper screen is then covered with your favorite seed-propagating mixture to the depth desired, usually about 8 to 10 inches, and the seeding done in the usual manner. Then the propagating frame is covered with quarter-inch or half-inch mesh galvanized screening. This can be tacked directly to the upperedges of the frame, but for ease in adding or removing mulch, or for weeding or spraying as needed, it is better to have this covering screen fastened to removable frames, under any situation making certain that the edges are tight. Thus, both at top and bottom one has a completely rodent-proof seed propagating bed.

However, the set-up as here described does not function merely as one which excludes rodents. The copper window screen at the bottom is the secret of its real success. When the seed germinates and drives its tap root deep into the soil the top of the root ultimately comes into contact with the copper screen, and the copper is just sufficiently toxic to kill the tip of the root but not the upper part Then from the upper part branch roots soon develop. Those then penetrate to the copper screen where, in turn, their tips are killed, forcing out additional lateral roots, and so on until the seedling has produced a bushy root system no longer than the depth of the soil above the copper screen. And if there is one thing the tree propagator wishes for a tree seedling it is a compact bushy root system.

Furthermore, if not overly crowded (and one easily can thin such a bed) the seedlings can be left alone for longer than in the usual bed since they never develop the overly long tap roots characteristic of so many of our horticulturally important trees. Also, in such a set-up one does not dig the seedlings for transplanting directly into the field. All one has to do is to flood the bed until the soil is thoroughly saturated and completely soft, so much so that the seedlings can easily be pulled up by hand with no damage to their root systems and far more complete than when spaded out.

It is obvious that this procedure would not be necessary with ordinarily shallow rooted types, but where one is dealing with those prone to the production of particularly heavy tap roots and few laterals during the first years of growth, the method has real advantages. The initial extra outlay is liquidated by eliminating the cost of at least one transplanting, and if the wood of the frame is treated wih a good preservative it should last long enough to become a real asset, the only care needed over a period of years being the necessary renewal or reconditioning of the soil before each planting cycle.

Propagating mediums: Fortunately there is one topic unnecessary to discuss with this group and that is the troubles one has with damping-off of seedlings and losses from rots and other diseases afflicting the bases of cuttings. Nor is it necessary to note that the ideal propagating medium has yet to be found. Regardless of our individual preferences for one or another type for special purposes, we still have to strike some sort of compromise each time we prepare anything from a single flat to a house full of benches.

When we stop to think about it there is something approaching the ludicrous about the conflicting demands we place on our propagating mediums. They must retain water, yet they must drain thoroughly and quickly, and they must "firm" properly when the cuttings are placed, yet they dare not pack tightly under continued watering. Here is our first great set of compromises for in both the tacit understanding that the medium must be aerated to the bottom is clearly enunciated. Lastly, and rightly, dreading the inroads of pathogenic organisms at the cut end, we have demanded that the propagating medium be sterile. Clean sharp sand, vermiculite, pearlite, shredded sphagnum, and our own pet combinations of these are the stand-bys. The sand, vermiculite and pearlite can be obtained in reasonably sterile condition But the oft-repeated statement that shredded sphagnum is sterile is strictly for laughs Bottom peat, while not sterile, is relatively free of living organisms, whereas the type of fairly fresh, top sphagnum, best liked by most of us, actually is teeming with organisms. What we should say is that such sphagnum, being highly acid, inhibits the growth of the bulk of pathogenic organisms, and so is reasonably safe to use, save in a few exceptional cases

The current trend toward propagating in sphagnum, often sufficiently fresh to continue its growth, or in a mixture of this sphagnum and sand, has some interesting backgrounds. Completely inert materials such as sand and pearlite often have rather wide and sudden fluctuations in pH, unknown to most of us, particularly if the water we use is at all alkaline. And such fluctuations are not good. The addition of an oragnic component such as sphagnum buffers the medium and holds these fluctiations in check Here in its buffering action is one of the reasons for our gradual shift to propagating mediums containing sphagnum. The fact that some of the sphagnum cells are so constructed as to retain water, while at the same time its coarse structure resists packing and so permits easy access of oxygen also are points in its favor. But the more I delve into the situation the more I am convinced that another reason for the trend toward use of raw sphagnum over other media for the propagation of certain things lies in the fact that the raw sphagnum is not sterile, but contains a rather wide variety of micro-organisms. And this is where I get right into the middle of the topic of my title.

The friendly fungi: Our battle with the organisms of disease is so constant that we have rather lost sight of the fact that there is a host of micro-organisms always willing to extend a helping hand to the propagator or gardener if he would but give them half a chance Here I will quickly pass by those organisms which constantly convert raw organic materials into substances which the plant is capable of assimilating, those which transform the nitrogen of the air into nitrites as well as those which convert nitrites, and the host of others with which the good earth teems. Passing by all these, for they are part of the common lore of soil science, I wish to go to a group of which so little is known that our ignorance of them is almost appalling. I refer to those fungi regularly and helpfully associated with the roots of the great bulk of our forest, field, and garden plants.

Pick up any standard text of horticulture or botany and look in the index for the word "mycorrhiza." And don't be amazed if you can't find it. If you do find it, don't be at all surprised if not more than a short paragraph on the subject appears on the page cited. Although European workers long have been concerned with these matters, it was not until recently that an American worker got sufficiently interested in the problem to summarize in book form in 1950, the world's scientific knowledge on the subject. This was done by A. P. Kelley in his volume entitled "Mycotrophy in Plants," published by the Chronica Botanica Company

What are mycorrhizae? Still entirely in the realm of technical language, this word "mycorrhiza" (or "mycorrhizae" in the plural) needs to be translated. Literally, it means "fungusroot" and connotes an association between the root or other underground structure of one of the higher plants with the strands of a fungus. It further connotes a mutually beneficial association, one which technically is known as symbiotic. So deeply are we ingrained with the idea that any fungus which penetrates the tissues of another plant must, by this act, be a dangerous enemy, that we have overlooked the great host of fungi regularly associated with the plants all about us, which do penetrate the underground parts of the plants, but which cause absolutely no damage. In fact in a number of proved cases, some of these plants could not exist without the aid of the fungus any more than the fungus could exist without aid from the higher plant. Here is where the symbiosis — the living together — principle comes in.

Although it is easy to understand that the non-green fungus plant derives at least some nourishment from the green plant, the question immediately arises as to what benefit the green plant, drives from the fungus which penetrates its roots, or in some instances its rhizomes First, when one turns to any horticultural or botanical text one usually discovers a long discussion of root hairs in relation to water and mineral absorption. But take a good look at any illustration of root hairs one can pick up. Actually they are outgrowths of normal epidermal cells, being active and functional only near the growing point of the root. If the illustration is a drawing, it usually is schematized and inconclusive. If it is a photograph, almost invariably it is that of a young seedling scarcely out of the seed coat.

In the young seedling root hairs usually are easily seen with the unaided eye But the truth is, if one gets down on one's hands and knees and digs about most carefully among the roots of mature trees and shrubs, or around the flowers and vegetables in one's garden, one can find plenty of young, growing root tips, but is not very likely to find a single root hair, even with the aid of a strong magnifying glass. You may find structures which you think are root hairs, but if you will take the trouble to make special preparations of these roots ends, sectioning them no thicker than 8 or 10 thousandths off a millimeter on a precision cutting apparatus and then stain them with special dyes, under a good microscope one then often discovers that what were thought to be root hairs actually are the minute strands of a fungus associated with the root of the green plant.

In brief, although the seedlings of nearly all of our green plants do have functional root hairs, as they get older many seem to lose the ability to produce these structures and so must rely on the associated fungi to transfer to them the water and minerals necessary to their well-being. In certain intances it has been demonstrated that the green plant has somehow lost the ability to produce the hormones necessary for active root growth, and relies on the associated fungus for these important substances. And in a few plants there are indications that the green plant, although capable of manufacturing and storing starch has in part lost the ability to redigest it in the underground storage organs and make it again available to itself in times of food shortage, apparently the only reason that such species are still around is because they long have had a fungal associate inside their tissue which does have the ability of producing and secreting the enzymes necessary to digest this stored starch Of course the fungus takes a nip of this available food, but it is apparent that when digested there is plenty for both organisms

There is a great temptation at this point to go into the complexities of this curious association of two quite unlike sorts of plants. But Nature is so varied and her complexities so great that I would consume both your patience and time even to scratch the surface of this part of my topic. It is here important only to understand that a very considerable number of our wild and cultivated plants do have this sort of association. And while I would not imply that it always is a necessity for the well-being and growth of the green plant, we now have enough known examples of obligate mycorrhizal associations among our horticultural materials that it no longer is wise to ignore the situation.

Distribution of mycorrhizae among plants: It is a safe thing to say that mycorrhizae are widely distributed among the world's plants They have been found among the liveworts and mosses, in the roots and rhizomes of many ferns, and throughout all underground parts of the lycopods or "Christmas greens" The roots of cycads and conifers long have been classical examples of mycorrhizae. This is no new thing in the group for careful examination of the fossilized ancestors of the conifers which existed hundreds of millions of years ago, at a time when the Coal Measures of the Palezoic were being laid down, clearly indicates that already their roots were supplied with mycorrhizal fungi, just as they are today. And there is scarcely a group of flowering plants among the monocots or dicots which when carefully examined has not yielded clear evidence of this association in at least some if not all members

Climatically, mycorrhizal associations have been found in plants from the equatorial jungles to the last rocky outpost in Arctic regions. So far as soil types are concerned, there seems to be no limit to their distribution. Here, however, there is a curious situation. Many plants regularly occurring on acid soils are known to be unable to produce fully formed or functional root hairs in highly acid media under experimental conditions. We suspect in such instances contact with the mycorrhizal fungus must be made in nature soon after germination of the seed. Such groups as the Heath Family seem to be especially notable in this matter. European growers who raise much of their Calluna and Erica material from seed make it a general practice to incorporate soil and mulch from their established heather beds with their seed bed mixture. The usually much better germination and early development of rhododendron and azalea seedlings on relatively fresh or undecomposed sphagnum points in the same direction, for a sphagnum swamp usually also supports a variety of plants of the same family requiring the same sorts of fungus associate, and these fungi would be in the upper layers of the bog.

The foregoing regarding frequency of mycorrhizal associations in acid soils does not imply that they do not occur in alkaline types In our alkaline soils of the Great Plains mycorrhizae are abundant, being widespread, even among the grasses. Among the legumes, everywhere abundant in this region, the root nodules with their contained nitrogen-fixing bacteria are a prominent feature. What is not generally known is that these same leguminous plants also are almost always associated with mycorrhizal fungi. It never has been studied, but my guess is that, much as in highly acid soils, the delicate root hairs of these plants find the going a little too severe in these highly alkaline soils and have given up in favor of the fungi with their more elastic cell walls and considerably more rugged protoplasm.

As one would expect, mycorrhizae are abundant in soils rich in organic material, the natural medium for fungi. However, they are curiously abundant on the roots of those plants growing in the most sterile of sands. Here the fungi might perhaps be classed as partial parasites, for almost all their food comes from the green plant; but they are not parasites since the fungus associate act as the actual absorbing system of the green plant, and in certain instances appears also to furnish root-growth hormones Pine plantations, occasionally in this country but more often in the southern hemisphere where pines do not naturally occur, have, at times on poor soils, seemed doomed to failure until the soil about the trees was inoculated with the proper fungi. This is not a complex operation, consisting merely of taking soil from under a vigorous pine and, without letting it dry out, placing small trowels of it near the young trees and just under the surface of the soil in the unthrifty plantation. Now this may sound very distant and quite unassociated with our every-day nursery practices. But, as I will soon point out, we do precisely this same thing every time we ball-and-burlap a plant either for moving in the nursery or for sale, for the plants which we regularly move with a good root-ball, no matter what the season, are notable for their obligate mycotrophy or, in less technical terms, for being unable to thrive unless their roots are associated with at least one of these "friendly fungi."

The roadside market and mycorrhizae: At first glance there would seem to be no connection between my topic and roadside garden markets, every year becoming more abundant. But a curious thing is happening These roadside outlets, whether directly connected with an established nursery, with one which carries only a few rows of growing-on stock, or whether it buys all its material directly from wholesale nurseries, all have one problem in common. They can't predict either the weather or the vagaries of customers on any particular day or week-end. As a result few items are left to be kicked about with bare roots, instead when offered they are prepared B & B or in containers so that they can be held for an indefinite time, with only an occasional watering. So much for the selling end.

Then along comes Joe Blow, out for a drive with the Missus and the kids, who just happened to stop to "look around" Joe has had experience buying plants for his little paradise in the treeless flatlands of Suburbia and looks with a jaundiced eye on nursery materials. After all, he hasn't had much luck with the stuff he has bought in the past from a couple of mail-order houses. Whether he knows it or not Joe's yard consists largely of raw mineral soil dug out of his cellar hole, and covered wth a thin veneer of material dubiously called "top soil." Joe isn't much of a plantsman and what he has done in the past is to dig some sort of indifferent hole, stuff his mail order bush into it, and slap the dirt back, with maybe a dribble of water on top for good luck With the proper know-how, Joe might have saved most of these mail-order plants, lacking it, all but the forsythia were lost. But in the roadside market his Missus has convinced Joe that he should buy a blue spruce, a small azalea, and a couple of rose bushes. Loading these into the back seat with the kids, Joe goes home, digs holes in what passes for a lawn, takes off the wrappings and drops the stuff into the holes and slams as much of the dirt as possible back in with them And, curiously enough, these plants often thrive

Now I would not here cast either aspersions or stones at the legitimate mail-order nursery business. It has its place, but it is operating under certain definite handicaps, so far as assured success of the material is concerned when planted. The newer plasticc-coated wrappings have helped a great deal in getting material to the customers in good condition. But the parcel post nature of much of this business demands that the plants be sent not only bare root but these trimmed to the quick. Thus the plants were delivered essentially devoid of their associated mycorrhizal fungi, for these occur primarily with the growing ends of the roots, the part cut off before shipment, or dried out in transit.

In contrast, the material at the roadside market, with its burlap wrapping, was lifted from nursery soil already abundantly supplied with the proper culture of fungi and necessarily kept moist In the case of those plants in containers, the soil preparation might have been supervised by a nurseryman with some training, and while it may not be the best soil in the world, it still is far better than that in Joe's yard and even is likely to have been so mixed, perhaps by accident, that it also contains an assortment of mycorrhizal fungi, one or several of which may already have set up housekeeping with the plant in the container. Thus the roadside market, with its emphasis on B&B and container materials not only supplies a bit of soil suitable to the plant, which usually is lacking in the average suburban yard, but at the same time almost automatically delivers a culture of the requisite fungus, should it be the type of plant which requires it. Now this is a very roundabout way to get at an idea but it points up a thing of increasing importance in the nursery business — the need to get more and more of our materials to the customer with a reasonable sample of the soil in which the plant was grown, and in which the proper micro-organisms are present.

I am fully aware that old, experienced nurserymen are going to raise their eyebrows at all this and legitimately ask the question. If this is so important, why was it not known and practiced in the past? Now it so happens that an established nursery is about the last place in the world to discover the acute need of certain plants for their fungus associates. In the first place, a nursery rarely is established on poor sterile soils devoid of organic material And if there are deficiencies, the first thing done is to correct them. Finally, through exchange of stock, every nurseryman, quite unknowingly, has built up a veritable living museum of otherwise often quite rare mycorrhizal fungi which are spread throughout the place not only by shifting plants, but by machinery and others means, even on the boots of the workmen. This explains why certain plants can easily be shifted from place to place in the same nursery, or taken from one nursery to another with but little loss, but are notoriously difficult to establish as bare-root transplants in the average suburban yard.

Looking at the thing in perspective we also will have to adjust ourselves to present conditions. There was a time, not so long past, when the ground is less disturbed during house construction, and when the phrase "top soil" meant something to a building contractor. With the advent of the bulldozer in cellar digging and final grading what one usually finds for soil when planting a yard would be as great a puzzle to the soil scientist as to the gardener. To the nurseryman accustomed to bare-root planting of the bulk of his material, it often is a baffling problem. On a guaranteed contract job the best thing to do is to dig the proper size hole and fill in with good soil. But if you're selling retail to Joe Blow the Suburbanite, there is no point in explaining to him how to dig the hole, put some well rotted cow manure in the bottom and then fill in with good garden soil as the plant is set. In the first place Joe doesn't keep a cow, and doesn't know anybody who does. And as for "good garden soil" he doesn't have it, and wouldn't know it if he saw it.

However, as pointed out earlier, in order to maintain and protect his stock in a roadside garden market, the retail nurseryman without knowing it has taken the first step in achieving better success under the trying planting conditions which now so often confronts us. This first step is to supply the bulk of our materials either B&B or in containers already growing in a reasonably ample amount of the proper soil, at least sufficient for primary establishment of the plant, and also with the required mycorrhizal fungi if the plants be those which require them.

From bed to pot: Now if in all this gabble about merchandising and customer relations, I seem to have lost sight of another of the propagator's problems you are mistaken. While you were busy stooping over your propagating benches probing into their innards for the first signs of young white roots at the base of the cuttings, we merely sneaked out for a little business talk and a couple of quick ones with our old friend "Mike O'Rhisa" Let us now suppose that, in the meantime, the cuttings or seedlings have come along and are ready to be potted up. Currently, few of us would think of exposing these young tads to the dangers lurking in unsterilized soil. And so we get our supply of clean flats or in the case of cuttings an ample supply of 2-and-a-quarters or even 3's and go to work, after moving over to the bin of thoroughly sterilized soil. Talk to an old propagator and usually you will discover, while he freely admits that he doesn't have quite so much trouble with damping-off and similar ailments as he used to experience, the plants don't seem to take hold quite so well or look so well on the bench as they did when potted up in soil wheeled in directly from the old-fashioned compost pile, sifted, and used just as it came Pressed for detail, the Old Boy will admit that this statement is not true for all items, but he will grumblingly maintain that for some things they just don't start off like they used to in the good old days when propagators also were gardeners and still smelled of manure And for some things the Old Boy is right.

In completely sterilized soil, no matter what its texture or feel and no matter what synthetic fertilizers it contains, there still are none of the normal soil micro-organisms slowly converting the raw organic materials into substances usable by the plant. There are no bacteria supplying extra amounts of vitamin B_1 to nearby roots. And, unless already infected in the propagating beds, there are no living fungi to start a healthy, normal mycorrhizal association. And it takes a long time for the soil in a pot inside a greenhouse to acquire a supply of such organisms, travelling in as they must on flecks of dust or by wind-blown spores And when they do come in they are not all present in a community of organisms living in biological balance in that soil There are no organismal checks and balances and the first to arrive may, by unlimited growth, produce an unbalanced soil condition which, while it may not be pathological, may still be undesirable. Fortunately it will not be long until these young plants will be placed outside in nursery beds where natural conditions prevail and so ultimately will hit their normal growth stride

Now I would not for a minute say that we should throw away our soil sterilizers, nor would I necessarily advocate going back to the expensive and time consuming construction and maintenance of the old-fashioned compost pile. But what I do say is that we should be looking forward to the time when we know what constitutes a proper balance of essential micro-organisms for "healthy" soils and introduce cultures of these organisms into our regularly sterilized potting soils, just as we do certain bacteria when we plant legumes.

Today there is no place where one can obtain such cultures, and for the simple reason that nobody knows exactly what the organisms are, let alone how to produce them in mass culture. But I maintain that here is a field of research for our scientific experimenters in horticulture which will yield returns far beyond many projects being worked on today.

The mycologist, the botanical student of fungi, has been very remiss, for as yet he knows almost nothing about which fungi are associated with which green plant in the various mycorrhizal associations. All we can say is that we suspect that the more common of our fungi often are responsible We do know that, in the main, the mycorrhizal fungi of our garden and field crops usually belong to different groups from those associated with our woody materials. Nor do we know how specific the relationships really are. What we suspect is that in various instances different kinds of fungi are capable of forming mycorrhizae on the same species of green plant What I personally suspect is that in certain soil types particular species of fungi are more efficient as mycorrhizal associates than others. Lacking a certain fungus a species of green plant seemingly gets along as best it can with other species of fungi which may happen to be avavilable. But in the long run, this would not seem to be the most efficient way to grow our plants once we know more of these intricate biological associations.

Looking some distance into the future one can envision a potting bench stocked with various types of sterile potting mixtures Nearby on a shelf will be a series of containers holding cultures of living microorganisms. By experimentation it will have been discovered that certain combinations of organisms with a certain soil mixture yields the best results for magnolias when potted out of the propagating bench The same soil mixture with another culture may work best for beech (the same combination likely will be used for oaks and chestnuts if one is doing other than seed propagation). Still another series will be used with the heaths, the rhododendrons and azaleas and the rest of their kin, and so on This all may seem unnecessarily complex, but one never should predict too far ahead just what competition in a field will do toward forcing ever more efficient methods of production. Let us recall that there once was a time when a 50% loss at the first transplanting was taken in stride by many nurserymen. Today such losses, if continued, soon would throw many nurseries into bankruptcy.

And so, in conclusion, it all boils down to two basic questions. What is the most efficent and economical way to produce the various plants with which the propagator and nurseryman must deal? And, how can these materials be best brought along in the field and delivered in a satisfactory manner to the customer? It is unnecessary to tell you that the answers to these questions are not simple ones. They involve a series of exceedingly complex biological and economic siuations. Today I have touched on only one phase of the problem. I have chosen this phase, not because we fully understand its importance, but simply because we don't know how important it yet will prove to be.

Let us truthfully admit that the bulk of our standard horticultural materials in the trade today are common and widespread primarily because they are easy to propagate and grow in nurseries, yet in many instances these do not represent the potentially best ornamental materials in their groups. The problem seems one primarily of learning how better to propagate and grow these other materials. Perhaps it is only learning which mycorrhizal fungus to supply some of these plants This would seem to be a very simple thing to ascertain. But it may be more complex than we suspect for it probably also involves learning just what type of soil as well as other soil organisms the necessary fungus will tolerate. This we have had to learn the hard way with our rhododendrons. In all of this there is, however, a note of comfort for the experimentally minded plant propagator. The latest publication on plant propagation, just off the press, has not told the whole story. There is much yet to be learned, and we will not soon work ourselves out of jobs.

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PRESIDENT SCANLON: Thanks, Louis, for doing a fine job in reading Dr. Camp's paper. It is not the policy to have papers read by other than the writer, however, in this instance we thought that the information warranted the deviation of our policy.

The session recessed at 12:00 following several comments by various members of experiences relating to points in Dr. Camp's paper.