LINDEN.

The linden requires an abundance of deep rich soil and suffers much from gas, from drought, and from insect attacks. It does fairly well in Washington, but is little planted now because of the extra care it requires as regards soil and water. In Berlin, Frankfurt, Hamburg, and Paris, the leaves of most varieties of linden fall prematurely on account of insect and fungus attacks. In Philadelphia a few years ago all the large lindens were killed by borers. A further objection to this tree is the litter made by its blossoms and fruit.

TULIP-TREE.

The tulip-tree is too large except for the widest avenues and park borders, where there is a quantity of rich deep soil and abundance of room. It is likewise difficult to transplant, the branches are very brittle, and the leaves are continually dropping throughout the season. It is, however, practically free from enemies.

BLACK LOCUST.

The black locust is a rapid grower, hardy, easily propagated and transplanted, and does well in poor soil. It is successfully cultivated in Paris, where the top is kept small and spherical and the branches thickly clustered. Its hard and durable wood is beginning to be used in Paris for paving the streets. On the other hand, the tree is scraggly and angular in form, its branches brittle, its foliage short-lived, its pods unsightly, and its roots badly given to sprouting. The locust borer often kills the black locust, as well as the honey locust, and has been known to spread from these trees to certain species of oaks.

FIG. 17.—*Black locusts near Père Le Chaise, Paris.*

WILLOW.

The weeping willow is the only species used on streets, and its occurrence is rare. It grows rapidly and when perfect makes a fine appearance, but the wood is tender and is often attacked by fungi, while the tussock moth and other leaf-eating insects frequently destroy its foliage. The white willow is excellent for windbreaks and for planting along the banks of streams, railroads, and other embankments. Fine rows of this

FIG. 18.—*Old white willows along Cascadilla Creek, Ithaca, planted to preserve the banks of the stream.*

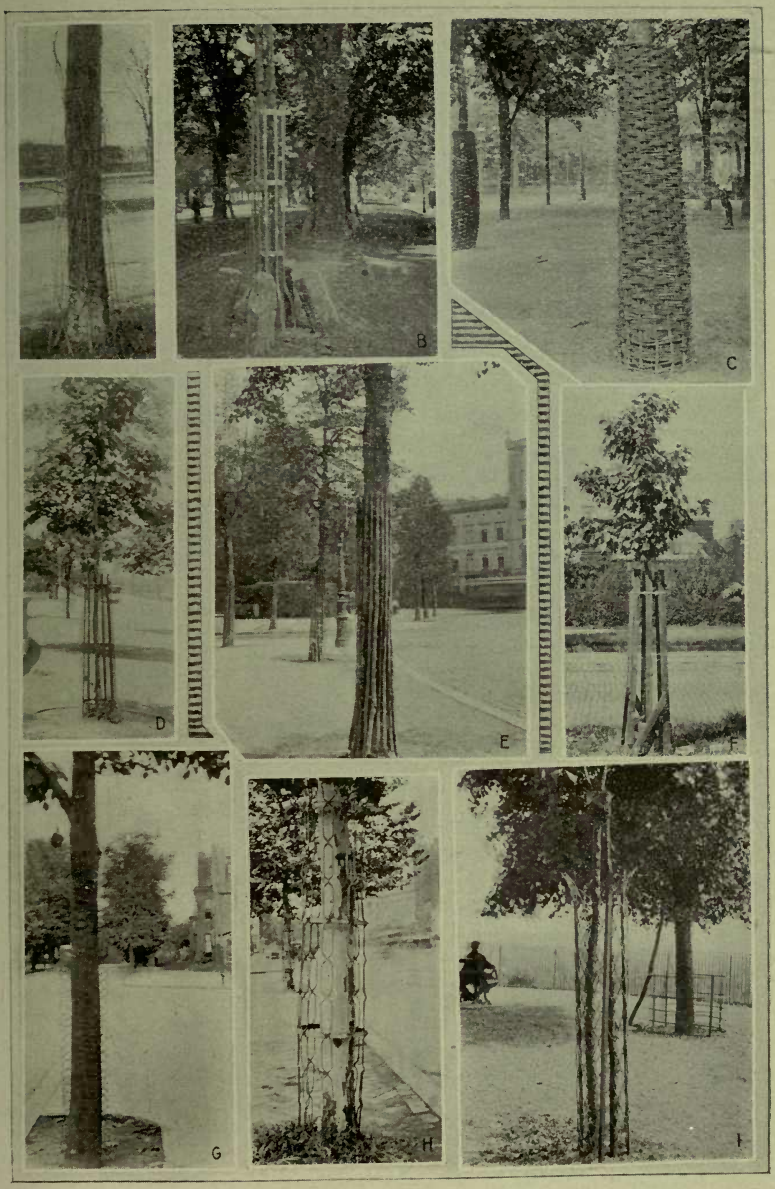


PLATE II—THE PROTECTION OF SHADE TREES.

Pamphlets on forestry in New York.

NEW YORK FORESTRY PAMPHLETS

VOL. III

Tree Study -- John Bentley, Jr., Cornell Univ.
How the Trees Look in Winter -- L. H. Bailey, College of Agriculture, Cornell University, 1899.
Evergreens, and How They Shed Their Leaves -- H. P. Gould, College of Agriculture, Cornell University, 1899.
The Cultivated Poplars -- Bull. 68 -- L. H. Bailey, Cornell Agri. Experiment Station, 1894.
Shade Trees -- Bulletin 205 -- W. A. Murrill-- Cornell Agri. Experiment Station.
Studies of Some Shade Tree and Timber Destroying Fungi -- Geo. F. Atkinson -- Bulletin 193, Cornell Agri. Experiment Station.
Blister Rust of Pines and the European Currant Rust -- Geo. G. Atwood, New York State Department of Agriculture. Horticultural Bulletin No. 2.
Damping Off -- Bulletin 94, Cornell Agri. Experiment Station -- Geo. F. Atkinson.
Control of Two Elm-Tree Pests -- Glenn W. Herrick Cornell Agri. Experiment Station.
The Bronze Birch Borer -- M. V. Slingerland -- Bulletin 234 -- Cornell Agri. Experiment Station.
The Larch Case-Bearer -- Glenn W. Herrick -- Bulletin 322 -- Cornell Agri. Experiment Station.
The Snow-White Linden Moth -- Glenn W. Herrick -- Bulletin 286 -- Cornell Agri. Experiment Station.
The Elm Leaf-Beetle -- Glenn W. Herrick, Circular No. 8 -- Cornell Agri. Experiment Station
Hints on Rural School Grounds -- L. H. Bailey -- Bull. 160, Cornell Agri. Experiment Station.
Mushrooms: II -- Geo. F. Atkinson -- Bull. 168, Cornell Agri. Experiment Station.

TREE STUDY

" Peace of the forest, rich, profound,
Gather me closely, fold me round;
Grant that the trivial care and strife,
The petty motive, the jarring sound,
Melt and merge in your lovelier life.
The myriad whispers of grass and pine,
The stir of wings in the quest divine,
I claim their music and make it mine."

ELIZABETH R. MACDONALD

THE ELM

JOHN BENTLEY, JR.

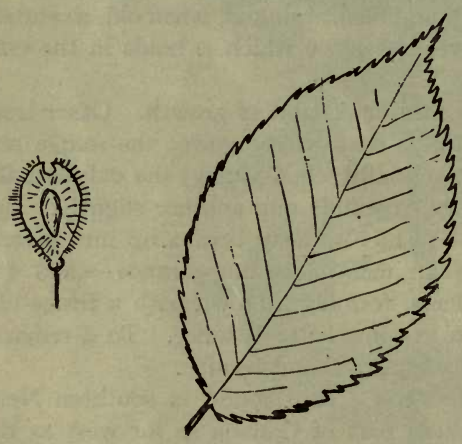
Of the many trees that are common in New York State, the elm is doubtless the most familiar to boys and girls. The reason for this is plain, when we consider that the elm is a tree of the farms, the home lawns, and the streets of the towns, rather than a tree of the deep woods. While it is found occasionally in the forest, it is almost always scattered among other trees and never forms a large proportion of the forest, as do maples, birches, pines, or oaks. Throughout the New England States, New York, and Pennsylvania, the elm is one of the commonest shade trees, not only for the streets of the towns and villages but also for the grounds about the home. The tree is so graceful and beautiful, and, when old, so stately and dignified, that it well deserves the place which it holds in the estimation of the people.

The elm has a very distinctive form and habit of growth. Other trees seen from a distance are not always easy to recognize: the maple and the beech look somewhat alike, especially when young; the oak and the chestnut, the ash and the hickory, resemble one another slightly. But the elm, with its massive trunk — which quickly breaks up into several large branches, giving the tree an urn-shaped appearance — and the delicacy of the twigs and branchlets, forming a crown with a fringe-like margin, is easy to recognize even at some little distance. To a remarkable degree it combines strength with grace and beauty.

The elm is a widely distributed tree. It is found in southern Newfoundland and through the southern part of Canada as far west as the northern shore of Lake Superior. It grows along the Atlantic coast as far south as Florida, although it never reaches very large size in the southern part of its range. Westward it is found from South Dakota to Texas, although not in such large numbers as in the East. Everywhere it shows a preference for the low, rich lands that border rivers and streams, and it grows to its largest size where the soil is rich, fertile, deep, and moist. Under favorable conditions it will grow to a height of one hundred and twenty feet and a diameter of eleven feet. Many very large trees have become famous, as the large elm at Lancaster, Massachusetts, and the two elms on the river bank at Wilkes-Barre, Pennsylvania. It is the wide spread of the branches, as well as the massive size of the trunk, which makes the elm impressive; sometimes the crown of a tree measures one hundred and twenty feet across.

The elm tree, large as it is, springs from a very small seed. The flowers, which are inconspicuous, blossom early, before the leaves are fully grown, fade soon after, and are as quickly followed by the ripening seeds. These small seeds have wings on the margins, with sharp points, and are very

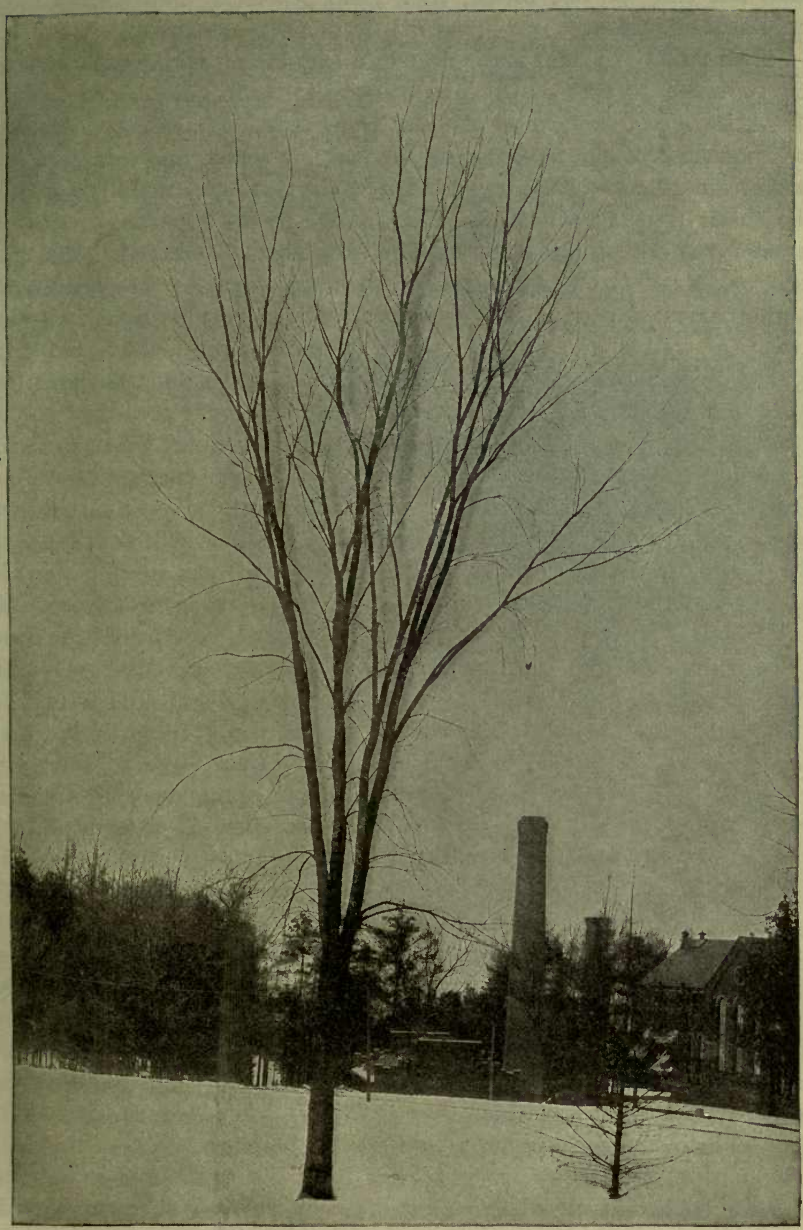
short-lived. Unless they fall on soil that makes a good seed bed and germinate immediately, they will die. They cannot wait, as do the seeds of the hickory, pine, and many other familiar trees. (Can you think of another familiar tree that ripens its seeds in early summer? See the Rural School Leaflet for September, 1912, page 163.) Besides plenty of moisture, which is one thing that the little elm seedling must have at the start, the quality of the soil and the amount of light that comes to the seedling have great influence on its growth. The soil must be rich and mellow, so that the rootlets can penetrate easily and find plenty of food material, and there must be plenty of light, so that the seedling can grow rapidly and become able to take care of itself before the autumn frosts arrive. This demand for light is one reason why we do not find elm trees in the deep, dark woods. When we do find an elm in the forest, it is because there was an opening in which the little seedling could get a start. Elms will not do well when they are overtopped by their neighbors.



Leaf and fruit of American elm

When standing where there is plenty of room and light, the elm tree grows rather rapidly. Many men who do not consider themselves old can remember the time when, as boys, they watched their fathers set out elm trees along the roads or on the lawn, and those trees have now grown to be of large size. But the largest elms — those that are one hundred feet high and six to ten feet in diameter, with the large, spreading crowns — are probably two hundred years old or even older.

Whether the elm is more beautiful in summer or in winter it is difficult to say. In summer its dense foliage hangs in graceful sprays from the drooping branchlets at the ends of the long limbs, swaying in the breeze and making a delightful shade. The upper side of the leaf is dark green; the under side is grayish green, reflecting a soft light which is very pleasant. Stripped of its foliage the elm presents an appearance in winter which shows its strength — not the rugged strength of the oak, with its gnarled, irregular branches, but a supple strength suggestive of self-contained reserve force. It is in the winter, too, that the delicacy of the smaller branches is seen to best advantage. Every wind sways



American elm in winter

them but they do not break; they yield gracefully and seem to enjoy the blasts of winter.

Unfortunately the elm is the prey of a tiny insect, which eats the leaves and threatens to destroy the tree entirely in some parts of the country. This little insect, known as the elm leaf-beetle, has damaged thousands and thousands of elm trees during the past few years; and although many persons have worked hard to get rid of it, the pest is continually spreading. The shade trees in towns and cities suffer most, apparently, and it is necessary to act promptly if the elm trees are to be saved. The insect itself is only about one quarter of an inch in length, brownish yellow in color, marked with a dark line along each side of its back. It sleeps during the winter, and the same warm days that bring out the elm leaves awaken this enemy of the elms. The beetles fly to the trees and begin to feed by eating small holes in the leaves. In a very few days the eggs are laid, and these quickly hatch into little grubs which begin in earnest to eat the leaves. So many eggs are laid that the number of grubs at work on the leaves is enormous. In fifteen or twenty days the grubs have completed their growth, and, unfortunately, their work of destruction also. They now crawl down the tree, and by the time another ten days have passed they emerge as fully grown beetles and are ready to repeat the process. Sometimes there are two complete broods of the insects in a single season, but the last brood as a rule does less damage than the first.

The only way to save the elms from this enemy is to spray the leaves with a poisonous liquid. Although it costs twenty-five to sixty cents to have a tree sprayed, it will be necessary to spray our elm trees systematically if we wish to save them. Those who are interested in the work of saving the elms should write to the State College of Agriculture and ask for a copy of Professor Herrick's Experiment Station Circular No. 8, entitled "The Elm Leaf-Beetle."

The next time you are in the woods, see whether you can find any elm trees growing where the woods are thick. If you see any, notice the shape of their trunks and their crowns. Compare them with the trees that grow along the streets in town. What do you think makes this difference in form? Again, if you find any elm trees in the woods, notice the kind of soil in which they grow best. Is it wet or dry? What other kinds of trees are found growing with the elm?

About the last of May or the first of June, watch the elm to see when the seeds begin to fall. Take a few of them and sow them in a garden bed where the soil is soft, rich, and moist. Perhaps you will be able to see the small seedlings grow to a size that will enable them to take care of themselves before winter sets in.

The wood of the elm is useful for purposes demanding great toughness. It is often used in the making of barrels and fruit baskets. It is hard to split and work, and for that reason carpenters do not use it for woodwork or finishing; but if a tough wood is needed, a better wood than that of the elm is difficult to find.

THE PINES OF NEW YORK

JOHN BENTLEY, JR.

In the winter months, when most of our forest trees are leafless, the firs, spruces, and pines, with their dark green foliage, are a cheerful sight. It makes us feel, somehow, that after all the woods are not lifeless in winter, and that there are some trees bold and hardy enough to withstand the snow and the cold. Pines are particularly noticeable, because there is more motion and life in their foliage than in the stiff, rigid foliage of spruces and firs. Then, too, pines are more familiar to most of the boys and girls in the State, because spruces and firs belong to the cold climate of the mountains.

White pine

There are five pines that are native to New York State, besides several others that may be found occasionally in our parks. The five native trees are (1) the white pine, (2) the pitch pine, (3) the red, or Norway, pine, (4) the jack pine, and (5) the Jersey scrub pine. The last two are not very common, however, and most of us will find only the three first mentioned.

The pines as a group are marked by three characteristics which all boys and girls should notice first of all. They are: (1) the needle-shaped

leaves, borne in clusters of two, three, or five needles; (2) the cones, in which the little seeds are borne; and (3) the wood, which always contains more or less pitch, or resin. These characters distinguish the coniferous (cone-bearing) trees from the broad-leaved trees. The term "evergreen" should not be applied to the pines, spruces, and firs, because there are other trees, as the holly and the live oak, which retain their leaves throughout the winter and are just as truly evergreen as is the pine or the spruce.

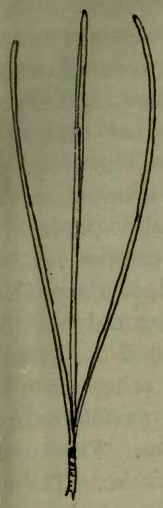
White pine needle cluster

Then, again, there is the larch, about which we learned last year (Rural School Leaflet for September, 1912, page 160), which bears cones and yet sheds its leaves every year. The leaves of the larch are needle-shaped, it bears cones, and there is some resin in the wood, and therefore it clearly belongs to the same family as do pines, firs, spruces, and hemlocks. In order to avoid all confusion, therefore, I would suggest that we learn to call all cone-bearing trees "conifers," which means "cone-bearers." Then let us call the others "broadleaf trees"; this will properly include the live oaks and the holly, and will do away with the confusing term "deciduous" (leaf-shedding) trees. Another term that is frequently heard is "hardwoods." As generally used, this term means the broadleaf trees, although there are some conifers with very hard wood — yellow pine, for example — and some "hardwoods," or "broadleaf" trees, with very soft wood, such as the poplar and the willow. The use of confusing terms should be abandoned and the terms "conifer" and "broadleaf," while sounding a little strange at first, will express our meaning more nearly.

The pines are nearly all of great value because of their wood, which is strong for its weight, straight-grained, and easily worked — that is, carpenters have little difficulty in planing and shaping it to their purposes. Some of the pines have very hard, heavy, resinous wood, as the southern yellow pine; but our northern white pine is light and soft and contains only a moderate amount of resin. The white pine was formerly the most important timber tree of all the northeastern States, and many millions of board feet of white pine have been cut from the forests of New York State within the past century. It is still considered a very valuable tree, and lumbermen are always glad when they can find any white pine to cut because they know that it will bring a good price in the markets.

The white pine is a tall, straight-trunked tree, often reaching a height of one hundred and twenty-five feet in the dense forests of the Adirondack Mountains. When growing in the woods the trunk is frequently clear of all branches for sixty or seventy feet, but when grown in the open,

where it has plenty of room, the crown is broad, with many limbs growing to within fifteen or twenty feet of the ground, and under these conditions the tree never grows very tall. The lumberman likes best of all the tall, straight trees of the forests, for these will yield fine, straight-grained lumber with few knots.



Pitch pine needle cluster

The white pine can be distinguished from the other pines of this State by the needles, which grow *in clusters of five*. Examine the foliage of a pine tree; you will see that the needles, instead of growing singly, grow in bunches, or clusters. In the white pine there are always five needles in a cluster. The individual needles are two and one half to five inches long, slender, flexible, bluish green, with a fine white streak. Let us now look for some cones. We may find some growing on the tree, or we can examine those that have fallen from the tree and are now lying on the ground. The white pine cone is about five inches in length, is usually slightly curved, and is slender, rarely exceeding an inch in thickness. Let us look a little more closely and see whether there are any spines, or prickles, on the cone. If we have picked up a dry cone the seeds have doubtless been shed and scattered. If we can find a fresh cone with seeds in it, we can see how each seed is provided with a thin wing, which enables the wind to blow it for long distances.

Pitch pine

Now let us consider the pitch pine, which is probably the next most common pine tree of this State. It is generally found growing on very poor soils, where only the hardiest trees or shrubs will thrive. This tree can grow in these poor situations because of its thick bark (often two inches thick at the base of the tree) and because it can resist fire much better than can the white pine. It is not nearly so neat in appearance as the white pine; its branches are irregular, the trunk is not so tall and straight, and the old cones frequently hang on the tree for years. The

foliage is stiff and the needles are borne in clusters of *three*; this at once distinguishes it from the white pine. The needles are a dark yellow-green instead of a blue-green. The cones are short and stout, about two or three inches long and two inches thick, and the cone-scales are armed with prickles. There is not the slightest resemblance between the white pine and the pitch pine, either in the needles, cones, or bark; and if you have an opportunity to look at the wood after the tree has been cut, you will find that there is no more resemblance there. The wood of the pitch pine is coarse-grained, full of pitch, and not adapted to the fine work for which white pine is used. Indeed, the wood of pitch pine is of little value except for coarse, rough lumber and for excelsior.

The red pine, or Norway pine, as it is frequently called, is a tree that is not found in many parts of this State. It is common only in the Adirondack region, where it grows on light, sandy soils and has plenty of sunlight. It may be found occasionally, however, in other parts of northern New York. It can be distinguished by its *long, flexible needles* (four to six inches long), which are borne *two in a cluster*. The cones are two to two and one half inches long and *have no prickles*. Taking the cones and the needles together, there is no danger of confusing this tree with the other two pines mentioned.

The red pine reaches a height of seventy-five or eighty feet. The wood is harder than that of the white pine, yet, like white pine, it is not durable in contact with the soil. Because of its hardness it is not so valuable a timber as white pine, but the red pine possesses the great advantage of being a tree that will grow well on land too poor to produce a satisfactory crop of white pine. It rarely makes close forests, because it is a tree that demands a great amount of light for its growth. Red pine trees are never found in large numbers together, at least in this State, but are found mixed with other trees, especially at the edge of lakes or in openings throughout the sandy stretches of country that are common in the Adirondack Mountains.

The jack, or scrub, pine is not frequently seen in this State except in dry, sandy, barren soils in the northern part. It is usually a small, scrubby tree, with irregular branches, and of such poor form that it is practically worthless for lumber. The leaves are bluish green, covered with a gray bloom, and about two inches in length. They are borne in clusters of *two*, are twisted, and have a tendency to spread apart. The cones are small (rarely more than two inches long) and are armed with small prickles, which, however, may drop off.

The Jersey scrub pine is still more irregular and worthless as a lumber-producing tree. It grows in poor, sandy soil and is found growing wild only on Long Island. The needles are borne in clusters of *two* and the cones have prickles.

THE MAPLES OF NEW YORK

John Bentley, Jr.

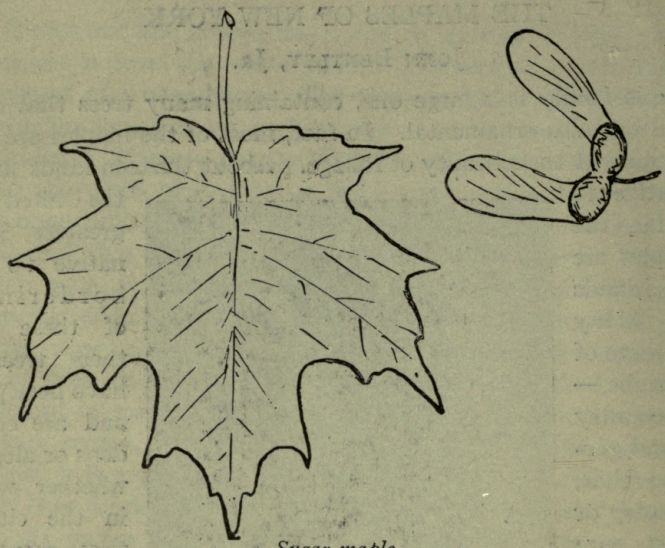
The maple family is a large one, containing many trees that are not only useful but also ornamental. In fact, most of the maples are valued chiefly because of their beauty of foliage. About thirteen kinds are considered native to the United States, but by far the greatest number of the maples are native to Asia and the islands bordering that continent. Many of these foreign maples — some of them trees, and some shrubs — have been planted in this country and are common in parks and gardens or along city streets; so that, whether we are in the country or in the city, we are almost sure to see maple trees.

Sugar maple

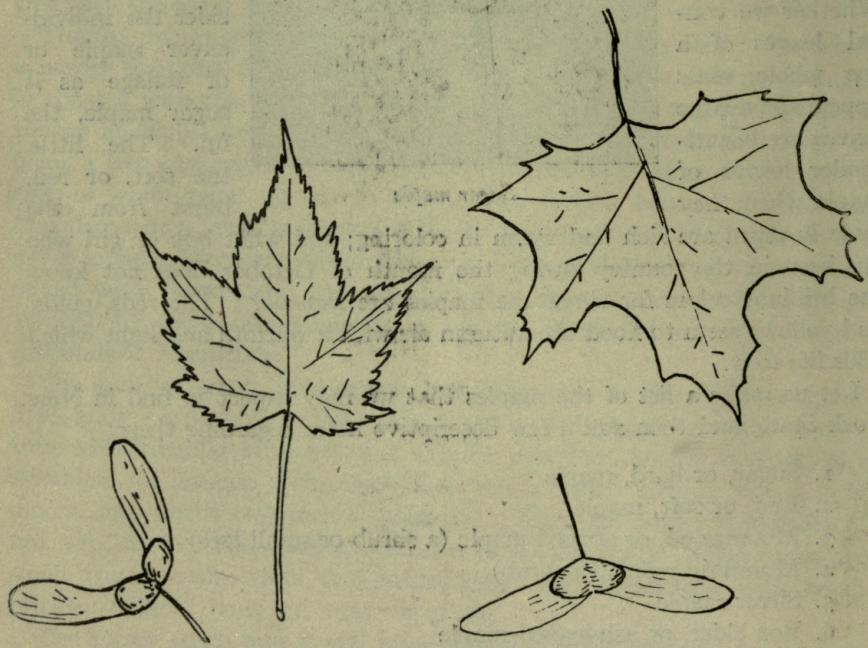
Maples are noticeable chiefly, perhaps, because of their foliage. Whether we consider the individual leaves of a silver maple or the whole mass of foliage as it appears on a large sugar maple, the leaves are beautiful. The little tender leaves of the soft, or red, maple when they burst from the buds in April are rich and warm in coloring; and what boy or girl who has been in the country during the month of October does not know the brilliant colors for which the maples are famous? The reds, golds, and yellows seem to flood the autumn air with a warmth and light which adds life to it.

Let us make a list of the maples that we may expect to find in New York State, and then add a few descriptive notes regarding them:

1. Sugar, or hard, maple
2. Red, or soft, maple
3. Moosewood, or striped maple (a shrub or small tree)
4. Mountain maple (a shrub)
5. Silver maple
6. Box elder, or ash-leaved maple
7. Norway maple (not native, but commonly planted)
8. Sycamore maple (imported)

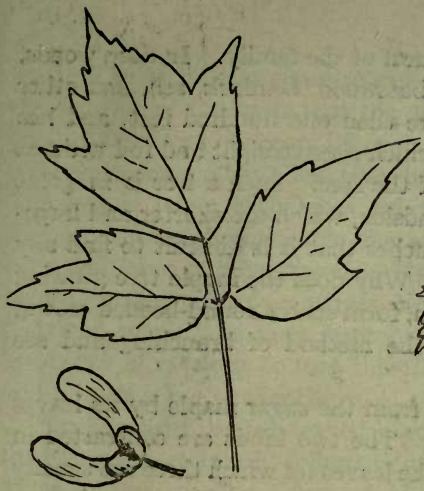


Sugar maple



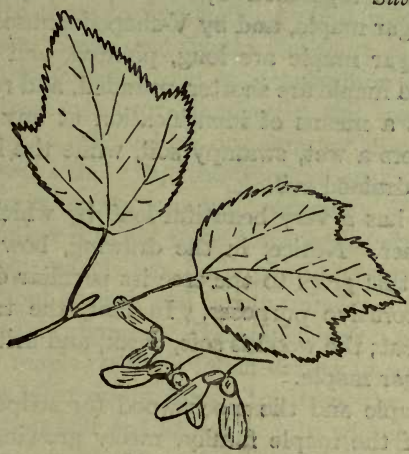
Red maple *Norway maple*

Outline drawings for blackboard work

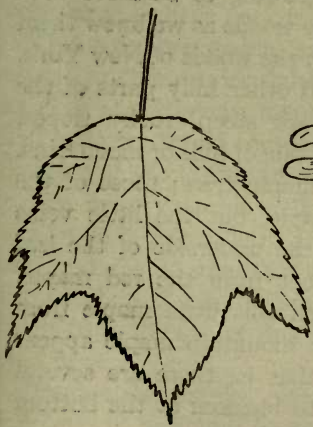


Box elder

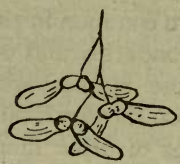
Silver maple

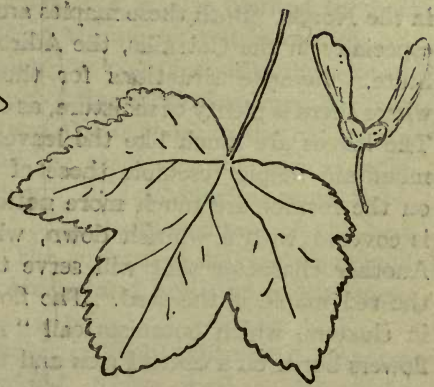


Mountain maple



Moosewood maple





Sycamore maple

Cutline drawings for blackboard work

The sugar maple is the largest and finest of the family. In deep woods, where it grows with the beech, birch, basswood, hemlock, ash, and other trees, it often reaches a height of more than one hundred feet, and has a trunk perhaps four feet in diameter which rises straight and full without a limb for more than half the height of the tree. Such a tree is in great contrast to those growing along the roadside, which are shorter and large-crowned and which have so many branches that it is difficult to find any one stem that seems to be the leader. Why does the maple tree growing in the open, where it has plenty of room, form such a round-headed crown, with no well-defined leader? Study the method of branching and see whether you can find out.

The red maple can be distinguished from the sugar maple by its leaves in summer and by its buds in winter. The two kinds are contrasted in the drawings. Note that the lobes of the leaves (of which three are usually very conspicuous) are separated by U-shaped depressions, or sinuses, in the case of the sugar maple, and by V-shaped sinuses in the red maple. The buds of the sugar maple are long, pointed, and of a brown color, while those of the red maple are shorter, rounded, and red in color. These marks will serve as a means of identification at any time of the year. The red maple prefers a wet, swampy soil, while the hard maple thrives in a rich, cool, well-drained soil.

The silver maple has a very beautiful leaf, by which it can always be recognized in summer. Notice, in the drawing, how deeply and finely the leaves are cut; this gives to the tree its peculiar delicacy and makes it desirable for decorative purposes. In fact, the tree is of little use except as an ornament; the wood is soft, weak, and brittle when compared with that of the sugar maple.

The mountain maple and the moosewood (or striped maple) are very humble members of the maple family, rarely growing to be more than shrubs; but they add greatly to the beauty of the woods as we know them in the North. Both these maples are common in the woods of New York, especially in the Catskills, the Adirondacks, and other hilly parts of the State. Favorite situations for these maples are steep, rocky slopes, where there is plenty of moisture, as on the north side of hills or mountains. The leaves are much like the leaves of other maple trees; those of the mountain maple resemble those of the red maple, but the little veins on the former are much more noticeable and the underside of the leaf is covered with a whitish down, which is absent from the red maple. Another character that will serve to distinguish this little maple from the red maple is the seed. The flowers of the mountain maple appear in clusters, which botanists call "racemes"; that is, there are several flowers borne on a central axis and they begin to blossom at the bottom

first. The artist has come to our assistance again, and you will see in the drawing of the seeds that the difference in the fruit is clearly brought out. The red maple bears its seeds in clusters close to the stem.

The moosewood has a leaf that distinguishes it easily from other maples. The leaf is large, with lobes only slightly cut, and is soft in texture. Perhaps the most noticeable character of this tree — one by which the boys will learn to recognize it — is the bark. This is reddish or greenish brown marked with pale stripes running up and down, so that the name "striped maple" is very appropriate. The flowers of this maple also are borne in racemes, so that this feature, together with the striped bark, will always serve to identify it.

The box elder, or ash-leaved maple, is the odd member of the family, for it has leaves totally different from those of the other maples that we know in this country. Instead of a single, simple leaf, this maple has a compound leaf with three to five leaflets. If it were not for the fruit, which is a true maple "key," we should feel more inclined to call it an ash — a feeling that is shown in one of the common names for the tree. The box elder has been used for planting in the treeless regions of the Middle West because it will endure dry weather and will grow rapidly even on relatively poor soils. But the wood is weak and perishable and the tree almost always grows crooked, especially if it is exposed to winds; so that altogether it is not to be considered very valuable.

The Norway maple, which has been planted extensively as a shade tree because of its rapid growth and heavy foliage, is a native of Europe but does very well in this climate. The leaves bear a general resemblance to those of the hard maple, but are much darker in color, usually larger, and thicker. If one is in doubt about the tree, the milky sap from a freshly broken leaf stem will distinguish it. In winter the leaf buds are very large and the bark is smooth and dark-colored.

The sycamore maple, another European tree, is also planted to some extent in this country although it does not grow so well in our climate as does the Norway maple. The leaves are conspicuously three-lobed, and are very broad compared with those of the native hard maple. The margins of the leaves are serrated, somewhat like those of the red maple.

The most valuable and useful of all the maples is the sugar maple. The wood is heavy, hard, and close-grained. It is used for furniture, flooring, and many small wooden articles. It also makes one of the best fire woods that our forests produce. The custom of making sugar and sirup from the sap of this tree is well known and needs no special mention here.

Besides the maples mentioned above, it is likely that many Japanese maples will be found in parks and gardens. These small maples, rarely larger than bushes, are remarkable for the beauty of their leaves.

THE OAKS OF NEW YORK

John Bentley, Jr.

A brave old oak

There are nearly fifty different kinds of oaks in the United States, and if we should include the several varieties, some of which are indistinct, the list would be so long that it would be discouraging to try to learn all of them. Fortunately we can learn to distinguish those that are common in New York. Although there are some fifteen or sixteen kinds of oaks reported as growing in this State, we shall describe but ten. The others are rare or of very local occurrence. It will be necessary to have not only the leaves, but the acorns and sometimes the twigs and the winter buds, in order to distinguish all the oaks described.

In the first place, we can divide the oaks into two general groups: those that have acorns maturing in *one season*, known as the *white oaks*; and those that have acorns maturing in *two seasons*, known as the *black oaks*. A further distinction between these two groups is that the black oaks have leaves the lobes of which are tipped with bristles, while the lobes of the leaves of the white oaks are smooth and rounded. Between the lobes are indentations which botanists call "sinuses." These sinuses are variable and are often a help in identifying the different species. On pages 136 and 137 is given a key for identifying the different species of oaks. Note the use of the term *sinus* in this key.

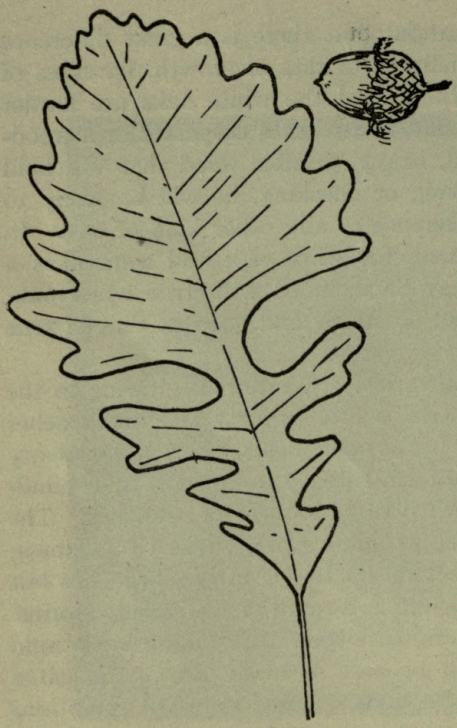
As a family the oaks are very useful; but there is a great difference between the several species, especially as to rate of growth, hardness of wood, and usefulness of wood. In general the white oaks are harder and more durable than the black oaks, and when a carpenter or a wood-worker wants a piece of very hard, heavy, durable wood that will hold its shape without shrinking, warping, or checking, he will be likely to choose a piece of white oak in preference to any other kind of oak. In the market, swamp white oak passes for white oak and sometimes a small quantity of chestnut oak may be included with true white oak; but the wood of chestnut oak is not so strong and good as that of true white oak.

In form the oaks present a great variety. White oak growing in the woods has a long, clear stem for perhaps fifty or sixty feet and reaches a height of over one hundred feet. In the open fields, where it has plenty of room to develop a big crown, the form is likely to be short and round-headed, with a stout trunk and with little of it clear of branches. The oak always presents an appearance of great strength and sturdiness; the winds of winter have little effect on its tough, strong branches but these are frequently gnarled and irregular as a result of exposure to storms. The acorns of the white oak will germinate soon after falling in autumn if the conditions are favorable; but because so many acorns are eaten by squirrels, and because so many others do not find the right conditions of soil and moisture, only a small number succeed in growing to a size that will enable them to live over the first winter.

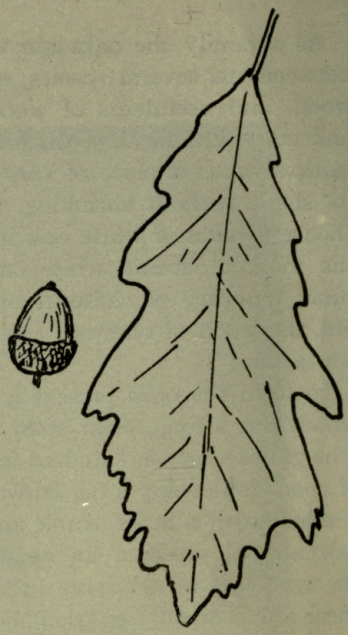
Although a widely distributed tree, the white oak is found most commonly on good moist soil in rich bottom lands or in protected hollows. In the country adjacent to the Ohio River valley the white oak finds the best conditions of soil, climate, and rainfall. It will grow also on rather dry, stony soil, but it never reaches such good size under these conditions.

Of the black oaks, the common red oak is the most desirable because of the rapidity of its growth and the general quality of its wood. Although not nearly so strong as white oak, it is heavy and rather hard and will be useful where great strength is not required. The grain of the wood is rather coarse and it never seasons so well as does the white oak. In form the red oak develops a very large, wide-spreading crown, with a number of large branches; but it almost always has a well-formed stem, making possible the cutting of good saw logs from it. The red oak grows farther north than any of our native oaks, and is not nearly so particular as the white oak as to quality of soil.

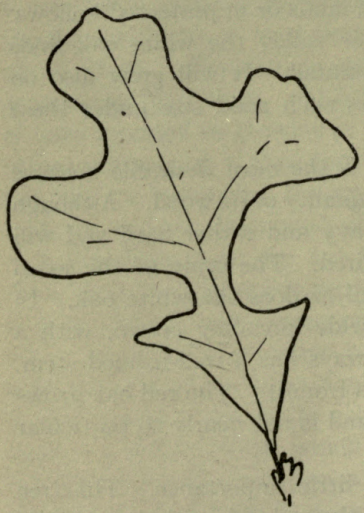
The common black oak is of relatively little importance. The tree does not grow to such good proportions as the red oak and the wood is



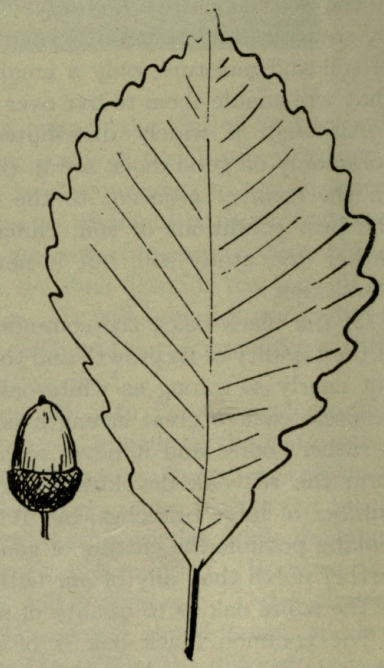
Bur oak



Swamp oak

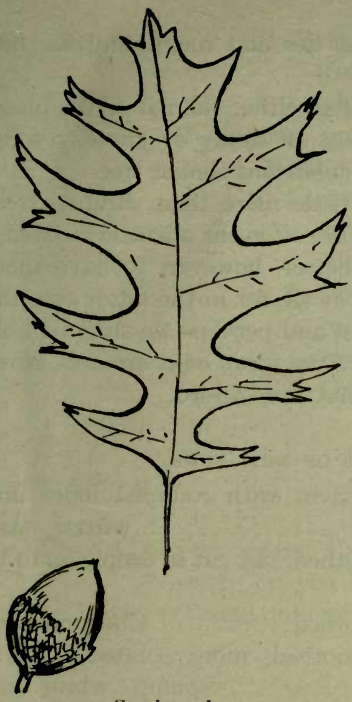


Post oak

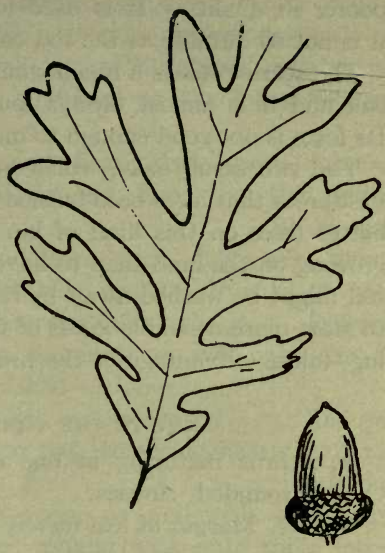


Chestnut oak

Outline drawings for blackboard work

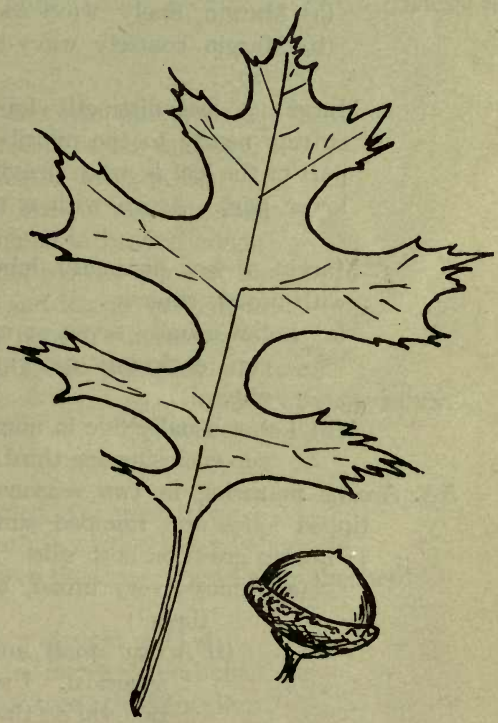


Scarlet oak



White oak

Scrub white oak



Pin oak

Outline drawings for blackboard work

poorer in quality. It is used for railroad ties and rough timbers, but it is not so durable as the red oak.

The scarlet oak is a much smaller tree than either the red or the black oak and it is almost always found growing on sandy or gravelly soils. Its form is not good enough to make it an important timber tree.

The two scrub oaks, which are really little more than shrubs, cover vast areas that have been burned over and are often the obstacle to having better trees on this kind of land. It is better, however, to have them growing on the land than to have nothing at all, for in the latter case the soil might be washed away by heavy rains; and perhaps we shall be able to start more desirable kinds of trees where the scrub oaks are now growing, taking advantage of the protection that they afford.

KEY TO THE COMMON OAKS OF NEW YORK

A. Acorns maturing in one season; leaves with rounded lobes and rounded sinuses.....WHITE OAKS

1. Margin of leaf merely wavy-toothed, not cut so deeply as to be called lobed
   - (a) Margin finely wavy-toothed.....Chestnut oak
   - (b) Margin coarsely wavy-toothed, more pointed than in (a).....Swamp white oak
2. Margin of leaf distinctly lobed; one pair of broad sinuses cutting nearly to the midrib of the leaf, so that the upper part of the leaf is much heavier and broader-looking than the lower part. Acorn with a mossy cup.....Bur oak, or Mossy-cup oak
3. Margin of leaf distinctly lobed sometimes very deeply cut, with broad, sinuses
   - (a) Lobes usually seven or nine in number; acorns pointed; cup enclosing not more than one fourth of the nut.....White oak
   - (b) Lobes usually five in number; acorns not so pointed, and cup enclosing one third to one half of the nut..Post oak

AA. Acorns maturing in two seasons; leaves with pointed, bristle-tipped lobes and rounded sinuses.....BLACK OAKS

1. Leaves green on both sides
   - (a) Sinuses very broad, broader than the lobes between them
     - (i) Acorn small and flat, the nut almost hemispherical. Usually found growing in moist, rich soil on the banks of streams or the borders of swamps.....Pin oak

(ii) Acorn slightly larger and more nearly round. Kernel whitish. Usually prefers dry soils on ridges and well-drained situations. . Scarlet oak

(b) Sinuses usually not so broad as the lobes between them

(i) Leaves thick and firm; dark green, lustrous above; more or less fuzzy on the underside. . . . . Black oak

(ii) Leaves thin and firm; dark, dull green above; on the lower side usually smooth, or with fuzzy hairs near the veins only. . . . . Red oak

Or by their acorns these two oaks can be distinguished as follows:

Cup very flat, saucer-shaped. . . . . Red oak

Cup not so flat, enclosing nearly half the nut. . . . . Black oak

2. Leaves green above, gray-green or yellowish green and scurfy on the lower side; usually with only three lobes. (Found only on Long Island). . . . . Blackjack

"What does he plant who plants a tree?
He plants a friend of sun and sky;
He plants the flag of breezes free;
The shafts of beauty towering high;
He plants a home to heaven anigh,
For song and mother-croon of bird
In hushed and happy twilight heard —
The treble of heaven's harmony —
These things he plants who plants a tree."

HENRY CUYLER BUNNER

"The cattle also are very glad of a great tree,
They chew the cud beneath it while the sun is burning,
And there the panting sheep lie down around their shepherd.

"He that planteth a tree is a servant of God,
He provideth a kindness for many generations,
And faces that he hath not seen shall bless him."

HENRY VAN DYKE

It is better to observe for five minutes and draw for one, than to observe for one and draw for five.

We may make our drawing lesson more interesting by telling the class something about the object which they are to draw, involving in our story facts that will tend to impress upon their minds some of the most salient characteristics of the object. We should encourage the children to discuss the object, drawing out facts from their own observation. Certain kinds of trees, like certain races of people, have a general similarity, yet every single tree has an individuality of its own.

Let us apply a few essential questions that will help us to determine at least the kind of tree it is, the race to which it belongs; for first we must get its general character, seeing its big proportions and shape; and later must search for its individualities.

Is it tall for its greatest width?

How far does the trunk extend before dividing?

At what height do the lowest branches begin?

What is their general direction?

Do they appear to radiate from the trunk?

How do the main branches compare in size with the trunk?

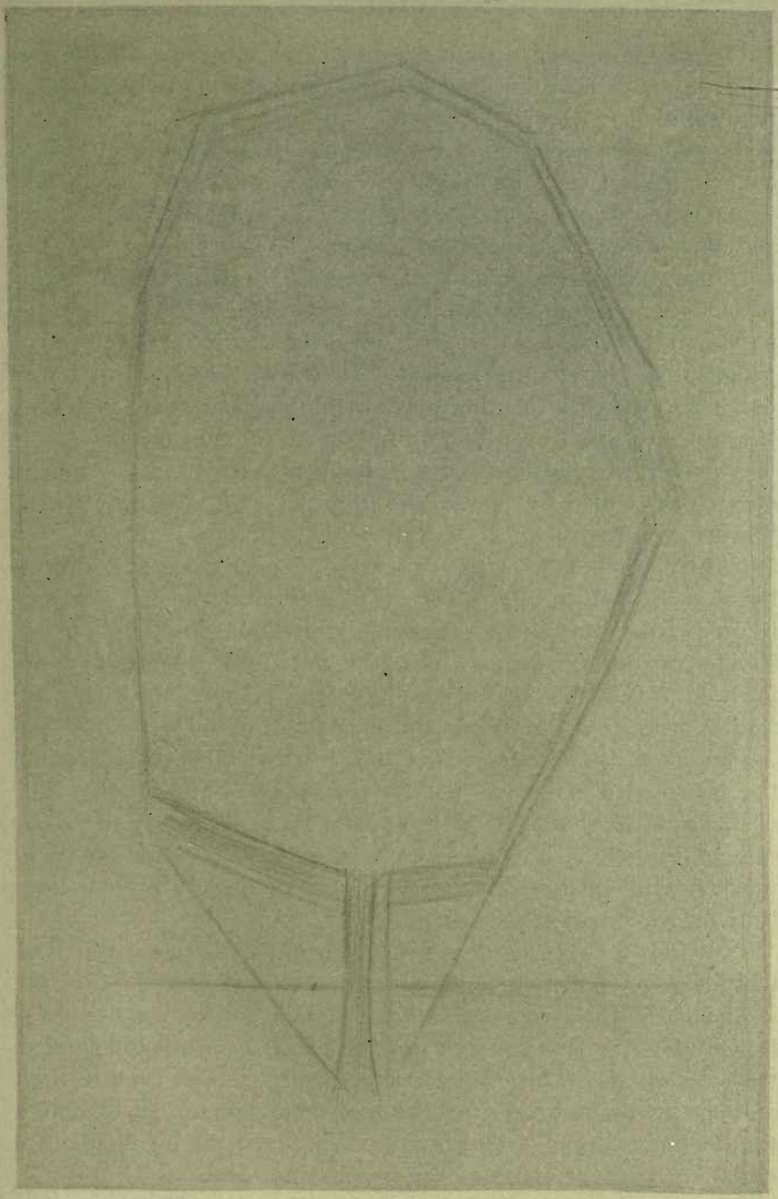
Are they crooked or straight?

The manner of branch growth must be studied carefully.

We see in our elm (Fig. 34) that the trunk divides at about a fourth of its height into several main branches, while in the cases of the pepperidge (Fig. 29) the trunk extends to the very top of the tree, the branches being small in proportion to the trunk, not varying much in size, and taking an oblique downward direction. Notice the weird expression of these trees with their crookedly bent tops, one side of each trunk being almost devoid of branches.

The trunk of the sassafras (Fig. 30) continues nearly to the top of this tree, while the large branches, though unsymmetrical, give it a well balanced appearance.

Again in our picture of the thorn-apple (Fig. 31), we are at once impressed with its irregular form, the branches on the left taking a more oblique direction than those of the other side, the trunk dividing a little short of half the height of the tree.



35. *Blocking-in the elm tree (Fig. 34). The first work which the artist does when he draws the tree.*

We may now take up our lesson. Our subject is an elm tree (Fig. 34); our medium, lead pencil; our drawing to be rendered in outline.

Material.—Almost any good drawing paper, white or buff in color, will answer our purpose: 9x12 is a good size. Our pencil should be of medium grade lead (F. or HB.) of any standard make, Kohinoor preferred.

If procurable, we should have a light drawing board 17x22 inches (here is an opportunity for the carpenters) to place the paper on, otherwise a very stiff piece of cardboard; or a large geography book might answer. It is best, however, to fasten our paper, which we cannot do in using the book. For fastening the paper we shall need four thumb tacks for the corners.

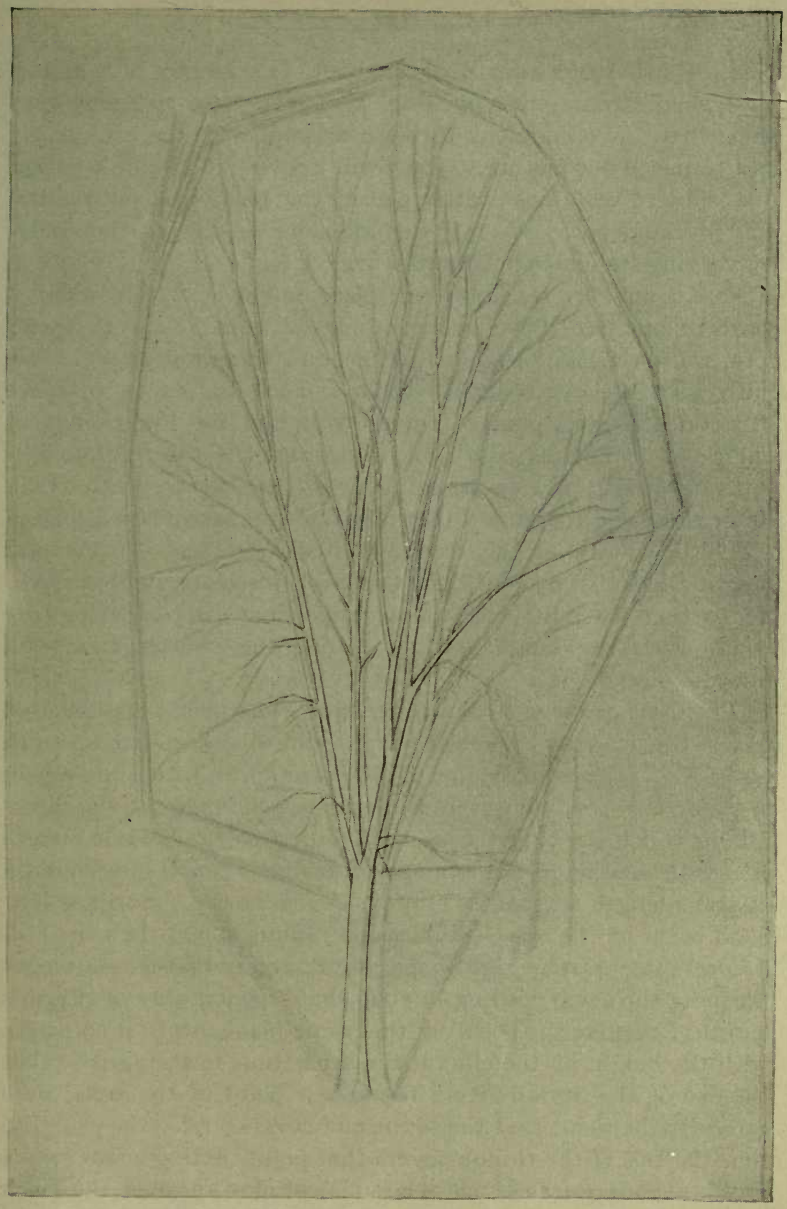
A Faber or multipex pencil eraser is needed; also a sponge eraser with which to remove the light lines and clean the drawing before lining it in.

Our position.—Our point of view will depend upon our subject, but it is not well to be so near as to necessitate raising the head in order to see the top of the tree. If we take longer than one sitting for our drawing (which I do not think advisable, as we must not choose too complicated a subject) we must mark our position in order to again obtain the same point of view.

Position of the drawing-board.—Our paper must be placed on the board with its edges parallel to those of the board. The drawing-board should be held perpendicular, or nearly so, to the direction in which it is seen, for if the board is tilted far backward, it will be fore-shortened and our tree probably will have been drawn longer than it should be.

How to look.—The tendency of the beginner is to see and draw too much in detail. It is most essential that we look first for the large shapes, the greatest dimensions; next for the smaller ones; last for detail. It is not well for the pupils to work too close to their drawings. They should occasionally sit well back in their seats or get up and stand behind their chairs in order to obtain the general effect of their drawing, to see that the big shapes are right and that the spirit of the tree has not been lost.

As an aid to placing our drawing so as to best fill the space it has to occupy, we may use what the French call a "*cherche-motif*," the English, a finder. This is nothing more than a small



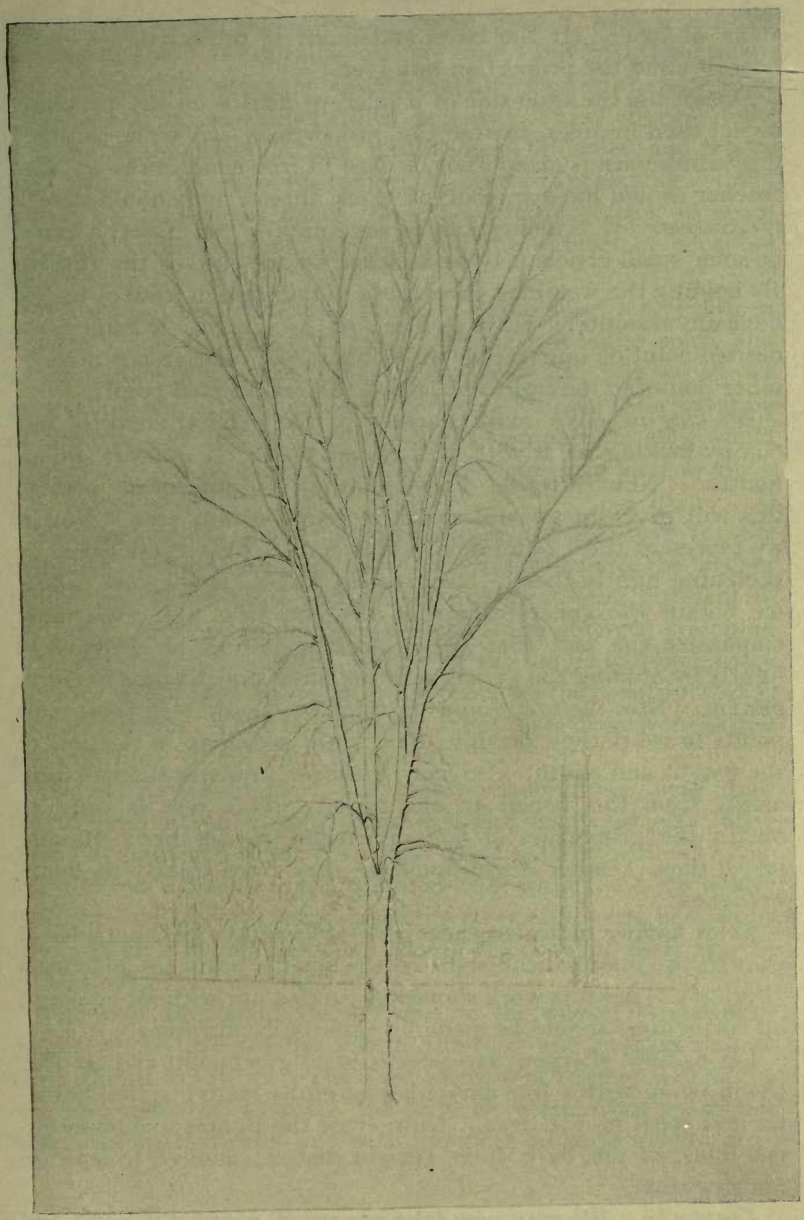
36. *Working in the details with sharp lines. The original pencil sketch is not followed exactly.*

piece of stiff paper or cardboard, about 5x8 inches, in which is cut a small rectangular opening ¾x1 inch; the size may vary somewhat. We may look through this opening, the card acting as a frame to our picture. This will help us to decide whether our subject will look better placed the horizontal or vertical way of the paper. We may include more or less in the finder by varying its distance from the eye.

Now, I am sure we would not place ourselves within a dozen yards of our tree if we wished to get its general effect; therefore, we must have plenty of foreground in our drawing. We must give the eye a chance to look, allowing plenty of space between the lowest point of our drawing and the lower edge of our paper. We must also avoid crowding it to the right or left.

As the height of tree we are to draw (Fig. 34) is greater than its greatest width, we find that it will fill the space best if placed the vertical way of the paper. After indicating the extreme height and width by four light marks, before carrying the drawing further we must test these proportions by comparing the width with the height, always testing the shorter dimension into the longer, viz.:

To test the drawing.—Close one eye. The pencil may be used to test the drawing by holding it in front of one at arm's length (as in Fig. 33) perpendicular to the direction in which the object is seen; also revolving it in a plane perpendicular to the direction in which the object is seen, in order to compare one dimension with another. For example, hold your pencil horizontally at arm's length so that its blunt end covers the outermost left-hand point of the elm. Slide your thumb along the pencil till it covers the extreme right-hand point; retain that measurement (keeping the same position in your chair, pencil always at arm's length); revolve the pencil in the same plane until it coincides with the height of the elm, at the same time lowering it so that the end of the thumb covers the lowest point of the tree; note carefully the point that the blunt end covers; raise the pencil so that the end of the thumb covers that point, noting again where the blunt end occurs and notice how many times, and over, the width goes into the height. In our elm (Fig. 34) we find that the width goes about once and six-sevenths, into the height, or a little



37. *The outline drawing complete, and the first pencil marks erased.*

short of twice. If the latter statement is preferred, we must bear in mind the proportion left over.

Do not use the scale side of a ruler or marks on the pencil or object used in order to test the proportions. A scale or other mechanical means should not be used in free-hand drawing. The teacher should have a spool of black thread and should give a piece about 2 ft. 6 inches long to each pupil. An eraser, a knife, or some small article may be attached to one end of the thread. By holding the weighted thread as a plumb-line in front of us, we have an absolutely vertical line; so by having it intersect a desired point of our tree we may obtain the relative positions of other points to the right and left of this intersected point.

Blocking-in.—We may conceive of the general shape of our elm by looking at it with half-closed eyes. It appears in silhoutte. Now imagine lines joining its outermost points; this will give the general mass or shape of our tree. Now if we represent these outermost points contained in these lines, by sketching lightly these "blocking-in" lines, as they are called, we obtain the general shape of the elm (Fig. 35). We must emphasize the fact that these blocking-in lines be sketched in lightly by holding the pencil near the blunt end, using a free-arm motion. Now before going farther we again test these new points to see if they occupy their right positions in relation to the height and width. Do not, however, transfer the measurements from the pencil to the paper. This test is only to obtain the proportion of one dimension to another. Having tested these smaller dimensions we may draw lightly the main branches.

After having indicated their general direction and character of growth, we may indicate some of the smaller branches and twigs (Fig. 36). All this work should be carried out without erasing; all corrections should be made by slightly darker lines.

Let us now sharpen our pencils to a good point and go over the drawing with a fine dark line, carefully studying the character and spirit of the tree. Now erase the lighter and superfluous lines, as the dark lines remain distinct enough to indicate our drawing.

Lining-in.—We may now take our pencil nearer the point and

proceed to line-in the drawing, going over it with a definite consistent line. If desirable, we may accent and bring out certain parts of the tree stronger than others by darker or shade lines and short strong markings called accents. These are especially effective at the junction and underside of branches, and where one wishes to give the object a nearer appearance. We should be cautious in using them, however; but lack of space does not permit further discussion of the subject of accented outlines.

We should also allow the pupils to make short ten or fifteen minute "time sketches" of trees. In these, it is the spirit and general effect of the tree that we must strive for. Above all, we must allow our little draughtsman to give his own interpretation of the tree. A helpful suggestion as to proportion, etc., would be in place, but we must allow his individuality to have as much play as possible.

The suggestions given on these pages are necessary for the beginner. Some of them are hard facts; but it lies with the teacher to develop the æsthetic and artistic qualities lying dormant in the pupil, ready to be moulded and started in the right direction.

If you have confined the pupils to the flat copy, break away from it; allow them to create. Let them see the beautiful things all about them. They will respond. Let them draw from nature and still life. Train them to observe.

The early summer days, just before school closes, with their bright sunlight and strong shadows, make many subjects interesting as light-and-shade drawings. Fall with its brilliant coloring gives us a chance to use the color-box, while the early winter twilights will bring many an interesting silhouette before our boys and girls, which next day during the drawing hour may be carried out in pen and ink.

The most successful teacher will be the one of sympathetic nature whose love reaches out to the boys and girls, as well as to all things beautiful. The most successful teacher will be the one who endeavors to place the children where they may view nature sympathetically and with the most intimate relationship.

These leaflets are designed to suggest means and methods by which teachers may interest children in nature-study. The ultimate object of our work is to inculcate a love for country life, and this can best be done by interesting the coming generation in country things. The teacher will also find nature-study to be directly valuable as a means of education, or training the mind of the child. We want your full co-operation and your unreserved criticism. Any communication which you may send to us will receive prompt and direct attention :

The following leaflets have been issued to aid teachers in the public schools in presenting nature-study subjects to the scholars at odd times :

1. *How a squash plant gets out of the seed.*
2. *How a candle burns.*
3. *Four apple twigs.*
4. *A children's garden. For the pupils.*
5. *Some tent-makers.*
6. *What is nature-study?*
7. *Hints on making collections of insects.*
8. *The leaves and acorns of our common oaks.*
9. *The life-history of the toad.*
10. *The birds and I.*
11. *Life in an aquarium.*
12. *How the trees look in winter.*

Bulletin 159 gives a general review of the Cornell Agricultural Extension Work.

These will be sent free to all engaged in teaching in the public schools of the State of New York.

Address,

Bureau of Nature-Study,

College of Agriculture,

Ithaca, N. Y.

TEACHER'S LEAFLETS

FOR USE IN THE PUBLIC SCHOOLS

PREPARED BY

THE COLLEGE OF AGRICULTURE,
CORNEL UNIVERSITY,
ITHACA, N. Y.

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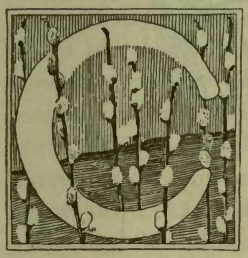
NO. 13.

FEBRUARY, 1899.

I. P. ROBERTS, DIRECTOR.

Evergreens, and How They Shed Their Leaves.

BY H. P. GOULD.



ONE-BEARING evergreens are familiar to everyone; yet this familiarity is usually with the trees as entire objects. We do not often stop to analyze a tree in order to find out what gives it its characteristic appearance or to see what makes it look as it does.

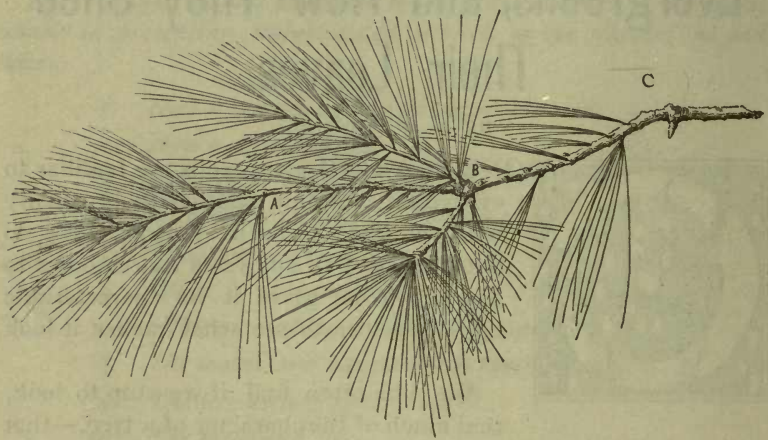
We will often find, if we stop to look, that much of the character of a tree,—that is, its general appearance or the way in which it impresses us,—is due to the leaves and to their arrangement on the branches. This is true of many of the evergreen trees.

Note to the teacher.—This leaflet has two particular objects: to teach how evergreens shed their leaves, and to enable you to distinguish a few of the evergreens which are most commonly met. These studies (and those suggested in Leaflet No. 12) should be the means of adding much cheer to the winter. Encourage pupils to make collections of cones, to observe when they shed their seeds, and how long (how many seasons) they remain attached to the branch. Remember that mere identification of the kinds of trees is not the highest type of nature-study.

Cones are good subjects for free-hand drawing. Beginners should draw them in outline, omitting the shading. Encourage pupils to draw single leaf-clusters of the different pines, cautioning them to get the right number of leaves in each case.

Why are certain kinds of trees called evergreen, in distinction from those which are said to be deciduous? The reason is obvious. One kind is always green from the presence of foliage, while the other sheds all of its leaves every season. The evergreen trees, like the pines and the spruces and firs, always appear to be well covered with foliage, so it does not often occur to us that these trees shed their leaves. And yet perhaps we can recall happy hours when we used to play beneath some large pine tree where the ground was carpeted with pine "needles."

The falling of the leaves of the maple trees or the oaks is a



38. *Shoot of the common white pine, one-third natural size.*

familiar sight, but who has seen the spruce leaves fall, and who can tell when the pine needles drop?

That the evergreen trees do shed their foliage, as truly as the maples and the elms do, we will not question, for we can see the fallen leaves under any tree. Look up into the top of a spruce or pine. See that the interior is bare of foliage. The leaves are towards the ends of the branches, where they receive sunlight. Yet the branches which are now on the interior once bore leaves, for we can see the leaf-scars.

It will be interesting to find out something about the leaves of our common evergreens. Let us look at some of them.

The white pine.

In Fig. 38 is shown a white pine branch. Notice that the leaves are borne in bunches or clusters of five. Each bunch of leaves is produced in the axil (or angle) of a minute scale-like body, but this scale cannot usually be found except on the very young growth. It has been worn away or broken from the older growth by the wind and the rain and the other forces of nature.

Another strange fact should attract our attention. The leaves of the maples and other deciduous trees are borne only on the present season's growth; but this is not the case in the pines, and kindred trees. If we trace back the growth of the past two or three years, we shall find that there are as many leaves on the wood that is two years old as there are on the last season's growth; and in many cases we can find leaves on the part of the branch that is three years old. This means that the pine leaves or needles are two and sometimes three years old when they fall. The Fig. 38 shows the falling of the leaves from the different years' growth. The part of the branch between the tip and A is the last season's growth; between A and B it is two years old; the part between B and C is three years old. The part that grew four seasons ago—beyond C— has no leaves.

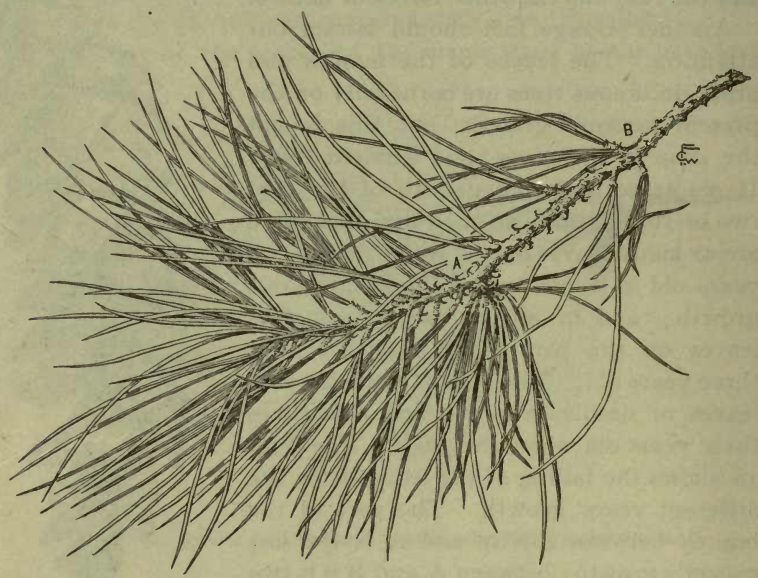
39. *Cone of white pine. It has shed its seeds. Half natural size.*

The different season's growth is not indicated by distinct "rings" as in the case of deciduous trees (See Leaflet No. 3), but by the branching. Each whorl of branches about a limb represents the end of a season's growth. A young pine tree, or the younger limbs of an old tree, show this character very plainly.

Do the leaves of the pines and of the other evergreen trees fall at the end of the growing season, as the leaves of most of the deciduous trees do? Or do they gradually become lifeless and fall at any season, from the force of the wind and other forces of

nature? Tie a large sheet of cloth in the top of some evergreen tree, in such a way as to form a receptacle to catch the leaves. Do you catch leaves in winter as well as in summer?

There are several different kinds of pines, so we must picture carefully in our minds the foliage of the white pine, for it is different from that of any others. The leaves are soft and very slender, and from three to four inches long. The base of each cluster of leaves is at first surrounded by a small sheath-like



40. *Shoot of common pitch pine. One-half natural size.*

body, but this falls away when the leaves are still very young. A scar is left when the leaves drop and these scars can often be seen on parts of the branches that are eight or ten years old. Do the leaves of other kinds of trees make a scar when they fall?

The white pine cones, in which the seeds are borne, are conspicuous objects. They are five or six inches long and slightly curved. It will be interesting to find out if the seeds ripen the same year in which they are formed. Perhaps a cone still containing seeds can be obtained. Carefully tear it apart and see where the seeds are attached. Red squirrels sometimes eat the pine seeds. A white pine cone, which has shed its seeds, is shown in Fig. 39.

This kind of pine is found widely scattered in New England, New York and westward to Minnesota and Iowa and along the Allegheny Mountains as far south as Georgia ; also in some parts of Canada. It is a valuable lumber tree.

The pitch pine.

This kind of pine is very different, in many respects, from the white pine. Let us find some of the differences. Instead of having leaves in bunches of five, it has them in clusters of three, and the base of each cluster is inclosed by a scaly sheath which does not fall away as in case of the white pine ; neither does the little scale-like body upon the branch, in the axil of which the leaf-cluster is borne, fall away, but it may be found just below the leaf, and even on branches that are several years old. Sometimes a sheath is found with only two leaves. We shall want to know, too, how old the leaves are when they fall. Do they remain on the tree longer than the white pine leaves do?

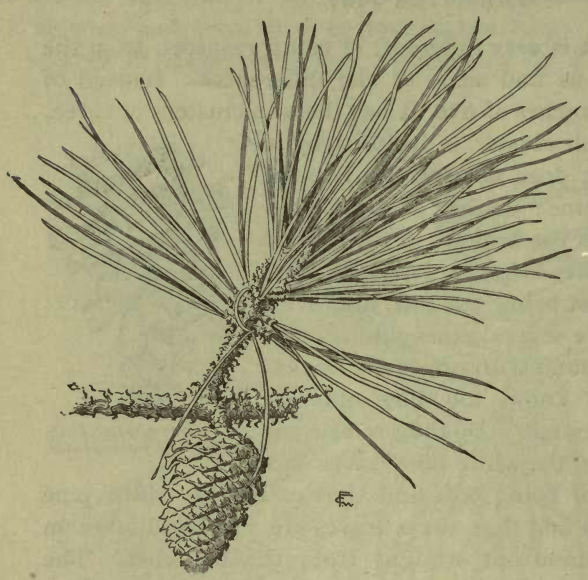
41. *Cone of pitch pine. One-half natural size.*

Again, instead of being soft and slender as the white pine leaves are, we shall find that these leaves are rigid and large in comparison, and stand out straight from the branches. The shape of the leaves is also distinct from the white pine needles. See if you can find any other differences.

A pitch pine branch is shown in Fig. 40. The part between the tip and A is the past season's growth. Observe the foliage on the part that is two years old. Part of it has fallen. We often find it on growth which is older than this ; but in this specimen there are no leaves on the three-year wood.

The cone of the pitch pine is very unlike that of the white pine. Fig. 41 gives a good idea of one which has shed its seeds. Compare this with Fig. 39 ; or, better, examine the two kinds of cones side by side. The pitch pine cones are sometimes borne in clusters of two or more and they persist,—that is, remain on the tree for several years after the seeds have ripened and scattered.

Notice how the new cones are borne with reference to last season's growth. Are they attached to the tip of a branchlet? Or are they closely attached to the side of a branch? Figs. 42 and 43 will help us answer this question. The little cones in Fig. 43, near the tip of the twig, are just beginning to form.



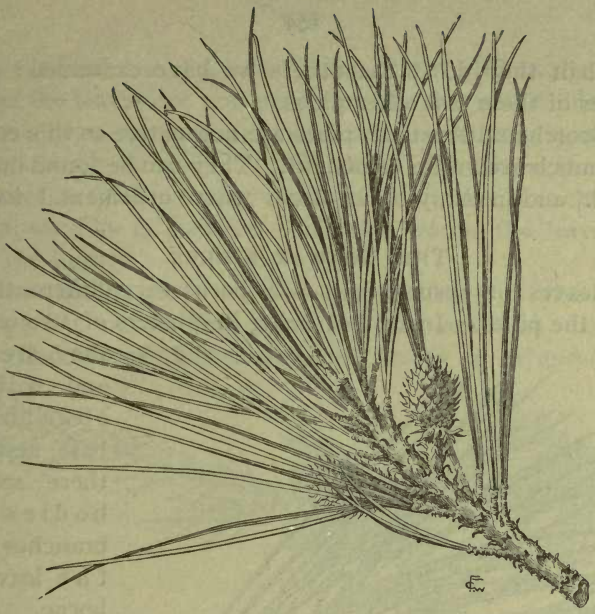
42. *Pitch pine. One-third natural size.*

The pitch pine usually grows in sandy or rocky soil and is found in the United States along the Atlantic coast to Virginia, along the mountains to Georgia, westward to Western New York, Eastern Ohio, Kentucky and Eastern Tennessee. It has little value as timber, because it does not grow large enough.

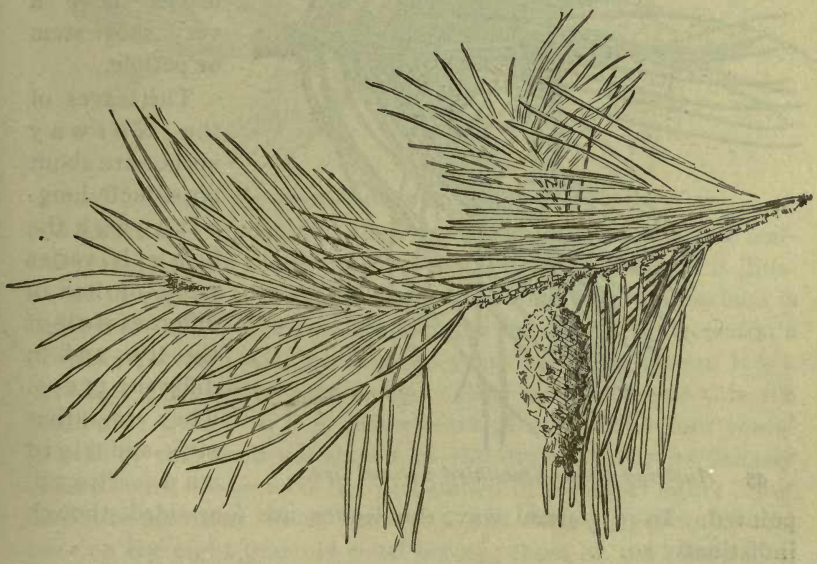
Scotch and Austrian pines.

In the same manner, other pines may be studied. Fig. 44 shows a cone and bit of foliage of the Scotch pine, and Fig. 45 the Austrian pine. These cones grew the past season and are not yet mature. After they ripen and shed the seeds which they contain, they will look something like the cone in Fig. 41. The Scotch pine has short and blue-green needles. The Austrian pine is coarser, and has long dark-green needles.

There are but two leaves in a cluster on these kinds of pines and we shall find that the sheath which incloses the base of the leaf-cluster is more conspicuous than in either the white or pitch pines. Do the leaves persist in the Scotch and Austrian pines



43. *Pitch pine, showing young cones. Half natural size.*



44. *Scotch pine. Half natural size.*

longer than they do in the others we have examined? Study the cones of these and other pines.

The Scotch and Austrian pines are not native to this country, but are much grown for ornament. They can be found in almost any park, and in many other places where ornamental trees are grown.

The Norway spruce.

The leaves of spruce trees are borne very differently from those of the pines. Instead of being in clusters of two or more, they are single and without a sheath at the base; neither are there scale-like bodies on the branches where the leaves are borne. Notice, too, that the leaves have a very short stem or petiole.

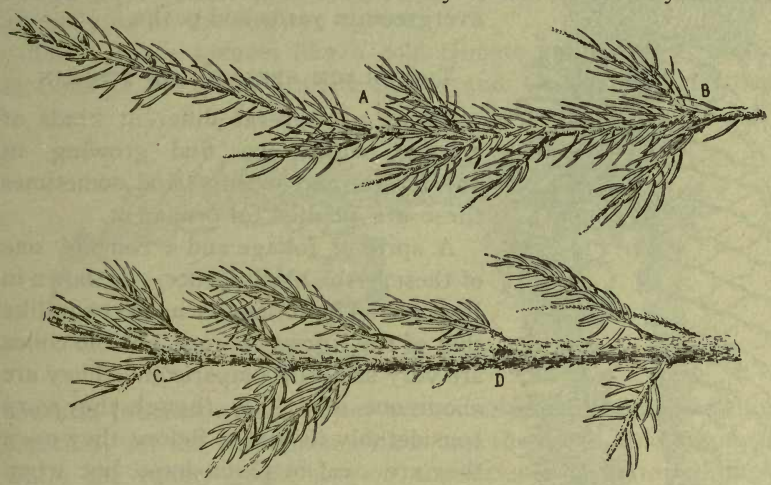
45. *Austrian pine. One-third natural size.*

The leaves of the Norway spruce are about one inch long, although the length varies more or less in different parts of the tree and in different trees. They are rather stiff and rigid and sharp-pointed. In a general way, the leaves are four-sided, though indistinctly so.

It will be interesting to study the position which the leaves

take on the branches. A hasty glance might give us the impression that the leaves are not produced on the under side of the branches; but a more careful examination will convince us that there are nearly as many on the under side as on the upper. The leaves are all pointing outward from the branch and as nearly upward as is possible. In other words, the leaves grow toward the light.

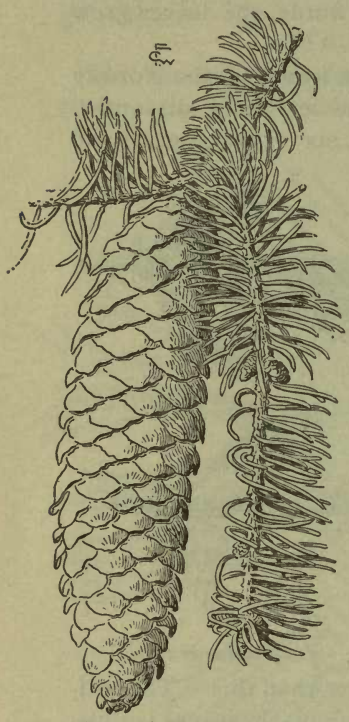
We must not forget to see how long the leaves of the Norway spruce persist and to find out when the leaf-scars disappear. We can find leaves that must surely be six or seven years old



46. *Twig of the common Norway spruce. Half natural size.*

and sometimes we can find them even older than this. The leaf-scars, too, remain a long time. The falling of the leaves is illustrated in Fig. 46. It shows the extremities of a limb which is eight years old. The part between the tip and A is last season's growth; between A and B it is two years old; and beyond B is a part that grew three seasons ago. The section beyond C is six years old; from C to D is seven years of age. The four years' growth of this limb not shown in the drawing was as densely covered with foliage as is the part shown in the upper figure; but there are not many leaves between C and D (seven years old) and none on the eight-year-old wood (except those on the branchlets, and these are younger.)

The cone of the Norway spruce is nearly as long as that of the white pine, but it is not so rough and coarse as the white pine cone is. The cones are usually borne on the tips of small branchlets, although occasionally one is found borne in the manner shown in Fig. 47. The cones usually fall the first winter.



47. *Cone of Norway spruce. Half size.*

The Norway spruce is not a native of this country, but, like the Scotch and Austrian pines, it was introduced from Europe and is grown very widely as an ornamental tree. It is the commonest evergreen in yards and parks.

The black spruce and its kin.

There are several different kinds of spruces which we find growing in our forests and swamps, and sometimes these are planted for ornament.

A sprig of foliage and a cone of one of these,—the black spruce,—is shown in Fig. 48. The foliage is not very unlike that of the Norway spruce, but the cones are very small in comparison. They are about one inch long, though they vary considerably in size. Before they open they are oval or plum-shape, but when mature and the scales of the cone have expanded, they are nearly globular. They are often borne in clusters, as well as singly, and persist for many years after the seeds have fallen. The position of the cones will depend upon their age. When young, they point upward, but they gradually turn downward.

The white spruce resembles the black very closely in general appearance. The leaves of the white spruce have a whitish or dusty looking tinge of color and when crushed or bruised, give forth a peculiar disagreeable odor. The cones vary in length from an inch to two inches, and in shape are more cylindrical or finger-shaped than the cone of the black spruce.

The foliage of the red spruce lacks the whitish tinge of color of the white spruce and the cones, which are from one inch to two inches in length, are obovate in shape — that is, the widest place is through the upper part of the cone, and from this point it gradually tapers to the tip. They seldom persist longer than the second summer.

The leaves of all these different kinds of spruces vary greatly in length, thickness and sharpness of point, according to the part of the tree on which they grow, and their surroundings. The shedding of the leaves on these or other spruces can be determined as easily as in the Norway spruce.

These three spruces like a cold climate and grow in many sections of northern United States and Canada and farther

48. *Black spruce. Half natural size.*

south in the mountains. They are sometimes all found growing together, but the black spruce likes best the damp, cold swamps, while the others grow best on the drier and better drained lands. The black spruce is commonest. The red spruce is least known.

The balsam fir.

This is another evergreen tree which grows naturally in the cold, damp grounds of the northern United States and Canada, and to some extent in the eastern states as far south as West Virginia.

The foliage is borne in much the same manner as that of the spruces; yet there are interesting differences in the characters of these two kinds of leaves. Perhaps the most noticeable difference is in the shape; and the color of the fir leaves will attract our attention because the under side is a silvery color, while the upper side is green. What is the nature of the tip of the leaf? and how does

it compare with the pines and spruces in this respect? Does the leaf have a stem or petiole? or is it attached directly to the branches without any stem? How are the leaves shed?

The cones are about three inches long and present a rather delicate appearance. It will be interesting to determine the position of the cones, that is, the direction in which they point, and to learn if it is the same when they are young that it is after they have matured.

The grayish colored bark of the trunk and limbs bears many "blisters" from which Canada balsam is obtained.

The hemlock.

A hemlock twig is an interesting object. It may have many characters in common with the spruce and fir, yet the impression which we get from it, or from a large hemlock tree, is entirely distinct. The arrangement of the leaves and the gracefulness of the drooping branchlets are most pleasing. We are lead to examine it more closely. We notice that the leaves appear to be borne in two more or less regular rows,—one on each side of the branch or twig; but in reality they come from all sides of the branch, and it is the position which the leaves assume that gives this two-rowed appearance.

The leaves have a short petiole or stem, and this stem rests along the side of the branchlet in such a direction that the leaves are placed in single rows on either side of the branch. The petioles of the leaves are nearly parallel with the branch while the leaves often make a decided angle with the petiole. This fact can best be brought out by carefully examining a small twig.

While we are noting the arrangement of the leaves on the branchlets, we should also take notice of the points of similarity and difference between these leaves and the spruces and firs. We shall find that there is more in common, at least so far as shape and color are concerned, between the hemlock and fir than between the hemlock and spruce.

The small delicate cones, borne on the tips of the branchlets, will also attract our attention (Fig. 49.) We may wonder at their small size, for they are only about three-quarters of an inch long, and very delicate, yet a second glance at the tree will impress us with

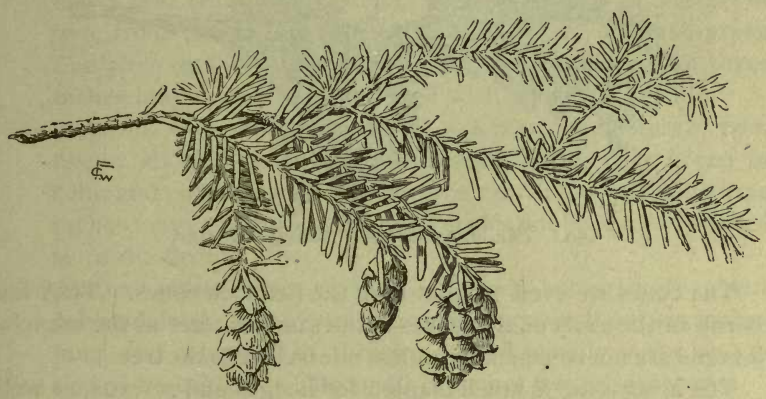
the number of cones which the tree bears: and we conclude that, although the cones may be small, yet there are so many of them that there will be no lack of seeds.

It is more difficult to trace the age of a hemlock limb than of many other kinds of trees, yet we can easily determine that many of the leaves are several years old when they fall.

The bark of the hemlock is used in tanning leather. The tree is much used for lumber. Where does it grow?

THE ARBOR-VITÆ.

One might almost wonder, at first sight, if the arbor-vitæ (often, but wrongly, called white cedar) has any leaves at all.



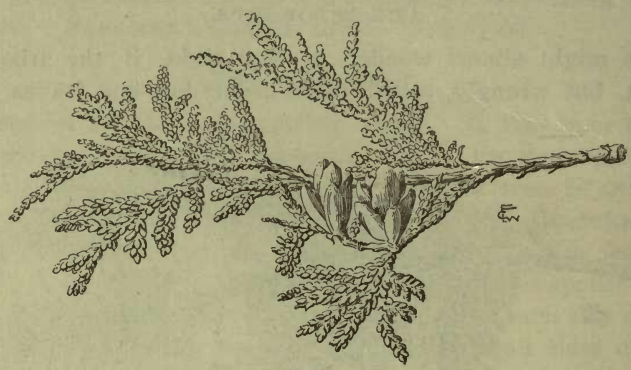
49. *Spray of the hemlock. Two-thirds natural size.*

It does possess them, however, but they are very different in size and shape from any of the others which we have examined. They are small scale-like bodies, closely pressed together along the sides of the branchlets, in four rows. Leaves pressed to the branches in this manner are said to be "appressed." The leaves of the arbor-vitæ are so close together that they overlap one another. The leaves are of two distinct shapes, sometimes known as the surface leaves and the flank leaves. The former are located on what appears to be the flattened surface of the branchlets, while the latter are on the sides or edges. See Fig. 50.

If we carefully look at the leaves, we shall notice a raised spot

near the point or tip. This is said to be a resin gland. This gland can be seen more plainly on the surface leaves that are two years old.

Most of the leaves persist for at least two and sometimes three years; but even older ones can be found. These older leaves, however, do not exist as green active leaves, but merely as dried up and lifeless scales. These lifeless leaves, are probably detached from the branches by the forces of nature.



50. *The Arbor-vitae. Nearly full size.*

The cones are even smaller than the hemlock cones. They are borne in the axils of the leaves in the same manner as the branchlets and are not conspicuous unless one is close to the tree.

The arbor-vitæ is much planted for hedges and screens, as well as for other ornamental purposes. There are many horticultural varieties. The tree is abundant in a wild state in New York.

Summary on the Kinds of Common Evergreens.

The white pine (Pinus Strobus).—Leaves in clusters of five, soft and slender; cones five or six inches long, slightly curved; bark smooth except on the trunks and larger limbs of old trees, where it is fissured.

The pitch pine (Pinus rigida).—Leaves in clusters of three, from three to four inches long, rather rigid; cones two to three inches long, often in clusters of two or more but frequently borne singly, persisting long after the seeds have been shed; bark more or less rough on the young growth and deeply fissured on the trunks of old trees.

The Scotch pine (Pinus sylvestris).—Leaves usually in clusters of two, from two to four inches long, rigid, of a bluish-green hue when seen in a large mass on the tree; cones two to three inches long and the scales tipped with a beak or prickle.

The Austrian pine (Pinus Austriaca).—Leaves in clusters of two, five or six inches long and somewhat rigid, dark green in color and persisting for four or five years; cones about three inches long, conical in shape and scales not beaked or pointed as in the Scotch pine.

The Norway spruce (Picea excelsa).—Leaves borne singly, about one inch long, dark green, four sided; cones about six inches long, and composed of thin scales, and usually borne on the tips of branchlets. The small branches mostly drooping.

The black spruce (Picea nigra).—In general appearance, this is not very unlike the Norway spruce, but the small branches stand out more horizontally and the cones are only one or one and one-half inches long, recurving on short branches. The cones persist for several years after shedding the seed.

The white spruce (Picea alba).—Leaves about one inch long, having a glaucous or whitish tinge; twigs stout and rigid, of a pale greenish white color; cones from one to two and one-half inches long, more or less cylindrical or "finger-shape," and easily crushed when dry.

The red spruce (Picea rubra).—The foliage lacks the whitish tinge of the white pruce and is of a dark or dark yellowish color; twigs stouter than those of the black spruce and not

so much inclined to droop; cones about one inch long, obovate and usually falling by second summer.

The hemlock (Tsuga Canadensis).—Leaves about one-half inch long, flat with rounded point, green on the upper side, whitish beneath, and borne on short appressed petioles; cones about three-quarters of an inch long, oval or egg-shape, and borne on the ends of small branchlets and often persisting for some time.

The balsam fir (Abies balsamea).—Leaves narrow, less than one inch long, borne singly, very numerous and standing out from the branchlets in much the way of the spruce; cones about three inches long, cylindrical, composed of thin scales and standing upright on the branches, or recurved; bark smooth, light green with whitish tinge.

The arbor-vitæ (Thuya occidentalis).—Leaves very small, scale-like and over lapping one another in four rows, adhering closely to the branchlets; the cones oblong and small,—a half inch or less in length,—and composed of but few scales.

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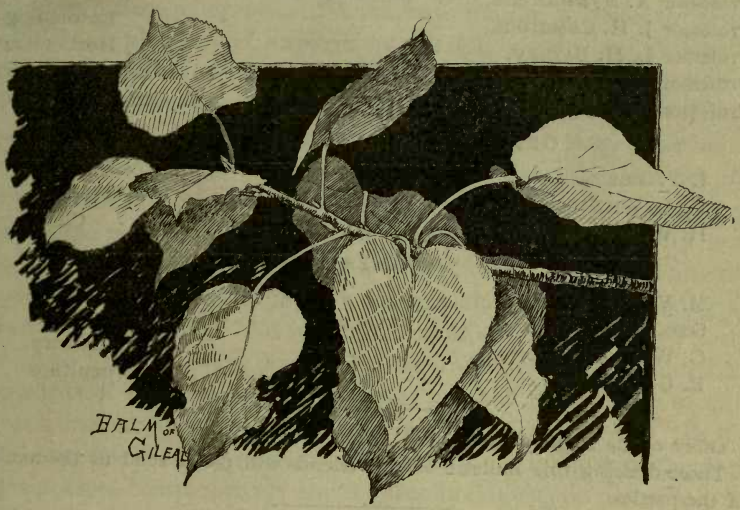
Bulletin 68. August, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

The Cultivated Poplars;

WITH REMARKS UPON THE PLANTING OF GROUNDS.



By L. H. BAILEY.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.

THE CULTIVATED POPLARS.

I. GENERAL REMARKS.

There has been little attempt in experiment station literature to discuss matters of ornamental gardening. The so-called practical problems connecting directly with bread-winning have necessarily and properly absorbed the energies of investigators. But the ornamentation of rural and suburban homes is quite as much within the province of experiment station work; and it should also be remembered that the growing of plants is itself an industry which enlists a vast amount of capital, and this nursery business has received little direct and explicit aid from experiment station publications. The present essay is undertaken for the double purpose of explaining certain fundamental principles in landscape gardening—a subject to which the poplars readily lend themselves—and of unraveling a web of difficulties respecting the species and varieties of poplars, into which the nursery catalogues seem to have fallen. An investigation of the botanical and horticultural features of the poplars has been assiduously prosecuted for upwards of two years, and the writer has had the free use of various nurseries and plantations in Western New York and the aid of botanists in many parts of the country. As a group, the poplars possess comparatively small value in landscape planting, but this very fact affords me the opportunity I seek to press home the fallacy of certain common practices amongst planters.

At the outset, I must be allowed to explain that landscape gardening is the embellishment of grounds in such fashion that they shall possess landscape or nature-like effects. This definition at once removes from our consideration all the formal effects of flower-beds and sheared trees, which, while useful at times, bear no closer relation to landscape gardening than a cup of paint bears to the fine art of painting. In other words, a landscape garden—and that should mean every country yard, however small or simple—should have in it the elements of a picture. It should appear to have one thought or feeling running through it all, and this is

a condition which is impossible when trees or bushes or flower-beds are scattered all over the place, for in such case one is attracted by these individual and detached objects and is not particularly impressed with the place as a whole or as a unit. Such a yard is a nursery. An artist would not care to paint such an area. If a yard is to be a picture, it must have a sense of frame-work about it,—certain strong groups of bushes or trees about the borders, and the central area should be a more or less open greensward with very cautious planting. The different parts are then in masses or in bold contrast, and the place has character. At the same time, the partial shutting off of the surrounding areas sets bounds to the place, defines it, and makes it to appear personal, snug and home-like. One should learn that it is not plants which make a place attractive, but the arrangement of plants. In fact, many otherwise attractive places are ruined by a wealth of good plants scattered without purpose over the lawn.

It is but a corollary of this discussion to say that plants which are simply odd or grotesque or unusual should be used with the greatest caution, for they introduce extraneous and jarring effects. They are little in sympathy with a true landscape garden. An artist would not care to paint an evergreen sheared into some grotesque shape. It is too formal and it has no elements of true beauty. It is simply curious, and shows what a man with plenty of time and long pruning shears can accomplish.

This leads me to one of the proper subjects of this paper, the planting of the Lombardy poplar. Fortunately, this tree is less planted in New York than in many western states. Its chief merits to the average planter are the quickness of its growth and the readiness with which it multiplies by cuttings. But in the north it is apt to be a short-lived tree and it suffers from storms, and it has few really useful qualities. It may be used to some advantage in windbreaks for peach orchards and other short-lived plantations, as explained in Bulletin 9 of this station ; but after a few years a screen of Lombardies begins to fail and the habit of suckering from the root adds to its undesirable features. For shade, it has little merit, and for timber none. People like it because it is striking, and this, in an artistic sense, is its gravest fault. It is unlike anything else in our landscape, and does not

fit into our scenery well. The Lombardy should rarely, if ever, be seen as a single specimen ; and above all, its formality and stiffness should not be emphasized by planting it in rows along country roads. A row of Lombardies along a roadside is like a row of exclamation points !

But the tree can often be used to good effect as one factor in a group of trees, where its spire-like shape, towering above the surrounding foliage, may lend a spirited charm to the landscape. It combines well in such groups if it stands in visual nearness to chimneys or other tall formal objects. Then it gives a sort of architectural finish and spirit to a group of trees ; but the effect is generally lessened, if not altogether spoiled, if more than one Lombardy is in view. One or two specimens may often be used to give vigor to heavy plantations about low buildings, and the effect is generally best if they are seen beyond or at the rear of the building. Now and then one

Attractive Group of Lombardy Poplars.

sees a picturesque clump of Lombardies standing alone, like that shown upon page 207. Here the one original tree has given rise to a varied progeny of sprouts, and the mass has a freeness of outline which can never be obtained in a regularly planted clump of these trees from which the suckers are continually removed. This particular clump is one of the most picturesque objects in a sweeping landscape near Perry City, Schuyler County, N. Y., but its excellence is purely accidental.

Another feature of common ornamental planting which is well illustrated in the use of poplars, is the desire for plants simply because they grow rapidly. A very rapid-growing tree nearly always produces cheap effects. This is well illustrated in the common planting of willows and poplars about summer places on lake shores. Their effect is almost wholly one of cheapness and temporariness. There is little that suggests strength or durability in willows and poplars, and for this reason they should always be used as minor or secondary features in ornamental or home grounds. Where quick results are desired, nothing is better to plant than these trees, but better trees, like maples, oaks, or elms, should be planted with them and the poplars and willows should be removed as fast as the other species begin to afford protection. When the plantation finally assumes its permanent characters, a few of the remaining poplars and willows, judiciously left, may afford very excellent effects ; but no one who has an artist's feeling would be content to construct the frame work of his place of these rapid-growing and soft-wooded trees.

I have said that the legitimate use of poplars in ornamental grounds is the production of minor or secondary effects. As a rule, they are less adapted to isolated planting as specimen trees than to use in composition,—that is, as parts of general groups of trees, where their characters will serve to break the monotony of heavier foliage. The poplars are gay trees, as a rule, especially those, like the aspens, which have a trembling foliage. Their leaves are bright and the tops are thin. A few of them in judicious positions give a place a sprightly air. I especially love the common aspen or *Populus tremuloides* of our woods (Fig. 14). Its light dancing foliage and silver-gray limbs always cheer me, and its autumn color is one of the purest golden-yellows of our land-

scapes. I like to see a tree of it standing out in front of a group of maples or evergreens. Its whole attitude is then one of familiarity.

The cottonwood is perhaps the best of all our poplars as a single specimen. It makes a noble tree, spreading its gray branches far and wide. But like the aspen, it is cheerful and restive. One is not moved to lie under it, as he is under a maple or an oak. Its leaves rustle with the lightest movement of air. The ripple of its foliage always recalls to my mind the play of wavelets upon a pebbly shore. The day is never so dark, but the cottonwood reflects a flood of light.

Some of the forms of the black poplar of Europe are especially satisfactory for the production of lively effects in planting. Of these, I know of none better than the form known to nurserymen as *Populus elegans*. It has a most pleasing light and tremulous foliage, the effect of which is heightened by a twiggy character of growth and a reddish cast to the leaf-stalks and young shoots. It is an elegant tree, and well adapted to planting in front of heavier foliage in the most conspicuous portion of the grounds.

Some of the silver or white-leaved poplars produce the most striking contrasts of foliage, especially if set near darker trees. Bolle's poplar (*Populus Bolleana* of the nurseries) is one of the best of these trees. Its habit is something like that of the Lombardy. The upper surface of the deeply lobed leaves is dark dull green, while the under surface is almost snowy white. Such emphatic trees as this should generally be partially obscured, by planting them in amongst other trees so that they appear to mix with the other foliage, or else they should be seen at some distance. Other varieties of the common white poplar or abele are occasionally useful, although most of them sprout badly and may become a nuisance. But the planting of these immodest trees is so likely to be overdone that I scarcely dare recommend them, although, when skilfully used, they may be made to produce most excellent effects. If any reader has a particular fondness for trees of this class (or any others with woolly-white foliage) and if he has only an ordinary farm-yard to ornament, let him reduce his desires to a single tree, and then if that tree is planted well on the inside of a group of other trees, no harm can result!

There are various weeping and grotesque horticultural varieties of the poplars, as of other trees. Concerning the use of these, I need only say that they are curiosities and that they should not be given prominent positions directly in front of the house. I think that no one will care to dispute me if I say that a person who fills his front yard with such specimens, has little appreciation of natural objects. A few grotesque specimens in positions of secondary importance may be desirable, as in a side or back yard, but one will find that the more he cultivates a love of natural scenery the less he cares for mere monstrosities.

I may seem to have placed myself in the position of writing a bulletin upon a group of trees which, upon the whole, I should be quite as willing to discourage as to augment; but my object has been rather more, as I intimated at the outset, to point out certain common defects in habits of thinking about ornamental trees, and to discourage the use of trees simply because they are odd, quick-growing and cheap. I wish that there were fewer Lombardy poplars in many parts of the country, fewer of the ugly white or silver poplars, and more of the American and European aspens, of the large-toothed aspen, of the cottonwood, and the Russian Certinensis poplar. Many of the species are excellent for covering sand-hills—for which the white poplar is well suited—or rough or waste places, and they are capable of adding much light and cheer to a yard. But planters are too prone to use certain ones over freely.

Poplars are often disagreeable upon the lawn because of the abundance of down or wool which they give to every breeze in May and June, when the seed-pods burst. There is really little occasion for this annoyance, however. The poplars are diœcious, —that is, the male and female flowers are upon different trees (although both sexes are rarely upon the same trees in the cottonwood). Nurserymen, therefore, should grow only the male specimens. The cuttings from a male tree—or one producing no cottony seeds—will give progeny of the same character. Of the Lombardy, there is only the male sex in the country, the female never having been introduced, or at least not distributed, so far as I know; while the weeping willow is represented only by the female plant. Some of the species and varieties are worth plant-

ing for the catkins which are produced so freely in early spring. The European aspen (*Populus Tremula*) is particularly desirable in this respect (Fig. 13); and this species also has a most interesting habit and foliage.

It should be said, in passing, that most of the poplars are hardy trees and thrive in a great variety of trying situations. This, together with the ease of propagation and their cheapness, combined with free and rapid growth, makes them the best of trees for nurse plantations,—that is, for temporary shelter for other trees and bushes. In this respect the common aspen poplar is one of the most valuable of all trees in the reforestation of American lands. It springs up quickly in clearings, and during its comparatively short life holds the soil and protects other vegetation and finally contributes its own substance to the maintenance of the stronger forests. In this manner it has exerted a most powerful effect upon the configuration of our forest areas and upon the fertility of the land from remote time. The same qualities make it valuable, in many instances, in extensive ornamental plantings.

The recent introduction of Russian poplars has added considerable confusion to nursery lists, and it was this fact which first led me to take up this inquiry. The chief merit of the Russian trees is for planting in the northwestern prairie states, but all of them are worth attention for exposed localities in this state, as well as for ornamental planting. I am convinced that the so-called *Populus Certinensis* (properly *P. laurifolia*) is one of the very best trees to plant where quick results are wanted and where some feeling of strength and durability is also desired. The best discussion of these Russian poplars which I know is contained in Bulletin No. 9 of the Minnesota Experiment Station by Professor S. B. Green, published in 1889. The following is a more recent sketch of these trees by the same author, prepared for this occasion:

"*Russian Poplars in the Northwest.*—In the arboretum of the Minnesota Experiment Station are 12 kinds of Russian poplars that were received from the Iowa Agricultural College. Most of them have been grown in our collection for seven years, and some of them have been tried for a much longer period in other parts

of Minnesota, in Iowa and the Dakotas, but not long enough anywhere in this country to warrant final conclusions. Those who live in locations naturally in timber can hardly understand the importance of the genus, to which these trees belong, to the pioneers on the wind swept prairies. The ease with which many of them are increased, their rapidity of growth, great hardiness against extremes of heat and cold, excessive moisture, and prolonged drouth, make them widely sought as pioneer trees in most severe locations, for the formation of wind-breaks and for shade from the scorching sun.

"I would not be understood as recommending the general planting of poplars where our finer deciduous trees readily succeed, but for a strong effect in the shortest time in severe locations they have no rival except the large growing willows, which may generally be used with them to advantage. Among the collection of poplars commonly referred to as of Russian origin, are trees having a great variety in growth and foliage, so that by the judicious use of them alone one can secure very good effects in landscape planting. They are not, however, and never have been, represented as new species, but as hardier forms of species already introduced into this country, and in the following notes I have grouped the kinds under the several heads where they evidently belong, using their nursery or horticultural names. Aside from the few exceptions noted, they are all easily increased from hard wood cuttings made in the fall or spring.

"ANGULATA CLASS—*Young growth plainly marked with ridges or angles.*

Dudley's Populus [properly *P. balsamifera*, var. *viminalis*]. Growth only moderate; when young rather upright in habit, but somewhat pendulous when old. Our older specimens have been badly injured by leaf rust in dry summers, and on this account I have ceased propagating it. The leaves are broadly lanceolate, very wavy on the edges and the young branches very angular.

"*P. betulifolia* is probably the same species as *P. nigra* of the eastern nurseries. It makes a tree that is rather open in habit, inclining to a straight trunk with branches coming out at nearly right angles. The foliage remains bright and fresh even in dry sod land in severe seasons. It is not especially valuable for tim-

ber but is interesting and useful for contrasting with other trees; leaves very thick, very large and broadly deltoid, much larger and broader than leaves of the cottonwood under like conditions.

"*Wobsky Poplar.* One of the most distinct of its class; of rapid growth and open regular habit. As a timber tree it is upright and valuable, but it seems to be more susceptible to the work of the poplar borer than other kinds and it occasionally loses its foliage in dry places. On account of these weaknesses it will not be largely planted in this section, but occasional trees may often be used to give variety. The leaves are large, ovate heart-shaped, stiff and very flat, of a shiny blue-green color on the upper and a light green on the lower side. Buds large and sticky. The young growth is only slightly angular.

"*P. Certinensis* [*P. laurifolia* of botanists] was introduced into this country and disseminated by Arnold Arboretum. It is perhaps the best of the collection for general prairie and ornamental planting in this section; perfectly hardy even in the severest exposures and rarely, if ever, affected with leaf rust which so often checks the growth of the cottonwood. Its timber makes very good siding for buildings and floors, and answers many of the purposes for which pine is generally used. It does not warp or crack like our native cottonwood. It is rather upright in form, with thick leathery leaves and of very rapid growth. It does not grow quite as fast as the native cottonwood nor resist the attacks of the leaf beetle so successfully, but it is a much longer-lived tree and stands close planting very much better. It is grown readily from cuttings, which in our forest plantation made a growth of a trifle aver 12 feet in three years from half-inch cuttings planted eight inches apart in rows eight feet asunder. The leaves are thick and leathery with a wavy edge. The new wood is strongly angular. [The form of leaf is shown in Figs. 7 and 8.]

"The *Populus Petrovski* so closely resembles *P. Certinensis* that I think them one and the same thing. Professor Budd obtaided this in Russia and thinks it different from the latter. If this is true it does not show its characteristics until older than any specimen we have.

"The poplar known as *P. pyramidalis* var. *fastigiata* is evidently the Russian form of the Lombardy, if not the same thing. It has been introduced in the hope that it would prove hardier and longer lived than the common form, but in our experience of some seven years, young trees of either form have never been injured in this vicinity. It may, however, prove to be a longer lived tree than the common Lombardy, which is well known to be quite hardy, even in somewhat severe locations, when young, but to be very short lived on the dry prairies of the Northwest. It is, however, interesting to know that while the common Lombardy poplar is an almost worthless tree in most parts of Minnesota, yet near Duluth and along Lake Superior it is quite a success.

"BALSAMIFERA CLASS.—*With large sticky buds and young growths free from ridges or angles.*

"*Populus balsamifera* of Asia, as we have it, is probably the type of which *P. laurifolia* and *P. Sibirica var. pyramidalis* of horticulturists are but variations. The lamented Chas. Gibb said he saw in the botanical gardens at Kazan a specimen of this two feet in diameter and 50 feet high, and although it resembled *P. Sibirica* when young, it is quite different from it in form when old. Either of the next two kinds are preferable to it for planting, as the leaves of this have an unpleasant way of curling together.

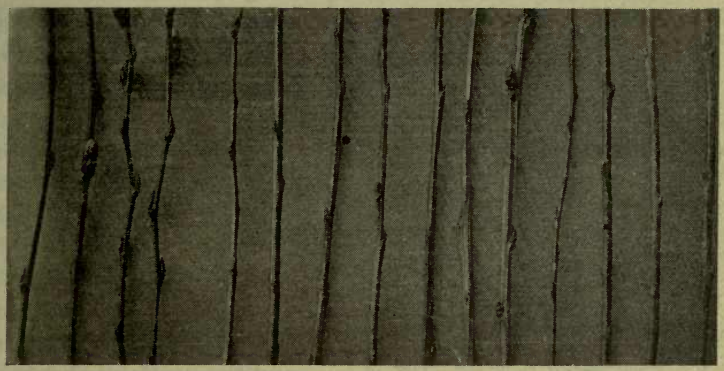
"*P. Sibirica* var. *pyramidalis* [a form of *P. balsamifera*, var. *intermedia* of botanists], makes a fair growth and is desirable for ornamental planting. I think the foliage will endure more hardship than the *P. balsamifera*, to which it is similar in form.

"*P. laurifolia* [of horticulturists, but *P. balsamifera*, var. *intermedia* of botanists] is the best of this class. It is little slower growth than the *P. Certinensis* but like it healthy, vigorous and a good timber tree, and much superior to the cottonwood for lumber or fuel. Its thick leaves withstand the hottest, dryest air of the West, either standing alone or in shelter belts. The leaves are thick and leathery, oval in form, a smooth clear white on the under side, and a bright clear green on the upper; generally flat, but sometimes a little folded.

"WHITE POPLAR CLASS.—The typical Russian form of this is rather more upright than the common white poplar and does not

sprout so much. This latter quality will be considered desirable by growers of occasional specimens. On the other hand, it is not so easily propagated as the common form and is perhaps, no hardier, so that it will not supplant it for forest plantations where the beautiful white, fine-grained wood of this species is desired, and where the habit of sprouting from the roots is no drawback.

"*P. alba* var. *Bolleana* is very different from the common white



a b c d e f g h i i k l m n o

1. WINTER TWIGS OF POPLARS.—a, b, c, d, *forms of Populus grandidentata;* e, *P. angustifolia;* f, *P. nigra, var. elegans;* g, *P. balsamifera, var. latifolia (Nolestii);* h, *P. nigra (Eugenie);* i, *P. monilifera;* j, *P. laurifolia (Certinensis);* k, *P. balsamifera, var. viminalis;* l, *P. nigra (form known as Canescens);* m, *P. alba, var. canescens;* n, *P. alba, var. nivea;* o, *P. alba.*

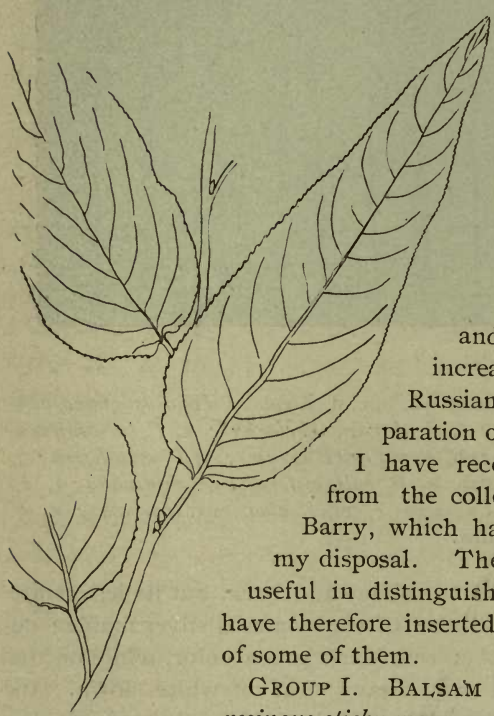
poplar, which it resembles in foliage and bark, but its leaves are nearly as deeply lobed as those of the common silver maple; on the upper side they are of a rich dark green color, while on the lower side they have a very heavy coat of white down. Its growth when young is nearly as upright as the Lombardy poplar with a tendency to a globular formed head when old. It is, however, a long lived tree even in severely dry sections in the West, where the Lombardy poplar is worthless. It is of rather moderate or slow growth. I find it much more difficult to propagate than most other poplars, but have had fairly good success with cuttings taken off in the fall, and well callused before planting

in the spring, in the same manner as practiced with grape cuttings in the West. It grafts readily on several of our common poplars and on strong growing kinds its growth is considerably increased.

"*P. alba* var. *argentea* closely resembles the species but has heavier down on the underside, and is rather more spreading in habit, and is more easily propagated from cuttings."

II. THE CULTIVATED SPECIES OF POPLARS.

The following catalogue attempts to refer the nursery and horticultural names of poplars to their proper botanical species, and it includes various notes upon the horticultural values of the different types. The genus appears to be much confused amongst nurserymen, and the perplexity has been increased by the arrival of the Russian varieties. In the preparation of this monographic list, I have received the greatest aid from the collection of Ellwanger & Barry, which has been freely placed at my disposal. The winter twigs are often useful in distinguishing the species, and I have therefore inserted a photograph (Fig. 1) of some of them.



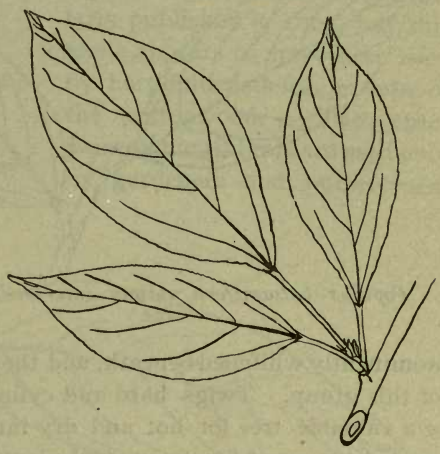
2. Populus angustifolia. (½ *nat. size.*)

GROUP I. BALSAM POPLARS, *or those with resinous-sticky more or less elongated buds.*

1. **Populus angustifolia** (James, Long's Exped. i.497). YELLOW or BLACK POPLAR of the west. Fig. 2. A pyramidal small tree with ovate-lanceolate willow-like leaves and cylindrical twigs, native from South Dakota west and south. It is sparingly cultivated. It is a tree of good habit and soft clear green

foliage, and is worth attention in the composition of groups. May be confounded with *Populus balsamifera*, var. *viminalis*, which see. The slender, cylindrical winter twigs with small buds (e, fig. 1) are very different from the heavier and angled shoots, with coarse buds, of the other (k, fig. 1).

2. **Populus balsamifera** (Linnæus, Sp. Pl. 1034 (1753). BALSAM POPLAR, TACMAHAC. Fig. 3. A tall upright tree, with a narrow straight top, growing in woods and along streams in the Northernmost States, and also in Northern Europe and Asia. Leaves thick and firm, erect, whitened beneath, usually smaller than in most other poplars of this Group: in shape ovate-lanceolate or oval, tapering towards the top and sometimes at the base, finely and obtusely toothed. Young branches nearly or quite cylindrical.



3. Populus balsamifera (16 Voronesh.) (½ nat. size.)

The native form is occasionally seen about farm buildings and roadsides, where it makes a durable and pleasant tree; but it is most too stiff for the pleasantest effects and too narrow for the best shade. The dull whiteness of the under side of the leaves affords a pleasant variety and contrast in its foliage, and the fragrance of the resinous buds in spring is pleasant to most persons. It is a desirable tree for occasional planting, but, like the Lombardy, it generally appears to best advantage when placed amongst other trees. It is a hardier tree than the Lombardy, and does not run quickly to such extravagant heights. In cultivation from Russian sources, it is known as Nos. 16 and 26 Voronesh and 32 Riga. Fig. 3 shows ordinary foliage (16 Voronesh) about half size.

The balsam poplar is probably the most variable of poplars.

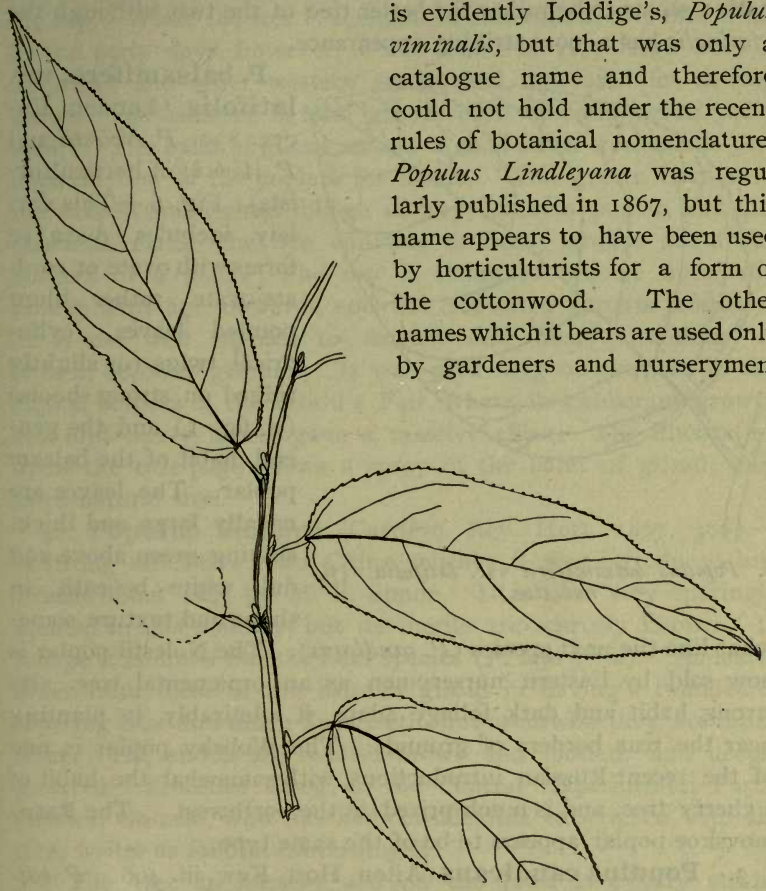
In cultivation in this country it is represented by no less than three well marked botanical varieties, differing from the species and from each other in the habit of growth, shape and color of leaves and character of twigs.

P. balsamifera variety **intermedia** (Loudon, Encyc. of Trees and Shrubs, 830 (1842). *P. laurifolia* of American horticulturists, not of botanists. *P. Sibirica pyramidalis*, of horticulturists). Fig. 4. A comparatively slow growing tree of close upright habit, from Northern Europe, where it is used as a street tree. The leaves are very thick and hard, finely serrate, oval in outline, and prominently whitened beneath, and they are commonly rather small for this group. Twigs hard and cylindrical. It is considered to be a valuable tree for hot and dry interior climates; and it also has distinct merit for ornamental planting. It eventually becomes a large tree. The *Populus laurifolia* and *P. Sibirica pyramidalis* of American nurserymen are, so far as I can determine, only minor variations of one varietal type. All these trees are amongst the recent introductions of Russian poplars.

4. Populus balsamifera variety *intermedia.* ⅔ *nat. size.*

P. balsamifera var. **viminalis,** (Loudon, Encyc. 830, t. 1510. *P. viminalis*, Lodd. Cat. (1836). *P. Lindleyana*, Booth, Rev. Hort. 1867, 380. *P. salicifolia*, *P. crispa*, *P. Dudleyi*, and *P. pyramidalis suaveolens* of horticulturists. Also sometimes called *P. laurifolia*). Fig. 5. A tree of only moderate and rather slender growth, with a partial weeping habit when old; native to northern Europe. It is at once distinguished from other forms of *Populus balsamifera* by its sharply angled twigs (k, fig. 1), and broad-lanceolate willow-like leaves which are finely serrate and often crinkled-margined.

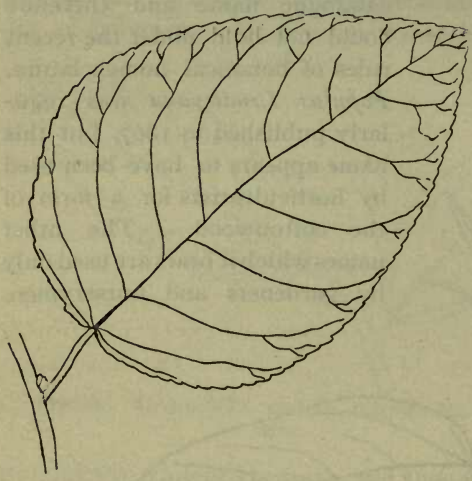
I am inclined to regard this as a distinct species from the balsam poplar. If it should be elevated to specific rank, it would be difficult to determine a correct name for it. Its first specific name is evidently Loddige's, *Populus viminalis*, but that was only a catalogue name and therefore could not hold under the recent rules of botanical nomenclature. *Populus Lindleyana* was regularly published in 1867, but this name appears to have been used by horticulturists for a form of the cottonwood. The other names which it bears are used only by gardeners and nurserymen.



4. *Populus balsamifera* var. *viminalis*. (½ *nat. size.*)

But however much doubt may attach to the botanical position of this small tree, it is valuable to planters if a tree of willow-like aspect but with more pronounced color effects and greater size and durability is desired. It is very like the native *Populus angustifolia*, which it represents in Europe, but is readily distinguished by its angled or furrowed stems, and less tapering and

crisped leaves which are conspicuously finely reticulated and whitened beneath. The color of its foliage is a grayish green, and in this respect it affords a contrast to the native species. The native seems to be rather the better tree of the two, although the *viminalis* has a more striking appearance.



6. *Populus balsamifera* var. *latifolia*. (½ *nat. size.*)

P. balsamifera, var. **latifolia** (Loudon, Encyc. 830. *P. Nolestii* and *P. Wobsky* of horticulturists). Fig. 6.—This variety includes Asiatic forms with ovate or cordate-ovate rather blunt pointed leaves, cylindrical twigs (or slightly ridged on strong shoots) (g, fig. 1) and the general habit of the balsam poplar. The leaves are usually large and thick, shining green above and dull white beneath, in shape and texture somewhat like the next species (*P. candicans*). The Nolestii poplar is now sold by Eastern nurserymen as an ornamental tree. Its strong habit and dark foliage adapt it admirably to planting near the rear borders of grounds. The Wobsky poplar is one of the recent Russian introductions, with somewhat the habit of a cherry tree, and is much prized in the northwest. The Rasumovskoe poplar appears to be of the same type.

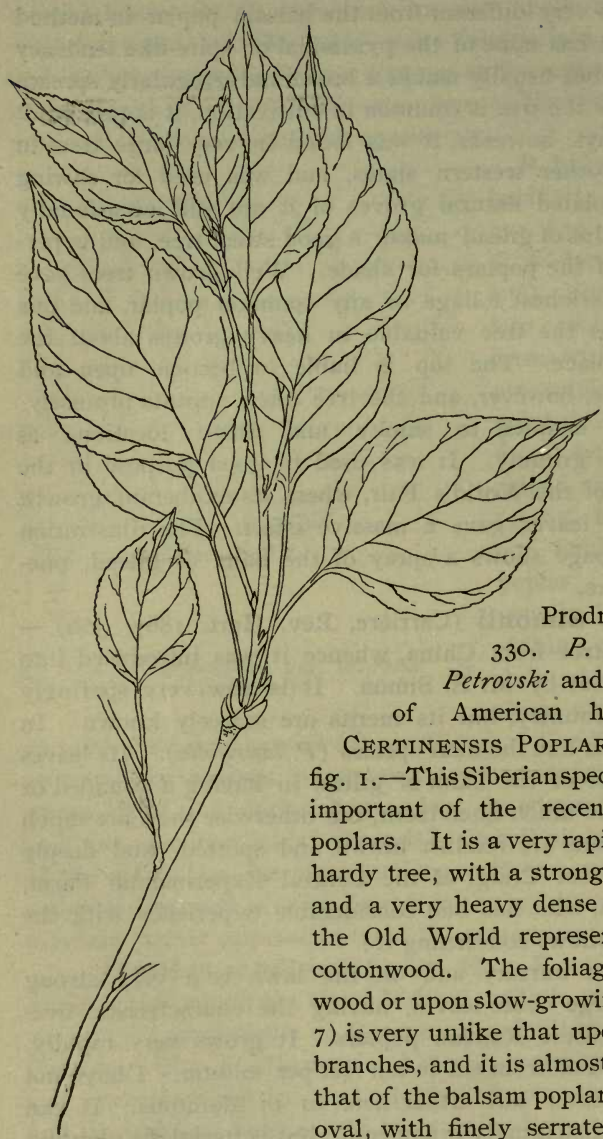
3. **Populus candicans** (Aiton, Hort. Kew. iii. 406. *P. balsamifera*, var. *candicans*, Gray, Manual, 2nd ed. 419. *P. Ontariensis* and *P. macrophylla* of European horticulturists). BALM OF GILEAD. Fig. on title page.—A strong-growing spreading native tree, frequently planted, and esteemed for its vigor and hardiness and the resinous fragrance of its large buds in spring-time. The leaves are broad and heart-shaped, green above and veiny and rusty-white beneath, and the leaf-stalk is usually hairy and somewhat

flattened. It is very different from the balsam poplar in method of growth, as it has none of the pyramidal or spire-like tendency of that species, but usually makes a broad and irregularly spreading top. While the tree is common in cultivation, it is rare wild. In the early days, however, it was found in very large trees in Michigan and other western states, and was used for sawing timber; and isolated natural groves of it are still occasionally seen.* The balm of gilead makes a good street tree, and is perhaps the best of the poplars for shade. Well grown trees have the darkest and richest foliage of any common poplar, and this character makes the tree valuable in heavy groups about the borders of a place. The top is liable to become open and broken with age, however, and the tree often sprouts profusely. It is not well adapted to smoky and dusty locations, as it soon becomes grimmy. It was used to good purpose in the lagoon borders of the World's Fair, where its exuberant growth and stiff heavy leaves gave a massive effect. The illustration upon the title-page shows a spray of the balm of gilead, one-third natural size.

4. **Populus Simonii** (Carrière, Rev. Hort. 1867, 360).—A strong strict tree from China, whence it was introduced into France about 1861 by M. E. Simon. It is now very sparingly planted in this country, but its merits are scarcely known. In foliage it is much like the next species (*P. laurifolia*). Its leaves differ from those of the balm of gilead in having a rounded or tapering base and much finer teeth, but otherwise they are much alike. The shoots are reddish brown and spotted, and deeply grooved. Professor Craig, of the Central Experimental Farm, Ottawa, Ontario, who has had considerable experience with the tree, writes as follows concerning it:

"The tree in nursery and on the lawn is a very strong grower, with large ovate leaves, having the characteristic five-sided shoots of these Russian poplars. It grows very rapidly, making a growth of from six to ten feet per annum. I have not known it to winter kill either here or in Manitoba. It can hardly be termed strikingly ornamental, but is useful for planting

* Botanical Gazette, v. 91.



7. *Populus laurifolia* (*or P. Certinensis*). *Slow-growing shoot.* (⅔ *nat. size.*)

where windbreaks are desired quickly. Like the Carolina poplar, it has a strong upright habit of growth."

5. **Populus laurifolia** (Ledebour Icones Plantarum Nov. Ross. v. 23, t. 479 (1834). *P. balsamifera*, var. *laurifolia*, Wesmael, D. C. Prodr. xvi. part ii. 330. *P. Certinensis*, *P. Petrovski* and *P. Bereolensis* of American horticulturists).

CERTINENSIS POPLAR, Figs. 7, 8; j. fig. 1.—This Siberian species is the most important of the recently introduced poplars. It is a very rapid-growing and hardy tree, with a strong central leader, and a very heavy dense foliage. It is the Old World representative of our cottonwood. The foliage upon the old wood or upon slow-growing shoots (Fig. 7) is very unlike that upon the vigorous branches, and it is almost identical with that of the balsam poplar, being broadly oval, with finely serrate margins, and whitish beneath. The twigs, also, are cylindrical. But the strong shoots are

strongly angled or grooved and the foliage is much like that of the native cottonwood but darker; and the growth is more close and erect. The sketch in Fig. 8 distinguishes the leaves perfectly, however:

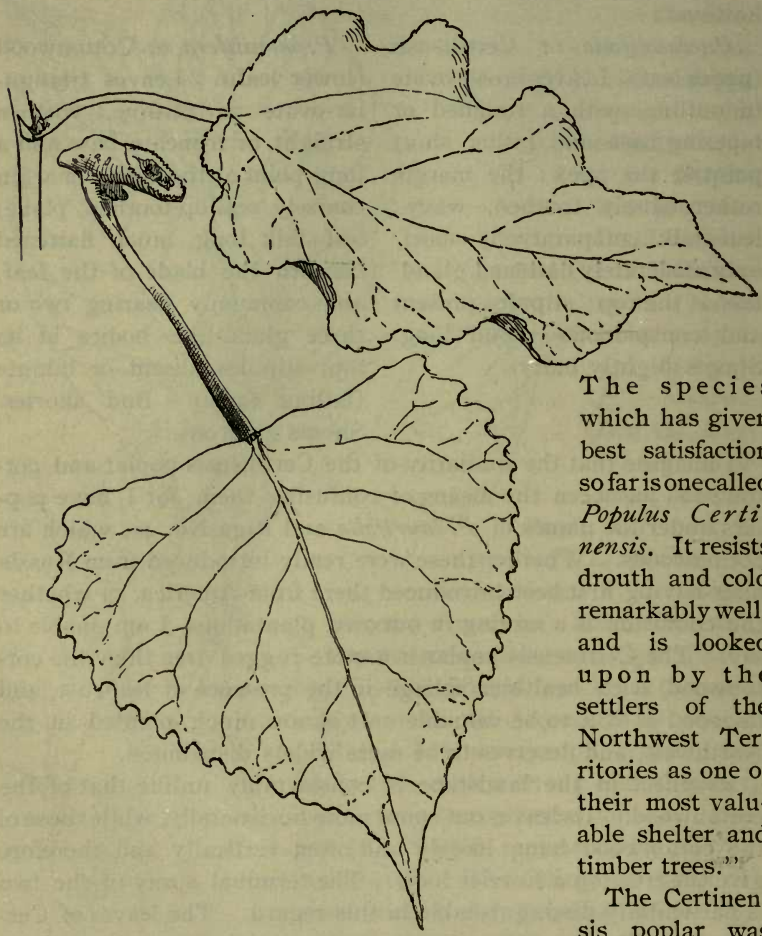
P. laurifolia or Certinensis (upper leaf). Leaves broad-ovate in outline, with a rounded or tapering base and rather short point at the apex; the margin rather closely toothed, wavy; leaf-stalk comparatively short, only moderately flattened, gland-less at the top; stipules present and conspicuous. Bud long. Shoots slightly hairy.

P. monilifera or Cottonwood (lower leaf). Leaves triangular-ovate in outline, with a straight or truncate base and a long point at the apex; margin coarsely scallop-toothed, plane; leaf-stalk long, much flattened beneath the blade of the leaf, and commonly bearing two or three gland-like bodies at its top; stipules absent or minute (falling early). Bud shorter. Shoots glabrous.

I imagine that the similarity of the Certinensis poplar and cottonwood has been the means of confusing them, for I have poplars under the names of *P. laurifolia* and Riga No. 40, which are cottonwoods. Whether these were really introduced from Russia after having first been introduced there from America, or whether the confusion is a mixing in our own plantations, I am unable to say. The Certinensis poplar is a more rugged tree than the cottonwood, with healthier foliage in the presence of leaf-rust, and its wood is said to be valuable. It is now much planted in the Northwest, and deserves to be more widely distributed.

Its effect in the landscape is considerably unlike that of the cottonwood. Its leaves out stand more horizontally, while those of the cottonwood hang loosely and often vertically and therefore give the tree top a heavier look. The terminal spray of the two is particularly distinguishable in this regard. The leaves of Certinensis upon the strong erect shoots stand almost squarely at right angles with the shoot, and, at some distance, therefore present only their ruffled edges to the eye, producing a most unique and picturesqne effect. But on the whole, at least for the present, I should consider the cottonwood the better tree for ornamental planting in this state.

Professor Craig, of Ottawa, writes of the species: "I have been sending out cuttings of these so-called Russian poplars to Manitoba and the Northwest Territories for the past four years.



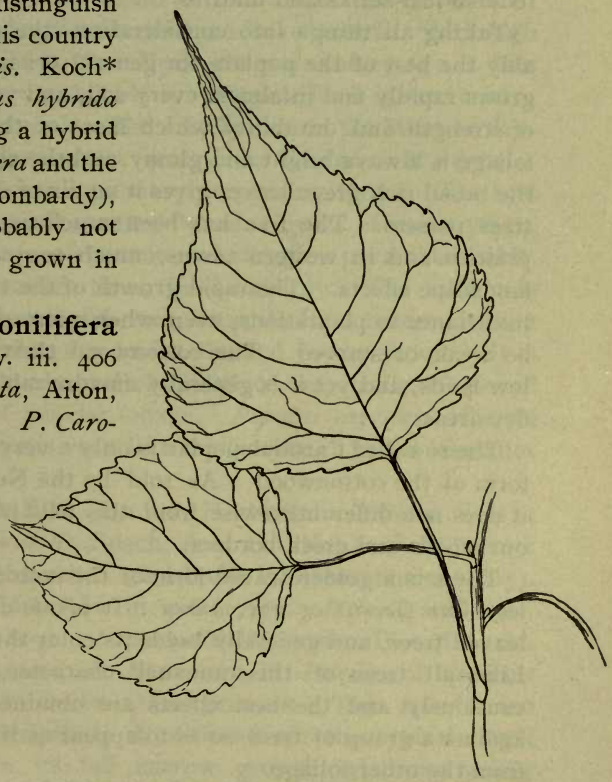
8. Certinensis poplar (above), and Cottonwood (below). (½ nat. size.)

The species which has given best satisfaction so far is one called *Populus Certinensis.* It resists drouth and cold remarkably well, and is looked upon by the settlers of the Northwest Territories as one of their most valuable shelter and timber trees."

The Certinensis poplar was used in the lagoon plantations at the World's Fair, but because of its rapid growth in the direction of its leader, it made a less picturesque small tree than either the cottonwood or balm of gilead, which were similarly planted.

The name *laurifolia*, or "laurel-leaved," is generally applied in this country to another plant,—*Populus balsamifera*, var. *intermedia*. The name originated with the Russian botanist Ledebour, and he published a good illustration of the tree he had in mind and it is an admirable portrait of the large and crinkly leaves of the tree which in this country goes under the name of *Populus Certinensis*,—a name which, so far as I can learn, is simply a garden or nursery name. No. 39 Riga, as I have it, is the same. Neither am I able to distinguish the tree grown in this country as *Populus Bereolensis*. Koch* mentions a *Populus hybrida Berolinensis* as being a hybrid between *P. balsamifera* and the Italian poplar (or Lombardy), but his tree is probably not the same as the one grown in this country.

6. **Populus monilifera** (Aiton, Hort. Kew. iii. 406 (1789). *P. angulata*, Aiton, Hort. Kew. iii. 407. *P. Carolinensis*, Moench, Verzeichniss Weissenstein, 81 (1785: Catalogue name). *P. glandulosa*, Moench, Methodus, 339 (1794). *P. Canadensis*, Michx. f. Hist. Arb. Am. iii. 302, t. 12. *P. Carolina* of nurserymen).



9. *Populus monilifera, unusual form.* (½ *nat. size.*)

COTTONWOOD, CAROLINA and CANADIAN POPLAR. Fig. 8, 9; i, fig. 1. A strong growing handsome tree of large size, ranging from

* Dendrologie. ii. iA, 497.

western New England to Florida and the Rocky Mountains. Its leaf characters are sufficiently outlined above (under *P. laurifolia*), but it is variable in shape and color of leaves. Some of the forms are fairly distinct in foliage and aspect, and they appear to be associated with particular horticultural names, in the nurseries. Fig. 9 shows a form with very long-pointed and round-based leaves; but it usually bears, also, the typical triangular foliage. Some of the most ornamental specimens of cottonwood are those which have reddish leaf-stalks and midribs.

Taking all things into consideration, the cottonwood is probably the best of the poplars for general ornamental planting. It grows rapidly and in almost every soil, and yet it possesses an air of strength and durability which most of the poplars lack. Its foliage is always bright and glossy, and the constant movement of the broad rich green leaves gives it an air of cheeriness which few trees possess. The tree has been much used upon the western prairies and in western towns, much too abundantly for good landscape effects. The rapid growth of the tree gives a feeling of luxuriance to plantations, even when most other trees appear to be weak or starved. The cottonwood thrives best upon rather low lands, and yet it is generally an admirable tree upon high and dry areas.

The so-called Carolina poplar is only a very luxuriant cultivated form of the cottonwood. As sold by the New York nurserymen it does not differ otherwise from the wild *Populus monilifera* of our woods and creek borders.

There is a golden-leaved form of the cottonwood known as variety *Van Geertii* or var. *aurea*. It is one of the best of yellow-leaved trees, and generally holds its color throughout the season. Like all trees of this unusual character, it should be used cautiously, and the best effects are obtained when it is planted against a group of trees so as to appear as if naturally projecting from the other foliage.

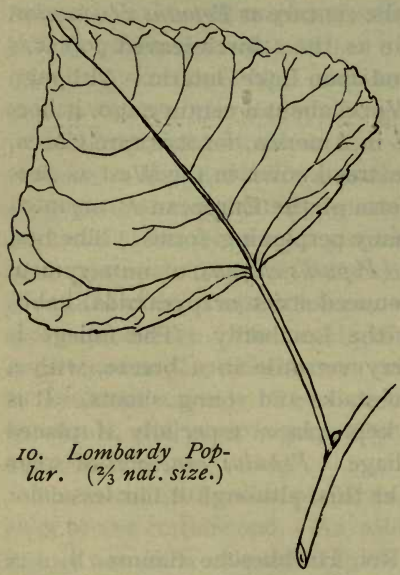
7. **Populus nigra** (Linn. Sp. Pl. 1034 (1753). *P. Hudsonica*, Michx. f. Hist. Arb. Amer. iii. t. 10. *P. betulifolia*, Pursh, Fl. Amer. Sept. ii. 619. *P. Eugenie* of nurserymen). BLACK POPLAR. h and l, fig. 1. A European tree of medium to large size, with leaves somewhat resembling those of the cottonwood, but

generally smaller and much less deeply toothed, shorter in proportion to their width and often with a tapering or rounded base. The tree usually has a pyramidal habit of growth and a dark cast to the foliage. The leaf-stalk is flattened, so that the foliage moves freely in the wind. It is a less lustrous tree than the cottonwood and grows more slowly. Specimens were found escaped along the Hudson by Michaux, who thought it an American species and published it early in the century as *Populus Hudsonica*. Pursh in 1814 published it again as the "birch-leaved poplar," *Populus betulifolia*, from trees found upon Lake Ontario. Although is was found half wild in New York about a century ago, it does not seem to have increased itself in America, for it is rarely seen, even in cultivated ground. The tree known in the West as *Populus betulifolia* is only a robust form of the European *P. nigra*.

The black poplar runs into many perplexing forms. The best which I know is var. **elegans** (*Populus elegans* of nurserymen. f, fig. 1). It is a tree of pronounced strict or pyramidal habit, but considerably broader than the Lombardy. The foliage is small and light colored and very versatile in a breeze, with a handsome reddish tint to the leaf-stalks and young shoots. It is worth growing in every well kept place, especially if placed against a planting of heavier foliage. *Populus canescens* of some American nurserymen is very like this, although it has less color and brightness.

P. nigra, var. **Italica** (Du Roi, Harbkesche Baumz. ii. 141 (1772). Var. *pyramidalis*, Spach, Ann. Sci. Nat. 2nd ser. xv. 31 (1841). *P. Italica*, Moench, Verzeichness Weissenstein, 79 (1785). *P. dilatata*, Aiton, Hort. Kew. iii. 406 (1789). *P. fastigiata*, Desf. Hist. Arb. ii. 265 (1809). *P. pyramidalis*, Rozier, Dict. d'Agric. vii. 619. *P. pyramidata*, *P. Pannonica*, *P. Polonica* of horticulturists). LOMBARDY or ITALIAN POPLAR. This tree is too familiar to need description. It differs from the typical black poplar (*P. nigra*) in its tall narrow growth, glabrous young shoots, a confirmed habit of suckering from the root and generally a more tapering base to the leaves. It is one of the characteristic trees of parts of Italy, and it is from one of the Italian provinces, Lombardy, that its common name is derived. The tree is probably native in Asia, however.

The Lombardy poplar was much prized in this country a hundred years ago. John Kenrick established a commercial nursery of ornamental trees in Newton, Massachussetts, in 1797, and two acres were "devoted to the cultivation of the Lombary poplar, which was about the only ornamental tree for which there was any demand in those days."* It is probable that very few, if any, of the trees sold by Kenrick are still living, even in localities where the climate is not severe; and this is evidence that the tree is short lived—a fact which all careful observers must have noticed.



10. Lombardy Poplar. (⅔ nat. size.)

A hardy type of the Lombardy is grown in the Northwest. Professor Budd gives the following account of it.†

"In the summer of 1882 Mr. Gibb and the writer were surprised to find the Lombardy poplar in perfect health in central Russia, where our American black locust, honey locust and other trees killed down each winter as does the common peach in north Iowa. Our surprise came from the fact that Loudon inclined to the belief that *Populus dilatata* [one name for the Lombardy Poplar] was native to the valley of the Po in Lombardy, from whence it came to England and America. But Russian botanists soon assured us that its home was in the east and that its hardiness varied like other species, and hence depended on the region from whence it was obtained. Under the name of *Populus dilatata* we imported the hardy kind from Voronesh, in central Russia. As this is 300 miles north of the sea of Azoff, from whence came the Russian Mennonites of Minnesota, I suspect

*Garden and Forest, i. 302.

†Rural Life, Aug. 31, 1893, p. 12.

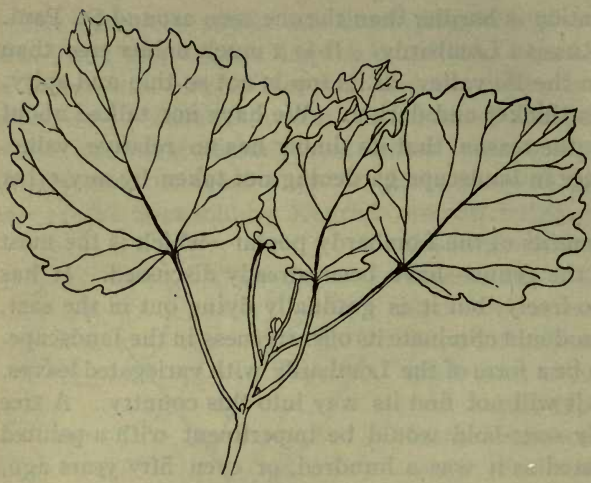
that our importation is hardier than the one seen around St. Paul. We call it the Russian Lombardy. It is a much nobler tree than the variety from the Po valley, as its top is not so thin and spiry, and its foliage is thicker and darker. We have not talked about this poplar for the reason that its timber has no relative value. Yet it fills a place in landscape gardening not taken by any other tree."

The various merits of the Lombardy poplar—which is the most familiar tree of the genus—have been already discussed. It has been planted too freely, but it is gradually dying out in the east, and time will no doubt eliminate its offensiveness in the landscape. There is said to be a form of the Lombardy with variegated leaves, but I hope that it will not find its way into this country. A tree which is already over-bold would be impertinent with a painted foliage. "Planted as it was a hundred, or even fifty years ago, in all possible situations, without regard to its surroundings or to the positions in which it was placed, it did more, perhaps," says *Garden and Forest*, "than any tree which has ever been planted, especially in some parts of Europe, to disfigure the landscape. There is no tree, however, which can take its place, or which can so quickly send up a tall, slender shaft to break a low or monotonous sky line. It became an unpleasant feature in the landscape only when it was used without judgment and without discretion."

GROUP II. ASPENS and WHITE POPLARS, *with short non-glutinous often pubescent buds.*

8. **Populus Tremula** (Linnæus, Sp. Pl. 1034). EUROPEAN ASPEN. Figs. 11, 13.—An open-headed, light-leaved tree, common throughout Europe, and occasionally cultivated in this country, especially in its weeping form. Leaves small and thin round-oval, more or less whitened beneath, especially when young, bordered with deep and rounded incurved teeth. Leaf buds small. The leaf-stalks are long and slender and flattened, giving a restless motion to the foliage.

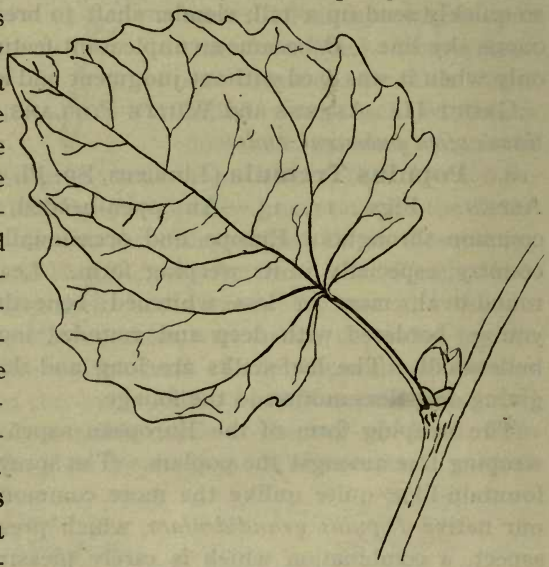
The weeping form of the European aspen is perhaps the best weeping tree amongst the poplars. The spray is light, airy, and fountain-like, quite unlike the more common weeping forms of our native *Populus grandidentata*, which present a stiff weeping aspect, a combination which is rarely pleasing. The lightness



11. Populus Tremula (⅔ nat. size).

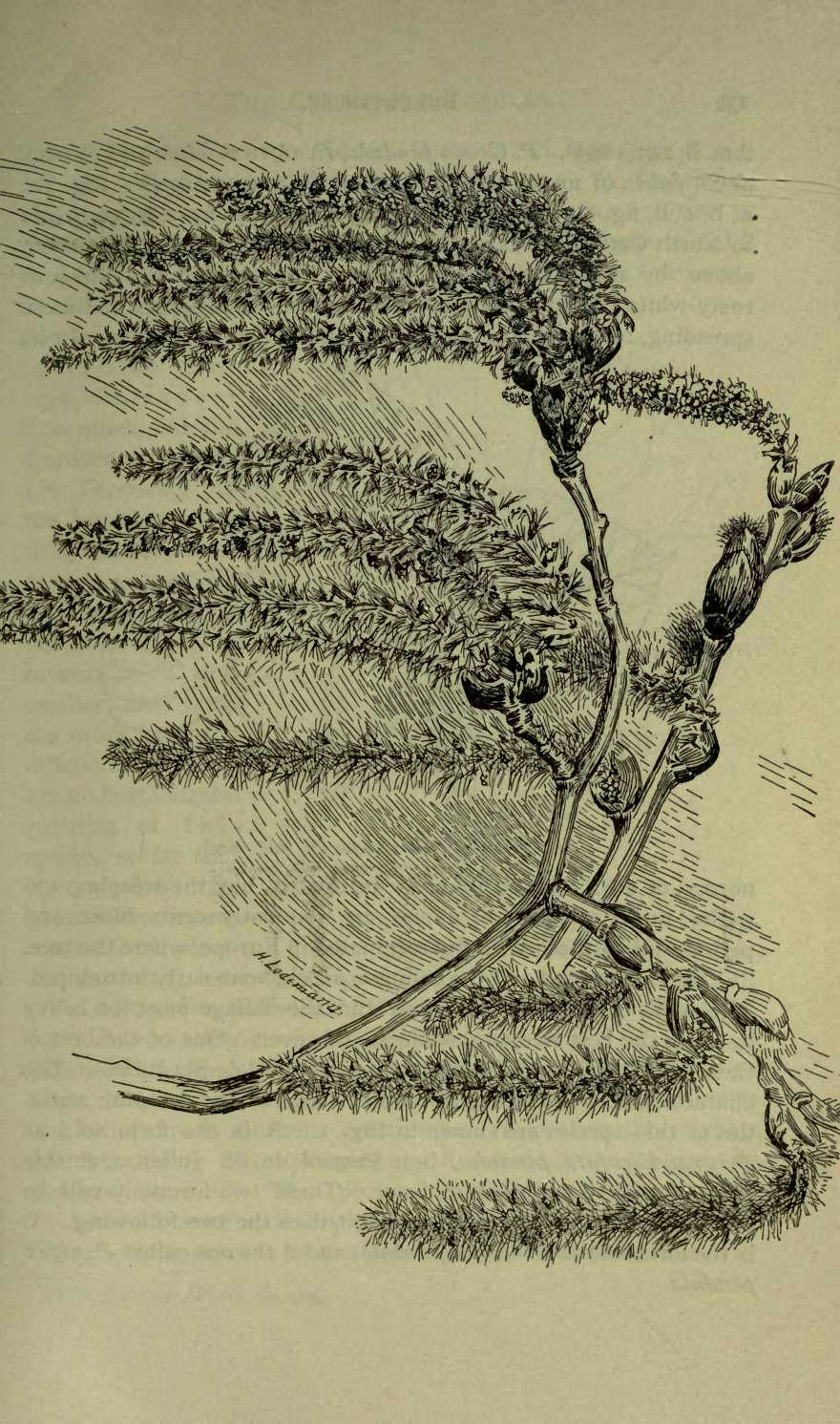
of the foliage of the European aspen has been remarked by writers from the earliest times. Gerarde, in 1597, remarks that the tree "may also be called Tremble, after the French name, considering it is the matter whereof womens tongues were made, (as the Poets and some others report) which seldome cease wagging."

A characteristic interest attaching to this tree is the profusion of very long catkins which appear in earliest spring, even before our native poplars are in bloom. They appear at Ithaca late in March or the first of April. The staminate or male catkins are particularly pleasing, and planters should select that sex, if possible. The illustration on the next page shows these interesting flower-clusters nearly full size.



12. Populus grandidentata. (½ nat. size.)

9. **Populus grandidentata** (Michaux, Fl. Bor.-

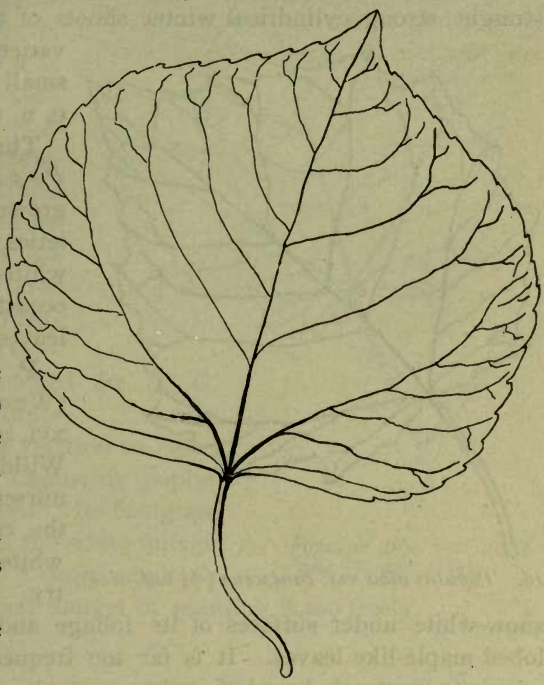

H. Lüdemann

Am. ii. 243(1803). *P. Græca pendula*, *P. nigra pendula* and *Parasol de St. Julien* of nurserymen). LARGE-TOOTHED ASPEN. Fig. 12; a, b, c, d, fig. 1.—This is a common native tree from Nova Scotia to North Carolina. It is distinguished from the European aspen, above, by much larger and thicker leaves which are bluish or rusty-white beneath, more ovate in outline, with larger and more spreading teeth, stouter leaf-stalks and larger leaf-buds. In its

14. Populus tremuloides (⅔ *nat. size*).

normal or erect form, it is rarely cultivated, but the weeping varieties, under a variety of names, are frequently seen. Most, and perhaps all of these varieties originated in Europe, where the tree, like the cottonwood and the common aspen, were early introduced. The habit of the tree is too stiff and the foliage most too heavy to make the best weeping subjects, however. One of the best of these weeping forms is that known as Parasol de St. Julien. The characteristic weak or zigzag winter twigs of the weeping varieties of this species are shown in Fig. 1. A is the form sold as *P. grandidentata pendula;* b is Parasol de St. Julien, and this twig shows a flower-bud midway. These two forms, it will be seen, have a stiffer or straighter habit than the two following. C is the form sold as *P. Græca pendula*, and d the one called *P. nigra pendula.*

10. **Populus tremuloides** (Michaux, Fl. Bor.-Am. ii. 243 (1803). *P. trepida*, Willd. Sp. Pl. iv. 803. *P. Græca* and *P. Atheniensis* of horticulturists). COMMON ASPEN or POPPLE. Fig. 14.—This is the commonest of the American poplars, and it ranges from Labrador to Kentucky, New Mexico and California. It is the species which springs up in recent clearings. In aspect it is much like the European Aspen (*P. Tremula*), but the leaves lack entirely the deep teeth of that species and they are green on the under side. The catkins are also smaller, and there are other botanical differences. There are no horticultural varieties of this species, so far as I know; but the plant is worthy attention from planters, as already indicated (page 208).



15. Populus Sieboldi (⅔ *nat. size*).

11. **Populus Sieboldi** (Miquel, Ann. Mus. Bot. Lugd. iii. 29. *P. rotundifolia* of American nurserymen). Fig. 15. A Japanese species with foliage somewhat like the last only much larger and whitish below. Professor Sargent says* that "this tree is not rare in southern Yezzo, where it grows to the height of twenty or thirty feet, springing up in considerable numbers on dry, gravelly soil." The species is little known in this country. It makes a tree of spreading habit, with rather dark and heavy foliage. It appears to be hardy in western New York.

**Garden and Forest*, vi. 404.

12. **Populus alba** (Linnæus, Sp. Pl. 1034 (1753). WHITE POPLAR, ABELE. A common European tree frequently planted in this country. Leaves much like those of *Populus grandidentata*, but smaller, usually thicker and more angular, the under surface—especially early in the season—woolly white. The straight, strong cylindrical winter shoots of this species and its varieties, with the very small buds, are shown at o, n, and m, in fig. 1.

16. Populus alba var. *canescens* (⅔ *nat. size*).

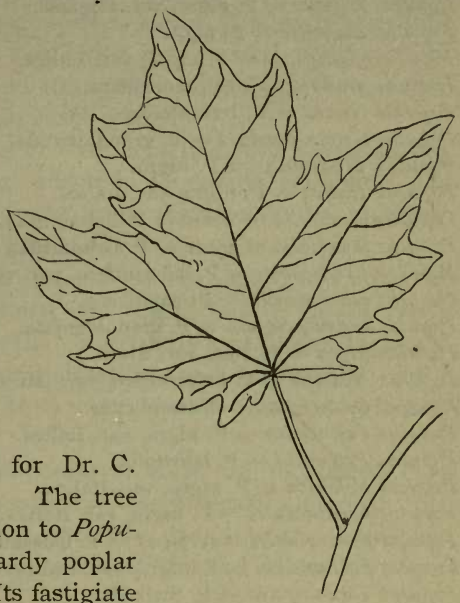
The typical form of *Populus alba* is less grown here than the varieties with lobed and very white-bottomed (and occasionally variegated) leaves.

P. alba, var. **nivea** (Wesmael, DC. Prodr. xvi. 2d part, 324. *P. nivea*, Willd. *P. argentea* of nurserymen). This is the commonest form of white poplar in this country. It is known by the snow-white under surfaces of its foliage and the three or five lobed maple-like leaves. It is far too frequent about old yards, where its inveterate brood of suckers make it a perpetual nuisance. It is sometimes called Silver maple, from the resemblance of its foliage to that of the maple. The tree is so obtrusive in its character that it can rarely be used with good effect in home grounds. As a street tree in cities it is particularly offensive for the cottony covering of the under side of the leaves and of the shoots holds soot and dust, and it looks repulsively dirty. It is a misfortune that the tree were ever brought into the country, for few people appear to know how to make a considerate use of it.

P. alba, var. **canescens** (Loudon, Encyc. 820). Fig. 16. Leaves broad or nearly circular in general outline, prominently notched but not lobed, the under surfaces and the young shoots

very white-woolly. This tree is met with occasionally. Its horticultural value is not greatly different from that of var. *nivea*.

P. alba, var. **Bolleana** (Lauche, Wochenschrift der Deutsche Garten, No. 32, Aug. 10, 1878. *P. Bolleana*, Lauche, l. c.). BOLLES' POPLAR. Fig. 17. A very tall and narrow-topped tree, with cottony leaves rather more deeply lobed than those of the var. *nivea*. The tree was introduced into Europe in 1875 from Turkestan, and it was named for Dr. C. Bolle, an arboriculturist. The tree bears about the same relation to *Populus alba* that the Lombardy poplar bears to *Populus nigra*. Its fastigiate habit combined with the white foliage and shoots, make it a most emphatic tree and there is great danger of planting it too freely.



17. Populus alba var. *Bolleana* (⅔ *nat. size*).

INDEX TO SYNONYMS.

Populus angulata = P. monilifera.
Populus argentea = P. alba, var. nivea.
Populus Atheniensis = P. tremuloides.
Populus Bereolensis = P. laurifolia.
Populus betulifolia = P. nigra.
Populus Bolleana = P. alba, var. Bolleana.
Populus Canadensis = P. monilifera.
Populus canescens of some = P. alba, var. canescens.
Populus canescens of some = P. nigra, var.
Populus Carolina = P. monilifera.
Populus Carolinensis = P. monilifera.
Populus Certinensis = P. laurifolia.
Populus crispa = P. balsamifera, var. viminalis.

Populus dilatata = P. nigra, var. Italica.
Populus Dudleyi = P. balsamifera, var. viminalis.
Populus elegans = P. nigra, var. elegans.
Populus Eugenie = P. nigra.
Populus fastigiata = P. nigra, var. Italica.
Populus glandulosa = P. monilifera.
Populus Græca = P. tremuloides.
Populus Græca pendula = P. grandidentata.
Populus Hudsonica = P. nigra.
Populus Italica = P. nigra, var. Italica.
Populus laurifolia of some = P. balsamifera, var. intermedia.
Populus laurifolia of some = P. balsamifera, var. viminalis.
Populus Lindleyana = P. balsamifera, var. viminalis.
Populus macrophylla = P. candicans.
Populus nigra pendula = P. grandidentata.
Populus nivea = P. alba, var. nivea.
Populus Nolestii = P. balsamifera, var. latifolia.
Populus Ontariensis = P. candicans.
Populus Pannonica = P. nigra, var. Italica.
Populus Petrovski = P. laurifolia.
Populus Polonica = P. nigra, var. Italica.
Populus pyramidalis = P. nigra, var. Italica.
Populus pyramidalis suaveolens = P. balsamifera, var. viminalis.
Populus pyramidata = P. nigra, var. Italica.
Populus rotundifolia = P. Sieboldi.
Populus salicifolia = P. balsamifera, var. viminalis.
Populus Sibirica pyramidalis = P. balsamifera, var. intermedia.
Populus trepida = P. tremuloides.
Populus Van Geertii = P. monilifera.
Populus viminalis = P. balsamifera, var. viminalis.
Populus Wobsky = P. balsamifera, var. latifolia.

COMPENDIUM.

Landscape gardening is the embellishment of grounds in such manner as to secure landscape or nature-like effects. The style of planting, therefore, should be free and easy, devoid of all formalisms and unusual or forced effects. There should be broad open spaces of greensward and heavy masses, or groups, of trees and bushes; and the heaviest plantings should be about the borders of the place. Scattered planting of individual trees and bushes is fatal to good effects. Trees which are simply odd or

curious introduce irrelevant and jarring effects, and they should never be made emphatic or prominent features of a place. Trees of very unusual or striking character, as the Lombardy and Bolle poplars, must, likewise, be used with the greatest caution, and, above all, their formality and strangeness should not be enforced by planting them in rows, in rural places.

The poplars are examples of trees which should be used only for secondary or incidental effects in landscape gardening, and never to construct the body or main features of the planting. Cheap trees produce cheap effects.

The Lombardy poplar may be used to advantage now and then in a group of trees to add spirit and vigor; but it should rarely be seen as an isolated specimen. The tree is used indiscriminately, because it grows rapidly in all situations and because its oddity pleases many people. It is so much abused that its legitimate value is obscured.

The varieties of the white poplar or abele are, in general, even less desirable than the Lombardy. As ordinarily planted, they are immodest and ugly trees, especially the whitest varieties, and their use in farm yards, country cemeteries and all small places should be discouraged.

Poplars which should be encouraged for ornamental planting are the common cottonwood, the common wild aspen, the normal or erect form of the large-toothed aspen, the Certinensis poplar, Populus elegans of the nurseries, and the European aspen.

Poplars of particular value for shelter belts and timber are the Certinensis, cottonwood, balm of gilead, and possibly Populus Simonii.

Species of rather heavy and dark foliage and strong growth, and which may be used for groups or masses, are the balm of gilead, Nolestii, and probably Populus Sieboldi and P. Simonii.

Among the species and varieties which are interesting because of natural peculiarities and which may be used for incidental effects or as single specimens, are Populus angustifolia, various forms of the balsam poplar (especially the variety viminalis), and forms of the European black poplar.

Weeping varieties are found in several species. The best is probably the drooping form of Populus Tremula, the European

aspen. There are good weeping forms of the large-toothed aspen (Populus grandidentata), but they are apt to be too stiff for the best effects in a drooping tree. There are yellow-leaved or variegated forms of some species, of which the best is the variety of the cottonwood known as Van Geert's golden poplar.

The best single species of poplar for general planting in New York, is probably the common cottonwood or Carolina poplar (Populus monilifera). The second choice is the new Russian species known as Populus Certinensis (properly P. laurifolia).

L. H. BAILEY.

Bulletin 205. **September, 1902.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

BOTANICAL DIVISION. Walter Mulford

SHADE TREES

By W. A. MURRILL.

PUBLISHED BY THE UNIVERSITY

ITHACA, N. Y.

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CORNELL UNIVERSITY, ITHACA, N. Y., Sept. 1, 1902.

THE HONORABLE COMMISSIONER OF AGRICULTURE,

ALBANY, N. Y.

Sir:—I have the honor to submit for publication under Chapter 430 of the Laws of 1899 a bulletin on "Shade Trees in Cities" prepared under the direction of Professor G. F. Atkinson by Dr. W. A. Murrill, who a few years ago was Assistant Cryptogamic Botanist of this station. The work was begun by careful study of the shade trees in Ithaca during one year, and was then continued by Dr. Murrill in some other cities in this country and in some of the capitals of Europe.

The matter of the bulletin is of general interest, but is of more special interest to persons living in villages and cities. The conditions of environment for trees, especially in cities, is so different from their natural environment, that there often result certain injuries which are difficult to determine. Mr. Murrill has discussed these matters as well as the general care of the shade trees, the selection of suitable varieties, and methods of planting, pruning and protection.

There is just at present a widespread interest in the matter of village and city improvement, and I believe that this bulletin will contribute matter of interest and value to those who are seeking information concerning the uses of trees in villages and cities and the methods for their successful propagation and protection.

Very respectfully yours,

I. P. ROBERTS.

SHADE TREES.

BY WILLIAM A. MURRILL, A.M., PH.D.

One of the most obvious facts of the present day is the gathering of agricultural populations into towns and cities. Connected with this fact is the problem of municipal government and the amelioration of the conditions of city life. The object of this bulletin is to increase the growing interest in shade trees as material aids to the healthfulness and attractiveness of cities and towns and to consider the principles underlying their selection and care. It is hoped that an intelligent appreciation of the requirements of city trees will thus be awakened in this country such as exists in the older cities of Europe.

In the treatment of the subject, a discussion of the value of shade trees with some account of the kinds found in various cities has received first attention. The merits of different trees in common use are next considered and lists made of those which have been found by experience to be best fitted for street plantings and those which have failed in greater or less degree to fulfill the rigid requirements demanded. Lastly, the work of planting, pruning, protecting, caring for wounds, and other operations connected with the general care of street trees are discussed at some length.

The illustrations are made from photographs by the author, with the exception of those representing leaf-blight of the maple, which were photographed by Miss A. V. Luther.

The Value of Shade Trees in Cities.

The cultivation of trees in cities is beneficial in many ways. In the first place, they add to the healthfulness of a city by cooling and purifying the air. Besides cutting off the direct and reflected rays of the sun, foliage exercises a marked effect on the temperature by evaporating large quantities of water from its surface, and the reduction of the temperature in this way is greatest on dry, hot days when it is most needed. Leaves also

absorb impure and hurtful gases and manufacture the oxygen needed by animals for respiration. Circulation of the air, due to unequal temperature, is likewise promoted by trees properly pruned and arranged ; while the air of basements and cellars is rendered less humid by the removal of surplus water from the surrounding soil through the medium of roots and foliage.

Secondly, trees add materially to the comforts of a city life. In New York, where the streets are narrow and the houses high, shade may not ordinarily be considered a matter of prime importance as regards health, but it is a matter of public comfort, and when the heat becomes intense as it has during the past two summers, it may be of great importance in protecting life. Deciduous trees seem specially designed to shield our sidewalks from the glare of the sun in summer and to expose them to its warmth in winter. In many cities, especially in those of Europe, trees are used during the summer as canopies for courts and restaurants, and the broad shaded sidewalks are often furnished with lunch tables, which are much more attractive than those indoors. Living thus in the open air not only contributes largely to comfort, but also to health.

In the third place, trees give pleasure. They soften the hard lines and add attractive forms and colors to the monotony of buildings. Their bright green foliage is eagerly watched for in the spring and the changing colors are a constant source of pleasure in autumn. The most attractive cities are those in which well-shaded streets and beautiful parks are most abundant. Lastly, trees add greatly to the value of property and draw men and money to a city. The cities of the future will have wide streets planted with trees as a matter of business. In such cities people will remain far into the summer, when the streets and shops of treeless cities are deserted ; and the business men will reap the profits. During the controversy last summer over the passage of tramcars across Unter den Linden, Emperor William not only objected to the trams, but expressed his intention of planting two additional rows of trees along the sidewalks on this avenue ; and, when some one hinted that the shopkeepers might object, he replied : "Oh, no. People prefer shade to sun in summer, therefore more people would pass through a shady street. Consequently it would be better for the shopkeepers."

THE MERITS OF VARIOUS TREES DISCUSSED.

Experiments thus far made do not give a correct idea of what trees will do in cities when properly cared for; but certain facts have been determined with regard to many species which should be considered in making up a list for use in cities. Without this discussion of the merits of each tree, a list would neither be understood nor appreciated. I therefore give below some of the points for and against the most commonly cultivated shade trees, following their order in the list, which order is substantially according to merit.

OAK.

So far as experiments have shown, oaks are the best shade trees for cities. They are strong, durable, and beautiful, and have few enemies. Owing to a popular notion that oaks grow slowly, they have heretofore been little planted on streets, but several cities are now beginning to make use of them. The oldest oaks are to be seen in Hamburg, where the city has encroached upon the ancient forest. An avenue of this same species (*Q. pedunculata*) has been recently planted in Cologne, which, so far as I have observed, is the only city in Europe that has made use of the oak for street planting. In this country, the oldest oaks may be seen in Washington, where the red oak and pin oak in particular have been very successfully grown. Red oaks have also been recently planted in Boston between Franklin Park and Huntington Avenue. The best species of oak are, probably, the red oak, the pin oak, and the scarlet oak; but there are several other species almost as good as these, though none of quite so rapid growth as the red oak. The white oak is somewhat objectionable on account of its slow growth and because its leaves remain upon the tree after they are dead. The number of oaks given in the list might be much increased. Those selected are of various sizes and have been given a trial.

FIG. 15.—*Avenue of pin oaks east of the White House, Washington, D. C.*

SYCAMORE.

The sycamore is an excellent shade producer, the leaves appearing at the proper time in this latitude and remaining on the tree as long as could be desired, when they give place to the persistent and graceful fruit. With a little protection it passes the

northern winters uninjured and develops rapidly into a splendid and shapely tree large enough for the widest avenues or capable of being adapted by pruning, to which it most readily submits, to very narrow streets. Such is the activity of its young wood and bark that the stem is at times completely girdled without appreciable injury, and the outer layers of its cortex are annually sloughed off during late summer and autumn, leaving the new layers beneath entirely free from soot and dirt accumulated during the summer. It is partly due to this, perhaps, that it enjoys with the ailanthus the distinction of being best adapted to parts of cities where smoke and dust abound.

The only serious enemy of the sycamore is a fungus which attacks its shoots and young leaves in early summer, greatly disfiguring the tree. In some cities of southern Europe complaint is made of the thick hairy covering which becomes detached from the young leaves and twigs and gets into the nose and mouth producing an inflammation known as the "sycamore cough." This tree is, however, most widely and abundantly employed in the cities of India, Persia, and Europe, while in America it is deservedly growing more popular as a street tree every year. In London, it is considered by many to be the only tree that will thrive in the dirt and smoke of so large a city.

Of the two common species of sycamore, the eastern is smaller and of closer growth than our native species, though less hardy and less beautiful in form. It was for some time thought, also, that the eastern species was less subject to attack by the sycamore fungus, but this is probably not the case. In this country, the oriental sycamore is usually preferred, while in Paris the western species is used exclusively, since it seems to conform better to the style of pruning adopted in that city.

AILANTHUS.

The ailanthus is another importation from the orient, less common than the oriental sycamore, and, on account of some especially objectionable qualities, very unpopular with the public. Some of these qualities, however, are not serious faults and may be entirely corrected with proper care. For example, the unpleasant odor at blossoming time is confined to the male flowers, and trees bearing these flowers need not be cultivated. The habit of sprouting profusely at the roots, though dangerous to pavements, renders the propagation of the ailanthus extremely easy, and also make it possible to select only the desirable trees. Those who object to the odor of the male flowers for two or three days, however, must endure the sight of the ugly brown fruit-clusters which often hang upon the tree throughout the winter. A fault which cannot be remedied is the early maturity and disfigurement accompanying rapid growth. When young, the ailanthus is vigorous and shapely, if properly trained, and its large leaves are green until frost, but most of the old trees I have seen, present a very scraggly and unsightly appearance. There are fine avenues of this tree in Paris, where it

is unrivalled for vigor and general thriftiness. When these trees show signs of failing, they will be cut down and the avenues replanted.

The qualities which make the ailanthus especially desirable as a shade tree are its ability to grow in even the most barren soil and to thrive in the midst of smoke and dust and other adverse surroundings peculiar to city streets. When the question is not what tree would be the most ornamental, but what tree would live and grow in a particular locality, then the ailanthus should certainly be considered.

NORWAY MAPLE.

The Norway maple appears to be the best maple we have for street use, though most of the trees I have seen are still comparatively young. Care must be taken to prevent its heading too low and making too dense a shade, but this can be easily done by timely and skillful pruning. Like the sugar maple, it suffers from dust and smoke, though not to the same extent, while it endures other street conditions much better, as may be seen by comparing the two species in any of our cities. After the first two or three years it makes a strong and rapid growth, and develops into a shapely tree well adapted to street use and free from any serious pests.

GINKGO.

The ginkgo is a new and very promising tree from Japan. There is a fine avenue of them in Washington and they seem to stand the winter as far north as Boston, where several young trees have recently been planted. At Rochester, the extremities of the lower limbs are often winter-killed, and in northern Germany it cannot be successfully cultivated on account of the severe cold and injury to its branches from snow. This tree is in many ways an ideal street-tree, and is without enemies of any kind. One must wait many years for shade, however, and the form of the tree must be adapted to street-use by careful pruning.

The indications are that the ginkgo will make a valuable addition to our list of shade trees; but experiment alone will definitely determine its value. A new tree often has many advantages in the way of soil and attention which would work wonders if bestowed to an equal degree on some ordinary and less esteemed species; while it might be difficult to say just what effect the vigorous conditions under which many of our city trees exist would have upon the species newly introduced. It is to be hoped that the ginkgo will not have to suffer all that some other trees have borne.

ASH.

The ash is a rapid grower and practically free from insects and diseases. Its foliage does not appear so early as to exclude the sun from the soil in spring-time. The wood is strong and valuable, but the branches are badly deformed by the wind. As its roots lie near the surface, it is adapted to

low soils. Thus far, the ash has not been very much used in cities. Of the various species of this tree, the white ash is much the best.

HACKBERRY.

The hackberry is another of our common native trees which deserves to be more frequently planted. It is shapely, not choice as to soil, grows rapidly, resists drought, is easily grown from the seed and easily transplanted, and is free from any serious diseases. Various leaf-eaters and gall insects attack its foliage, and its branches are often disfigured by distortions attributed to a gall-mite and a powdery mildew, but none of these troubles seriously injure its value as a shade producer nor endanger its life. It is said to be frequently used for shade in the west.

SWEET-GUM.

The sweet-gum develops rapidly and well in a great variety of soils and is practically free from insects and fungus attacks. The beauty of its foliage in autumn more than offsets the extra care required in transplanting and the litter caused by its fruits.

KENTUCKY COFFEE-TREE.

This tree can be grown only in rich damp soil. I have seen it very rarely in cities, but the specimens I have observed were very handsome and I think it deserves a trial in soils to which it is adapted.

ELM.

The merits of this most popular shade tree are so well known that I need not record them here. It should not be planted however, to any great extent in the large cities of the East, unless provision is made for regular and thorough spraying and other precautions taken to hold in check its various insect enemies, among which the leopard moth and the imported leaf-beetle are the most destructive. The elm is adapted to wide streets and requires deep moist soil. Its condition in many of our cities is far from satisfactory, and its use as a street-tree is in many localities attended with considerable risk. In towns and villages where the leaf-beetle is as yet unknown, the elm is grown with great success.

Other species of elm are occasionally planted in our cities, but none are equal to the American elm in general fitness for street use. The slippery elm, for example, cannot be used on account of its mucilaginous bark, which is relished by the small boy as a substitute for chewing gum; and the English elm, which does well in Berlin and Hamburg, is so greedily attacked by the elm leaf-beetle when planted here that it is not only useless for purposes of shade, but forms a centre from which this insect easily spreads to neighboring trees of our own species. Incidentally, the English elm is sometimes used as a trap tree in working against the elm leaf-beetle.

SILVER MAPLE.

The silver maple is a graceful tree of very rapid growth and possesses many qualities of an ideal street tree; but it is especially subject to injuri-

ous scales, and is often killed by borers, while its branches are liable to be broken by the wind. There are twenty-five thousand trees of this species in Washington, many of which bear injuries received during wind storms. Many also have been headed back on account of their extensive growth and are now diseased and unsightly. The silver maple endures city life very well and, if it escapes its various enemies, develops into a fine though not a durable tree ; and its cultivation is always attended with risk.

HORSE-CHESTNUT.

In the Spring, the horse-chestnut is an object of great beauty, but in late summer or autumn, when the red spider and mildew have completed their ravages, it seems unfit for the streets of any city. It is exceedingly tenacious of life ; few other trees have suffered so much and survived the shock. In the deep good soil of Bonn, the horse-chestnut is a large and splendid tree. In Paris, it is abundantly and successfully used for planting places and borders. But on the streets of most cities it loses its foliage too early because of drought and the effects of its numerous enemies, so that it cannot be recommended for general street planting.

FIG. 16.—*A canopy of horse-chestnuts. Jardin des Tuileries, Paris.*

HONEY LOCUST.

The honey locust is a fine tree with many good points, but too thorny for city use and often killed by locust borers. The side branches also have a troublesome way of going into the windows of houses and the pods are somewhat objectionable.

SUGAR MAPLE.

The sugar maple grows more slowly than the silver maple and its branches are not subject to injury from storms. It is likewise free from most insect pests, is easily transplanted, and capable of enduring our severest winters. Unfortunately, however, this beautiful tree does not thrive in cities. Its requirements as to soil and water are unusually exacting and its foliage is very sensitive to dust and smoke, especially during periods of drought. I have examined the sugar maple in many cities, but have not found one in which it was cultivated with uniform success.

LINDEN.

The linden requires an abundance of deep rich soil and suffers much from gas, from drought, and from insect attacks. It does fairly well in Washington, but is little planted now because of the extra care it requires as regards soil and water. In Berlin, Frankfurt, Hamburg, and Paris, the leaves of most varieties of linden fall prematurely on account of insect and fungus attacks. In Philadelphia a few years ago all the large lindens were killed by borers. A further objection to this tree is the litter made by its blossoms and fruit.

TULIP-TREE.

The tulip-tree is too large except for the widest avenues and park borders, where there is a quantity of rich deep soil and abundance of room. It is likewise difficult to transplant, the branches are very brittle, and the leaves are continually dropping throughout the season. It is, however, practically free from enemies.

BLACK LOCUST.

The black locust is a rapid grower, hardy, easily propagated and transplanted, and does well in poor soil. It is successfully cultivated in Paris, where the top is kept small and spherical and the branches thickly clustered. Its hard and durable wood is beginning to be used in Paris for paving the streets. On the other hand, the tree is scraggly and angular in form, its branches brittle, its foliage short-lived, its pods unsightly, and its roots badly given to sprouting. The locust borer often kills the black locust, as well as the honey locust, and has been known to spread from these trees to certain species of oaks.

FIG. 17.—*Black locusts near Père Le Chaise, Paris.*

WILLOW.

The weeping willow is the only species used on streets, and its occurrence is rare. It grows rapidly and when perfect makes a fine appearance, but the wood is tender and is often attacked by fungi, while the tussock moth and other leaf-eating insects frequently destroy its foliage. The white willow is excellent for windbreaks and for planting along the banks of streams, railroads, and other embankments. Fine rows of this

FIG. 18.—*Old white willows along Cascadilla Creek, Ithaca, planted to preserve the banks of the stream.*

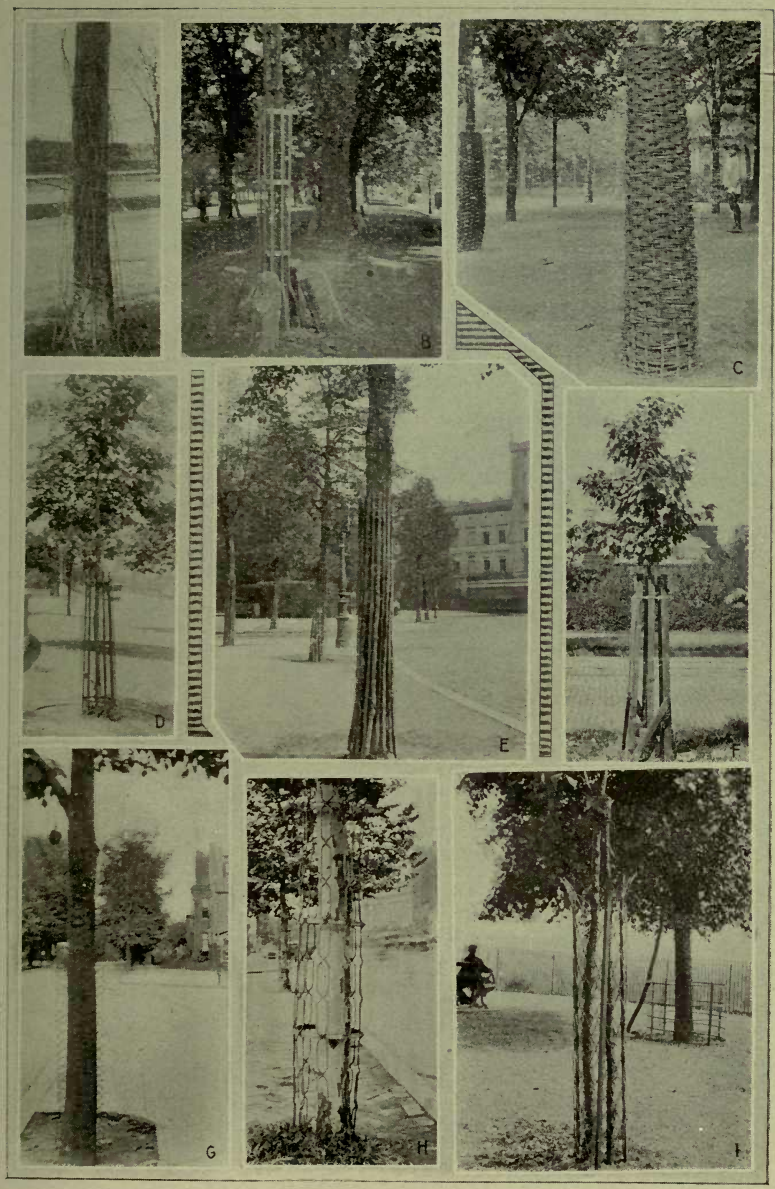

PLATE II—THE PROTECTION OF SHADE TREES.

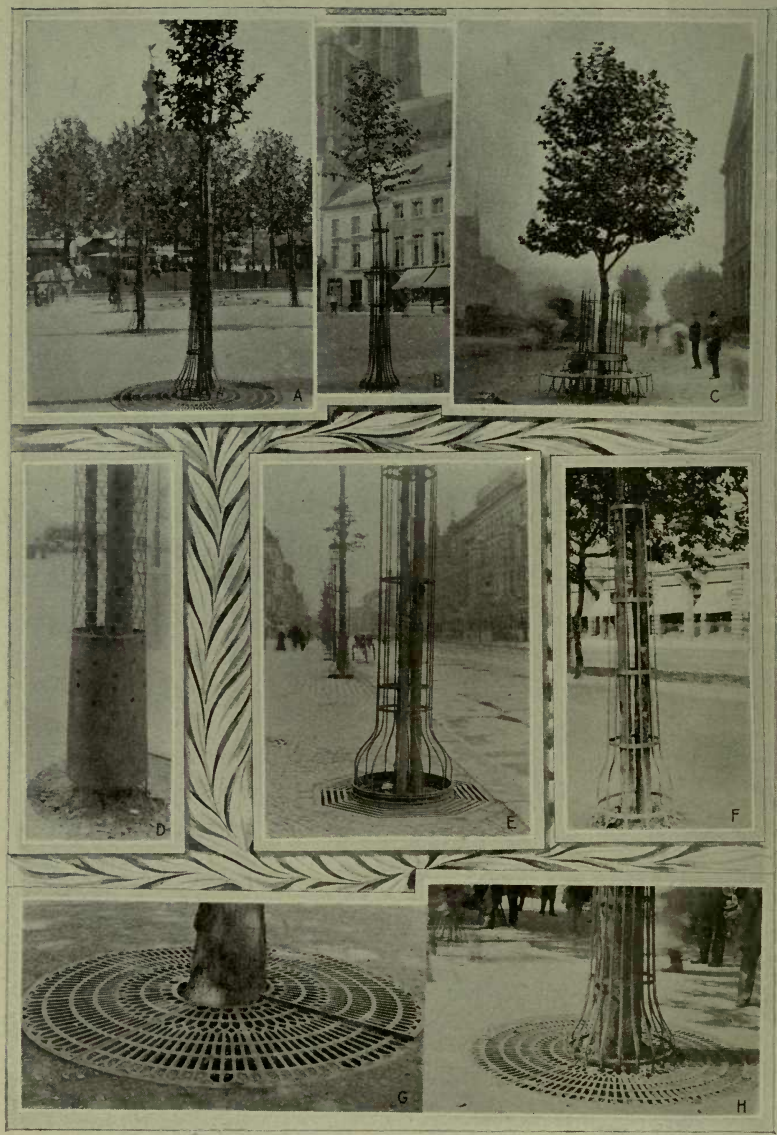

PLATE III.—THE PROTECTION OF SHADE TREES.

DESCRIPTION OF PLATES.

PLATE II. The Protection of Shade Trees.

A. A tree protected with thorns.

B. Basaltic pillars about horse-chestnuts at Bonn.

C. Wicker protectors about lindens at Frankfurt a. Main.

D. Light iron guard about young maple near Prospect Park, Brooklyn.

E. Jackets of pine poles west of Brandenburger Thor, Berlin.

F. Box-guard about young red oak, Washington.

G. Wire netting on older tree, Washington.

H. Iron guard about Sycamore on Pennsylvania Avenue, Washington.

I. Two forms of iron protectors, Primrose Hill, London.

PLATE III. The Protection of Shade Tree.

A. Young sycamore in full coat of mail, consisting of support, guard, and grill. Place de la Bastille, Paris.

B. Iron guard, about English field elm in front of the Antwerp cathedral.

C. Protector and circular iron bench around sycamore on Mile End Road, London.

D. A form of protector used in Frankfurt a. Main.

E. Young linden with wooden support, iron guard, and hexagonal iron grill, Potsdamerstrasse, Berlin.

F. Linden with iron guard, Heidelberg.

G. Grill used alone about base of ailanthus one foot in diameter on boulevard Montparnasse, Paris.

H. Older Sycamore with grill and guard, Place de la Bastille, Paris.

tree may be seen in Ithaca along the streams that descend from the surrounding gorges and are subject to overflow from the melting of ice. It is also used along the Thames in the western part of London to prevent erosion of the banks during the ebb and flow of the tide.

TREES RECOMMENDED FOR GENERAL STREET PLANTINGS.

Oak, Red (Quercus rubra L.)
Pin (" palustris Du Roi.)
Scarlet (" coccinea Wang.)
Black (" velutina Lam.)
Shingle (" imbricaria Michx.)
Willow (" Phellos L.)
Sycamore, Oriental (Platanus orientalis L.)
American (" occidentalis L.)
Ailanthus (Ailanthus glandulosa Desf.)
Maple, Norway (Acer platanoides L.)

TREES RECOMMENDED FOR FURTHER TRIAL.

Ginkgo (Ginkgo biloba L.)
Ash, American (Fraxinus Americana L.)
Hackberry (Celtis occidentalis L.)
Sweet Gum (Liquidambar Styraciflua L.)
Kentucky Coffee-tree (Gymnocladus dioica (L.) Koch.)

TREES WHOSE CULTIVATION ON THE STREETS OF LARGE CITIES IS ATTENDED WITH CONSIDERABLE RISK.*

Elm, American (Ulmus Americana L.)
Maple, Silver (Acer Saccharinum L.)
Horse-chestnut (Aesculus Hippocastanum L.)
Locust, Honey (Gleditsia triacanthos L.)
Maple, Sugar (Acer Saccharum Marsh.)
Linden, American (Tilia Americana L.)
Tulip-tree (Liriodendron Tulipifera L.)
Locust, Black (Robinia pseudacacia L.)
Willow, Weeping (Salix Babylonica L.)

*Many of these trees thrive well in villages and towns. After reading the previous discussion, several excellent trees might be selected from this list for a given locality.

THE PROTECTION OF SHADE TREES.

Protectors are of three kinds. The young tree needs a *support* to hold its trunk erect and its roots in place against the soil; it also needs a *guard* to shield it from the bites of horses and other injuries to its stem ; and it often needs a *grill* to prevent the trampling of the earth about its base and the consequent injury to its roots.

The support is usually a straight pole or joint ten to twenty feet long made of chestnut, spruce, oak or other wood, set firmly in the ground next to the tree either on the south side, where it shields the stem from the sun, or in line with the row of trees, where it is least conspicuous. The tree is attached to its support in several places by means of iron, leather or cloth bands padded with cushions of wool, rushes, or other soft material to prevent abrasion. The support is removed at the end of the third or fourth year after planting, or when the tree is fully able to support itself.

The most primitive guard I have seen in use is a handful of branches from a thorn bush arranged somewhat loosely about the tree trunk. These I saw on the streets of Fontainebleau, and I am told that they are not infrequently used along country roads and in small villages throughout France. The next in order of simplicity, perhaps, is the jacket of pine poles seen often in Berlin. These poles are fastened together by means of wire and may easily be removed when desired. They are cheap and efficient, and not so conspicuous as the wooden box so well known in America. In Frankfurt, jacket guards for young trees on retired streets are made of willow branches woven into tall tapering basket-like forms quite unique in appearance. In Bonn, the fine old horse-chestnut trees of Poppelsdorf Allée are protected in situations exposed to passing vehicles with shafts of stone planted about the tree at a little distance from its base. These shafts are columns of basalt brought from the north bank of the Rhine.

In Washington and many other cities, the most common tree guard is an elongated box made of narrow boards which encloses the stem of the tree up to a distance of five feet or more from the ground. The box guard is easily made and very efficient,

but clumsy and unsightly and affords an excellent retreat for insects. Wire netting is a cheap and excellent protector for trees and is now extensively used in America for the purpose. In the case of young trees, it may be passed around the stem and nailed to the support; while on older trees it is usually attached to wire nails driven into the trunk. In Washington, the young trees are generally protected with box guards and the older ones covered with loose wire netting. In the parks of London, the young trees are protected with wire netting, which is removed as the trees become older, except in the case of those having tender bark; and on London streets where iron guards are used the trunk often has the additional protection of a wire covering. Wire netting is also frequently seen in Frankfurt, but has not yet been introduced into Paris and Berlin, and many other cities on the continent.

The best guards are made of iron, and, although somewhat expensive, are widely used, especially in Europe. In Paris and London, they are generally employed; in Frankfurt and Berlin, they are used on the busier streets; while in Antwerp, Bonn and Cologne, they are being introduced with the trees recently planted. Unless city trees are under municipal control, the styles of iron guards are likely to be very varied and often cheap and inefficient. In Paris, they are contracted for by weight as well as measurement and are very strong and durable. The Paris guard is about seven feet high, cylindrical in form, and constructed in two parts, the iron slats being riveted to semi-circles of iron. It is fastened to the tree support at the top and to the grill at its base, or, in the absence of the grill, it is loosely fixed in the earth. This style of guard has been adopted in many parts of Europe.

In America, combinations of iron rods and heavy wire netting are frequently seen, while it is not uncommon to use rather low iron guards and cover the trunk above the guard with ordinary wire netting. In Frankfurt, the base of the tree is often protected by a perforated cylinder of sheet-iron set on short legs and above this is rather stout closely woven wire.

All guards of whatever kind should be fastened securely to the tree in such a way that no injury will result from rubbing;

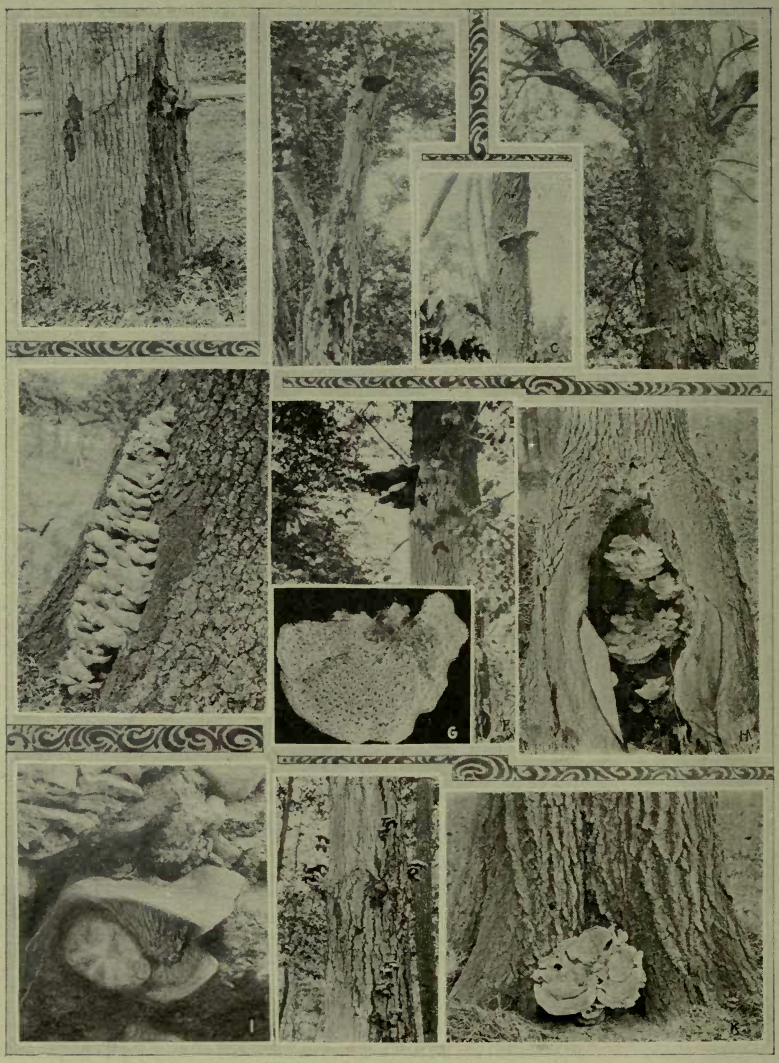

PLATE IV.—SOME FUNGI WHICH ATTACK SHADE TREES.

and, as the trees grow larger, care should be taken to loosen and enlarge the guards as the trees require. Neglect in this matter has occasioned the death of quite a number of shade trees.

Grills are designed to prevent the trampling of the soil about the base of the tree and are especially desirable on street corners and other places where many people pass. On paved sidewalks where the traffic is large and the amount of exposed earth at a minimum, some such means of keeping the soil light and porous may be considered a necessity. Grills also afford an excellent means of watering trees during periods of drought. The con-

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DESCRIPTION OF PLATE.

PLATE IV. Some Fungi which attack Shade Trees. The Trees mentioned are living, unless the contrary is stated.

A. White Oak on the campus of Cornell University attacked by *Polyporus applanatus.*

B. *Polyporus hispidus* on Sycamore at Wiesbaden, Germany.

C. *Polyporus* on black locust, Falls Church, Virginia.

D. Silver maple in Washington which has been headed back, seriously attacked by *Polyporus obtusus.*

E. *Polyporus sulphureus* on black oak, Palisades Park, New Jersey.

F. *Polyporus squamosus* on English field elm, Tower of London.

G. Upper surface of same.

H. *Daedalea quercina* on white oak, Palisades Park, New Jersey.

I. Fruit bodies of *Pleurotus ulmarius* appearing on the roots of a dying sugar maple which had been uncovered in the process of lowering the street. Eddy Street near Cascadilla Place, Ithaca.

J. *Pholiota adiposa* on red maple, Palisades Park, New Jersey.

K. *Polyporus Beatiei* found at the base of a large black oak tree near Blacksburg, Virginia. Related to *Polyporus frondosus.*

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struction of the grill may be readily determined by examining the accompanying illustrations. It is made of sections of iron grating which fit together about the tree in a circular, rectangular, or hexagonal form and are supported on wooden pegs driven into the ground. A special form of grill is sometimes used on very busy streets, which extends outward beneath the sidewalk leaving considerable space about the tree, while, being covered with pavement, it permits free use of the sidewalk up to within a foot of the tree trunk. Grills are regularly used with the iron guards in Paris, Berlin, and London in places where they

are needed. Their use in many other cities would greatly improve the general condition of street trees.

PRUNING AND CARING FOR WOUNDS.

The natural forms of shade trees should be preserved as far as possible; but since trees are rarely adapted to the requirements of a city street, more or less pruning usually becomes a necessity. Pruning should, however, be indulged in as little as possible, and no branch should be removed from a tree without a good reason. The cutting of trees into various artificial shapes cannot be justified on any reasonable ground whatsoever.

If a street tree has been properly trained in the nursery, very little pruning is needed, and this only for the first few years after planting, during which time the original form is preserved by trimming the fast growing limbs, removing the crooked ones, and shortening those that droop as they become larger and heavier. When one must use an untrained tree, steps should be taken at once to elevate the trunk and encourage the growth of a straight central stem with subordinate branches. The lower limbs of a tree should never interfere with the street lights or with passing vehicles. In Paris, the height of the trunk is required to be fifteen feet. The top of a tree should not be allowed to become so dense as to exclude the sun from the soil beneath or from buildings near-by. The foliage is also more uniform and better developed when light and air are admitted to the interior of a tree, and this increase in leaf surface adds materially to its healthful effect.

It often happens that trees have been neglected until very large. To bring them into shape requires considerable care, but it should be undertaken if they interfere with the proper use of the street. Trees that have been trained and are simply overgrown can be easily brought back within bounds by thinning out or shortening the overgrown branches. Old and failing trees may often be stimulated to new growth by judicious pruning. When branches are injured by accident or broken by wind or snow, pruning becomes a necessity. It is also wise to remove all dead branches as soon as they are discovered.

The best time for general pruning in New York State is in the

spring before growth begins, or from the middle of February to the middle of April. Sap-running trees are best pruned from the middle of May to the middle of June. In case fall pruning is preferred, trees that run sap should be finished before the middle of October and other trees after this time. Injured or dead limbs should be removed when observed. The latter are best seen before the leaves fall. Dead branches are unsightly and dangerous to passers-by and to children playing beneath them, while they also endanger the life of the tree by carrying decay into its trunk. A hollow trunk often has its beginning in a neglected dead branch. Dead branches also absorb sap and afford breeding places for injurious insects and fungi.

FIG. 21.—*Sugar maple on South Hill, Ithaca. A hollow trunk often has its beginning in a neglected dead branch.*

Pruning is the removal of some branches and the shortening of others. The smaller the branches when cut, the better it is for the tree. While in the nursery, branches are best removed in the bud stage and best shortened by having their tips pinched off. If disbudding and pinching is carefully attended to, the work of pruning in after years is greatly lessened, while the form and vitality of the tree is greatly improved.

When trees are planted from the nursery with a full height of stem and with the top already formed, it is necessary only to preserve this form by encouraging the leader and checking the growth of ambitious side branches by cutting their tips. When trees with low stems and unformed tops are planted, the stem

should be gradually elevated by cutting back the lower branches to one-half or two-thirds their length each year for two or three years and then removing them entirely. In case several spring from the same point on the trunk, one or two should be cut at a time, the others being kept very short while the earlier wounds are healing. In shaping the top, select a leader and make it as vigorous as possible by trimming all strong shoots near it and cutting back the more vigorous side branches. The proper form is best determined by the use of the dendroscope with a dendrometer. As the tree grows older, a few more of the lower branches will have to be removed and possibly some of the upper ones taken out to keep the top from becoming too large or too dense.

FIG. 22.—*Silver maple in Ithaca "headed back."*

The removal of large branches is always attended with a certain amount of risk and this risk is largely increased when more than one or two are removed during the same season; but if the wounds are carefully dressed and borers kept out, decay may usually be avoided, though the loss of food cannot be replaced. An overgrown top should usually be corrected by thinning out some of the longer branches. This is better than heading them back, because the effect of the latter process is to destroy the beauty of the tree and to produce a dense objectionable cluster of branches as well as to open a sure road for the entrance of disease. The cut end of a large branch rarely heals over, the adjacent parts die, and decay gradually extends to the trunk.

Certain large and vigorous trees that stand pruning particularly well, such as the elms, lindens and sycamores, may best

be headed back, each limb being cut to one-half or one-third its length. From these cut ends new branches arise, which grow out vigorously and uniformly, soon obliterating the more conspicuous effects of this style of pruning. By pruning the healthy limbs of old and failing trees, new vigor is imparted to them. Such pruning should usually be accompanied by the improvement of the soil. Very old elms in the London parks have responded to this method of treatment with remarkable vigor.

FIG. 23.—*Branch cut even with the trunk.*

All misshapen and injured limbs should be trimmed or entirely removed. The sprouts that may appear about the wounds for a few seasons after pruning should be cut off during the latter part of summer. Epicormic branches induced by the entrance of too much light into the tree are unsightly and intercept the rising sap; they should be removed with the sprouts above mentioned.

The work of pruning should be begun at the top of the tree and completed at the bottom. In this way the desired form can be better secured, and there is less danger of accident. The men employed should be careful not to do more damage by breaking and bruising than they do good by pruning. A rope properly adjusted about the waist and fastened to a stout limb above the workman is an excellent means of sustaining the principal weight of the body while moving about through the tree. The form and direction of the cut when removing branches depends upon the position of the branch on the tree and upon whether it is to be simply shortened or entirely removed. Erect branches are shortened by cutting them at an angle, thus preventing the undue entrance of water; while side branches are cut perpendicularly for the same reason. The sap-lifter or small branch left near the cut, should always be on the under side of the shortened branch, since if left on the top it

grows erect and injures the symmetry of the tree. Branches to be removed should be cut off *even with the trunk.* This rule should be invariably followed with all trees, the conifers not excepted, even though the labor be increased five-fold. When large branches are shortened or removed, splitting and tearing may be prevented by making two cuts, the one beneath the branch being made first and followed by another above and about a foot farther from the trunk. A dead limb should be cut back even with the shoulder at its base.

FIG. 24.—*Pruning properly done, but wound not dressed.*

The work of pruning is by no means complete until the wounds are carefully smoothed down and properly dressed. This treatment enables the healing tissue to cover the wounds in the shortest possible time and prevents the decay of the wood while healing is taking place. Exposed wood gradually loses water and cracks are produced in which dust and moisture collect and form a substratum for the growth of bacteria and moulds. Later the spores of larger fungi enter and by developing in this mass of decayed wood become sufficiently vigorous to attack the heart-wood and thus pass into the trunk of the tree.

If some substance is applied to the wound which will prevent the evaporation of water and the consequent checking, decay may be avoided. Various mixtures have been used for this purpose, of which lead paint and coal tar are probably the best. Both are antiseptic as well as protective, if applied in thick layers. In the case of large wounds, which require several years to heal, it is well to put on a second coat after two or three years. Thin coal tar is not suitable for this purpose as it does not prevent

the evaporation of water. It may be thickened by burning in an iron kettle. Coal tar does not injure the tissues to any appreciable extent, since only the surface of the wood is cauterized by it and there is no vital connection between this wood and the callus which covers it. When used on the elm, it is prevented from adhering at times by water blisters peculiar to this tree. In these cases, it should be rubbed off and another coat applied.

FIG. 25.—*Large elm in Ithaca covered on one side with sheet-iron.*

Wounds made by accident may be treated similarly to those made in pruning, after the injured tissues have been removed. Split trees should be joined with a bolt instead of a band. Bruised, loosened, or dead bark should be entirely cut away, since it can never aid in repairing the injury, but on the contrary, encourages decay and prevents the growth of new bark. Decayed wood should be removed and the cavity painted with coal tar, then plugged with dry oak wood and this smoothed on the outside even with the trunk and coated with tar. If the hole is too large to plug, a board is sometimes nailed in it and painted with tar or covered with zinc to keep borers away. At Wiesbaden, large holes are filled with cement, probably because cement is so abundant in that region and so easily used. I noticed cement also used on trees in St. James' Park, London. At Bonn, they make use of a heavy tarred felt for covering large cavities in the trunks of trees. Sheet iron is often employed for this purpose in America, and to a limited extent in Europe. If the cavity is not made thoroughly antiseptic, however, the use of any of these coverings is of doubtful advantage, since the exclusion of dry air and light tends rather to encourage than to prevent decay. In case the tree is hopelessly diseased, anything that will strengthen the trunk or conceal an

unsightly wound may be considered advantageous, unless it prevents proper inspection of the tree and in this way becomes dangerous.

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Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

Studies of Some Shade Tree AND Timber Destroying Fungi.

By GEO. F. ATKINSON.

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Walter Mulford

STUDIES OF SOME SHADE TREE AND TIMBER DESTROYING FUNGI.*

By Geo. F. Atkinson.

A great deal of attention has been given in the past to the study of injuries to trees caused by the microscopic fungi, but comparatively little study has been made of the relation of the larger fungi to the destruction of trees and timber. The most notable work which has been accomplished in this direction is that of Robert Hartig of München, Germany, whose contributions have appeared in the publications of the "Forstlische Versuchsanstalt," in his book on the Diseases of Trees, and in other places. During the past two years there have appeared several excellent bulletins from the Missouri Botanical Garden and from the U. S. Dept. of Agr., giving in detail the results of some work by H. vonSchrenk, of Washington University, St. Louis.

About five years ago the writer began studying the injuries which some of the higher fungi produce upon shade trees and timber trees. Very little of this work has as yet been published. Use has been made however of some of the studies and photographs accumulated in the progress of the work, in the author's "*Mushrooms; Edible, Poisonous, Etc*" (1900), and in other places; while a short article was published on "Some Wood Destroying Fungi," as special report No. 9 in the Geological Survey of Louisiana, Feb. 1900. It has been my plan as far as possible to select one or more individual cases and then endeavor to trace the history of the relation of the fungus and its host. This would include a study of the present conditions, and an effort to determine, by examination, the time in the past when the fungus entered, the mode of its entrance and progress, as well as the probable cause of the wound which provided the entrance court for the tree enemy. In a number of cases these

*The principal facts in this paper were presented before the Mass. Hort. Soc., Boston, Mar. 1901.

have been worked out quite satisfactorily. The studies have been made in New York State, chiefly at Ithaca and in the forests of the Adirondack Mountains.

A word might be said at the outset in regard to the relation of these wood destroying fungi to others, as well as in regard to their structure. They are among the higher fungi and belong to the larger group known as the *Hymenomycetes* to which the mushroom also belongs. In fact it is becoming customary with some to apply the term "mushroom" to all of the *Hymenomycetes*. However widely these plants differ in their form and structure they all agree in the general character of their fruiting surface. It forms a thin layer or "membrane," covering definite parts of the fruit body, and consisting of innumerable club-shaped cells standing side by side. Each one of these club-shaped cells is called a *basidium*, and usually bears four spores.

56.—*Polyporus borealis. Fruit bodies growing from wound on hemlock spruce.*

There are several large families, or orders in the group. I will call attention to a very few in each family in order to show more definitely the form and general character of the species examined here. In one of these families the fruit body is often spread over the surface of the wood in

thin smooth patches, or some forms are shelving, when the underside is smooth and is the fruiting surface. These belong to the family *Thelephoraceæ*. A few of its members are very destructive to wood and some are parasites on trees. In another family the members are known as "coral fungi," or "fairy clubs" a large number of them belonging to the well known genus *Clavaria*, from which the family name *Clavariaceæ* is derived. The fruiting surface is distributed all over the surface of the plant. To a third family, *Hydnaceæ* belong the "hedgehog fungi," with the fruiting surface on spines, a few species of which are well known. A number of the members of the two last named families grow on wood, but often appear in late stages of decay. A few species like *Hydnum septentrionale* on maple, and *H. schiedermayeri* on apple, are destructive.

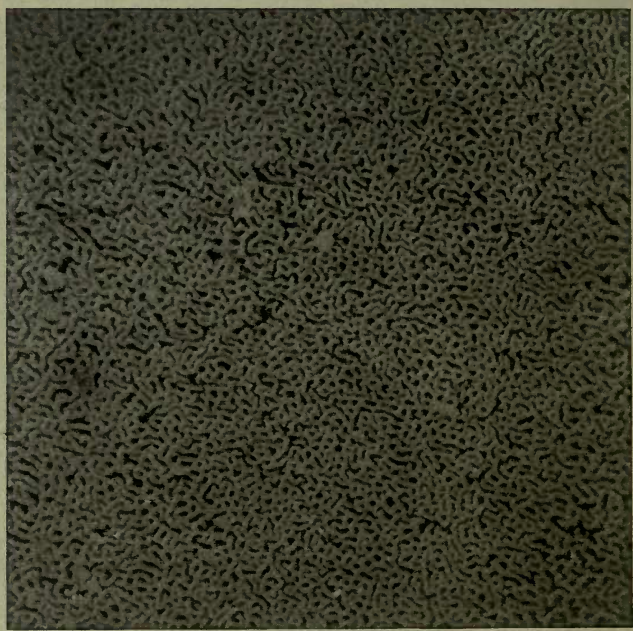
57.—*Polyporus borealis, section of fruit body.*

The two largest families are known as the *Agaricaceæ*, to which the common mushroom belongs, and the *Polyporaceæ*. In the latter the fruiting surface is in the form of a honey-comb on the under side of the fruit body. It is to this last named family that the species belong which are treated of here.

The gross characters, those which are quite easily made out without the aid of a microscope, are chiefly the ones presented here, since a detailed account of microscopic structures and changes brought about in the wood by the action of the fungus, are rather too technical for full treatment in this paper.

POLYPORUS BOREALIS.

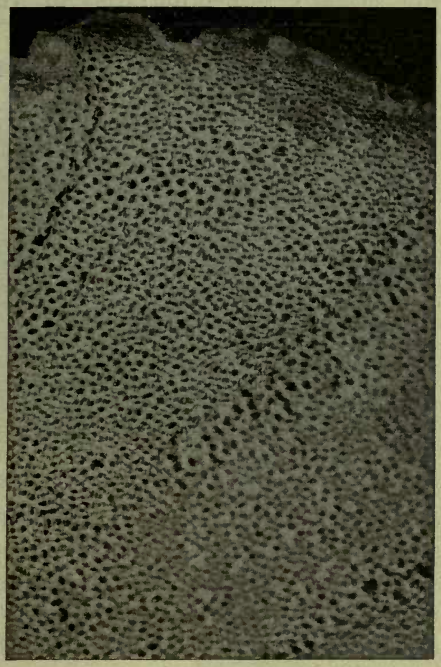
Polyporus borealis occurs on pines, spruces, the hemlock, etc., and is widely distributed over the North Temperate Zone. It occurs on living or dead trees. It is a "wound" parasite, entering through broken branches, through wounds caused by impact of falling timber, or where the cambium has been scorched by fire. The fruit bodies are entirely white. When



58.—*Polyporus borealis, Hymenium with sinuous pores.*

old or dry they often take on a pale yellowish tinge. They are shelving, the cap attached directly to the tree, broad at the free end and tapering somewhat in a wedge-shaped manner toward the base. They are rarely single, and sometimes scattered over the trunk. They usually occur, several close together overlapping in an imbricated fashion, and joined at the base in a common trunk at the exit from the tree.

The fruit bodies are rather soft and spongy. They last only for the season. They are 10 to 20 cm. (4 to 8 inches) long by 6 to 15 cm. broad. They form larger masses where several are joined. The upper surface is rough with coarse tufts of mycelium giving it a very shaggy or sodden appearance. The honey-combed surface is below. The hymenium consists of quite regular pores with rounded openings in some specimens, or irregular, elongated and sinuous pores in other specimens, resembling the pores of *Dædalea*. But they are evenly sunk in the substance of the cap and therefore lack the essential character of that genus. The walls of the pores are thin, and the edges often irregular and jagged.



59.—*Polyporus borealis, Hymenium with rounded pores.*

There are two cases of its occurrence on living coniferous trees which I have carefully studied. One case is that of a hemlock spruce (*Tsuga canadensis*). The other is that of a red spruce (*Picea rubra*), the common timber spruce of the Adirondack region.

The hemlock spruce was a large tree, 60 cm. (2 ft.) in diameter, on a steep slope in one of the deep gorges (Fall Creek) at Ithaca, N. Y.

This example was observed in the autumn of 1899. The fruit body of the fungus was situated at a large wound on the trunk near the base. It consisted of several caps closely joined at their origin from the trunk of the tree. This is well shown

in the several photographs. A section through the entire fruit body (Fig. 57) shows the radiating lines formed by the general direction of the mycelium in the caps from their common origin in the tree trunk.

One of the photographs gives us a clue to the manner in which the mycelium of the fungus entered this particular tree. The log, lying in the foreground, close by the trunk of the affected tree, tells the tale. This tree in its descent, years ago, struck the slightly projecting base of the standing hemlock, and knocked off a large area of the bark and cambium, or growing region, at this spot. This wound was too large and the tissues

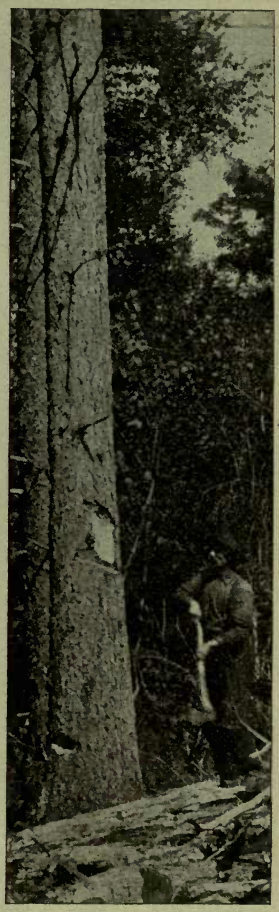
60.—*Polyporus borealis. Disintegration of wood.*

too much bruised to permit rapid healing over. It offered therefore a sure infection court through which the mycelium entered.

This also shows that the healing has been going on for a long time from the margin of the wound. But the wound is so large, it is yet far from being healed. Had it later healed over, it could not, of course, save the tree from destruction because the wound parasite was already permanently established in the interior, or heart, wood. Thus the wound which gave entrance to the fungus mycelium also offers a place for its exit in the formation of the fruit body.

From the time the mycelium entered the trunk at this wound, which must have been from 25 to 40 years ago, the mycelium gradually made its way into the heart, and from there grew downward into the roots and upward through the heart to the

top of the tree. Its presence on the roots was determined by the occurrence of the fruit bodies from a few places on exposed parts of the large roots, while external evidence of its having reached the top of the tree was shown by a number of dead limbs in the top, some of which had fallen. Evidence of its having reached the top was also found on cutting down the tree, and taking out sections at different points in the trunk. Here was found an abundance of mycelium and the heart wood was in an advanced stage of decay.



61.—*Red spruce affected with Polyporus borealis.*

The mycelium advances in certain definite directions in the wood of the tree. This is probably due to the structure of the wood. It grows in three different directions: parallel with the axis of the tree trunk, *i. e.* up and down; radially, from the center toward the periphery; and tangentially. At one stage of development the mycelium may be very profuse and abundant. It then is present in the form of cords or strands which lie radially or tangentially in the channels which have been dissolved by the action of the fungus ferment on the wood. These strands lie quite close together and are parallel. After being developed in considerable abundance the strands of mycelium largely disappear having burrowed open channels and furrows through the wood in the radial and tangential directions.

Shrinkage of the wood occurs at the same time because of the disappearance of a considerable content of the water and of the wood substance. This shrinking results in checking the wood into numerous minute cuboidal blocks, marked off primarily by

the position, and solvent action, of the mycelium. This becomes more pronounced if the wood dries, if the tree is cut or if blocks of the wood are cut from the trunk and allowed to dry. In the early infection of the wood, and the early stages in the advance of the mycelium, before the larger strands have become established, the openings made by the mycelium are very minute. They take the same directions as the larger openings. In fact the mycelium, instead of making a general attack upon the tissues, begins its advance at certain regularly separated points, and then extends along in parallel lines. If the wood is cut out at this early stage, one can see these minute perforations thickly scattered over the exposed surface. Sometimes, even in this early stage, shrinkage of the wood will have taken place. If not very marked when freshly cut from the wood, the shrinkage of the wood on drying, marks it off in a beautiful manner, by fine lines and holes into cuboidal areas.

62.—*Effect on wood of red spruce by the mycelium of Polyporus borealis.*

In many of these cases of the heart rot of trees, after the heart wood is well affected, the mycelium being well established and vigorous, gradually encroaches on the cambium or living area beneath the bark. In this way, many of the branches in the top of the tree die, and in some cases later the cambium of the trunk may be so destroyed as to kill the tree outright.

The red spruce example, in the Adirondack woods, was a tree of handsome proportions near Pearcefield Falls, in the Raquette River, left by the lumberman a few years prior to 1896, the season when I observed the tree. At some distance there was no indication that the tree was diseased and I enquired of my guide, who had at one time some experience in cutting timber, why the tree was left. "That tree ain't no good," he replied. As we approached nearer, he said, "don't you see the gum running from all the knot holes?" This he explained was regarded as a sure sign of "heart rot." Furthermore the tree was "checked" on one side, the crack being quite large and extending for some distance. The check was probably caused by a wrench given the weakened tree during a heavy wind. There was no other external evidence that the tree was diseased, and to satisfy myself that the tree suffered from "heart rot," I had my guide cut out a few blocks of the wood from the trunk. Two inches beneath the bark, the wood was found in a "dozed" condition. The heart was not in a very advanced stage of decay though the area was very extensive. The mycelium visible to the eye was very scanty. Still the wood showed numerous fine perforations, and

63.—*Fruit bodies of Polyporus borealis, showing shaggy cap.*

as some shrinkage had taken place, it presented the very fine divisions into minute blocks described above. I then searched more carefully for some fruit form of the fungus and found at the ground level, buried under leaves, a fruit body of the *Polyporus borealis* between two buttresses of the base of the trunk. The tree was not felled, and consequently there was no opportunity of ascertaining the special mode of infection in this case.

POLYPORUS SULPHUREUS.

The sulphur polyporus has a very wide distribution and occurs on a great variety of broad leaved trees as well as on certain of the conifers. It is known on the apple, walnut, butternut, locust, oak, ash, pine, hemlock spruce, and other trees. It occurs on living trees, the fruit bodies growing from knot holes or wounds from the mycelium in the heart of the tree; or the fruit bodies arise from portions of the trunk killed by the fungus. It is also a very common fungus on dead and decaying logs, stumps and roots.

64.—*Polyporus sulphureus. Large tubercular fruit body on oak.*

The plant is easily recognized by the yellowish color of the caps which are of the shelving form, sometimes scattered, but more often closely overlapping. Sometimes the caps are so closely crowded as to form a large tubercle 20 to 25 cm. or more in diameter. The upper surface of the cap is a bright orange red, while the lower surface, the honey-combed fruit surface, is sulphur yellow. The fruit bodies are rather soft, the color soon fades, they are quickly attacked by insects, or decay after several weeks. They are short lived therefore, while the mycelium within the trunk is perennial, or at least lives from year to year without an annual infection.

OAK TREE KILLED BY POLYPORUS SULPHUREUS.

A scarlet oak tree (*Quercus coccinea*) growing near the grounds of Cornell University was under observation for several years. The tree was standing on the edge of the Fall Creek gorge, not far from the Fisk McGraw mansion and opposite the present electric power plant of the Ithaca Street Railway. It was first observed in 1897. At this time the mycelium of the sulphur polyporus had advanced so far from the heart wood into the sap wood, that the latter, as well as the cambium layer, on one side of the trunk near the base, had been killed. This gave an opportunity for the exit of the fungus and the formation of the fruit bodies on the outside. Fig. 65 is from a photograph taken in 1897. They are fine specimens, but are much more scattered than is usual with this species. The fruit bodies appeared during the succeeding seasons of 1898 and 1899. During the latter season the tree died from the injuries of the mycelium in its advance on the cambium or living portion of the trunk. It was felled, and several sections cut out from the trunk for observation.

65.—*Polyporus sulphureus. Scattered fruit bodies on living oak.*

66.—"*Punk*" *in cracks on oak log.*

The decay of the heart wood had reached an advanced stage so that it was quite soft, and the moisture content was much less than in healthy trees. The lessening of the water content of the heart wood during the growth and spread of the mycelium caused a shrinkage in the wood. This produced several radial checks into which the mycelium had grown forming sheets of pure mycelium, sometimes called "punk."

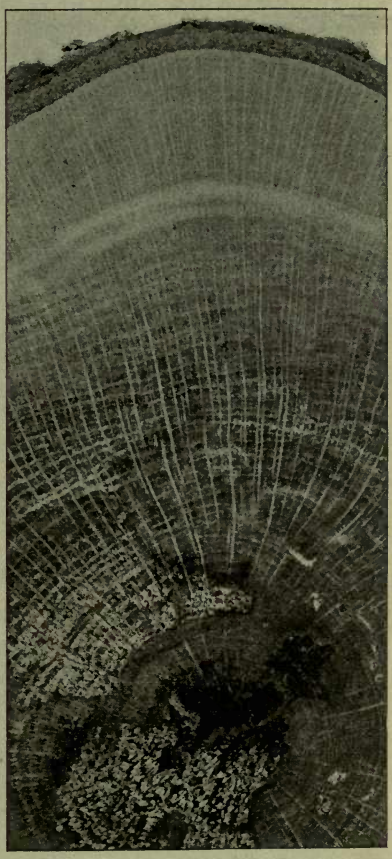
POLYPORUS SULPHUREUS IMPRISONED IN A WHITE OAK.

A white oak tree about 40 years old was growing quite close by the side of a larger tree on the grounds of Cornell University. The tree leaned slightly away from the larger one and there was a one sided development of the branches induced by stronger illumination from that side.

67.—*Section of living oak with imprisoned mycelium of the sulphur polyporus.*

The tree was felled in order to see if there was a corresponding asymmetry in the annual growth of the trunk which might be manifest in the excentric position of the annual rings. Before cutting the tree down there was no evidence that it was diseased. The trunk to all external appearance was sound. There were no broken limbs, no wounds, visible. On cutting the trunk into sections to study the annual rings, the heart wood through a large part of the trunk presented unmistakable evidences of partial decay following many of the annual rings and along by the medullary rays. The wood in these areas was being disorganized by the mycelium, and the latter forming the incipient stages of punk.

The case was an interesting one since the question arose as to how the fungus, now completely imprisoned, gained entrance to the trunk. The butt was sound so the fungus could not have entered through the roots. Perhaps it entered at a large branch broken a number of years ago and now completely healed over.

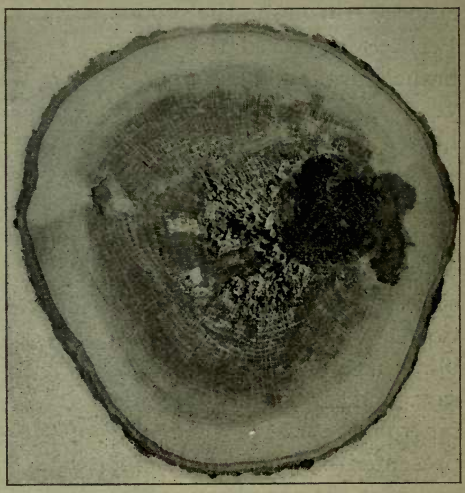


68.—*Section of oak showing decay at center.*

All of the sections showed more or less decay at the central core of the heart wood where some of the wood was so badly decayed in some sections as to break out or crumble from the friction of the saw. One of the sections not far from the base of the trunk presented on the lower end, and near the periphery, a circular black area, resembling the dead remnant of a branch which might have broken off years ago, and healed over. On the surface of the same side of this section was a prominent enlargement in the trunk, resulting from the healing process. But the evidence of a wound here was largely obliterated because the old bark had formed over the surface. There was only a minute opening, very obscure which was not completely healed over.

By examining successive sections of the trunk below this one it was observed that this black "core" representing the broken portion of the young tree gradually came to lie exactly in the central core of the trunk. This indicates quite clearly that the

injury occurred to the tree in the sapling stage, and that the sapling was broken off instead of one of the branches. One of the upper branches then became the "leader" and in course of time the broken end of the sapling was enclosed by the healing tissue.



69.—*Section of oak showing dead sapling stage near center.*

This section of the trunk was then sawed through lengthwise and in such a direction as to split the core of the dead sapling radially from the center of the new trunk. A view of one-half of this section is shown in Fig. 70. It shows the origin of the branch which became the new "leader" of the tree; as well as the large and irregular end of the broken sapling covered over by the healing tissue.

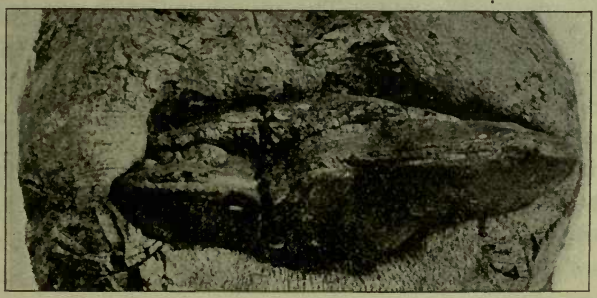
70.—*Section of oak showing slivered end of broken sapling.*

The cross section shows that this injury occurred more than 30 years ago, very near the time that Cornell University was founded. Some accident, the cause of which we cannot now determine, befell this tree in its youth and the sapling was broken off, while one of the topmost remaining branches in time replaced the main trunk.

An injury resulting from this kind of fractures leaves a long and slivered end some distance from the point where healing takes place. It must be a number of years then before the healing process can advance so far as to cover the fracture. In this instance over thirty years elapsed. The broken and slivered end of the sapling offered the most favorable lodgement place for spores of fungi, and for the accumulation of detritis resulting from the constant weathering of the exposed surface. In these places moisture is also conserved. The conditions presented are favorable for the germination of the spores and entrance of the mycelial threads. No more favorable infection court could be provided whereby the fungus is enabled to enter the heart wood.

71.—*Polyporus igniarius, tongue form of fruit body on beech.*

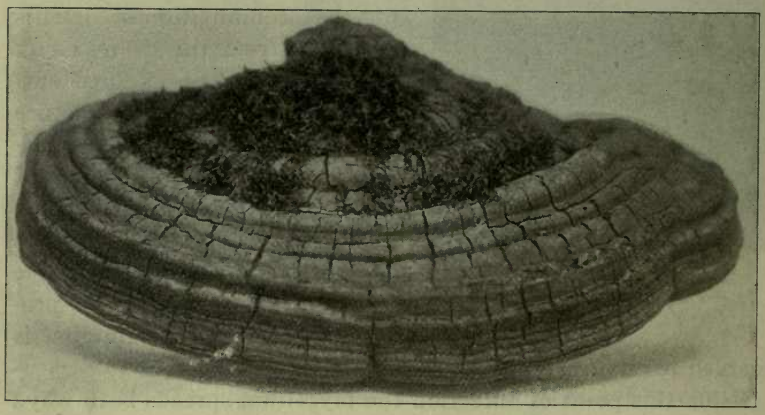
From this point of infection the mycelium spreads both ways down the old trunk of the sapling, and upward in the branch



72.—*Polyporus igniarius. Hoof form on beech.*

which forms the newly established leader. The progress of the fungus is comparatively slow, and the disorganization of the wood accompanies it. The slow growth of the mycelium is

probably due to several causes, the resistance which it meets from the wood, the action of tannic acids in the heart wood, as well as to the small amount of air in the interior of the tree. When sections of the trunk were cut, and piled together, the mycelium at the cut surfaces grew very rapidly. The mycelium here had access to air, and the moisture was conserved by the cut surfaces being in contact. In this way it was easy to demonstrate the presence of the mycelium in parts of the wood which



73.—*Polyporus igniarius, from maple.*

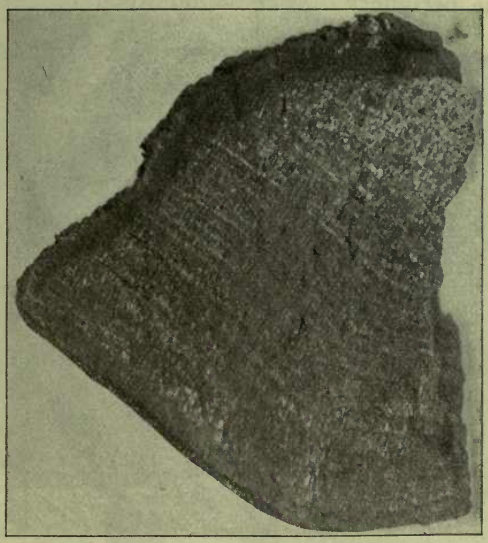
to the eye appeared sound. The mycelium grew out from the wood into the moist air, along the concentric annual rings, and the medullary rays, so that within 24 hours the location of the mycelium at these points was plainly demonstrated and photographs taken at this time marked the location of the mycelium in the infected areas. In several days time, however, the mycelium spread out between the cut surface forming thin sheets of "punk."

POLYPORUS IGNIARIUS.

This species occurs on broad leaved trees. It is known on the apple, oak, alder, beech, birch, maple and other species. The fruit bodies are hoof-shaped, very hard, almost stony, the upper surface black, while the lower surface, the fruiting surface, is brownish. The upper surface is marked by concentric furrows

and ridges which mark off the annual layers. The fungus is thus perennial.

It is very generally distributed through hardwood forests. It is especially abundant in certain hardwoods in the Adirondacks. In some sections a large percentage of the beech, birch and maple is affected. A quantity of the wood of affected trees was collected both at Childwood, St. Lawrence Co., in 1896, and at Clearwater, Herkimer Co., in 1898. At the latter place, the second flag station north of Fulton Chain, on the N. Y. C. R. R., there were excellent opportunities for studying it on the maple, and for determining the conditions which favor the entrance of the fungus into the heart of the tree. Since the mycelium cannot enter through the living cambium of the tree, an "infection court" must first be provided. These infection areas are provided in a variety of ways, in general their origin being the same as for other timber destroying fungi which enter through wounds.

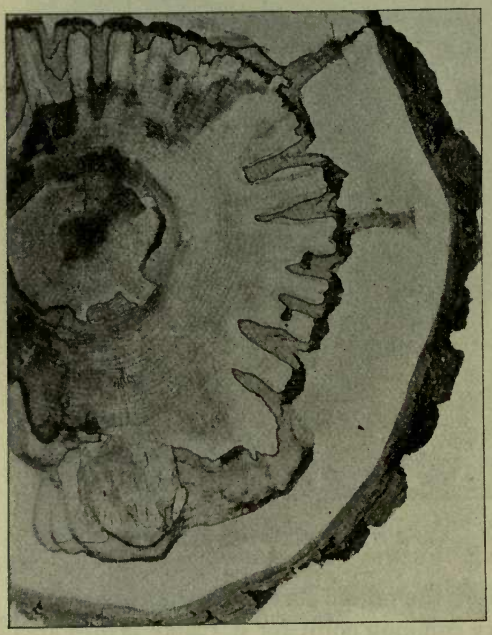


74.—*Section of fruit body of Polyporus igniarius.*

The conditions prevailing in a large portion of the mixed forests of the Adirondack region are such that a very common point for entrance is provided by the falling of the lower limbs. In the mixed forests the spruces and pines tower so far above the hardwood as to cut off much of the light. The hardwoods are thus so shaded that the area of foliage is considerably lessened, many of the trees having few limbs, and then bearing few leaves compared with trees in the open, or even in a hardwood forest where all the trees have an equal chance for light.

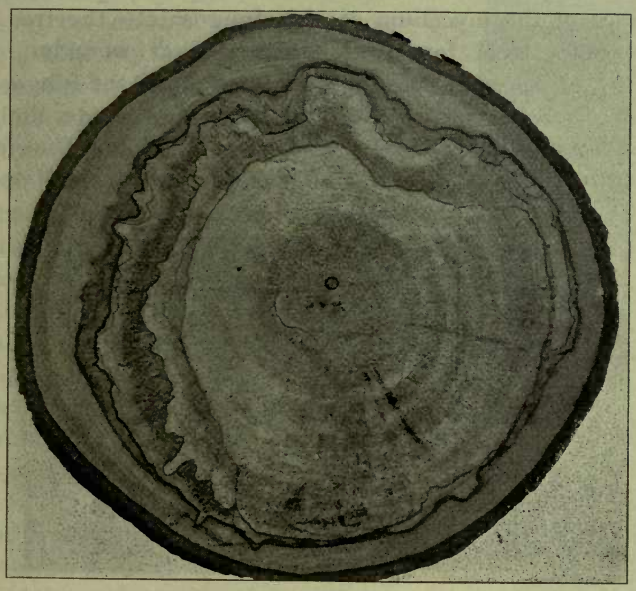
A maple tree about 20 cm. (eight inches) in diameter in the mixed forest at Clearwater had been affected by the *Polyporus igniarius* for a number of years. The fruit body was several years old, of a triangular shelving form, and 15 cm. broad. Several entire sections of the trunk, one of them bearing the fruit body of the fungus, were collected and shipped to Ithaca.

Cross sections of the tree present a very characteristic and often beautiful marking of the wood due to the different stages of decay and the coloration of the wood. The more advanced stages of decay lie at the centre, the less advanced ones toward the periphery. The sound wood at the periphery is limited from the decayed area toward the centre by a broad and irregular discolored area. The discolored area is of a light brown color, and this is farther sharply defined from the pale yellowish white area outlined by a narrow black line. The more advanced stages of decay, in this maple tree advanced toward the periphery in separated columns, showing on cross section a radiating or digitate figure. The radiations or "fingers," alternate with dark areas which extend inward from the periphery as shown in the photograph. Sometimes this figure is quite regular around a portion of the margin, while other portions are very irregular. The decay of the wood seems to proceed in waves from the centre toward the periphery, so that



75.—*Section of maple tree showing effect of mycelium of Polyporus igniarius.*

there appear several different stages. The outer one is marked by the dark discolored area, the next is pale yellowish white, the wood being quite soft, and an older and more advanced area at the centre of the heart. These different stages in the process of decay from the centre to the periphery are usually limited by the black line, which is bordered by a more or less well defined corona of color darker than the area upon which it is advancing.



76.—*Young trunk of maple nearly killed by Polyporus igniarius.*

In many cases these areas of decay progress very irregularly, and the figure becomes complicated and confused, especially in the later stages of the decay of a tree, so that dark lines extend very irregularly.

An examination of several maple trees bearing the *Polyporus igniarius* gave evidence that the peculiar discoloration of the wood, accompanied the mycelium of this species of fungus, and might perhaps be sufficient to identify the species even where no fruit form of the fungus was present. An examination of the

trunks of the beech bearing the *Polyporus igniarius* collected at Childwood, N. Y., in 1896, presented the same characteristic coloration and marking. The maple is said by some lumberman to be troubled by a disease which they term "black heart." It would be interesting to know if the coloration produced in the heart by the action of the mycelium of *Polyporus igniarius* is identical with this "black heart" disease.

It now becomes a matter of interest to determine the mode of entrance of the mycelium of this fungus into the tree. The fruit bodies were found to be situated at wounds. These wounds, or places of exit for the fruit form of the fungus, were "knot" holes formed by the dying away of the lower limbs, and the failure of the healing tissue to close the wound thus formed. The fruit form can make its exit through quite a small opening,

77.—*Effect of mycelium of Polyporus igniarius on wood of beech.*

and usually does, growing to larger dimensions outside as it ages. The first year's growth of the fruit form may then be quite small, as in Fig. 79 where it is but a small protuberance 1 to 2 cm. in diameter and showing no fruiting surface. This often increases in size each year, slowly, until 4 to 5 cm. in diameter, when it may increase more rapidly and each year form a new fruiting surface beneath.

The young fruit form shown in the photograph is on a trunk of a maple 10 cm. in diameter. This was the only evidence that the tree was diseased, all the other wounds at fallen limbs

having healed over. A section of the trunk shows that the heart rot had begun. It is in the first stages of the disease and confined to a limited area, that directly at the centre of the heart. There is present here only the discolored area which is characteristic of the other and younger area in older stages of the disease, described above. It is quite likely that the fungus enters at these slow healing wounds where the lower limbs have fallen, and that in some cases the wounds might entirely heal over and imprison the mycelium before the fruit bodies had an opportunity to form. That there was abundant opportunity for the mycelium of the fungus to enter at these wounds is shown by the evidence of a large proportion of the young maple trees in the mixed forest at Clearwater.

I have already called attention to the deep shade in the spruce woods where the tall spruces overtop the broad leaved trees, and of the effect which this shade has in checking foliage development on the younger maples. Even on the young and middle aged maples there are comparatively few branches and these near the top of the tree, the lower branches having died and dropped off. The same can be said of the beeches, birches and other broad leaved trees. Even on these topmost branches there are comparatively few leaves, because of the low light reaction. This means then that a comparatively small amount of the carbohydrates necessary in the formation

78.—*Ulcers on trunk of maple.*

of cell walls and woody tissue is manufactured. Consequently growth and the formation of wood goes on slowly. This interferes in a striking way with the healing processes needed to cover up the wounds caused by the falling limbs.

When there is an abundance of foliage and light, carbohydrates are formed in sufficient abundance to heal at a rapid rate. The healing tissue is firmer than the normal wood, and working from within and close to the branch, soon heals over and excludes the mycelium of the timber destroying fungi. On the other hand, when there are few leaves and a small amount of starch is formed the healing process goes on slowly, and before the opening caused by the falling limb can be closed, the portion of the branch exposed undergoes first weathering, and later the mycelium lays hold and enters, reaching the heart of the tree before the barrier of healing tissue is formed. From observations during several seasons it seems that this is a very common mode of entrance for the timber destroying fungi in the broad leaved trees.

79.—*Very young fruit body of Polyporus igniarius forming at a branch wound.*

A number of cases observed at Clearwater offer striking examples of the slowness with which the healing process goes on at branch wounds. The healing tissue formed slowly and did not close up against the base of the branch because of the small percentage of newly formed plant substance. Then for a series of years the healing would cease and an area around the knot would die back. Then for another series of years the healing would begin and advance over a portion of this dead area, when another period would intervene during which a still greater area would die back. In this way large and ugly, open ulcers

are formed, in which the wood within is exposed. This condition is shown in photographs from young maples. On a number of these examples there were no fungus fruit bodies, but a section of the trunk shows all the character of the heart rot caused by the mycelium of *Polyporus igniarius*.

The *Polyporus igniarius* has been known for a long time to inhabit fruit trees, especially the apple, peach, etc., under certain conditions. During August, 1900, I observed an apple tree by the

80.—*Fruit bodies of Polyporus pinicola on red spruce.*

roadside a few miles south of Cortland, N. Y., with fruit bodies of this polyporus on it. A number of years ago the tree had been pruned, by cutting several large limbs near the trunk, and others out some distance from the trunk. The tree was probably diseased at that time, and perhaps these limbs were dead or dying. This may have led to their amputation.

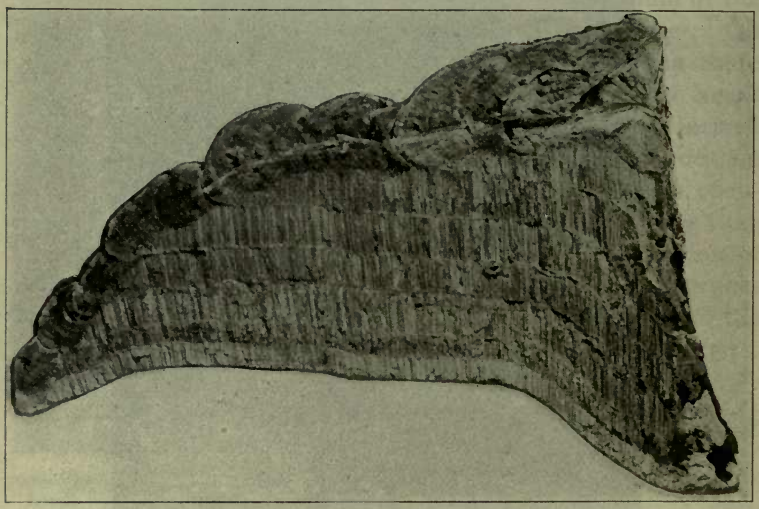
In all cases the fruit bodies of the fungus were formed at these cut surfaces, there being no other place of exit. The tree was probably seriously wounded when young, and the mycelium entering had spread all through the heart of the trunk and

branches, but was unable to form the fruit bodies until the larger limbs were pruned.

Several of the branches of this apple, bearing fruit bodies, were taken for examination. The character of the heart rot is in all essential respects the same as that observed in the maple and beech.

POLYPORUS PINICOLA.

The pine destroying polyporus is widely distributed in the United States and other north temperate regions. It occurs on



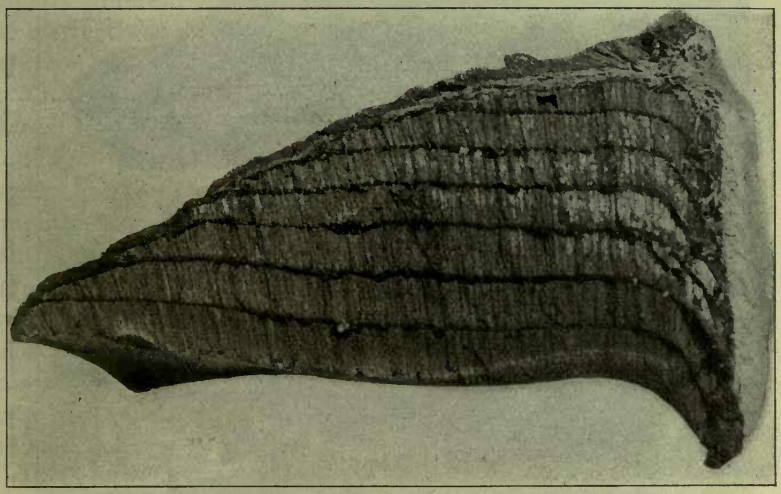
81.—*Section of fruit body of Polyporus pinicola, showing strata of tubes.*

various conifers, on the pines, spruces, balsams, larches, etc.

The fruit bodies are shelving, hard and firm, though not so hard as those of *Polyporus igniarius*. They are perennial and therefore single specimens increase in size from year to year, usually becoming broader below and of course thicker from each annual accretion layer.

The fruit body is marked on the upper surface by prominent concentric ridges and furrows. The marginal ridge is the one representing the latest year's growth. The color of the fruit body is from dark brown to nearly black at the base, varying to a reddish brown near the margin. The marginal zone represent-

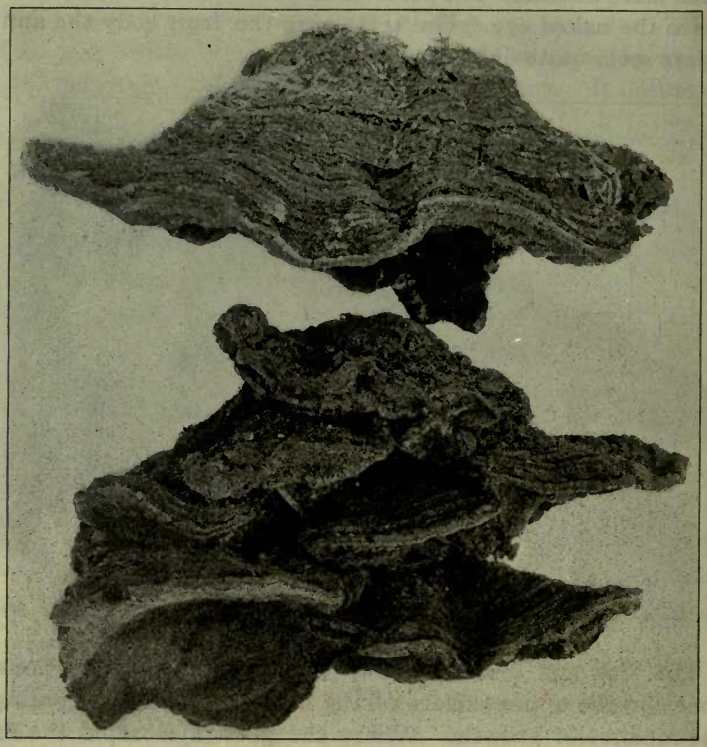
ing the latest growth varies in color according to the time of collection. When the marginal zone is young it is whitish or yellowish in color, becoming reddish yellow or red later in the season and having then a shining polished surface. The under surface is yellowish white, and on bruising, the yellow color is often more distinct. The pores of the under surface are just visible to the naked eye. On sectioning the fruit body the annual layers seem quite distinct.



82.—*Section of fruit body of Polyporus applanatus, showing tube strata.*

The size and distinctness of these concentric elevations or zones on the upper surface of the fruit body vary according to the rapidity of growth. Where the growth is rapid the zones are large and prominent on the fruit body, increasing rapidly in size each year. One fine specimen collected on a hemlock spruce in the vicinity of Ithaca is 40 cm. broad by 25 cm. long, and is only six or eight years old, there being apparently two imperfect zones which may represent years of very slow and imperfect growth. Of the six annual marginal accretions which are very prominent the measurements are as follows: First, 4 cm.; second, 6 cm.; third, 3 cm.; fourth, 2.5 cm.; fifth, 3.5 cm.; sixth, 4 cm. The usual size of the annual zone is from 2 to 3

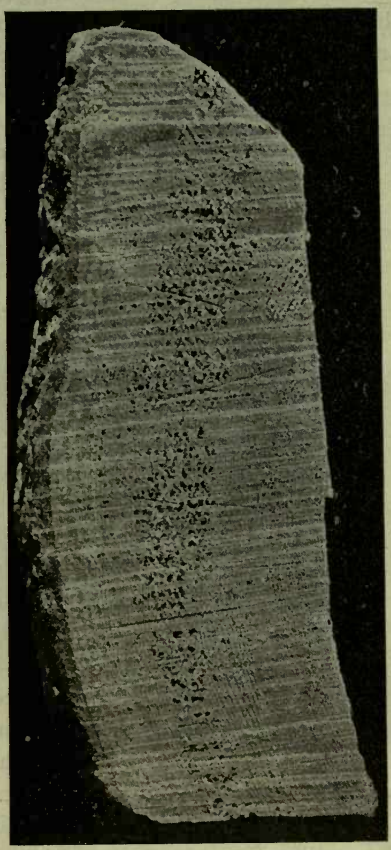
cm. Sometimes, however, they are much smaller, from 4 to 8 mm., and then they are not very prominent. In such cases, however, the color character of the different zones and the character of the under surface make it possible to distinguish the plant from others.



83.—*Fruit bodies of Trametes abietis, shelving form.*

In this and some other forms where the zones are not very distinct it is occasionally difficult to separate the species from forms of *Polyporus applanatus.* In the latter species the tube surface is sometimes yellowish. In the fresh condition, if a bruise or scratch occurs on the tube surface of *Polyporus applanatus* the exposed parts at once change to a dark brown or blackish color. When dry, however, this test will not yield the

results desired, but section the plant through the middle perpendicularly and compare the color and structure of the tube strata. In *Polyporus applanatus* the strata are deeper and very clearly differentiated. They are also of a dark gray, or hair-brown color, while the tube strata of *Polyporus pinicola* are whitish or yellowish-brown, and while clearly differentiated are not so distinctly so as in *Polyporus applanatus*.

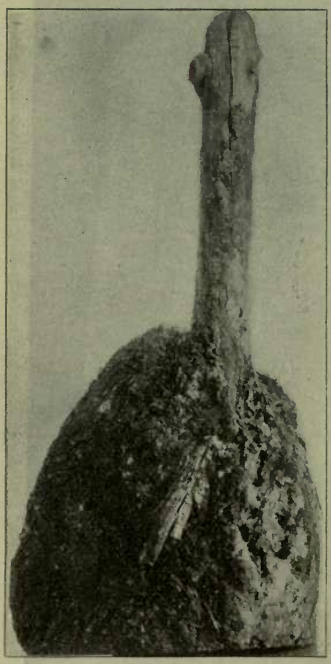


84.—"*Dozed*" *place in butt of red spruce from mycelium of Trametes abietis.*

The fruit bodies of *Polyporus pinicola* are sometimes found on the trunks of living trees but much more frequently they do not appear until the tree is dead. They are quite common on dead standing trunks and stumps and on fallen logs. They continue to grow after the tree is dead and in quite an advanced stage of decay.

In wood which is in quite an advanced stage of decay, extensive sheets of mycelium forming "punk" are often in the crevices formed by the checking of the wood. These sheets of punk are very similar to those formed by *Polyporus sulphureus* in deciduous as well as in coniferous trees. In the large number of cases in which I have found these sheets of punk in rotten logs or decaying tree trunks of conifers in the Adirondack mountains, I have not found any fruit bodies of the *Polyporus sulphureus*. Since these sheets of punk found in conifers are

usually ascribed to this species, I searched diligently for specimens on the trees. In no case in the Adirondacks have I yet found *Polyporus sulphureus* on conifers, although it probably does occur on them. This suggested that the sheets of punk in the conifers examined were connected with *Polyporus pinicola*, and many examples were studied in an endeavor to trace the connection of the sheets of punk in the trunk with the fruit bodies on the exterior.



85.—*Dead stub of red spruce where the mycelium entered.*

The direct connection was difficult to trace although in most examples it was not difficult to trace the punk through the log radially to the bark, but at this point in splitting the bark radially the direct connection of the punk was not seen. The most favorable examples for study were those in which the fruit body was just originating as a tubercle 4 to 6 cm. in thickness on the outside of the bark. In splitting several of these from the tree a circular patch of the punk was found on the inner surface of the bark and looked very much as if the mycelium issuing from the tree and connected with the fruit body had been riveted on the inner surface of the bark, but on splitting such structures radially no evidence of the connection of the bark with the fruiting body was presented. However, on splitting the bark tangentially successive sheets of punk were found between the inner sheet and the fruit body. These sheets at certain points extended obliquely and connected so that they formed a zig-zag connection. The firm layers of the bark prevented the direct radial exit of the mycelium, but by working in a zig-zag fashion between the bark layers it was enabled to make its exit. Having discovered this, it then became

an easy matter to trace the connection of the punk in the log with the fruiting body in all cases.

POLYPORUS PINICOLA ON BROAD-LEAVED TREES.

I have not found any record of *Polyporus pinicola* on broad-leaved trees. I have, however, found it on three different species in the Adirondack Mountains, on the beech (*Fagus ferruginea*), the birch (*Betula lenta*), and the maple (*Acer saccharum*).

TRAMETES ABIETIS.

This plant is common on spruces and balsams. It is a shelving form, and much smaller than the species of polyporus just

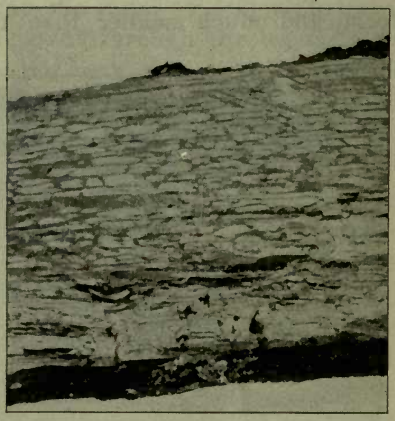
86.—*Fruit body of Tramates abietis spread out on surface of limb.*

described. The caps stand out from the wood 2 to 5 cm., are somewhat triangular in side view, and broader than long. The base is usually spread out where it is attached to the tree, and often the entire plant is spread over the surface of the wood. In this case no shelf form is developed. The upper surface of the shelf is marked by concentric furrows and ridges, and is more or less velvety or hairy. When young the fruit bodies are tawny in color, but in age they become a darker brown, especially above, while the fruiting surface is a yellowish brown.

TRAMETES ABIETIS ON THE RED SPRUCE.

An interesting example of a red spruce (*Picea rubra*) was examined during September, 1898 in the Adirondack mountains. This was near Nehasena, Herkimer Co., on the tract owned by Dr. Seward Webb. Through the courtesy of Prof. C. S Graves, who then had the supervision of the forestry operations on this tract, I had the privilege of following the lumberman for two days to inspect trees, or portions of trees, which were discarded after they had been felled.

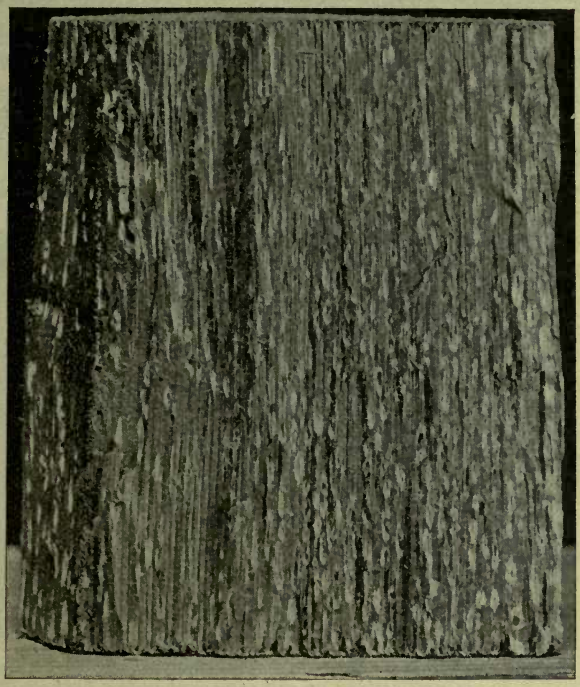
In this particular case the entire tree had been discarded, although two logs had been cut from the trunk. On approaching the tree I first came upon the stump, and searched here for some evidence of the reason for rejecting the timber. Near the periphery of the stump, in the older sap wood near its junction with the heart wood was a crescent shaped area in cross section about 3 cm. broad and 15 cm. long. This was distinctly marked off from the surrounding portion by the coarser fractures of the wood by the cross cut saw used in felling the tree. This indicated that the wood was here slightly "dozed." The remainder of the stump was sound. This small area showing such a slight alteration in the wood probably would not have been considered objectionable.



87.—*Pockets of decayed tissue in limb of red spruce.*

On examining the cut made for the first log, 16 feet above, the entire heart proved to be badly decayed. A large part of the sap wood was also invaded, and the cambium was being encroached upon. There remained only a thick shell of living and unaffected tissue underneath the bark. The heart wood was so soft that the fracture from the saw teeth was irregular, roughly cut and partially "ironed" down by friction from the

saw blade. Still another log above this one had been cut off by the woodmen in the hope that the heart would be sound, and that a good log could be obtained near the top. This cut, however, presented a condition similar to the first one, the heart and sap wood were badly decayed. This condition was sufficient to cause the abandonment of the entire tree. There were no evidences on the trunk, below the branches, of the fruit bodies of any fungus, nor of any injury which might have afforded an entrance for the fungus. The cut ends of timber were so badly roughed up by the saw that no structural characters in the diseased timber which might aid in the determination of the species of fungus could be seen. The next step was to determine the fungus and the place where it entered the tree.



88.—*Pockets of decayed tissue in trunk of red spruce.*

Since the decay at the stump was so slight, and the diseased area so small in comparison with the extensive injuries farther up in the trunk it was quite evident the fungus had not entered from below. Upon searching in the top of the fallen tree, it was found that the "leader" of the tree when about 5 cm. (2 inches) in diameter had been broken off, possibly by a falling

tree, 30 or 40 years ago. This leader, as a dead, decorticated object still projected 15 to 20 cm. above the point where the healing process was going on (Fig. 85). One of the upper branches at this point had become the leader.

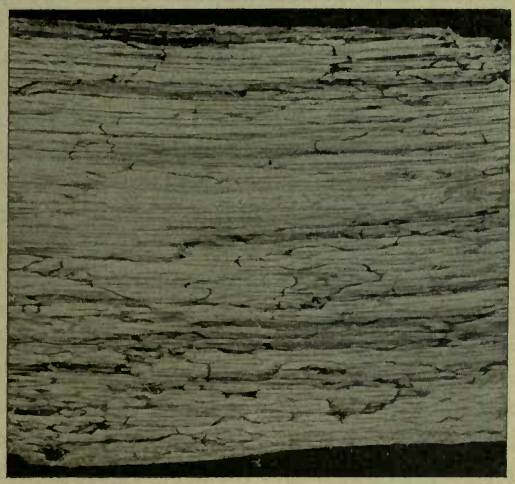
This old fracture of the main trunk years ago very probably provided an opportunity for the entrance of the fungus. Most conifers are provided with a quantity of free resin in the young branches or shoots, or the growing portion of the trunk. As is well known this resin flows freely from fresh wounds, and often continues for some time from old ones. The presence of this

89.—*Cross section of red spruce showing pockets from end view.*

resin and its free exudation from wounds is nature's most effective method of blocking the way to the entrance of timber destroying fungi in the conifers. When the wound is small, or the broken branch or shoot is young, the amount of resin forms an effectual barrier against the entrance of this class of fungi. Where the wound is larger, or the shoot is older, the process of healing over requires many years, and the older portions of the wood do not yield so great an amount of free resin.

The broken shoot in this example was 5 cm. (2 inches) in diameter. Healing began 20 to 30 cm. below the broken end. After 30 or 40 years the dead prong still projected 15 to 20 cm. above the healing surface, and probably never would have healed

over. During this long time the fungus mycelium had an opportunity to enter, travel down the heart wood of the trunk and reach the butt. It is interesting to observe that while the fungus mycelium gained entrance through the broken area of the leader in the top of the tree, and traveled downward, the greater injury to the trunk was some distance below. This is probably due to the greater amount of free resin in the younger portion of the trunk above. While the mycelium traveled downward through this, it did not spread rapidly here nor bring about such a complete disintegration of the tissue. Sections of the trunk just below the point where the fungus entered, and for some distance below, show the heart wood is finer and harder though invaded by the mycelium. The wood is also very much stained, brown irregular areas often marked off by black lines, or divided up into smaller areas by black lines. The mycelium also traveled upward in the newly established leader of the tree. From the trunk it had invaded many of the branches in the same way. As is usual in such cases a number of the branches had been killed. These dead branches then yielded readily to the disintegrating action of the fungus.



90.—*Rotten section from rotted log of red spruce.*

On a few of the limbs fruit bodies of *Trametes abietis* were found. A branch bearing a fruit body and broken at this point shows the gross structural characters of the wood affected by the mycelium of this species. This is shown in the photograph. At one stage in the decay of the wood there are numerous areas

in which the process of disintegration is localized, or where it proceeds much more rapidly than in the surrounding wood. These isolated centres are quite evenly distributed. The wood is broken down completely, and largely consumed, leaving a partial skeleton, or nearly all of it having disappeared. The remnant, as well as a thin layer of the bordering tissue, is bleached and white. It is thus in strong contrast with the reddish color of the surrounding wood where the decay has been checked or has proceeded more slowly. This rapid local disintegration, then, forms numerous small "pockets" distributed through the affected wood at a certain stage in the progress of the disease. They are plainly visible because of the bleached tissue.

91.—*Badly pruned oak tree.*

These pockets are a characteristic feature in one stage of the heart rot of the spruce from the mycelium of *Trametes abietis*. If they are found in the heart wood of the trunk of this individual spruce it would be quite conclusive evidence that the heart rot here was caused by this fungus, and that the infection having occurred at the broken trunk in the top of the tree many years ago had gradually spread down the trunk to the base and out into numerous branches, some of which have been killed as result. Sections of the trunk of this tree were cut out at different places and shipped to Ithaca for study.

On splitting sections of the trunk cut from the discarded logs, these characteristic pockets were found to be present, and Fig. 88 is from a photograph of a small block. These occur in the

portions of the trunk where decay has made considerable progress, the entire heart being invaded, and the fungus encroaching on the "sap" wood. When cut with the cross-cut saw, or even with a finer saw, the ends of the blocks do not show the pockets, since the soft wood is so readily fractured by the teeth of the saw. But when the end of a block is planed off smooth the pockets in transection are quite distinctly brought to view. They are shown in the photograph. From a side and end view shown in the photographs the pockets are seen to be oblong in side view and cylindrical in cross section. They are 2 to 3 mm. broad and 4 to 6 mm. long. In the younger portions of the trunk, some distance above the size where logs were cut, and below the point of entrance of the fungus, and thus nearer it, the pockets were not yet formed. This is probably due to the fact that while the mycelium first penetrated the heart wood here, the latter being younger was more resistant, and the process of disintegration proceeded less rapidly. The pockets appearing on certain of the branches is accounted for by the fact that these branches had been killed for some time, and were consequently in a less resistant condition.

92.—*Result of bad pruning of hickory, the limbs have rotted out allowing entrance of fungus mycelium.*

93.—*Proper way to prune, wounds healing up properly.*

The formation of pockets by the rapid disintegration of the tissues at many centers recalls the "peckiness" of cypress wood caused by the mycelium of a fungus yet unknown. The pockets

in the cypress wood are much larger, however, and the structural character of the affected wood is quite different. In the case of the cypress trunks affected with this disease known as "peckiness," it is believed that the fungus, while developing at the centres, excretes an enzyme or "ferment," which permeates the surrounding wood and acts as an antiseptic which prevents the further disintegration. It is possible that this is to some extent the case in the formation of the pockets in the spruce timber, that is, that the wood intervening between the centers of rapid disintegration, becomes permeated with an enzyme excreted by the mycelium which renders it immune for a time, or at least retards the disintegration of the wood. But if this is the case, the effect of the antiseptic is not lasting. In the case of fallen logs affected by the *Trametes abietis* the decay continues until all parts of the wood are in a much decayed condition. Still, in such logs, it is quite evident that the progress of the disintegration has been intermittent, certain centres having first decayed, and in time spreading from these pockets to surrounding areas until all the wood is brought under complete contribution to the mycelium. In such decayed spruce wood, there are further evidences that the decay has spread from numerous centers which have been extended until they finally met. This is shown in the varying coloration of the wood, and especially by black boundary or limiting lines. (Fig. 90.)

94.—*Shade tree used as a hitching post.*

It is evident from these and similar studies that there is no cure for the diseases caused by wound parasites after once the fungus has entered through the wound into the interior of the tree. For a few years there may be no apparent injury but with the lapse of time the tree becomes badly injured

if not destroyed. The trees may live for years, or even a century or more with the fungus inside still growing. They may be so weakened that they are broken down or uprooted during strong winds. Shade trees may be rendered unsightly, and lacking in density of foliage. Fruit trees may be rendered less fruitful if not ultimately killed. Timber trees in a very few years may be so injured as to be worthless for the market.

In their relation to forestry these studies emphasize the desirability of careful and economical methods in the felling of timber to protect the young stand from injury, in the supply of light to the forest floor, and in the protection from fire. For while many forest fires may not be so severe as to kill the trees outright the fire often scorches exposed roots, or the base of trunks, where the leaves are thick, or by a dead and dry log or stump, thus affording an entrance for these wound parasites.

In the handling of fruit and shade trees there should be the greatest care from the nursery stock to the fruiting tree to prevent wounds. In pruning operations especially should there be care in pruning smooth and close to the trunk, followed by the use of some antiseptic wash, or lead paint.

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STATE OF NEW YORK

DEPARTMENT OF AGRICULTURE

RAYMOND A. PEARSON, Commissioner

Walter Mulford

EMERGENCY BULLETIN

ON THE

BLISTER RUST OF PINES

AND THE

EUROPEAN CURRANT RUST

HORTICULTURAL BULLETIN No. 2

Prepared by

GEORGE G. ATWOOD

July, 1909

ALBANY

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1909

BLISTER RUST OF PINES (*Peridermium strobi*)
EUROPEAN CURRANT RUST (*Cronartium ribcola*)

Blister rust of pine has recently been found in this and other near-by States on a few white pine seedlings imported from Germany. Acting under authority of the State law and with the co-operation of all persons interested, this Department hopes to eradicate the disease promptly. The white pine (Pinus strobus), native to America is recognized as one of the most beautiful of trees and its value for timber is enormous. Judging by the experience of other countries where the blister rust disease prevails, it may be said that the American white pine is in grave danger so long as this disease exists in our country. Some foreign nurserymen have abandoned the business of white pine growing because of the losses on this account.

The recently increased interest in the subject of reforesting vast areas of our lands not adapted for farming purposes has led to a demand for coniferous seedlings far in excess of the supply. Millions of these seedlings have been imported from nurseries in other countries where the climatic conditions and cheap labor favor such production. A large proportion of these trees are grown from seeds of the pine which are annually exported from the United States. Young trees are suitable for forest planting when from two to three years old.

The disease has been found upon a number of the three-year seedlings imported in the spring of 1909. Unfortunately the presence of the fungus is not apparent at or before planting time. It develops sufficiently in June to be identified by the spore formations. The prominent character of the disease quickly disappears and by the first of July it can hardly be found even by the closest expert examination. The same appearances recur the following year. It is known that when the fungus once becomes fixed in a pine tree it will remain until finally the tissues of the tree are so involved as to kill it. Affected three-year seedlings are likely to die the first year of planting, but this is not an invariable rule. Two-year seedlings may be infected and not develop spores until they are three years old. Such seedlings imported from abroad should be very carefully inspected next May and June and all suspicious plants removed and burned as described below. The stages of growth of this fungus are complex and not generally understood. It does not spend the full cycle of its life on the in-

dividual tree which it infects and it does not spread directly from one pine tree to another.

The spores scatter in the early spring months and take lodgment on Ribes (currants and gooseberries). In the month of September an orange red rust appears on the under side of the leaves of the Ribes. The spores of this fungus then spread to pine trees where they develop in eighteen months as the blister rust of the pine. The fungus form found on Ribes (Cronartium ribicola) was first described fifty years ago and named by Dietrich. The form of fungus found on pine trees was first described and named by Klebahn in 1887 as a distinct species and by him named Peridermium strobi. Subsequently, through inoculation experiments, it was conclusively proven that Cronartium ribicola on the currant and Peridermium strobi on the pine are not separate species but only different stages of one and the same fungus. With this knowledge it is self evident that, as the disease cannot spread from one pine tree to another and can only be spread from the pine to the currant and from the currant to the pine, the disease can be suppressed if not entirely eradicated by burning all the infected pines and all the Ribes growing in proximity. If, therefore, we have suspected disease in valuable pines it is best to destroy the less valuable Ribes before they become diseased or show the fungi on their foliage. This procedure is specially urged where the pine plantings are important and where the Ribes are growing wild and are actually worthless.

Once before — in 1906 — this disease appeared in New York State. It was found by Prof. F. C. Stewart upon the grounds of the New York State Experiment Station at Geneva and prompt and radical treatment was resorted to, which is believed to have completely eradicated the disease. The report upon this outbreak and procedure was issued as Technical Bulletin No. 2 of the New York Agricultural Experiment Station, and owing to the fact that the edition is exhausted a large part of this bulletin is reprinted as an appendix to this circular.

Blister Rust of White Pine.

Prof. Stewart has given careful attention to the present appearance of the disease and the following statement was prepared by him:

"Blister rust is a fungus disease affecting the trunks and

branches of white pine trees. Trees of all ages are attacked. Small trees are often killed outright. On large trees many of the branches die. The disease is especially troublesome in nurseries. In Holland and northwestern Germany it has caused much damage. Diseased trees are recognized by the conspicuous yellow spore masses which break through the bark about June 1. The affected bark or branch is usually abnormally enlarged at the point of attack.

"In another stage of its life cycle the blister rust fungus attacks plants of the Ribes group (currants and gooseberries both wild and cultivated), producing a conspicuous red rust on the under surface of the leaves during August and September. Neither currants nor gooseberries are seriously injured.

"Fortunately, the disease cannot spread from one pine tree to another. It must first go from pines to Ribes (in May or June) and from Ribes back to pines (in August or September). In the trunks of pine trees the fungus is perennial, but on Ribes it affects only the leaves and cannot live over winter. In order that the disease may spread it is necessary to have both white pines and Ribes growing near together. Accordingly the best method of protecting pine trees against the disease consists in destroying all currants and gooseberries in the vicinity."

When the blister rust was found a few weeks ago in one of the Lake Clear nurseries of the State of New York, and reported by Mr. C. R. Pettis, a State forester, after identification had been verified by Dr. Perley Spaulding of the United States Department of Agriculture, Forest, Fish and Game Commissioner Whipple immediately called a conference of foresters and other officials of this and adjacent States, including also officials of the National Department of Agriculture. The following persons attended:

Mr. W. O. Filley, State Forester, New Haven, Conn.
A. F. Hawes, State Forester, Burlington, Vt.
Alfred Gaskill, State Forester, Trenton, N. J.
F. W. Rane, State Forester, Boston, Mass.
C. R. Pettis, State Forester, Albany, N. Y.
Dr. Perley Spaulding, Bureau of Plant Industry, Washington, D. C.
Dr. Harvey Metcalf, Bureau of Plant Industry, Washington, D.C.
Raphael Zon, Forest Service, Washington, D. C.
Hon. R. A. Pearson, Commissioner of Agriculture, Albany, N.Y.

Hon. J. S. Whipple, Forest, Fish and Game Commissioner, Albany, N. Y.

Austin Cary, Superintendent of State Forests, Albany, N. Y.

G. G. Atwood, Chief Nursery Inspector, Department of Agriculture, State of New York.

Prof. J. W. Toumey, Yale Forestry School, New Haven Conn.

H. R. Bristol, Superintendent of Woodlots, D. & H. Railroad, Plattsburg, N. Y.

Hon. George Aiken, Forest Commissioner, Woodstock, Vt.

John Foley, Assistant Forester, Pennsylvania Railroad Co., Philadelphia, Pa.

Prof. F. C. Stewart, State Agricultural Experiment Station, Geneva, N. Y.

S. N. Spring, Consulting Forester, New Haven, Conn.

Prof. C. C. Curtis, Professor of Botany, Columbia University.

Hon. R. P. Bass, Forest Commissioner, Peterboro, N. H.

It was unanimously agreed that no serious damage should result if prompt and efficient action is taken at once by all of the States concerned to eradicate all danger caused by the appearance of the disease at the few places where it has been found. Several of the northeastern states besides New York have imported large quantities of white pine seedlings for reforesting lands and a considerable number of private parties have also made importations. Thus far the trees positively known to be affected are believed to have come from a single nursery in Germany. Every effort is being made to trace all shipments from the nursery concerned, as well as to carefully examine other foreign importations. Valuable assistance is being given by the Federal Department of Agriculture. All persons in this State who have planted pine tree seedlings are urged to carefully study and carry out the recommendations below and to communicate with the Commissioner of Agriculture at once if suspicious symptoms are found. To succeed quickly in preventing danger from the disease it will be necessary to have the co-operation of all concerned. Operations have been started in other states. It is a disease that cannot be discovered until it has developed for a year and for that reason any inspection at the docks on arrival of trees could not be effectual.

At a conference held in the office of the Commissioner of Agriculture, attended by experts of the Department of Agriculture, Forest, Fish and Game Commission and the State Experiment

Station, the following procedure in connection with the eradication of blister rust was formulated and is now recommended to all concerned.

1. Procure as complete a list as possible of every place at which white pine stock has gone during the past two years. It is desired that this list include all stock imported from Germany and France.

2. Inspect all such premises and destroy all Ribes plants, wild and cultivated, within 100 yards from such trees, and even a further distance where practicable. The Ribes plants should be pulled up or cut off in such a manner as to prevent sprouting. For example, the skunk currant should be pulled up because it spreads from under-ground stems, while gooseberries and cultivated currants difficult to pull may be cut off below ground. Burn all such plants found as explained under No. 4.

3. Keep close tab on cultivated currants and gooseberries in all districts of the State where suspicious pines are located, and after July 15 keep closer watch than heretofore on currants and gooseberries throughout the State.

4. Destroy by burning all infected or suspicious pine or Ribes plants. This is especially important in 1909 for Ribes may be expected to show signs of the disease if at all after July 15.

The plants are to be burned where they are found or at a place to which they are carried in bags made of closely woven heavy cloth such as canvas or factory, and all such bags should be thoroughly boiled or otherwise sterilized at the conclusion of each day's work.

5. Suspicious pine plantings to be thoroughly inspected during the last two weeks in May and the first week in June (between May 10 and June 10 probably safe). This is very important in 1910 and should be repeated in 1911, the thoroughness in that year depending largely on 1910 findings.

The Forest, Fish and Game Commission is assisting in carrying out the above and has assisted further by sending out the following letter to those who have secured white pine seedlings through the commission:

"State of New York,
"Forest, Fish and Game Commission,
"Albany, *July* 10, 1909.

"Dear Sir.— The demand for trees, for reforesting purposes, was so great last spring, that we were unable to supply a suffi-

cient quantity from our nurseries and a large number were imported from Germany. We very much regret to say that we have since found some of the white pines were affected with 'blister rust,' although they were carefully inspected. This disease may, if allowed to take its course, become very serious, but if prompt action is taken it can be prevented from spreading to other trees or establishing itself.

"The disease is peculiar in that it lives for a time on white pine, then on currant or gooseberry bushes, and then back on the pine again, but never goes direct from pine to pine. The spores of this disease are borne on the pine in May, while they are not produced on the currants or gooseberries until August.

"A campaign has been carefully outlined by the State Department of Agriculture and the Forest, Fish and Game Commission in order to control the disease. The method is simply to remove and burn all currants and gooseberries, both wild and cultivated, either within a plantation or on a strip not less than three hundred feet wide around the outside of all such plantations. However, in order to have this method effective such gooseberries and currants must be destroyed before August first.

"Owing to the large number of places to which this stock has been sent and the short space of time in which the work ought to be done it is necessary we ask your co-operation in this matter. Therefore, will you begin at once to remove and burn all currant and gooseberry bushes, both wild and cultivated, either within or on a strip not less than three hundred feet wide all around your plantation?

"Hoping at an early date, to hear that we will receive your assistance in this matter, I remain,

"Very truly yours,

(Signed) "C. R. Pettis,

State Forester."

All nurserymen, horticulturists and other persons interested are urged to report promptly to the Department of Agriculture any outbreak or suspicious symptoms of the above-described disease.

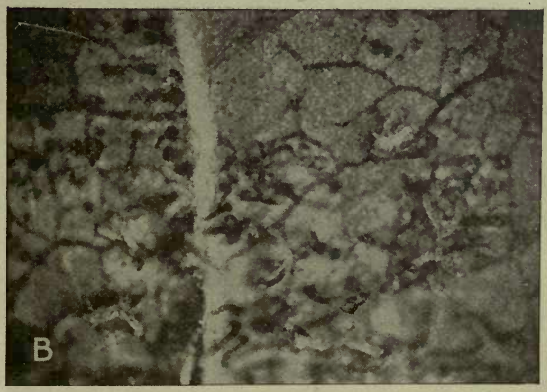

PLATE I.—THE UNDER SURFACE OF RUST-INFESTED CURRENT LEAVES.
A. UREDO AND TETEUTO SORI OF CRONARTIUM RIBICOLA (×4).
B. THE SAME, MORE ENLARGED.

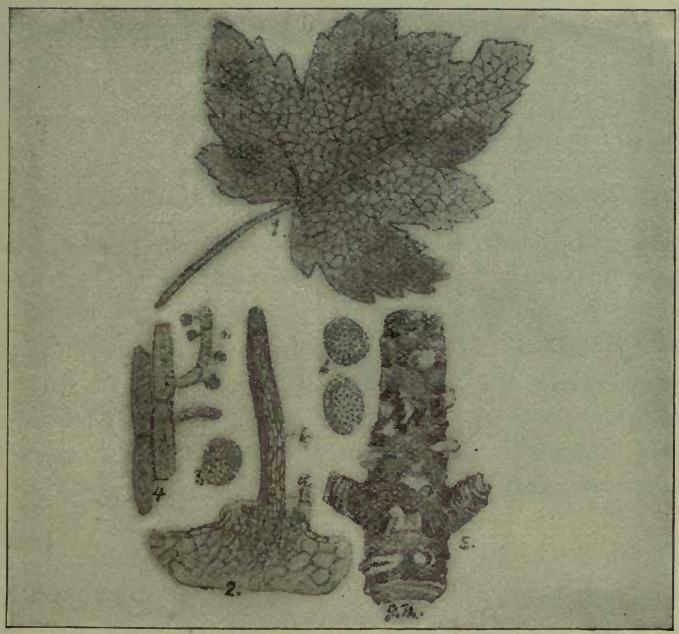

PLATE II.—THE CURRANT AND PINE RUST.

Cronartium ribicola.

1, Uredo and teleutospore stages on leaf of black currant; 2, Uredospores, *a*, and telutospores, *b*, cemented together to form an erect, hairlike structure (×50); 3, Uredospore, (×300); 4, Four telutospores, two of which are germinating, and one of the germ-tubes has produced four sporidia or secondary spores (×300); 5, Aecidia on bark of white pine; 6, Aecidiospores (×300). (After Massee.)

APPENDIX

AN OUTBREAK OF THE EUROPEAN CURRANT RUST

(*Cronartium Ribicola Dietr.*)

Reprinted from Technical Bulletin No. 2 of the New York Agricultural Experiment Station at Geneva; W. H. Jordan, Director.

By F. C. Stewart.

CIRCUMSTANCES ATTENDING THE DISCOVERY.

While passing the currant plantation on the Station grounds September 26, 1906, the writer observed an unusual appearance of the foliage on some plants. Upon plucking one of the leaves for examination we were astonished to find the under surface yellow with a rust. Even to the unaided eye it was evident that the rust belonged to the genus Cronartium and upon miscroscopic examination in the laboratory it proved to be *Cronartium ribicola* Dietr., a currant fungus of common occurrence throughout Europe but hitherto unknown in America.

The plantation in which the rust was found is one devoted to the testing of varieties. It contains about 175 plants and includes 54 different varieties representing three species; viz., *Ribes nigrum, R. rubrum, R. aureum.* Most of the plants were set in the spring of 1903, being transplanted from another plantation about forty rods away. The remainder of the plants were set in the spring of 1904. They varied in height from two to five feet.

Of the 54 varieties, 48 were more or less rusted while the other six were free from rust. The several varieties of black currants, *Ribes nigrum,* were most affected — Monarch, Clipper and Star being among the worst and having almost every leaf thickly covered with rust. In spite of this severe attack of rust the black currants were in full foliage. Some of the red and white varieties, *R. rubrum,* also were severely attacked, but most of them were only slightly affected. The plants of this species had already lost a considerable portion of their foliage from leaf spot, *Septoria*

ribis. One variety of *R. aureum* (Jelly) showed traces of rust. Four varieties of *R. rubrum* (Prince Albert, Gondouin White, Stultz and an unknown variety) and two varieties of *R. aureum* (Crandall and Utah Golden) were entirely free from rust.

The infested currant plantation was adjoined on the west by a plantation of goseberries containing many different varieties. Only one variety (Pearl) was affected and this but slightly.

In another part of the Station grounds, near the Director's residence and about forty rods east of the infested plantation, there are planted sixteen different species of Ribes, including *R. aureum,* but neither *R. nigrum* nor *R. rubrum.* Of these only one species, *R. irriguum,* was affected. There were two plants of *R. irriguum* and both were severely attacked.

DESCRIPTION OF THE FUNGUS.

The fungus *Cronartium ribicola* was first described and named by Dietrich fifty years ago. It appears during the summer and autumn as a conspicuous orange-colored powder on the under surface of the leaves of various species of Ribes (currants and gooseberries). Two forms of spores, uredo- and teleutospores, are produced on Ribes leaves. The uredospores are ellipsodial to ovoid, 19-35 x 14-22 μ with orange-colored contents and borne in sori forming pustules. The teleutospores are elongated, unicellular and massed together into peculiar orange-colored columnar processes which attain a maximum length of about two millimeters. These processes are usually curved. To the unaided eye they appear like coarse, yellow plant hairs, hence the German name "Filzrost" (felt-rust).

Another form (the aecidium form) of the currant rust fungus occurs on the trunks and branches of Pinus spp., especially the white pine, *Pinus strobus,* producing a disease called blister rust (Blasenrost of the Germans). The pine-inhabiting form was first described by Klebahn in 1887 as a distinct species and by him named *Peridermium strobi.* Subsequently, through inoculation experiments made by Klebahn and others, it was conclusively proven that *Cronartium ribicola* on the currant and *Peridermium strobi* on the pine are not separate species but only different stages of one and the same fungus.

GEOGRAPHICAL DISTRIBUTION AND ECONOMIC IMPORTANCE.

Cronartium ribicola occurs in several European countries, and probably in India, but has never been found in Australia or in South America and in North America but once.

It was originally described in 1856 from specimens collected in western Russia. Since that time it has been reported from other places in Russia even to the Ural Mts. on the east and to the Caucasus Mts. on the south. In Germany it is common and the injury which it does to the white pine is of considerable economic importance. Klebahn has reported a destructive outbreak of the disease among white pines in the vicinity of Bremen in 1887. Tubeuf, in 1898, stated that specimens of it were to be found all over Germany and that it was destructive in the northeastern part. Among other instances of severe damage he mentions a large nursery near the Holland border in which the culture of white pines had been entirely given up on account of the fungus. In another publication the same author stated that the disease was spreading and becoming a serious menace in Germany. Eriksson describes its epidemic occurrence in Sweden. Bos states that in Holland it is so abundant that in many localities the culture of white pines is impossible. It is also reported from Belgium, Denmark, Norway, Switzerland, France, Austria and England.

Judging from the European literature on the subject, it appears that as a currant disease *Cronartium ribicola* is regarded as of little importance even in those regions in which it is abundant, but as disease of white pines it has caused much damage.

American mycologists, believing that it must eventually make its appearance in this country, have been on the lookout for it for many years; but with the exception of the Bartholomew collection previously mentioned it has not been found anywhere in the Americas. No Cronartium on any species of Ribes and no Peridermium on *Pinus strobus* are known to America. The fact that America is the home of the white pine makes the absence of *Cronartium ribicola* especially noteworthy. Magnus, Klebahn, and others have commented upon this and discussed the probable origin of the fungus. The most plausible theory advanced regard-

ing the origin of *Cronartium ribicola* is that its original host was the Swiss stone pine, *Pinus cembra,* and that it was introduced into Germany in recent times from Russia where *Pinus cembra* forms extensive forests. Schellenberg expressed the opinion that it is also indigenous in the Swiss Alps on *Pinus cembra.*

It is altogether probable that the apparent absence of *Cronartium ribicola* from America is real; or at least the fungus cannot have existed here long. It is unlikely that collectors have overlooked it. Both on the currant and on the pine it is conspicuous and readily identified. The horn-like masses of teleutospores are characteristic and serve to distinguish it from other rusts occurring on Ribes leaves.

ORIGIN OF THE GENEVA OUTBREAK.

It would be interesting to know the origin of the outbreak at Geneva, but from the data now in hand it is not possible to locate definitely the original source of infection. It is likely that the fungus was imported with pines rather than with currants or gooseberries, since it is perennial within the stems and branches of the pine, while on Ribes it is confined entirely to the leaves. The only white pines in the immediate vicinity of the diseased currant plantation are two small trees standing 125 feet to the west. These were purchased from a Geneva nursery and set eight years ago. From a careful examination of these trees made in November they appeared in thrifty condition without any indication of Peridermium. Nevertheless, they may be the source of infection, notwithstanding their seeming freedom from disease. *Peridermium strobi* should be sought in April and May; by November it is difficult to recognize.

The two trees just mentioned are the only white pines on the Station grounds; and there are no specimens of *Pinus cembra, P. lambertiana, P. monticola* or any other Pinus having leaves in clusters of five. The nearest other possible sources of infection are a 12-feet-high *Pinus strobus* sixty rods east, an aged *Pinus strobus* about eighty rods north and a sixteen-year-old *Pinus cembra* the same distance to the southeast. There are several nurseries in the vicinity of Geneva and it may be that some one of them has imported diseased pine trees. The nearest nursery containing pines liable to the disease is about one-half mile west of the Experiment Station. It contains a block of *Pinus cembra*

and some *Pinus strobus* imported from France. Here may be the source of infection. However, contradictory evidence is found in the fact that a plantation of red currants (*Ribes rubrum*) directly across the road from this nursery was practically free from Cronartium. A careful search revealed just one leaf affected with *Cronartium ribicola,* which was in the teleuto stage. Another plantation of red currants between the nursery and the Experiment Station was entirely free from Cronartium. In fact the single affected leaf above mentioned is the only instance in which the Cronartium has been found outside the Station grounds although the neighboring currant plantations were carefully searched. Thus, the indications are that the source of infection is on the Station grounds.

This raises the question whether it is possible that the outbreak may have resulted from uredo- or teleutospores brought onto the Station grounds with imported currant plants. During the past ten years the Station has made several importations of currant and goseberry plants, the latest one being from Hexham, England, in the spring of 1904. Can these plants have been the source of infection? It has already been stated that the aecidium stage of *Cronartium ribicola* occurs on certain species of Pinus, especially *P. strobus.* It has been proven that the uredo stage on the currant may start from infection with aecidiospores from the pine; and that the aecidium stage on the pine may result from infection with teleutospores from the currant. Further, it is believed, but not conclusively proven, that aecidiospores can not infect pines and teleutospores can not infect currants. The uredospores may infect currants directly, but they do not survive the winter. In short, in the absence of pines the currant rust can not perpetuate itself. This is the generally accepted view and if it is a correct one the Geneva outbreak of currant rust could not have come directly from imported currants. However, some eminent mycologists have expressed doubt on this point. Eriksson, Fischer, Iwanoff, Nilsson, and Speschneff have all cited cases of the occurrences of *Cronartium ribicola* on currants in localities where *Pinus Strobus* was lacking; and Eriksson, particularly, has expressed the opinion that it may live from year to year on currants entirely independent of the aecidium stage on the pine. Klebahn, on the contrary, believes that this view should not be accepted without thorough investigation. In none of his numerous inocula-

tion experiments was there a recurrence of Cronartium the following season. In our own case the outbreak on currants can not be satisfactorily accounted for except on the assumption that the two nearby *Pinus strobus* trees were diseased last spring. It may be possible to determine this point next spring. If it can be proven that these trees were free from Peridermium in the spring of 1906 then it would seem that we have here evidence in support of Eriksson's view; for it is scarcely possible that pine trees sixty rods or more distant can have been responsible for so abundant an infestation.

ATTEMPT AT ERADICATION.

In order to stamp out the disease, if possible, every Ribes plant on the Station grounds has been destroyed. The two white pines standing by the currant plantation, also, will be destroyed if they show the disease next spring.* A careful watch will be kept over pines and currants in the vicinity of the Station and in case of the appearance of the disease next season measures will be taken to secure the prompt destruction of all affected plants. Perhaps the disease may be stampted out, but the chances are against it. The writer knows of no record of a successful attempt at the complete eradication of a fungus disease of plants. It is rarely attempted.

Even should this attempt prove successful, it can not be expected that the disease can much longer be kept out of America. Considering the frequency with which pine trees are imported it is a wonder that the disease has not made its appearance here before.

ITS PROBABLE IMPORTANCE IN AMERICA.

It is improbable that growers of currants and gooseberries in America have much to fear from this new disease. Even when currant leaves are abundantly infested with the rust fungus they appear to be but little injured by it. On the Station grounds black currants which were badly infested held their leaves until well into October.

The chief danger from *Cronartium ribicola* lies in its effect on pine trees, particularly the white pine. In parts of Europe it has wrought havoc among white pines and there is no apparent

* These trees have not shown presence of Peridermium Strobi though examined carefully since 1906.

reason why it should be less destructive in America should it become established here. Indeed, it may become even more destructive. It has not infrequently happened that a parasitic fungus introduced into a new country has become more virulent in its attack and caused greater damage than in its native country.

There is also the possibility that it may extend its list of host plants. In Europe it is known to attack only four species of Pinus; viz., *P. strobus, P. cembra, P. lambertiana and P. monticola,* all of which bear their leaves in clusters of five.

TREATMENT.

Since it is probable that pine trees and Ribes plants are both necessary to the perpetuation of the Cronartium, the destruction of all specimens of either of these two kinds of host must result in the extermination of the rust. Accordingly, the principal method of control recommended by European writers is the destruction of which ever of the two hosts is the least valuable. Wherever there is danger of the disease, currants or gooseberries should not be planted near white pines.

It is possible that on currants and gooseberries the rust might be controlled by spraying with bordeaux mixture, but no experiments have been made. On the Station grounds one application of bordeaux mixture made as soon as the fruit had set apparently had no effect on the rust.

BIBLIOGRAPHY OF CRONARTIUM RIBICOLA AND PERIDERMIUM STROBI.

With the appearance of *Cronartium ribicola* in this country there is likely to come renewed interest in it. In order to facilitate the labors of American mycologists who wish to examine the literature of the subject, the following *biblography has been compiled. It is not quite complete and several of the articles have not been seen by the writer. By far the most important of the references given in Klebahn's book, Die wirtwechselnden Rostpilze, which contains an authoritative resumé of the whole subject with numerous citations of literature.

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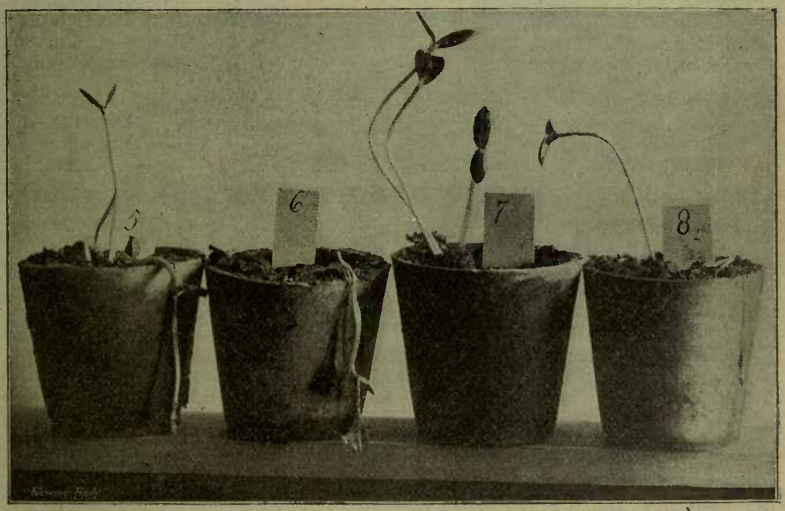
* For Bibliography see Technical Bulletin No. 2 referred to.

Bulletin 94. May, 1895.
Cornell University Agricultural Experiment Station,
BOTANICAL DIVISION.

DAMPING OFF.



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Walter Mulford

DAMPING OFF.

"Damping off" is a disease of seedling plants which rots or disintegrates the tissues at the surface of the ground. The tissues thus changed weaken, lose their firmness and supporting power, and the seedling falls prostrate on the soil. The disease is wide spread and sometimes very common. It occurs not only in gardens and fields but is a very frequent attendant upon the culture of seedling plants in the forcing house or bed. The trouble is favored by damp soil, comparatively high temperatures, and humid atmosphere.

The term "damping off" is therefore indicative of one of the attendant conditions of the soil inducing the disease. While this popular expression is thus far significant of the trouble it is by no means the exact statement of the case. The plants do not damp off because of the abundant damp or moisture in the soil. The dampness encourages the growth of minute parasitic plants, not visible to the unaided eye, which pierce the seedling, feed upon its substance and set up disintegration processes which result in the death and collapse of the affected parts. Soon after the plant falls the dissolution of the tissues near the surface of the ground has usually proceeded so far that communication by the ordinary physiological processes of life is cut off, and the plant then withers and dies. While damping off is due to the action of minute fungus parasites, it is by no means caused by one and the same

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Frontispiece. This is from a photograph of an experiment to show the parasitic nature of the Artotrogus debaryanus (Hesse). Before planting the cucumber seed the pots were filled with soil which was thoroughly wetted and then steamed in the steam sterilizer for several hours on three successive days in order to kill all the organisms. The seed was then planted and when just coming up some plant tissue with freshly developed stages of the fungus was placed by the seedlings in pots 5, 6, and 8, while pot 7 was left as a check. The result can be easily seen in the photograph, the check plants remaining unharmed while all the plants in 6 are killed and only one remains healthy in each of 5 and 8.

species. Different species of fungi may under some conditions produce nearly or quite identical phenomena in the progress and culmination of the disease. Some species develop phenomena allied to genuine cases of damping off, and the final result of which is practically the same, the decay of the stem near the surface of the ground and the collapse of the seedling.

Some variations in the external appearance furnish diagnostic characters correlated with the presence of certain species of the parasite, but it is doubtful if in any case the specific cause should be confidently asserted without recourse to microscopic examination, sometimes to be preceded by special treatment. In discussing the several species of fungi which have been found to contribute a share in the production of the disease it will be convenient to take up first the species to which the trouble is generally attributed, and then to follow with others which play a more or less important part in the development of similar or nearly identical troubles.

THE POTTING BED FUNGUS.

Artotrogus debaryanus[1] (Hesse).

This fungus is responsible for a large part of the damping off of young seedlings. It is very widely distributed, being very common in the soil of gardens and also in the forcing house. It is common also in many fields, but it probably is more abundant in soil where numbers of plants are grown from the seed in a more or less crowded condition, especially those plants which are known to be predisposed to its attacks. It has however been found in virgin soil taken freshly from the woods into the forcing house.[2]

It is thus a very common and unwelcome bed-fellow and pot-companion of many seedling plants which are more or less crowded

[1] Pythium debaryanum Hesse. The name Pythium was used in 1823 as a generic name for two species (Mucor spinosus Schrank, and M. imperceptibilis Schrank, Denkschr. d. k. acad. d. wiss. z. Munschen, 1813, 14) by Nees von Esenbeck Nova acta acad. Leop. XI, 2,515, which belong to another genus (Achlya, see Fischer, Rabenhorst's Krypt. Flora. IV, 332). Artotrogus (Montagne, Sylloge, 304, 1845) was the next name which was used for a member of this group and must consequently take the place of Pythium Pringsheim, Jahrb. wiss. Bot. II, 303, 1860.

[2] Humphrey, 8th Ann. Rept. Mass. St. Agr. Exp. Station, 221, 1860.

in the seed bed or forcing pots of our gardens and hot houses, especially if undue moisture is present in the soil. In the gardens it is frequently impossible to control the amount of moisture in the soil, and in the forcing house where often the light is defective, the air is not fresh or it is supercharged with moisture, it is often nearly or quite impossible by the ordinary methods to preserve that equilibrium of environment which will permit the growth of the seedling and at the same time check the growth of its inimical guest.

All experienced gardeners are probably familiar with the appearance of the diseased seedling when affected with the damping off fungus. At this day when the germ theory of disease, both animal and plant, has so completely poisoned the minds of all classes of people there is little difficulty in successfully advocating what is now an established fact, that the damping off fungus is a parasite in the seedlings and invades the tissue of the latter for the purpose of obtaining its food. It is fortunate therefore that especial attention can be given to setting forth the facts in the structure and development, and other peculiarities of the parasite, which are quite important to know in order to properly treat it, and also because it can then be distinguished from others either near or remotely related, some of which induce diseases in the early life of certain ferns or fern-like plants and cannot disease seedlings.

The first striking pecularity in a bed or pot of seedlings affected with the disease which attracts our attention is the prostrate condition of a few plants while others are upright and apparently healthy. The prostrate plants are found to be shrunken at or near the crown, i. e. near the root or the surface of the ground. Frequently when our attention is thus first called to the disease the collapsed tissue of some of the prostrate plants is so far disintegrated as to be in a soft and rotted condition, so that on pulling at the plant it breaks easily at this point. Farther investigation will show that usually the entire root system is by this time decayed, while the greater part of the stem above ground and the young leaves are still green and possibly quite fresh, or flabby, or more or less wilted.

The conditions of the aerial portions of the plant at this early stage of its fall are largely dependent upon the moisture content of the atmosphere. If the moisture be quite dry the seedling will be quite flabby before it falls and will soon wilt thereafter, but if the moisture content is large the tissue will remain quite firm for a time unless the soil upon which it is lying is so saturated with moisture as to encourage the rapid growth of the fungus in the prostrate portion of the plant. When this is the case the entire plant soon becomes a putrid mass and the tissues often take on a dark color.

After attention has been called to the trouble by the preliminary collapse of a few plants, if others are carefully noted some will probably present a paler green color than the perfectly healthy ones, especially near the surface of the ground. If such plants are carefully examined they will probably show the presence of the fungus in the tissues of the root and lower part of the stem, for the fungus requires several hours after entering the tissues to produce such changes which would be visible to the unaided eye.

Mycelium. If from one of these prostrate plants a portion of the collapsed part of the stem is teased apart on a glass slip, such as is used in microscopic work, in a little water and then examined under the microscope the vegetative phase of the parasite will probably be apparent. It exists as slender, colorless, thread-like irregular tubes, which appear to be more or less tangled in the tissues of the seedling. These tubes are the *hyphae*, as they are called, of the fungus, and collectively make up the *mycelium*. The hyphae are branched in quite a profuse manner, the successive branches usually forming somewhat more slender hyphae than the parent ones, so that the main hypha is frequently larger than the branches.

The hyphae course between and through the cells. Where a hypha passes through a cell wall it is very much constricted or very much more slender than it is in the cell lumen of the seedling or between the cells. The hypha in boring its way through these walls excretes a ferment, it is supposed, which dissolves the cellulose of the walls at the point of contact. A quite minute opening in the wall is sufficient for the growing end of the hypha to squeeze its way through and maintain communication with the

older portion, and has the advantage of requiring a much less expenditure of energy than if the opening were made of the same size as the hypha. After passing through the cell wall the hypha enlarges to the normal size.

While the mycelium is comparatively young the inner portion of the hypha is continuous, i. e., there are no cross walls partitioning the tubes into sections. This is a characteristic possessed by a very large group of fungi to which the *Artotrogus* belongs, known as the *Phycomycetes*. The protoplasm within the hypha is finely granular when the mycelium is young, but in the larger threads as they become older the granules become coarser, their contents are not so homogeneous, and the granules tend to collect into groups or very irregular masses, somewhat resembling the protoplasm in some mucors.

In a crowded seed bed after a few plants have fallen, unless the disease is checked, it will spread from these affected ones as centers to others near them and thus from the one or several starting points the plants will fall until nearly or quite all of them have been killed. Where the soil and atmosphere is quite damp and the temperature conditions so high as to favor rapid growth of the fungus it will grow out from the diseased part of the stem into or on the surface of the soil for a few millimeters in extent as a very delicate cottony mass or velvety pile. Where the adjacent plants are not too far distant the superficial threads may thus reach them and communicate the disease to them. In other cases minute motile reproductive bodies called *zoospores*, or *swarm spores* (perhaps more properly *zoogonidia*) are developed in a manner to be described later. These swim in the soil water to the more distant seedlings and thus spread the disease.

Sometimes there will be seen quite a profuse growth of a mycelium, which on the surface of the soil may spread several centimeters in extent. Usually this profuse growth is that of another fungus, a *Rhizopus*, or *Mucor*, or in other cases a different "damping off" fungus to be described in a later paragraph.

If the tissues examined as described above from a seedling which has not remained long after falling over perhaps the condition of the mycelium described will be the only phase of the plant (for the fungus is a plant) at that time present. If it has

been dead for sometime, however, there will probably be seen here and there on the hyphae a number of rounded or spherical bodies, three to five times the diameter of threads of the mycelium with which they are connected. These are reproductive organs of the fungus and will soon be described.

The characters of the mycelium alone are not in all cases sufficient for the correct determination of the plant. Let then this preparation on the glass slip lie free in an abundance of water, and place the slip in a small moist chamber sufficiently protected so that the air in the chamber will not become dry by evaporation at the point of contact of the two vessels. This can be avoided by placing a sheet of wet filter paper between the cover and the edges of the bottom vessel. A Petrie dish, such as is used in bacteriological work, is excellent for the purpose. Some wet filter paper should also be placed in the bottom and on this the support for the glass slip can be placed. For hasty examination the material can be teased out directly in the bottom vessel of the Petrie dish in a little water, and then this can be placed on the stage of the microscope whenever it is desired to examine it.

In twelve to twenty-four hours if the preparation is again examined many threads of the fungus will be seen to have grown out from the tissue and spread on all sides for a distance of one to two millimeters in the surrounding water, now presenting the characters noted above in a clear manner, except there are no constrictions of the hyphae corresponding to those where they pass through the cell walls of the host. The branching is in an alternate or irregularly monopodial fashion. There will also be seen numbers of the rounded bodies noted above on the mycelium, both within the tissue and on the mycelium which is growing free in the water around its margin.

Sexual organs. Oogonia. The larger number of these rounded bodies in the case of this species will probably be what are termed oogonia. These are developed in several relations to the hyphae which bear them. They may be terminal, i. e. on the ends of the hyphae which bear them, or on the ends of quite short branches, or intercalary, i. e. when they appear as swellings of the hyphae here and there without any reference to the end.

A terminal oogonium begins as a slight swelling of the rounded

end of a hypha or short branch, which continues until the spherical body is about 18μ–25μ in diameter. During its growth in size the protoplasm which fills the interior is supplied by the supporting hypha or oogoniophore, without, however, emptying any portion of the latter structure. When the oogonium has reached its full size, a septum, or partition wall, is formed cutting off its protoplasm from that of the stalk or oogoniophore. At this time the wall of the oogonium is thin and the protoplasm finely granular, though distinctly so, and completely fills the interior of the oogonium. The wall now increases somewhat in thickness, but remains colorless.

The egg cell of the oogonium is now soon differentiated, and in most cases, except where parthenogenisis takes place, is probably influenced by the development of the antheridium. The finely granular protoplasm of the oogonium becomes coarser and is gradually collected into numerous small irregularly rounded masses. At the same time all of the coarsely granular protoplasm contracts from the wall of the oogonium and moves toward the center forming there a rounded central mass somewhat less in diameter than that of the oogonium, being 14μ–18μ in diameter. This central sphere of coarsely granular protoplasm is termed the oosphere, or egg cell, and is really an unfertilized egg, the receptive cell of the oogonium. Between this egg cell and the wall of the oogonium is a space filled with a nearly clear, but finely granular and homogeneous fluid called the periplasm. At this stage there is no wall surrounding the egg cell and it is ready to be fertilized.

Antheridia.—The sole purpose of the antheridia is to supply the fertilizing element for the egg cell, and the antheridium is sometimes termed the supplying gamete, while the oogonium is termed the receptive gamete. The antheridia are of two kinds, stalk antheridia and branch antheridia. A stalk antheridium is formed from a section of the oogoniophore by the formation of a partition wall in the hypha cutting off an elongated cell one end of which is thus in contact with the wall of the oogonium, and its contents are only separated from those of the oogonium by the wall of the latter. This is the simplest of the two forms of the antheridia.

A branch antheridium is developed as a lateral branch of the oogoniophore, arising usually quite near the oogonium, but sometimes more or less remote from it, rarely on a separate hypha. The branch grows towards the oogonium and its rounded end comes in contact with the oogonium wall and becomes fixed at the point of contact. A septum is now formed in the branch cutting off an elongated cell varying from 15μ–40μ. This cell, one end of which is in contact with the oogonium wall, is the antheridium, and the proximal portion of the branch is the antheridiophore. More than one antheridium may be formed in connection with a single oogonium, frequently two and sometimes three. Both may be branch antheridia, or one may be a branch antheridium and the other a stalk antheridium, and other combinations may take place where more than two antheridia are present. There does not seem to be any rule in the number of antheridia which take part in the fertilization of the egg cell. Where several are in contact one or more may take part in the act of fertilization.

When the antheridial cell is formed its farther development is the same whether it be a branch antheridium or a stalk antheridium. The cell which is cylindrical or nearly so in form begins to swell and this continues until it is two to three times the original diameter, the greatest diameter being near the end which is in contact with the wall of the oogonium. At the same time it also becomes quite strongly curved and more or less twisted. In case the oogonium is a terminal one and possesses both a stalk antheridium, and branch antheridium, the stalk antheridium may curve so strongly to one side as to make it difficult to determine later which is really the stalk antheridium.

While these changes are taking place in the antheridium the granular protoplasm of the oogonium is moving toward the center to form the egg cell as described above, and now the end of the antheridium in contact with the wall of the oogonium, puts out a slender tube which pierces the oogonium wall, extends across the space occupied by the periplasm and touches the egg cell at the nearest point. This tube is known as the fertilization tube. At this point on the egg cell there is a small clear space called the receptive spot.

Nearly all of the protoplasm in the antheridium except a very

thin layer next the wall becomes coarsely granular, arranged in strings and is finally collected in the middle line of the antheridium. This is known as the gonoplasm, and soon passes through the fertilization tube and is emptied into the egg cell at the receptive spot, where it disappears in the substance of the egg cell and completes the act of fertilization.

While the passage of the gonoplasm is going on it can be seen that a thin wall is forming around the egg cell over the surface except at the point where the fertilization tube is located. When the gonoplasm has passed through, the wall becoms complete at that point, and the entire wall then thickens somewhat and soon becomes brown in color. The fertilized egg cell now becomes the egg, or oospore.

These phenomena in the development of the oogonia and antheridia and in the fertilization of the egg cell can be quite easily followed by teasing out a small section of the diseased plant tissue in water on a cover glass and arranging this for a cell culture in what is known as a van Tiegham cell. This can be placed on the stage of the microscope from time to time and the development traced. From such a culture made from a diseased young melon seedling the following record was made. The diseased tissue was teased out in water on a glass slip Monday, Jan. 28, and placed in a moist chamber. The following day, Jan. 29, a profuse growth of mycelium, oogonia and antheridia had taken place, the mycelium extending for 2mm to 3mm out from the diseased tissue. Jan. 30 a small portion of this tissue was farther teased out and mounted in fresh water in a cell culture. Jan. 31 farther growth had appeared and new oogonia and antheridia were developed. This continued for several days in the same culture.

On Feb. 1 at 12:30 P. M. as shown in fig. 1, the egg cell in the oogonium has formed and the antheridium curved over on one side is full size but the fertilization tube has not yet formed nor has the gonoplasm differentiated, the granular protoplasm being arranged in a network of threads. At 3:15 P. M. of the same day as shown in fig. 2 the fertilization tube is complete, the gonoplasm has formed and is about to pass through the tube, while a very thin wall is forming around the egg cell except at the receptive spot. At 9 P. M., fig. 3, the gonoplasm has passed through and the wall

of the oospore is complete. Fig. 4 represents an intercalary oogonium which was observed in the stage figured, at 12:30 P. M., Feb. 1. Two antheridia are here in contact with the oogonium *s. a.* a stalk antheridium and *b. a.* a branch antheridium. In both cases the fertilization tube is complete, and the gonoplasm has separated preparatory to passing through. The curving of the stalk antheridium has turned the main thread to one side, the branch antheridium arising quite closely by the side of the oogonium has curved inward to the wall of this organ. At 3:30 P. M., fig. 5, the gonoplasm has passed through the fertilization tube from both antheridia and a thin wall has formed around the now fertilized egg. Fig. 6 at 12 P. M., showed a terminal oogonium with two antheridia, one a stalk antheridium and one a branch antheridium, it being difficult in this case to say which is the stalk and which is the branch. An accident happened to this specimen and it was not seen again. Fig. 7 represents two terminal oogonia each with a stalk antheridium, first observed at 9 P. M., Feb. 1. At this time in the case of oogonium *a*, the egg cell is formed, and the gonoplasm in the antheridium has separated, while in oogonium *b*, the egg cell has not yet formed. From the fact that the stalk antheridium was on the under side of oogonium *b*, when it was first observed, the stage of its development could not be seen. At 2 P. M., on Feb. 2, however, fertilization was completed in both as shown in fig. 8. Fig. 9 represents an oogonium with a fertilized egg and two antheridia in contact with its wall; one, *a*, a stalk antheridium whose gonoplasm took part in the act of fertilization, and one, *b*, a branch antheridium from a different hypha from that on which the oogonium is borne. From the latter the gonoplasm was not used.

These oospores or fertilized eggs mark a very important phase in the life history of the fungus. They will eventually germinate and produce the mycelium again, which under favorable conditions will start the disease anew. But the remarkable thing about the oospores is that they cannot germinate immediately, except in rare instances, but must undergo a long period of rest, and hence are sometimes termed resting spores. In this condition they are capable of resisting degrees of cold and dryness which would prove fatal to the vegetative portion of the fungus. This accounts partly

for the appearance of the disease after long periods of drought and after the inclement weather of the winter season in some sections.

Not only does the thicker wall of the oospore offer greater protection against an unfavorable environment, but the protoplasm undergoes a marked change before it finally enters upon this enforced period of rest. This change is practically a metamorphosis, the complete nature of which we do not understand. Among other changes there is probably a change in the molecular or physical structure of the protoplasm by which a large amount of a fatty substance is separated and forms a very large globule and sometimes other smaller ones which occupy a large part of the space of the oospore. The protoplasm thus becomes transformed into a state highly resistant to outside conditions and incapable of growth for a long period, even though the environment may be most favorable for growth. The period of rest lasts for several, four to five, months. They will resist freezing for weeks, followed by drying, without injury.

Propagative organs. Organs of another kind than oogonia and antheridia are developed on the mycelium. The function of these is chiefly for the immediate and rapid propagation of the numbers of the parasite. The organs are, like the oogonia, either terminal or intercalary swellings of the hyphae, and at first do not differ materially from them before the defferentiation of the egg cell and antheridium. These organs are exactly alike in form but differ in the discharge of their functions and are termed respectively, conidia, resting conidia, and zoosporangia.

Conidia. The conidia measure about the same as the oogonia and when fresh water is added to them they will germinate immediately after maturity, which is attained upon reaching their full size.

Resting conidia. These are conidia which do not germinate immediately and acquire a somewhat thicker wall than the conidia. They pass through a period of rest before germinating. They are identical in form and size with the conidia. They are capable of growing after being frozen, and after drying, and serve in this way much the same function that the oospores do in that they tide the fungus over quite long periods which are unfavorable for the growth of the plant.

In germination the conidium thrusts out, by an extension of

its wall, at one or more points, a slender tube which elongates into a hypha exactly like those of the former mycelium. This enters a young seedling when favorably situated, and starts the disease again.

The conidia and zoospores are rarely developed so abundantly in this species as are the oogonia. In my cultures during Jan. and Feb. 1894–5 the oogonia were far more abundant and no zoosporangia were observed. DeBary says that sometimes one may search for weeks and even months and not find zoosporangia. I have therefore not had as yet an opportunity of studying the formation of the zoospores from the zoosporangia and cannot say whether or not they agree with those of *Artotrogus intermedius* (deBary), which will be described in the next paragraph. The following account is therefore abbreviated from published descriptions.[3] The zoosporangia are usually not to be differentiated from the conidia until the time for the development of the zoospores. They are either terminal or intercalary, and sometimes so much of the protoplasm migrates into them during development from the supporting hypha that this is emptied for a short distance near the point where the wall separates the zoosporangium from the contents of the hypha. They usually remain attached to the supporting hypha and at the time of maturity, if placed in fresh water containing oxygen, a short protuberance is developed on one side at nearly right angles to the supporting hypha, which grows to a very short tube of a varying length but always shorter than the diameter of the zoosporangium. Into this tube the protoplasm migrates and causes the end of the short tube to swell out into a rounded vesicle of about the same diameter as that of the zoosporangium, with a thin enclosing membrane. The protoplasm now breaks up into a number of kidney shaped masses, with two lateral cilia according to most authors, although Hesse[4] who first described the process in this species says that the zoospores are oval and uniciliate. These swarm about in the water for a few minutes, come to rest, round off and germinate in the ordinary way for conidia by sending out a slender germ tube

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[3] DeBary, Zur Kennt. d. Peronosporeen, Bot. Zeit. 39, 521, 1881, Beitr. z. Morph. u. Phys. d. Pilze, IV, 1881.

Schroeter, Pilze, in Engler u. Prantl, Naturl. Pflanzenfam. 1, 1 104.

[4] Hesse, Pythium debaryanum, ein entophytischer schmarotzer, Halle, 1874.

which when favorably situated will start the disease in fresh plants. It is probably by the development of these in wet soil during rain or at the time of watering the pots or soil in seed beds that the disease is spread so rapidly.

The fungus is however capable of developing as a saprophyte on dead or partially decayed organic matter in the soil so that with one watering it may become well seated in nearly all parts of the bed. To show that it is also a saprophyte it is a very easy matter to start it in the laboratory on the leaves or stems of seedlings which have been previously killed by boiling.

This damping off fungus was first described by Hesse in 1874 (l. c.) and named by him *Pythium debaryanum*. It was shown by him to be a parasite of seedlings, such as *Camelina sativa*, *Trifolium repens*, *Spergula arvensis*, *Panicum miliaceum* and *Zea mays*, while seedlings of *Solanum tuberosum*, *Linum usitatissimum*, *Papaver somniferum*, *Brassica napus*, *Ornithopus sativus*, *Onobrychis*, *Pisum*, *Hordeum vulgare*, *Triticum vulgare* and *Avena sativa* were not attacked.

DeBary made a comprehensive study of the sexual stage.[5] *Pythium equiseti* Sadebeck, is in his opinion the same species. *P. equiseti* was first described by Sadebeck[6] in 1874 from prothallia of Equisetum arvense, and in farther studies[7] it was shown that not only did it occur in potatoes affected with *Phytophthora infestans*[8] but that healthy potatoes could be inoculated with it. *Pythium autumnale* Sadebeck which grew in young plants of *Equisetum palustre* and *E. limosum*, produces oospores which develop parthenogenetically. Fischer[9] places this in *P. debaryanum*. A plant found in *Lepidium sativum*, and in *Beta* and *Sinapis* by Lohde,[10] was described by him as *Lucidium pythioides* and from

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[5] Beitr. z. Morph. u. Phys. d. Pilze, IV. 1881.

[6] Ueber einen der familie der Saprolegniaceen angehorigen Pilze in dem prothallien des Ackerschachtelhalmes. Sitzungsb. d. Bot. Ver. d. Prov. Brandenberg, 116–122, 1874.

[7] Neue Untersuchungen über Pythium equiseti. Sitzsungsb. d. Gesells. naturf. Freunde z. Berlin, V. 21, 1875.

[8] Ueber Infectionen welche Pythium-Arten bei labenden Pflanzen hervorbringen. Beibl. z. Tageb. d. 49 Vers. deutscher naturf. u. Aertze. 100, 1876.

[9] Rabenhorst's Krypt. Flora. Pilze, IV, 404, 1892.

[10] Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

the description there is little doubt that it is the *Artotrogus debaryanus*. *L. circumdans* described by the same author in a fern prothallium[11] develops only in the margin of the same, producing short conidiophores and zoosporangia with 4-8 zoospores. Fischer[12] also includes this with *P. debaryanum* Hesse, as well as the *Saprolegnia schachtii*[13] described by Frank in the thallus of the liverwort *Pellia epiphylla*. Zoospores were not seen and oogonia only rarely, the plant being usually sterile.

A number of these are probably rightly referred to *Artotrogus debaryanus* (Hesse). Unfortunately these plants cannot well be preserved for study in their several stages and in most of the cases probably no specimen of any stage has been preserved, so that it would be quite impossible at the present time at least to speak with any feeling of certainty on the proper disposition of these forms. There is need of a thorough and comprehensive study of the species of the genus, and considerable uncertainty will probably exist as to the proper disposition of some of the above species until they can again be found and critically studied.

The fungus has been several times reported in this country, and many notices of damping off have been made without, probably,

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[11] Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

[12] Rabenhorst's Krypt. Flora, Pilze, IV, 404, 1892. 4 Ibid.

[13] Notes on the fungus causing damping off, etc. Trans. Mass. Hort. Soc. I. 1891.

Explanation of Plate I. Artotrogus debaryanus (Hesse).

Figs. 1, 2 and 3, different stages in fertilization ; *a* antheridium, *oog*. oogonium, *e. c.* egg cell, *gon*. gonoplasm, *oosp*. oospore.

Figs. 4 and 5 intercalary oogonium with stalk antheridium (*s. a*) and branch antheridium (*b. a.*), in 4 with gonoplasm separated from the periplasm, and in 5 fertilization complete.

Fig. 6 terminal oogonium with stalk and branch antheridium.

Figs. 7 and 8 different stages in development, and fertilization, of sexual organs ; *b* in 7, oogonium before the formation of the egg cell.

Fig. 9 oogonium with stalk antheridium (*a*) which has fertilized the egg cell, and branch antheridium (*b*) from another hypha than that which bears the oogonium. In this branch antheridium the gonoplasm has separated, and the fertilization tube has formed, but fertilization took place from the stalk antheridium first and the wall of the oospore prevented the use of the gonoplasm from the branch antheridium.

All the figures drawn with aid of camera lucida and magnified 50 times more than the scale. Scale—1 millimeter.

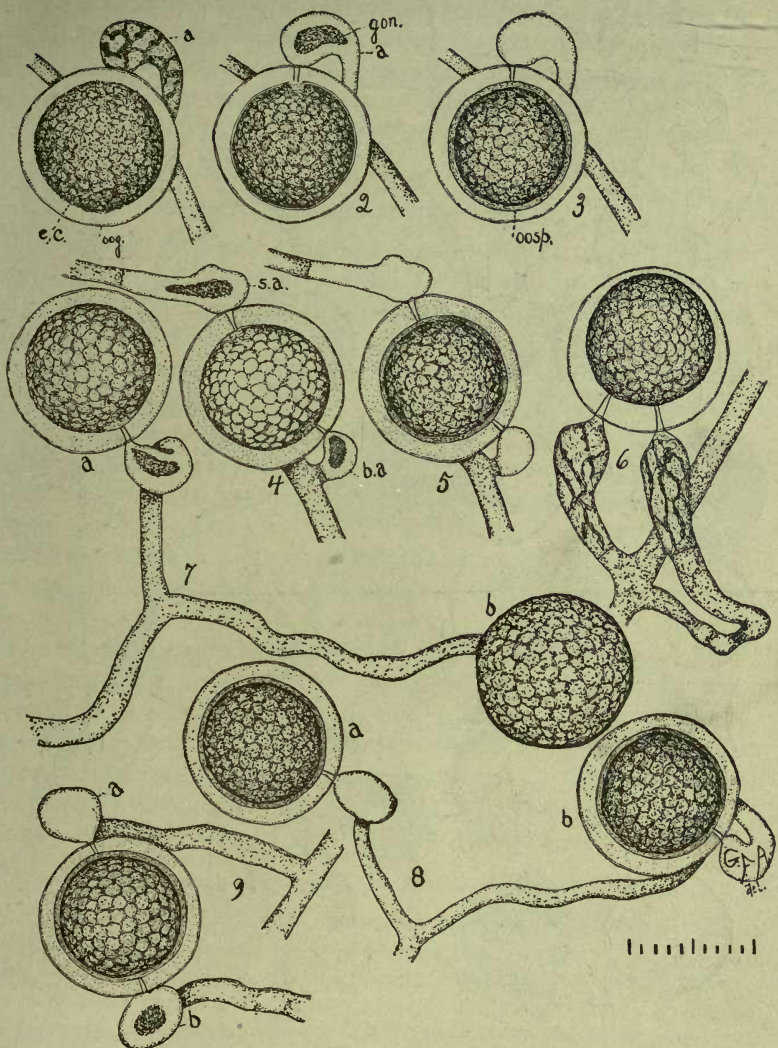

PLATE I.—*Artotrogus debaryanus* (*Hesse*).

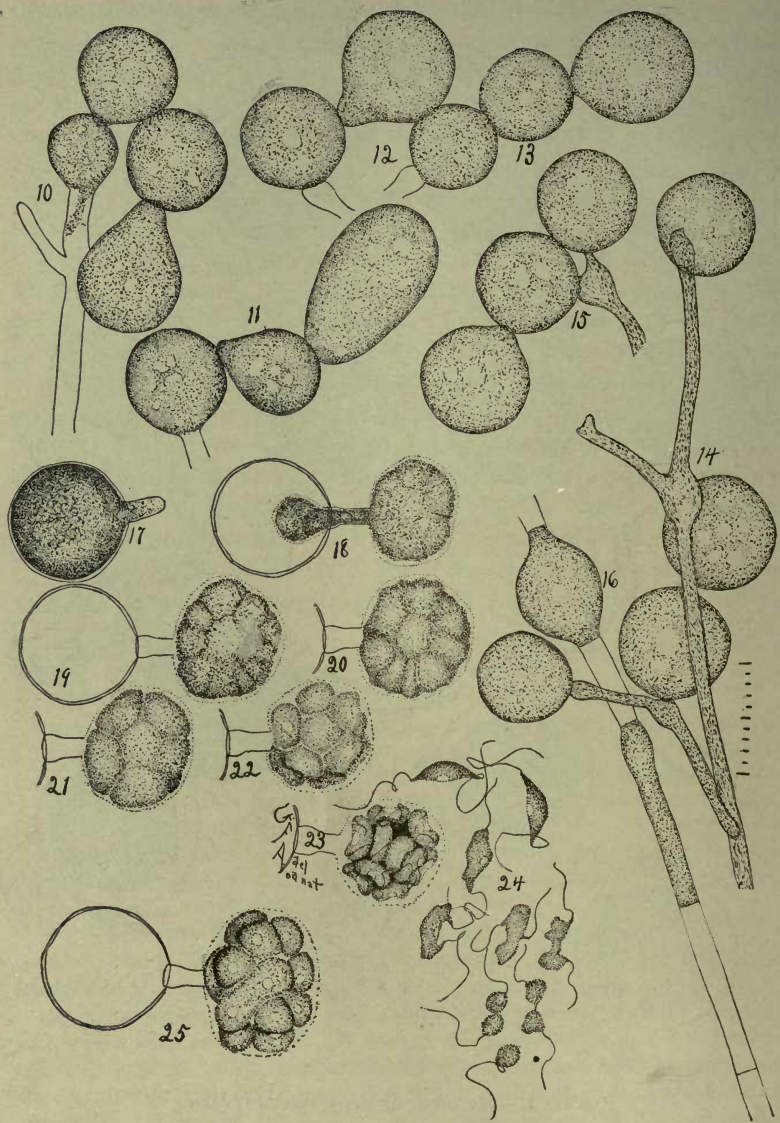

PLATE II.—*Artotrogus intermedius* (*deBary*).

any serious attempt to determine the species. T. W. Galloway from a careful study determined it from seedlings of *Gilia*, *Viscaria Lobelia*, etc., in the Botanic Garden of Harvard University. He did not however observe the zoospores. Humphey[14] also carefully determined the species, but does not describe the zoospores.

DAMPING OF PROTHALLIA.

Artotrogus intermedius (deBary).

This species was first noticed in fern prothallia growing in the botanical conservatories of Cornell University in the month of February, 1894. The affected prothallia were quite soft, limp, and darker in color than the healthy ones. Some were placed in water on a glass slip and kept in a moist chamber. The following day the fungus had grown out of the prothallial tissue and had extended a considerable distance over the slip. The mycelium is at first non setate and contains granular protoplasm which is present in minute irregular masses, having in the larger threads much the appearance of the protoplasm in some mucors, and in some cases well marked and strong currents of the protoplasm have been observed, which resemble the movement of the protoplasm in these plants.

The threads branch monopodially, the extent of the branching depending, to a certain extent on the amount of the vegetive growth. The threads put out in the water from the prothallia may be quite long and possess primary and secondary branches before condia are developed to any great extent. The conidia are developed at the ends of the main threads or their branches, the hypha swelling at the end into a rounded body several times the

[14] 8th Ann. Rept. Mass. State Agr. Exp. Station, 220, 1890.

Explanation of Plate II. Artotrogus intermedius (deBary).

Figs. 10, 11, 12, 13, conidia developed in chains.

Figs. 14 and 15, conidia borne in a manner resembling the conidial fructification in Phytophthora.

Figs. 17–23, different stages in the development of the zoospores.

Fig. 24, free zoospores with a cilium at each pointed end, passing into amœboid movement and becoming divided into oval unciliated zoospores.

Fig. 16, intercalary conidium.

All the figures from camera lucida drawings and magnified 50 times more than the scale. Scale 1 millimeter.

diameter of the thread itself. In other cases the thread may develop a conidium while it is still quite short and the growth of the thread in length practically cease. In other cases the conidia are developed at the ends of the primary or secondary branches as well as at the end of the main hypha. Where the conditions are not favorable for the rapid growth of the vegetative portion of the plant, sometimes the conidia are developed more profusely and rapidly so that they are many times produced in chains. Frequently these are in nearly straight chains, or they may form a curve, or again a short and close spiral so that they are held close to the point of origin in a small head.

The conidium may be spherical or broadly apiculate at the proximal end or more minutely apiculate at the distal end. Sometimes there is no enlargement of the fruiting thread at the point of origin of the conidium, but very frequently, and in a majority of cases which I have observed where they are grown in water, there is an oval enlargement of the hypha with a minute apical sterigma which bears the conidium. Where there is quite rapid growth of the fungus the hypha grows onward pushing the recently developed conidium to one side but not always freeing it, and soon bears another conidium in like manner. This continues so that several conidia may be borne at short intervals on the same branch, and the successive points of the origin of the conidia are not only marked by the attached conidia but by the oval enlargements on the branch. The appearance is thus in many cases very much like that of the conidiophores of *Phytophthora*, and deBary has called attention to the same fact. Many of the conidia become free.

Early in April of the same year cultures were again started on glass slips in water. A preparation was started Tuesday afternoon, April 10, at 3 P. M. At 6 P. M. considerable growth had taken place and several conidia were developed. At 9 P. M. another examination was made and quite a profuse growth was present and numerous conidia or zoosporangia.

At 9 A. M., Apr. 11, there were many free conidia and zoosporangia and the culture abounded in the form of fructification which so closely resembles *Phytophthora*. Fresh water was now added to the preparation, a cover glass placed upon it for the purpose of studying it with the high power of the microscope and for obtain-

ing camera lucida drawings. After making several sketches of desired objects one zoosporangium was discovered emitting the protoplasmic vesicle preparatory to the differentiation of the zoospores. When the eye first fell upon it the object was in the phase represented by Fig. 18. Soon the protoplasm had all passed through the short tube and was collected in a rounded vesicle at the end. There was a slight differentiation of the protoplasm at the time of the passage, but it was little marked. The differentiation became more and more marked showing that the mass was dividing into ten to twelve polygonal bodies. The surface of the forming zoospore next the wall of the vesicle, or the periphery, is the longer, and at the middle of the outer surface of the object there soon appears a depression which gives each a curved appearance. This form becomes more and more marked and now movement begins, which first appears as a kneading of the entire mass, and as they become more and more sharply differentiated each young zoospore produces an oscillatory movement with its center nearly stationary, the movement of course much restricted by the surrounding vesicle. As they assume more distinctly the curved appearance there is developed from each end of the zoospore a cilium by the lashing of which the movement becomes more violent and results soon in the release of the swarmers when they suddenly dart away.

The movement is now a complex one. The oscillatory movement is more marked with a tendency in many cases to produce figure of 8 cycles, which is combined with a jerky progressive movement in the direction of the longitudinal axis. Frequently when they come in contact with some object larger in size, they simulate to some extent the movements of a paramæcium along some object in the water.

The form of the mature zoospore is broadly fusoid, inequilateral with pointed ends which terminate in a long cilium. After five to ten minutes the movement of the swarm spores becomes slower and finally it nearly ceases and the body undergoes plastic movements resembling somewhat that of an amoeba as represented in Fig. 24. At first this amoeboid movement is irregular but after a few minutes it assumes a definite character which tends to cut the organism into two parts. This progresses until complete

fission results in the formation of two zoospores which are oval in form with the cilium attached directly at the smaller end.

This peculiarity in the development of the zoospores is one which has not heretofore been recorded except in a preliminary paper by the writer.[15] The species was at that time studied along with the seedling fungus, A. debaryanus (Hesse), and as this is reported as occurring also on fern prothallia (*Todea africana*) the species now under discussion was then supposed to be the same, and to this species it was doubtfully referred. But the development of the conidia is very different from that described for any other species of this genus resembling that of *Phytophthora* as stated above.

It cannot therefore at the present time be said with certainty that the zoospore formation in *Artotrogus debaryanus* is the same as that found for *A. intermedius*, though what evidence we already have on the subject might be interpreted to support that view of the case.

Where the soil is kept very damp and the air of the house is quite humid the prothallia are apt to be overrun by certain algae which choke the prothallia, shut out the air and light, prevent their proper development and frequently cause them to be completely sterile. Many of the prothallia are thus killed, sometimes entire beds or pots of them. A very common alga which I have several times observed is a variety of *Hormiscia flaccida* (Kuetz.) Lagerh. Species of *Oscillatoria* are also frequently present and produce a like injury.

If the pots or vessels in which the prothallia are grown are rested on sphagnum a layer of which can be placed in the bottom of the wardian case, and after the young prothallia have started, all of the watering be applied through this, the prothallia will do much better than if surface watering is practiced and far better than where the pots are rested in a vessel partly full of water. The air of the wardian case or of the house should not be kept too damp.

NOTE ON THE GENUS ARTOTROGUS.

Hesse who first described *Artotrogus debaryanus*[16] (*Pythium de-*

[15] Preliminary note on the swarm spores of Pythium and Ceratiomyxa, *Bot. Gaz.* XIX, 375, 1894.

[16] Pythium debaryanum, etc. Halle, 1874.

baryanum Hesse) says as stated above that the zoospores are oval and provided with one cilium. *Pythium equiseti*[17] Sadebeck which is generally considered to be the same plant, possesses two lateral cilia according to the descriptions, and deBary only says that the zoospore formation takes place in the oft described way.[18] In *Artotrogus proliferus*[19] (deBary), the author was unable to determine whether the zospores were uniciliate or biciliate. In the vesicle they are figured as reniform, but the ultimate zoospores are described as oval, one end being narrower than the other. Double zoospores were also described which possess two light spots instead of one. These ultimately divided, but before division according to the author, the double zoospore was like that of an organism controlled by two opposing wills. This was not the case with the biciliated zoospores observed by myself in *Artotrogus intermedius*, until amoeboid movement was beginning after a period of swarming, and when fission is about to take place. Possibly deBary observed the "double" zoospores just at that time.

(In *Artotrogus pythiodes*[20] (R. et C.) the zoospores are described and figured as biciliate one cilium attached at each pointed end of the zoospore exactly as I have found in the case of *A. intermedius*. But in *A. pythiodes* the authors say that the zoospores absorb the two cilia, round off and germinate, i. e. they do not divide, if the observations are clear on this point. This species was found on leaves of *Wolffia mitchellii*.

Other species of the genus are as follows. *A. hydnosporus*[21] Mont. in potatoes and in dead seedling plants: [22] *A. ferax* (deBary) in dead insects and in dead seedlings in water. *A. megalacanthus*[23] deBary in dead seedlings and parasitic in prothallia of *Todea*

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[17] Untersuchungen über Pythium equiseti, Cohn's Beitr. z. Biol. d. Pfl. III. 117.

[18] Zur Kenntniss der Peronosporeen, Bot. Zeit. XXXIX., 524, 1881.

[19] Pythium proliferum deBary, Pringsh. Jahrb. f. wiss. Bot, II, 182, 1860.

[20] Roze et Cornu, sur deuz nouveaux types generiques pour les Familles des Saprolegnees et dess Peronosporees, Ann. d. sci. nat. Bot. ser. 5, II. 72, 1869.

[21] Montagne, sylloge, etc., p. 304, 1845.

[22] Bot. Zeit. XXXIX., 562, 1881.

[23] Beitr. z. Morph. u. Phys. d. Pilze. IV., 19, 1881; Bot. Zeit. XXXIX., 578, 1881.

africana. *A. proliferus*[24] (deBary) saprophytic on dead seedlings and insects in water; *A. vexans*[25] (deBary) in dead seedlings and in diseased potatoes; *A. anguillulae-aceti*[26] (Sadebeck), parasitic in *Anguillula aceti; A. sadebeckionus* (Wittmack) producing epidemics of diseases in lupines and peas. Several other species have been impectly described.

A POTTING BED FUNGUS NEW TO AMERICA.

Completoria Complens Lohde.

This is an organism which is parasitic upon fern prothallia grown in forcing houses. It has been known in Europe for several years but was first found in this country during the winter of 1893–4, in the botanical conservatories of Cornell University, while studying the rotting of prothallia induced by *Artotrogus in termedius* (deBary), described in a former paragraph of this paper. Ultimately the prothallia decay but the first signs of disease when caused by this parasite alone is the appearance of a yellowish or yellowish brown color imparted by the prothallia as they lie on the soil of the pot or bed. The prothallia are so small that usually the color appears to reside in the entire prothallium when seen by the unaided eye. When examined by the aid of a microscope, however, unless the prothallium is in the last stages of the disease, the decay will be seen to be confined to "spots."

These spots vary in color from a yellowish green to yellowish brown, deep brown and finally blackish, dependent on the phase of the injury to the cell and its contents. At first the injury is confined to single cells either near together or far isolated, on the margin of the prothallium or at any point over its surface.

When the trouble is well advanced and there are numerous centers of the disease, as frequently happens, the prothallium will present a checkered or mosaic appearance, the different pieces of the mosaic being colored with the various shades of color detailed above. It also presents at this time quite a ragged appearance because many of the cells are dead and the disintegration of their contents makes holes in the plant and rifts in its edges. A short

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[24] Pringsh. Jahrb. f. wiss. Bot. II., 182, 1860.

[25] Jour. Bot. V., 119, 1876.

[26] Bot. Centralbla. XXXIX., 318, 1887.

note on the occurrence of this fungus in the United States was published by the writer in the *Botanical Gazette* for November, 1894. It is a very interesting fungus from its very simple structure, its peculiar form, mode of development, and as a plant parasite, from its being a member of the *Entomophthoreae*, which are almost entirely parasites of insects.

The vegetative body of the fungus is a more or less compact, grape like, or botryose cluster of oval or curved hyphal branches originating from a common center, and presenting on the surface a series of convolutions formed by the external hyphal branches lying close together over the surface. This vegetative body lies within a single cell of the prothallium, sometimes completely filling even quite large cells, while at other times the body may be smaller especially in smaller cells of the prothallium, where it sometimes consists of only a few hyphal branches closely curved upon their parent cells. These hyphal branches vary from 7 μ to 15 μ in diameter or may even be of a greater diameter, and are one and one-half to two times longer. When the plant body in a single cell becomes mature it may spread to the surrounding cells by certain of the external hyphal branches putting out a slender germ tube which pierces the adjacent intervening wall. This is done by the tube of the hypha excreting a substance which dissolves the cellulose of the wall making a small minute pore and at the same time turning the adjacent portions of the wall brown in color. The wall of the slender thread which squeezes its way through this opening is also colored brown, and this color is frequently extended to the slender portion of the thread or tube, in which the protoplasm passes or migrates to the center of the cell as shown in figure 44.

When it has reached the center of the cell lumen the free end enlarges and forms a rotund body which finally becomes oval. At this time it is about 15μ to 25μ in diameter, with quite coarsely granular protoplasm and with one or more large vacuoles. By this time also all of the protoplasm from the original cell has moved into this oval body in the center of the cell, leaving behind only the wall of the slender tube by which it gained entrance and which is still connected with the wall of the living organism. This old wall as well as the wall of the prothallial cell where the organism entered becomes brown in color soon after the proto-

plasm has passed through into the center of the cell of the host. From the free and smaller end of this oval cell a short protuberance grows curving to one side usually rather close to the side of the parent cell. Sometimes this branches quite soon in a dichotomous manner and the two short cells curve in opposite directions. If dichotomy does not occur at the beginning of the protuberance another branch arises soon from the original cell or from the branch. These protuberances become enlarged at a very short distance from their origin forming oval cells. These in like manner produce short branches, and the process continues until a botryose or convoluted mass of cells is developed which eventually fills the cell of the prothallium, and the elements of the botryoid body become angular from mutual pressure. The wall now becomes brown in color and the glomerule appears to be mature.

In this condition if these hyphal masses are teased out from the cell of the prothallium and kept on a glass slip in a small amount of moisture germination soon takes place. Hyphal masses so teased out from the prothallium and placed under the above conditions at 5 P. M. on Feb. 22, 1894, and kept at the ordinary room temperature during the night, the temperature falling somewhat below that of the day (the temperature was 70° to 80° Fahr., up to midnight and fell 50 toward morning and rose to 66 at 9 A. M.). At 9 A. M. Feb. 23d, the preparations were examined and the mature hyphal masses were germinating. In some cases the germ tubes were 500μ to 700μ long and all the protoplasm had moved out in the distal half of the tube (fig. 42). In germination under such circumstances a protuberance arises from one of the individual cells of the glomerule and extends soon into a tube the diameter of which is about 10μ. As the tube extends in length the protoplasm gradually disappears from the parent cell and passes into the tube. As the tube continues to elongate the protoplasm continues in the distal portion and the older portion of the tube becomes empty, nothing remaining but the wall. There appears to be a wall at the junction of the tube with the parent cell, if so it is formed after the protoplasm has passed into the tube. When the tube has become considerably elongated so that there is an empty portion from 200μ to 500μ in length there appear what seem to be transverse septa, or it may be the remains of a portion of the protoplasm situated in a thin transverse sheet in the tube. These

occur so regularly and at about 30μ to 40μ distant that the resemblance to septa is very striking if they are not really septa. If they are septa they are formed only after the protoplasm has passed these points. It may be that the growth of the tube was arrested for a certain length of time and the walls were formed while it was in this quiescent condition, or the growth of the tube may be naturally periodic. The protoplasm is coarsely granular, presenting here and there rather faint vacuoles, but there are so far as examined, no septa separating the protoplasm into distinct portions. The course of the tube is slightly sinuous, and also in an ascending position as the glomerule lay on the glass slip. Perhaps this was for the purpose of emerging from the water. After an examination the cultures were returned to the moist chamber.

While the fungus is progressing through a prothallium when one of these spore balls becomes mature, some of the cells lying adjacent to healthy cells of the prothallium germinate and grow directly into the new cell host. In doing so the germ tube is very much smaller since less energy is expended in making the perforation through the wall. After emerging from the wall in the new host cell the tube does not enlarge to the size of the tube when germination takes place in water on the glass slip, but remains about the same size as that of the perforation in the wall, until it reaches the center of the cell lumen where it enlarges into a rotund body as described above. Here it soon grows into the botryoid hyphal mass again. Other cells may germinate and course for a considerable distance over the surface of the prothallium and enter new host cells quite distant from the hyphal mass, but this has not been observed. In some cases more than one cell lying quite close to a new host cell will germinate and grow into the same. From the observations thus far made I should judge this to be quite common but not general.

The first ovoid portion of the mycelium in the center cf the cell of the host is considerably larger than the curved branch which develops at its apex and frequently larger than any which follow. The more slender form of these branches and the close apposition of the branches to the primary enlarged ovoid portion suggests a striking resemblance to an oogonium and antheridium. Thus far have not seen any conclusive evidence that these organs are I

present. However, frequently the conditions are favorable for the development of another form than the purely vegetative portion of the plant, and either simple resting spores are developed, or if sexual organs are present, then oospores. The number of resting spores varies from one to ten or even twenty in large prothallial cells where the botryoid fungus is well developed. The resting spores occupy the central portion of the mass and are surrounded by the smaller and terminal cells of the plant which now are empty. The resting spores are rounded, sometimes oval, in form and when mature are bounded by a very thick wall consisting of three coats which are smooth, but sometimes appear roughened by the closely cohering cell walls of the collapsed surrounding terminal portions of the botryose mycelium. The portions which become resting cells are always the larger and central portions. They are much larger at the time of the formation of the resting spores than when the fungus is in the vegetative stage, and since at first there appear to be no cell walls intervening it would seem that their increase in size came chiefly from the outer and smaller cells giving up to them their protoplasmic contents rather than that the additional nutriment came from the cell of the host which by this time is nearly exhausted. However, this point was not determined. The wall of the young resting spore is at first very thin and the protoplasm finely granular. The mature resting

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Explanation of Plate III. Completoria complens Lohde.

Figs. 26–30 different plants with mature resting spores showing the variation in number developed in a single plant; the resting spores surrounded by the empty peripheral cells of the plant, which may have developed conidia, or some of them entered adjacent cells of the prothallium, or possibly some of them fed the developing resting spores.

Figs. 31–32, younger stages in the development of the resting spores.

Fig. 34, plant developing resting spores at the center and a conidium from one of the peripheral cells.

Fig. 35 conidium germinating; 36, 37 and 39 germinating conidia with the germinal vesicles or proembryos developed from each one.

Fig. 40 germinal vesicle or proembryo developing the minute entrance tube which pierces the wall of the cell of the prothallium, 38 showing the entrance tube complete and the protoplasm having migrated to the center of the cell where the rotund body is formed, 41 branching of young plant in cell of host.

Drawn with aid of camera lucida and magnified 30 times more than the scale. Scale, 1 millimeter.

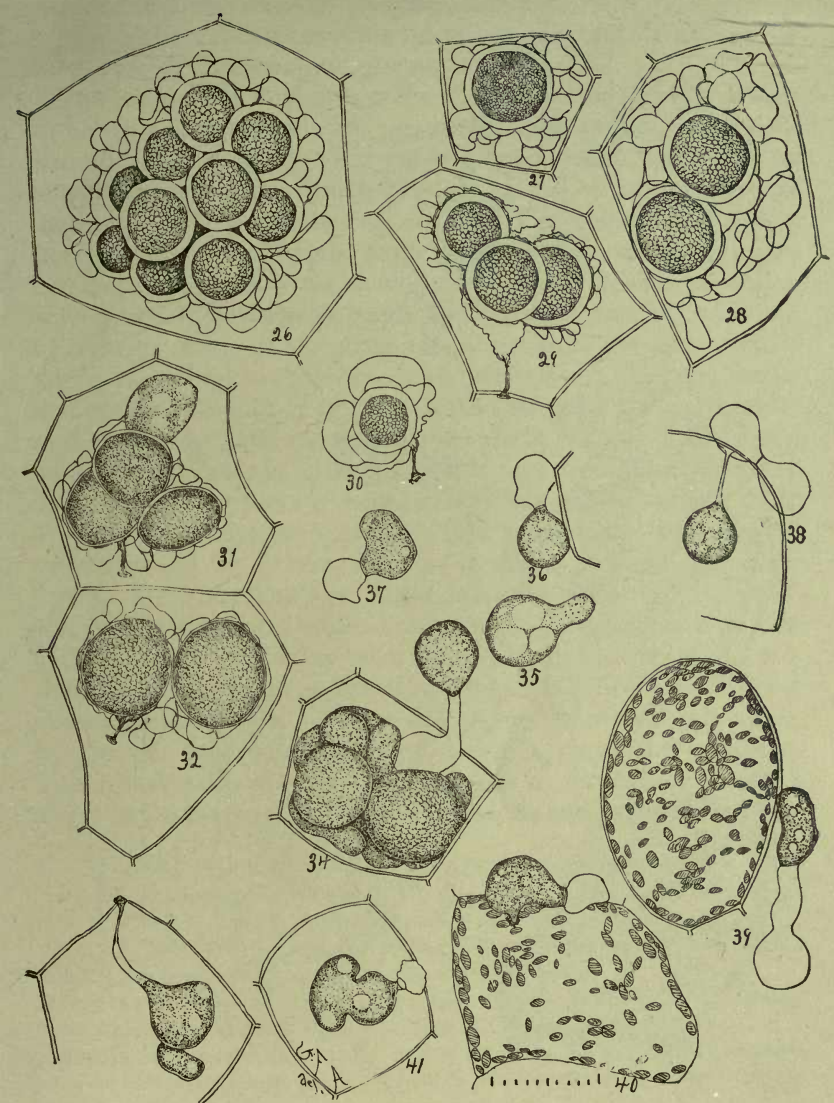

PLATE III.—*Completoria complens Lohde.*

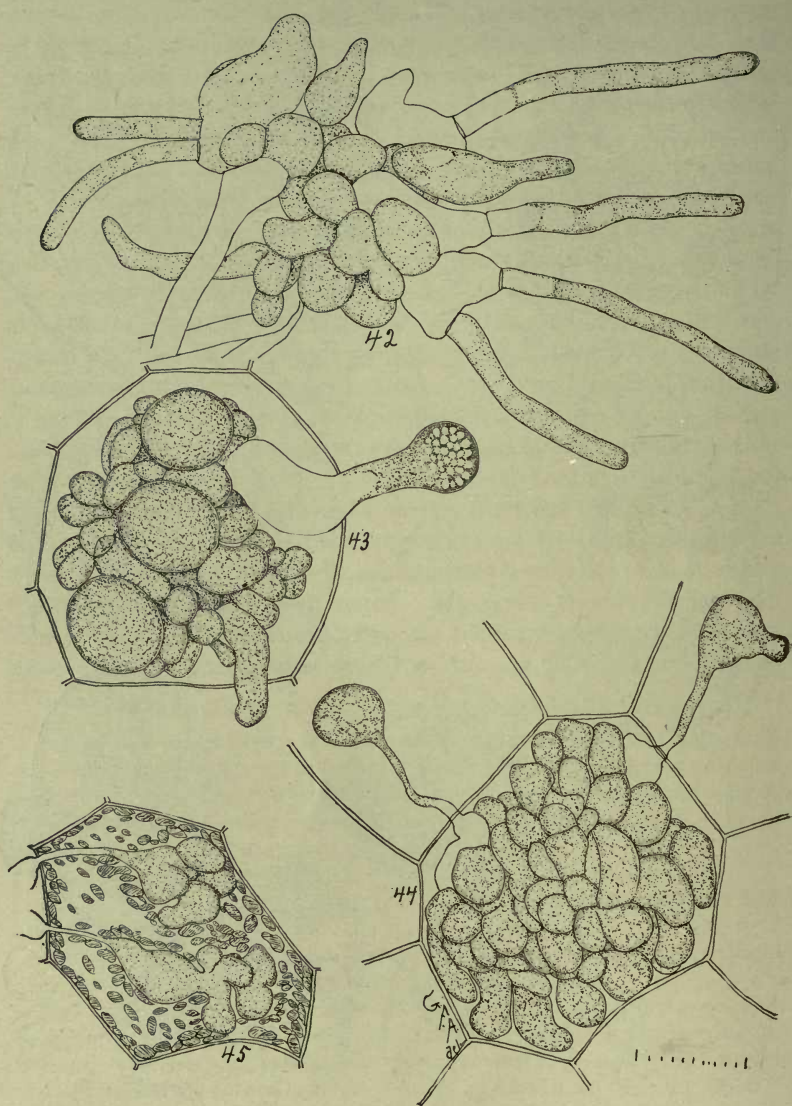

PLATE IV.—*Completoria complens Lohde.*

spore presents a very coarsely granular protoplasm the granules rounded in form and closely packed together.

Propagation also takes place by the production of non-motile Conidia from monosporous sporangia.

The conidia are oval or broadly obovate, colorless cells, with a thin wall and measure from 15 μ to 25 μ in diameter. In germinating, unless they are lying entirely immersed in water or in an abundance of a water which may be on the surface of the prothallium or on the soil, they do not form a mycelial tube directly. A very short tube is formed and into this the protoplasm migrates and causes the end of the short tube to swell out into an oval or oblong vesicle or the vesicle may be separated from the conidium by a constriction. This phase reminds one of the formation of the zoospore vesicle in the species of *Artotrogus*. But the formation of this tube and of the vesicle does not take place so rapidly as in *Artotrogus*, and the form of the vesicle is quite different and varies considerably in form as well as in size, but the most marked difference is that there is a firmer covering which appears to be in the nature of a well defined wall around the protoplasmic vesicle, while in *Artotrogus* there is only a protoplasmic membrane. Here the analogy ceases for zoospores are not formed. This cell is a germinal vesicle or proembryo, and from this proembryo arises the slender tube which pierces the cell of the prothallium and permits the parasite to enter. If the conidia are lying in an abundance of water they will germinate and produce a tube five to ten times the length of the diameter of the conidium. This I have several times observed, but in no such case have I observed the germ tube to enter a cell of the prothallium. Leitgeb

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Explanation of Plate IV. Completoria complens Lohde.

Fig. 42 botryose cluster of plant body after being placed in water, the peripheral cells germinating and forming long tubes.

Fig. 43 plant body, some of the central cells forming resting spores, and some of the peripheral ones developing conidia.

Fig. 44 plant body in one cell of the host, the peripheral cells developing tubes which penetrate adjacent cells of the prothallium.

Fig. 45 two young plants in one cell of the host having entered from an adjacent cell, early stages in the branching and development of the botryose plant body are shown.

All figures drawn with aid of the camera lucida and magnified 30 times more than the scale. Scale, 1 millimeter.

states that in such cases which came under his observation the conidium only developed a short tube and then soon died.

The conidia possess a prominent apiculus which in development is directed toward and rests partly in the stalk of the sporangium. The sporangium develops from some of the superficial cells of the botryose body, but so far as I have examined from cells which are larger than the usual external cells. The cell begins growth in an upright position or away from the moisture and appears very much like an ordinary vegetative thread which is produced when the plant is immersed in water except that it is greater in diameter. When 60μ to 80μ in length the end becomes enlarged and the protoplasm collects into the forming sporangium. While the sporangium is forming the protoplasm is more coarsely granular at the base, while at the terminal portion it is more hyaline, giving the appearance of quite large and rather numerous vacuoles. When the spore is mature it is ejected with considerable force in much the same manner as the spores of the Entomophthoræ.

The aerial development of the sporangia instead of aquatic is in correspondence with the nonciliated condition of the conidia. One case which came under my observation shows clearly the necessity for the aerial development of the sporangia in the formation of the conidia in this plant. In mounting an affected prothallium in water for examination I discovered a partly formed sporangium which projected out into the cavity of an old and emptied ruptured cell. In the growing condition of the prothallia in this case they were somewhat crowded so that they stood more or less erect. The sporangium then in growing also in an erect position away from the moisture would be directed into the empty cell above. Placing this prothallium in a horizontal position on the glass slip in a small quantity of water would immerse the sporangium in the water, or partly so. All of the water was then drawn off except just a sufficient amount to prevent the prothallium and fungus from drying and the preparation was placed in a moist chamber in order that from time to time it might be examined to watch the development of the sporangium. This stage of the sporangium is represented in figure 43. No farther development of this sporangium took place. But just at the base of the stalk another one began to be thrown up in a position per-

pendicular to this prostrate one. As the new one increased in height the old one gradually lost the protoplasm both from the forming sporangium and the stalk. In the course of 4 to 5 hours the sporangium was mature and the conidium ejected, when the sporangium and stalk collapsed and remained as a flabby membrane attached to the wall of the old stalk and sporangium which was still in the water and which still remained intact.

The conidium is capable of germinating immediately when there is sufficient moisture and the behavior seems to be manifested in three different ways according to the amount of moisture, or in some cases perhaps according to the proximity of the host. If the spore is entirely immersed in water a long slender germ tube is put forth similar to the tube which is emitted from the terminal cells of the botryose body of a vegetatively mature plant. Where less water is present the conidium germinates by developing a germinal vesicle, or proembryo as described above.

From the inner face, the one lying next the prothallium cell, of the broader end of the proembryo, a minute tube is thrust out which pierces the cell wall of the host and grows out to the center of the cell lumen where in the ordinary way it enlarges into the first ovoid body of the new plant (fig's. 38, 40). In other cases probably, where there is still a less quantity of moisture, the tube from the germinating spore is directed upward or away from the host and becomes a sporangium with a very short stalk or only the short narrowed end of the sporangium which serves as a stalk. Before this conidium is ejected from this secondary sporangium if it be immersed in water, the protoplasm will grow out into a long slender germ tube. If it were only partially immersed it might as in the case of the primary sporangium noted develop a new sporangium. In the case of the primary sporangium which was immersed in water and which developed a new sporangium at the base of the old one, as described above, the base of the stalk was not entirely immersed.

As stated above the primary sporangia in the cases observed developed from some of the larger of the external cells of the cluster. In one case this took place while the inner cells were developing resting spores (fig. 34). It may be possible that the sporangia are always developed from somewhat larger and richer cells of the periphery but more likely others of the cells can

develop sporangia when the conditions of the environment, which have not all been determined, are such as to produce this tendency to fruit in the organism.

I have found the fungus in the prothallia of *Aspidium* (*Cyrtomium*) *falcatum*, *Pteris argyria* and *Pt. cretica*.

It was first described by Lohde[27] and was later more thoroughly studied by Leitgeb, [28] who grew it in a large number of fern prothallia.

A New Cutting Bed Fungus.

Volutella leucotricha Atkinson.

April 10th (1894) two cuttings, in the botanical conservatory, of carnations which were damping off were called to my attention. These were placed in a moist chamber expecting to obtain the sterile fungus or an *Artotrogus*. Two days later, 12th, the stems were well covered with a fungus which formed elevated stromata, whitish in color or with a slight tinge of flesh color. With a hand glass the stroma was seen to be surrounded by several setae, which, however, did not present at the time a dark color as is the case with the common carnation anthracnose, *Volutella dianthi* (Hals.). At the time it was supposed that this lack of color in the setae might be due to the growth. Sections of the stromata showed the structure of a Volutella, but the conidia were considerably smaller than those of *V. dianthi* and the setae were quite different in form as well as in color. They taper but little toward the free ends, are quite blunt at the ends and usually more times septate.

At my request Mr. R. H. Pettit, a student in my laboratory, made a separation of the fungus for me by the agarp late method. The first trial was successful and in a few days the colonies of the *Volutella* were visible to the unaided eye, the conidia having been kept watch of during the stage of germination and the formation of the colonies. The growth of the colonies is quite different from that of the *V. dianthi* as well as the development of the fruiting hyphae, and there was no longer any doubt that it was

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[27] Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

[28] Completoria complens Lohde, ein in Farnprothallien schmarotzender Pilz. Sitzungsb. d. math. naturw. Klasse d. K. Akad. d. Wiss. LXXXIV, I, 288, 1881.

a different species from the *V. dianthi*, and the name *V. leucotricha* is here proposed for it.

Pure cultures were then started on bean and vetch stems and in a few days the characteristic stroma with the setae were developed in profusion on the surface of the stems. With the conidia from one of these cultures pure dilution cultures were made on April 20th. Instead of pouring a few drops of the first dilution into the second and from this into the third as I usually do with fungi having large conidia, the second and third dilutions were made by transferring with a double and twisted platinum needle. Plate number 1 and 2 were sufficiently separated for the study of colony characteristics and for photographing natural size. The colonies grow rather slowly and the plate No. 2 was ready for photographing on the 25th, and No. 3 on the 27th. In No. 2 the colonies were quite numerous and consequently rather small, from 4–6 mm. in diameter, while those in plate No. 3 where there were only 6 colonies were on the 27th 10 mm. in diameter. The colony steadily develops a thin and nearly circular weft marked by numerous fine radiating lines which because of the exceeding thinness of the weft are visible over the entire colony as it ages. There are quite regularly more dense radiating lines caused by the overlapping of certain radiating areas, and the margin shows a tendency to form roundish angles. The growth is quite sensitive to periodic changes in temperature which occur between night and day, as shown by the several concentric lines which are quite pronounced on the colony. At the center of the colony there is developed quite a compact stroma which is very much like that on a more solid substratum, like the stems of the vetch or bean. This stroma may be quite extensive and irregular in outline with a few outlying smaller and scattered ones, or there may be quite a large number of them at the center of the colony, the larger ones of course nearer the center and the smaller ones at the periphery. These individual stromata are so far like those developed in solid substrata, either in nature or culture tubes, that they are margined with the characteristic setae. A photograph of several of these growing in the agar in a Petrie dish is shown in fig. 52, plate VI, left upper corner. The photograph was taken from directly above and is magnified about 60 diameters.

In a few days after the appearance of the colonies the basidia

begin to develop. Some of them and probably the first ones are prostrate and wholly or partly immersed in the agar. They may be simple, or branched, when the branches may be opposite, or irregular, and in some cases the branches are assurgent, when most of them are thrown to one side. There is a strong tendency for the threads of the mycelium to assume a moniliform appearance by the swelling of the short cells thus producing a strong constriction at the septa. This tendency to a swelling of the cells of the mycelium is also shown to some extent in the basidia. Quite early many of the fruiting threads become erect and branch several times, the ultimate branches forming the basidia. The branches and the basidia are frequently opposite or whorled and when standing alone simulate very well the conidial fructification of a *Verticillium*. For some time the conidia are held in chains as they are developed successively on the same basidium. When moisture is sufficient, and this is usually the case in the Petrie dish, the capillarity of the film surrounding the conidia pulls them from the concatenate position and they are gathered into a globular head appearing as if they were developed in the form of a *Mucor*. Very soon at the center of the colony by the development of numerous fertile hyphae very closely, a true stroma is formed, and the conidia are held by capillarity in great masses upon the summit of the stroma.

April 24th a cell culture was prepared in a drop of nutrient agar at 5 P.·M. On the following day the conidia were germinating and a group of them was photographed (46, Plate V. upper left corner). The spores here at this time were 4–5 μ in diameter. The germ tubes are quite sinuous and at this age (17 hours from time of sowing) were 15 μ to 25 μ long, and about 2 μ in diameter. In the germinating spores are a few, 3 to 5, small and very strongly refringent granules in the hyaline and homogenous protoplasm, and are quite well shown in the photomicrograph. On the following day when the culture was 40 hours old another photograph was taken (fig. 47). By this time many of the conidia showed the development of three tubes, and the tubes were now quite long. In some cases the hyphae coming in contact, anastomose, one of these conditions being shown in the photomicrograph. One day later several of the conidia showed still other tubes so that in time two to several tubes may arise from a single conidium. The anastomosing in

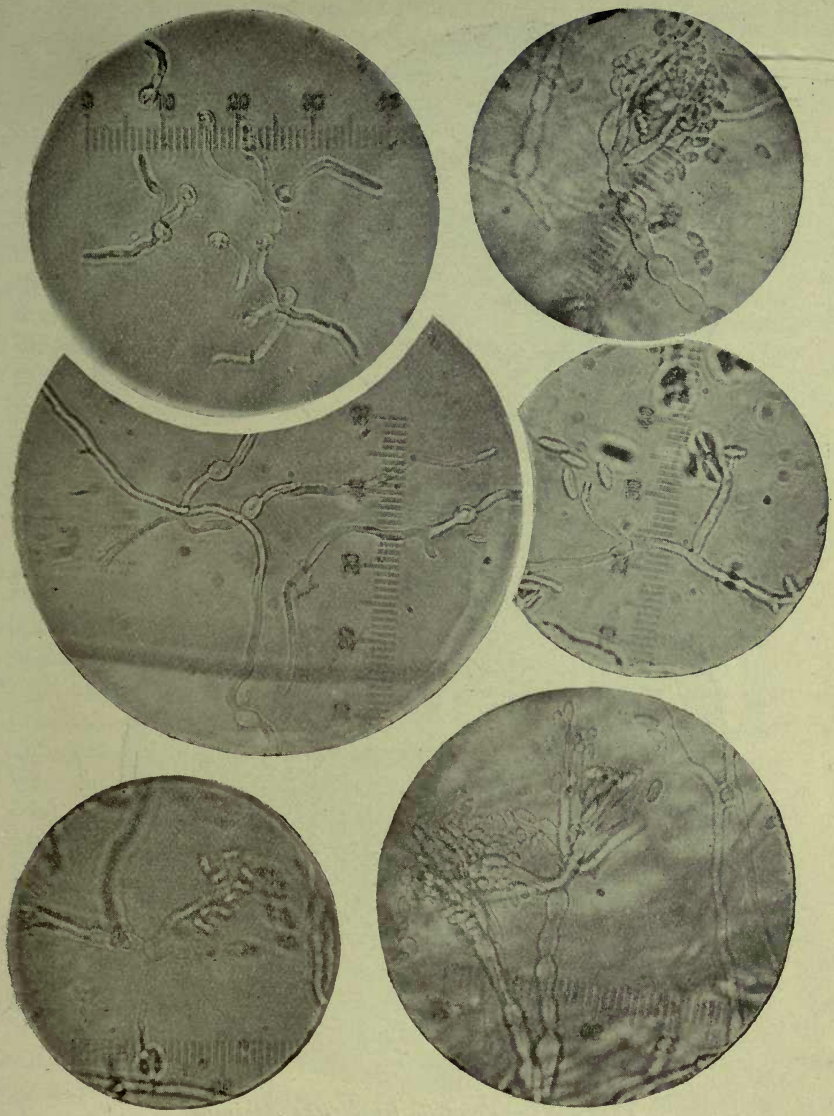

PLATE V.—*Volutella leucotricha Atkinson.*

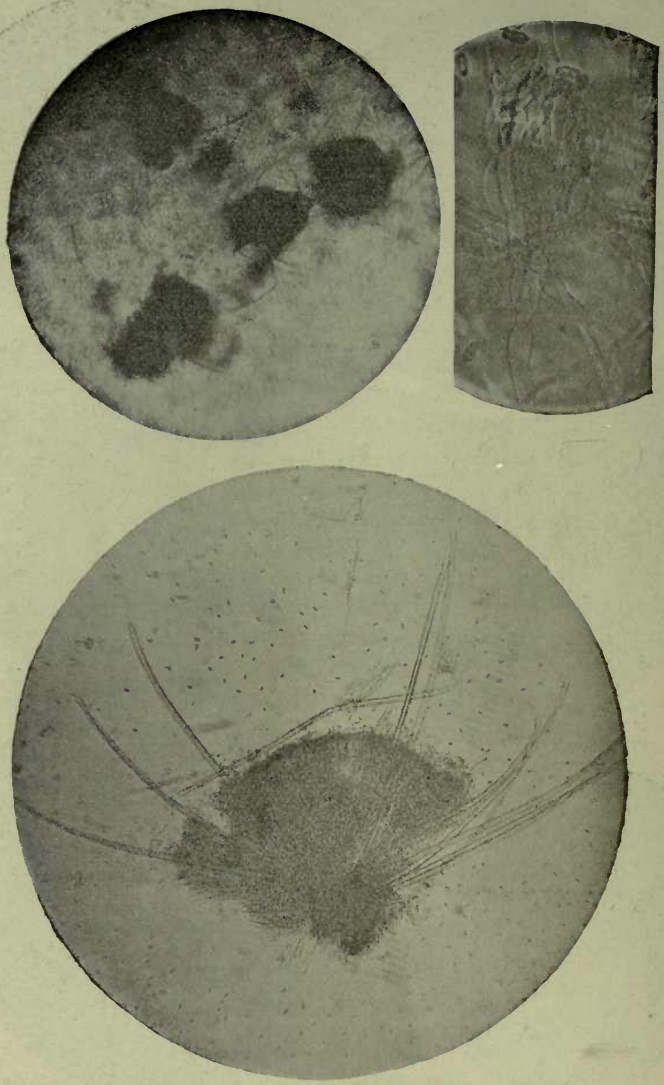

PLATE VI.—*Volutella leucotricha Atkinson.*

some cases is quite common. In this cell culture where the layer of nutrient agar was quite thin and the conidia numerous, fruiting did not take place very abundantly. In many cases the basidia are directly connected with the conidium, and in other and a majority of cases the basidia are developed from the hyphae at a variable distance from the conidium. The basidia under these circumstances are usually simple, terete and at the apex bear several conidia, which because of the rather large per cent. of water in the medium soon free themselves from the point of their origin and rest at one side. In a few cases the basidium is branched, or the fruiting hypha may bear lateral or opposite branches, and the terminal portion act as a basidium also. In this cell culture there was not the tendency for either the mycelium or the basidia to become swollen or enlarged. Two photomicrographs were taken of the conidium production in the cell culture, one showing the development of a basidium directly from the conidium (50 lower left) and one with two basidia near each other on a single thread of the mycelium (48 middle right).

In order to study the separate conidiophores, or fruiting hyphae recourse was had to the dilution culture, No. 1, in the Petrie dish. The conidia being so numerous in this dilution caused the development of numerous colonies in quite close proximity, and the fruiting was necessarily more scanty and a less tendency to the development of the stroma so characteristic of the fungus on solid substrata, or in the agar where they were not so crowded. There were therefore many scattered and independent fruiting hyphae or conidiophores. By placing a thin cover glass over portions of the plate these erect conidiophores were bent in a prostrate position, and the amount of moisture was sufficient to displace the greater amount of air so that the medium between the glass and the agar was nearly of the same density as the agar itself, and quite satisfactory photographs could be obtained when the subadjacent growth of mycelium was not too dense to interfere with the entrance of light, or to produce a hopeless confusion of threads which were not desired. Figs. 49, 51 and 54 represent some of the conditions of the conidiophores in this culture, which have been referred to above. (Figs. 46–51 and 54 were photographed at an amplification of about 600 diameters).

A portion of one of the fruiting stools which was teased out

from a culture on vetch stems was photographed with an amplification of 100 diameters and is shown in Fig. 53, Plate VI, lower figure. The preparation was mounted in water and the conidia which were so numerous that they would have clouded the preparation were mostly washed out. Quite a number, however, remained in the preparation, and show as minute oblong dark spots over the field of the photomiorograph. The fruiting stool is composed of numerous branched sporophores closely compacted together.

CANKER IN CUCUMBERS.

What is sometimes called canker in cucumbers has occurred during the two past winters in the horticultural houses of Cornell University. The appearance is that of a larger and deep ulcer in the stem at the surface of the ground. It occurs on plants of considerable size, on stems from 5 cm. to 1 cm. or more in diameter, the vines of which are several meters long. The ulcer has a dull brown color, the color of the external portion depending to some extent on the amount of soil which becomes worked into it. The tissues for some depth are soft and more or less putrid, dependent on the stage of the disease. It may advance so far as to cause the stem to rot off entirely, when of course the plant dies. In other cases the plant may not be ultimately killed but the ulcer has affected so deeply the vascular tissues as to interfere greatly with certain physiological functions of the plant. As the disease becomes serious the plants take on a sickly yellowish green color and become more or less limp. It soon soon runs its course, ending in death. During the month of December, 1894, sections of a diseased stem were placed in water and kept as described above for the seedling fungus, and in twenty-four hours a profuse growth of an *Artotrogus*, supposed to be the common *A. debaryanus* was developed. The species was at that time not accurately determined, and at the present writing there is none of the disease in the houses. The trouble is invited by keeping the soil around the stems in a too wet condition, just such conditions as favor the development of the seedling fungus. It is quite possible that another fungus to be described in a later paragraph may also have something to do with the etiology of the trouble.

DAMPING OFF BY A STERILE FUNGUS.

Much of the trouble in the nature of damping off both in the forcing house and in the fields is caused by a fungus which has been under study at several different times during the last three years, but up to the present time has refused all the encouragement, which it has been possible from present experience to offer it with the hope of inducing it to develop some characteristic fruiting organs in order that its real nature and affinities might thus be made known. There are quite characteristic features of the mycelium and of certain sclerotoid bodies developed on the mycelium, and which with a little care serve to distinguish it from other known fungi.

I first observed it while studying the diseases of the cotton plant. (See Bull, Ala. Agr. Exp. Station, Dec. 1892.) In the cotton growing states it is a very frequent parasite on young cotton plants and produces a very large percentage, so far as my observation has gone, of what is known as "sore shin" in that section. The trouble is caused by the fungus growing first in the superficial tissues of the stem near the ground and disintegrating them before it passes to the deeper tissues, in other words the fungus never seems to penetrate far in the living tissues but "kills as it goes" and the tissues become brown, depressed and present the appearance of the plant having a deep and ugly ulcer at the surface of the ground. The fungus does not spread into the tissues either above or below the ulcer to any extent, but literally eats away at that point until it has severed the stem at the affected place or the plant has recovered from its effects. The plants do not seem to suffer seriously from the disease until the woody portion containing the vascular bundles is nearly or quite eaten away.

In the latter case all communication between the root and the aerial portion of the plants is cut off and of course the plant withers and dies. But frequently the stem may be eaten off so far that the plant has not sufficient strength in the remaining tissue at that point to support it and it will fall over, and perhaps if the disease does not progress any farther it may remain fresh and green for weeks, but it is rare that after this stage the plant recovers sufficient strength at that point to erect itself again. Frequently however when the stem is nearly eaten off the disease may be arrested and the plant completely recover from the effects.

During the winter of 1894–5, some bean plants in the horticultural forcing houses of Cornell University were affected by this disease and quite a number of them presented brown and quite deep ulcers on the stems of the surface of the ground. A few of the plants went so far as not to be able to stand. Some of the worst ones were pulled up, but others which were quite badly diseased remained in the bed and all gradually recovered completely. The plants were six to ten inches in height when the trouble was called to my attention. When the plants attain this size the disease cannot make such headway, but even very young plants will frequently recover from the effects.

55.—*Sterile fungus grown on slide from seedling of Centaurea candidissima.*

It is more serious when it attacks smaller seedlings, as radishes, lettuce, etc. Egg plants and cabbages as well as others are known to be affected Both the plants in seed beds in the forcing houses have been quite seriously affected by this fungus. Lettuce is frequently eaten off at the surface of the ground and the plants supported by others near may remain erect and fresh for several days. Gradually, however, if not quickly, they wither and fall when the fungus grows in the tissues farther as a saprophyte. If such plants be placed in a moist chamber, it is not necessary to place them in water, in a day or two there will be developed on the surrounding moist paper on which it is well to place the plants, a profuse growth of mycelium composed of whitish threads. To be sure that these threads are those of this fungus and not those of some mucor it will be necessary to have recourse to the microscope. The most characteristic peculiarity of the threads of the mycelium is to be found in connection with the branching. The freshly developed threads branch freely but not profusely, they are colorless, composed of elongated cells 9 μ–11 μ in diameter and 100 μ–200 μ in length. The protoplasm is finely granular and contains numerous small rounded vacuoles. The branches extend to an angle usually of between 30 and 60 degrees from the main hypha and very near the point of attachment are a little curved toward the point of growth of the same. At the point of attachment with the parent hypha the branch is considerably smaller

than either the diameter of the parent hypha or the main part of the branch, and the septum separating the protoplasm of the greater part of the branch from that of the parent hypha is situated some distance from the latter, usually 15 μ–20 μ from the main thread. This portion of the branch then, the contents of which are continuous with those of the parent thread, is clavate in form. Species of *Botrytis* will occasionally be developed in diseased tissue of this kind, and sometimes develop phenomena of damping off similar to that produced by this fungus, though much more rarely, and the mycelium in its early stages cannot so far as I am able to tell be differentiated from this sterile fungus. But if a culture of the mycelium be made, in the course of a few days or in a week, if the mycelium be that of *Botrytis* the conidial stage or the clasping organs will be developed. But if it be that of this sterile fungus no such conidial stage will be developed.

Pure cultures of the fungus have been obtained at two different times. In the summer of 1892, from young cotton plants and again in February, 1895, from young lettuce plants which were damping off. It can quite easily be obtained in pure culture by transferring some of the mycelium grown in the air of a moist chamber, to some acidulated culture media. A very good medium is made by placing cuttings of bean stems, 7 to 8 centimeters long, in a culture tube and adding to this about 8 cc. of water and one drop of concentrated lactic acid. Several of these culture tubes should be prepared, and then sterilized in steam for two hours per day for three or four days in succession. The bean stems should project 2 to 4 centimeters above the liquid, and to the ends of these the mycelium can be transferred with a flamed platinum needle. Several transfers should be made and from portions of the mycelium which have been previously examined to be certain that mucors or other fungi are not present. Out of several transfers, if the growth in the moist chamber has been made with caution, a few pure cultures are quite likely to result.

Bacteria will be shut out by the acid in the medium, and if the culture is free from other fungi in a few days the mycelium will be visible as a silky white growth which spreads over the surface of the bean stems growing downward over them and also outward onto the surface of the glass tube. This growth continues to advance for several days with quite an even advance edge to the

weft. In the course of four or five days or one week, from the time that the mycelium is visible to the eye in the culture tube, there will appear first on the stems at certain points, and later on the surface of the glass tube, minute white powdery looking tufts on the mycelium. These are made up of closely and profusely branched threads, the branching sometimes presenting numerous and quite regular dichotomies, at other times quite irregular, and the terminal branches profusely lobed, the lobes standing in all directions and considerably more slender than the threads of the mycelium, and from 10μ to 20μ or more in length, occupying the distal portion of the branch for a distance from 20μ to 50μ. Another form of branching will also be present in which the closely set branches diverge at quite strong angles and are quite regularly constricted, presenting a moniliform appearance, and become eventually divided into short cells. These branches become more closely compacted and interwoven, forming rotund bodies at first white and quite small but eventually 2 to 4 millimeters in diameter and of a brown color. These bodies are probably sclerotia.

Upon the surface of these sclerotia are diverging threads with numerous moniliform cells which resemble chains of conidia. These are not true conidia since they do not easily become separated. By breaking down the sclerotia or by scraping the surface many of them become separated into chains of two or three cells or even become entirely separate. If placed in water, or in suitable medium, they will germinate, thus functioning like conidia.

The sclerotia have been kept for several months but in no case has any other stage of the fungus been developed from them.

At present it cannot be correlated with any known group of fungi but there are reasons for supposing that the sclerotia may be the resting stage of some hymenomycetous fungus. Frequently the threads become united into rope like strands and change to a brown color.

DAMPING OFF BY VARIOUS FUNGI.

Several fungi, probably quite a large number, produce phases of damping off at certain times while their evil effects are not confined to this peculiar class of injuries. *Phytophthora cactorum*

(L. et C.) Schroeter (*Phytophthora omnivora deBary*) was first discovered as the cause of decay of species of cactus in forcing houses. This fungus frequently destroys seedlings of trees, causing them to become brown and later to decay.

Several of the anthracnoses are known to produce genuine cases of damping off while their injury is by no means confined to this trouble. *Colletotrichum lindemuthianum* on bean seedlings is a good illustration of this, as Halsted[29] has already shown. The same author points out that a *Colletotrichum* on cuttings of abutilon, passiflora, clematis and jessamine causes them to damp off and in some houses ruins the bulk of the cuttings in the bed, while a *Gloeosporium* damps off rose cuttings.

Another anthracnose, *Colletotrichum gossypii* Southworth sometimes damps off seedling plants of cotton. Carnations are also affected in the same way by *Volutella dianthae* (Hals).

Halsted found a *Phyllosticta* in one case and in another case a a *Septoria* growing in the stems of decaying chrysanthemums, and while this was the only fungus present it was not certainly determined as the cause of the trouble. According to Halsted bacteria also cause seedlings of cucumbers to damp off.

A species of *Botrytis* which is very common in forcing houses producing a variety of diseases of various plants frequently damps off leaves and twigs of cuttings or well rooted plants. When the houses are quite damp the fungus gains hold on the plant, probably in the axil of the leaf or branch, because the water is held at these points for a longer time, and once well seated in the tissue continues its work until the leaf or branch is rotted off. Leaves of begonias and branches of roses have been so damped off in the horticultural houses at Cornell University.

A careful inquiry would probably reveal a large number of fungi which at times produce diseases almost if not quite identical with damping off so far as external appearance goes.

TREATMENT.

In the treatment of this trouble especial attention must be given to the environment of the plants and those conditions which favor the rapid development of the parasites. These conditions are

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[29] 4th Rept. N. Jr. Agr. Coll. Exp. Sta. 291, 1891.

known in most cases to be high temperature accompanied by a large moisture content of the soil, humid atmosphere, insufficient light and close apartments, and soil which has become thoroughly infested with the fungi by the development of the disease in plants growing in the same. Some excellent notes on the treatment of the disease by gardeners and horticulturists are given in the American Garden for 1890, by Meehan, Massey, Maynard, Watson, Lonsdale, Gardiner, and Bailey, and a short description of the potting bed fungus (*Artotrogus debaryanus*) by Seymour. The principal lines of treatment suggested there from the practical experience of the writers are as follows:

When cuttings are badly diseased they should be taken out, the soil removed, benches cleaned and fresh sand introduced, when only the sound cuttings should be reset. For cuttings is recommended a fairly cool house, and confined air should be avoided in all cases. As much sunlight as possible should be given as the plants will stand without wilting. When close atmosphere is necessary guard against too much moisture and keep an even temperature. The soil should be kept as free as possible from decaying vegetable matter. This is a very important matter, for several of the most troublesome of the parasites grow readily on such decaying vegetable matter and in many cases obtain such vigorous growth that they can readily attack a perfectly healthy plant which could resist the fungus if the vegetable matter had not been there to give it such a start. Soil which is dry beneath and wet on top as results from insufficient watering by a sprinkler favors the disease more than uniformity of moisture throughout the soil.

In seed beds use fresh sandy soil free from decaying matter. Avoid over watering especially in dull weather, shade in the middle part of the day only and keep temperature as low as the plants will stand.

he seedlings are badly diseased it will be wise to discard them and start the bed anew. In the early stages however they can frequently be saved by loosening the soil to dry it, and placing the pots in sunny places at such times as they will not wilt. Some advocate sprinkling sulphur on the soil and in some cases sulphur at the rate of one to thirty is mixed in the soil before sowing with good effect. When the beds are badly infested

Humphrey[30] advocates the entire removal of the soil, whitewashing the beds, and the introduction of fresh soil.

In houses heated by steam if it were possible to have, without too great expense, a steam chest where the pots and seed pans which are used could be placed and the soil thoroughly steamed for several hours it could be sterilized, and the finer and more delicate seedlings be grown then with little danger if subsequent care was used to not introduce soil from the beds. In testing the virulence of the *Artotrogus debaryanus* (Hesse), and of the sterile fungus, several experiments have been made by steaming pots of earth, growing seedlings in them and then inoculating some of the seedlings with the fungus while other pots were kept as checks, and all were under like conditions with respect to moisture, temperature, etc. The seedlings which were not supplied with the fungus remained healthy while those supplied with the fungus were diseased and many killed outright (see frontispiece).

CONCLUSIONS.

Damping off is caused by the growth in the seedlings or cuttings of fungus parasites which themselves are plants but microscopic in size. The plants when affected frequently present a paler green color. The tissues become soft at the surface of the ground, the plant falls over and dies. No one fungus is concerned even in the soft rot of seedlings. In related cases the plant may show a brownish ulcer at the surface of the ground which frequently increases in size until the plant is severed at this point and then dies.

Too great a moisture content of the soil, air, high temperatures, close apartments, and insufficient light not only favor the rapid growth of the parasites but they also induce a weakly growth on the part of the seedling so that it cannot so readily resist the disease.

The parasites can grow and multiply on decaying vegetable matter which is in the soil.

When once in the soil they can remain alive for months even though the soil become dry or frozen.

Soil used in seed beds or cutting beds should be free from de-

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[30] Mass. State Agr. Exp. Sta. Bull. 402, 1891.

caying vegetable matter or care should be used that the matter is thoroughly decomposed. Fresh sand is said to be the best for small seedlings.

Soil in which plants have once been diseased should be discarded if it cannot be sterilized by steam heat for several hours. Fresh soil free from vegetable matter should be introduced.

Water the soil thoroughly but not to saturation and do not water oftener than actually needed.

Keep the houses well lighted, well supplied with fresh air. Do not have high temperatures, keep as even a temperature as possible. When the disease first sets in stir the soil about the plants and do everything possible to dry the soil without killing the plants or raising the temperature, keep the temperature as low as the plants will bear. If this does not save them change the soil and clean the beds by whitewashing them.

When cuttings become seriously diseased change them to fresh soil, resetting only the perfectly healthy ones.

GEO. F. ATKINSON.

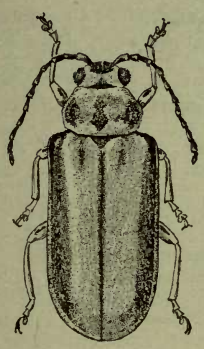
MAY, 1913 BULLETIN 333

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF THE COLLEGE OF AGRICULTURE

Department of Entomology

CONTROL OF TWO ELM-TREE PESTS



By GLENN W. HERRICK

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CONTROL OF TWO ELM-TREE PESTS

GLENN W. HERRICK

THE ELM LEAF-BEETLE

(*Galerucella luteola* Müll.)

The American elm is perhaps the greatest favorite among shade trees in the United States. It is probably more widely planted for this purpose than any other tree, especially in the eastern part of the country. Our forefathers in New England, remembering their beloved English elms, went into the woods, brought forth the slender, graceful young elms, and set them in front of their homes and along their streets. As their descendants marched westward they too remembered these fine trees and followed the commendable example of their fathers. The fine trunk of the elm, with its spreading branches terminating in graceful, pendulous tips, makes it a very beautiful tree. There is no street more attractive than an avenue almost arched with the mighty arms of the elms.

It is a source of great regret that the American elm is subject to the attacks of a most injurious insect pest, the imported elm leaf-beetle. But fortunately this pest can be controlled if fought with vigor and thoroughness.

The imported elm leaf-beetle was abundant and injurious in Baltimore, Maryland, in 1838. It must have come into the country about 1834. Since that time it has gradually extended its territory until now it is found as far north as Massachusetts and New York and as far west as Ohio and Kentucky. In New York State it is destructive in the eastern and central sections and will probably extend its activity gradually until it covers the greater part of the State.

Professor Slingerland[1] records the appearance of the beetle in Ithaca for the first time in 1902. A student in Cornell University, P. B. Powell, discovered the eggshells and the young and nearly mature grubs on July 13, 1902, on some elms along University Avenue, which leads to the Cornell University campus. Apparently the infestation was light, for only a few branches on a dozen trees were found affected. On July 16 beetles were found, and on August 2 the beetles emerged from larvæ collected earlier. The beetles must soon have invaded the trees on the university campus, and from that time until the spring of 1911 they steadily increased in numbers and destructiveness. By 1911 the trees had begun to show seriously the effects of the injury and a few had nearly succumbed. It

[1] Entomological News, vol. 14, 1903, p. 30.

is doubtful whether some of them will recover. Several English elms, which are more subject to injury from this beetle than are American elms, had to be cut down. A part of the injury to these trees, however, was caused by the elm leaf-miner.

The condition of the trees in 1910 was such that it became imperative to take preventive measures before another season should pass. Accord-

FIG. 164.— *Spraying a high elm with a Hardie machine*

ingly, the Board of Trustees of Cornell University made a liberal appropriation for spraying the elms on the university grounds, and preparation for the work was at once begun. The problem seemed a rather large one. However, the spraying has now been carried through two seasons, and, while nothing startling has been developed in the way of new methods or apparatus, the work has proved to be practical, economical, and efficient.

SPRAYING APPARATUS

The first question which presented itself was that of the apparatus to be used. It was necessary to procure machines that were not expensive. Moreover, many of the trees were on steep hillsides and were difficult to reach, so that the type of heavy machines used in work with the gipsy moth did not seem suited to the present problem. Again, there were

FIG. 165.— *Spraying a high elm with a Friend machine*

comparatively few trees and it seemed unwise to spend a thousand dollars or more for a very large machine. It was necessary, however, to have a machine that would maintain a high pressure in order to force a stream to the tops of the trees.

After a thorough consideration of all the points involved, it was decided that two power spraying machines of the following specifications should

be bought: (1) A Hardie Eastern Triplex power sprayer with 200-gallon tank; a triplex pump with $2\frac{1}{2}$-inch cylinders; a vertical 3-horsepower Ideal engine; two lines of $\frac{1}{2}$-inch hose, each 100 feet long; a 12-foot tower; two extension poles, one 20 feet and the other 12 feet long. (2) A Friend Hilly-orchard Model power sprayer with 200-gallon tank; a large-size California model pump; a $3\frac{1}{2}$-horsepower engine; an 8-foot tower; and other equipment the same as for the first-named machine. Each of these

FIG. 166.— *Spraying from tower and from ground*

machines was mounted on a truck ready for the field. The price of the Hardie machine is $274 f. o. b. Hudson, Michigan; that of the heavy Friend machine is $300 f. o. b. Gasport, New York. At all times it was possible to maintain 200 pounds pressure with either outfit, and both machines gave satisfactory results.

Bordeaux nozzles were used for all the work because these are adjustable. A solid stream could be thrown to the tops of the high trees, or a fine spray could be used for the lower limbs.

One man was stationed on the tower with the 20-foot extension rod. When he desired to change from a solid stream to a mist spray he merely lowered the nozzle to a man on the ground, who changed the adjustment of the nozzle. The man on the ground sprayed the lower branches, looked after the engine, and drove the team. An extra man was present, the so-called foreman, who directed the work, mixed the solutions, attended to breakdowns, climbed trees if necessary, and was generally responsible for the spraying operations.

There is one rather serious fault to be found with the long extension poles or with any of the common extension poles. The brass conducting pipe on the pole is too small in diameter to carry enough liquid and, besides, it greatly reduces the pressure at the nozzle. If a conducting pipe of larger diameter could be made of a lighter material that would stand the pressure, it would be advantageous. Much more liquid could be thrown; the spraying could be done faster, and thus a larger amount of space covered in a given time. Moreover, because of the pressure's not being lessened, the stream could be thrown higher. For the short poles, pieces of quarter-inch gas pipe 12 feet long were substituted in the work here described and these gave better satisfaction. Longer pieces of pipe than this, however, would be too heavy.

Smaller spraying machines

Low and medium-sized trees may be sprayed with fair efficiency with a hand-spraying outfit, such as is shown in Fig. 167. This consists of a barrel mounted on a two-wheeled cart for convenience in moving from tree to tree. A strong hand-pump is fitted into the barrel. With such an outfit a pressure of 75 pounds can be maintained, although this requires rather strenuous work on the part of the man who does the pumping. In connection with this barrel pump a tall, firm step-ladder is needed, also a piece of hose 50 feet long fitted to an extension rod 10 or 12 feet long. With an outfit of this kind, fairly large and tall trees may be sprayed efficiently and economically.

FIG. 167.—*Hand-spraying outfit*

High-power spraying machines[1]

In the crusade in New England against the gipsy and brown-tail moths, great improvements have been made in spraying outfits for forest and shade trees. The machines have been made much heavier and the engines are of high horsepower, so that solid streams are thrown to the tops of the highest trees from a nozzle held by a man on the ground (Fig. 168). This has greatly simplified the work of spraying forest and shade trees. Lines of hose 200 or 300 feet in length are laid along the ground, leading from the machine. In this manner trees on either side of the road, for a considerable distance back from the fences, may be sprayed without the machine's leaving the highway. Such machines cost about $1,000 and are rather expensive for most of the work with shade trees. However, they furnish almost an ideal method of spraying trees. With a high-power machine of this type it is not necessary to have a tower or to climb trees.

The large machines used in the work with gipsy moths have triplex pumps and 8- or 10-horsepower engines. The two- and four-cycle engines have been used, the latter apparently having given the better satisfaction. Lately the two-cylinder marine-motor type of engine has been tried and has proved very satisfactory. With these machines either 1½-inch or 1-inch hose is used, the latter being preferable. The nozzle is of much the same type as that used on fire hose.

SPRAYING OPERATIONS

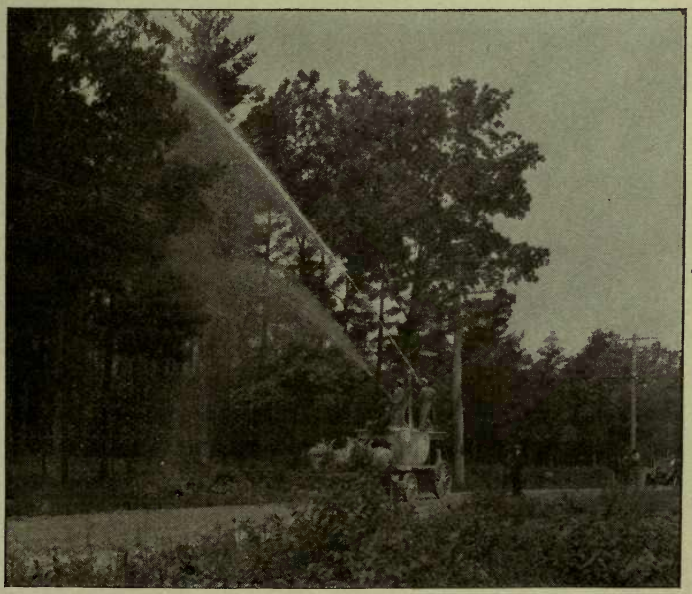
In 1911 the first spraying was begun on May 16. This application was made just as soon as the trees were in good leaf, although not in full leaf. The adult, over-wintering beetles became active at least as early as May 2. They had been observed on the windowpanes of houses for some time previous to this date, therefore they must have left their hibernating places several days before. On May 11 the elms were rapidly coming into leaf. The beetles were on the trees and were eating ravenously on those trees that were well in leaf. The work was delayed, however, until the following Monday, May 16, in order that more of the trees might come into fuller leaf.

In 1912 the season was considerably later and spraying for the beetles was not begun until June 13. The trees were well in leaf by May 27, however, for on May 27 and 28 spraying for the elm leaf-miner was done. There was a difference of about ten days between the two seasons. In 1912 the beetles were first noted on the trees on May 17. By May 21 they were abundant and were eating ravenously.

[1] Bulletin 87, Bureau of Entomology, United States Department of Agriculture, pp. 64–67.

PHOTOGRAPH BY C. R. CROSBY

FIG. 168.— *Spraying trees from the ground with high-power machines in Massachusetts*



PHOTOGRAPH BY C. R. CROSBY

FIG. 169.— *Spraying trees with high-power machines in Massachusetts*

Paste arsenate of lead was used for the most part, at the rate of 3 pounds to 50 gallons of water for the first application. For the second application the proportion was $3\frac{1}{2}$ pounds to 50 gallons of water. On about thirty-five trees powdered arsenate of lead was used, at the rate of $1\frac{1}{2}$ pounds to 50 gallons of water.

In all there were on the university grounds about five hundred and thirty trees that were sprayed in 1911. About one hundred of these were scattered over the steep hillsides west of the buildings and along University and Stewart avenues. Many of the trees were nearly a mile from the campus water supply, and the majority were scattered and not easy to reach. Exclusive of permanent equipment, the cost of spraying these trees twice was $464.90, or an average of approximately 88 cents each. The scattered trees raised materially the average cost of the whole. If all the trees had stood along streets and reasonably near a water supply, the average cost, the writer thinks, would have fallen below 70 cents. With the two machines it took ten days to make the first spraying and eleven days to make the second. The second spraying was done more thoroughly and there was much more leaf surface to be covered; on the other hand, experience had made the men more efficient. The great majority of the trees were over forty years old, while some were older; nearly all of them were large.

DETAILS OF COST OF SPRAYING ELMS ON CORNELL UNIVERSITY CAMPUS[1]

In order to give a clear idea of the cost of spraying elm trees, a few details of the work on different days are here presented. The men were paid $2 a day with the exception of the foreman, who was an experienced man and who received $5 a day. The men who drove the teams and sprayed the trees were inexperienced. The amount paid for teams was $2 a day.

On June 20 the two machines sprayed eighty-two trees, some of which were small. The total expense of this day, including men, teams, arsenate of lead, and gasoline, was $24.91, an average of $30\frac{2}{5}$ cents per tree. On June 16 sixty-six trees were sprayed at a total cost of $22.14, an average of $33\frac{1}{2}$ cents per tree; these were all large trees. On June 19 fifty-nine of the largest trees on the campus were sprayed — those along Central Avenue southward from the Library. The cost of spraying these trees was $23.965, an average of $40\frac{3}{5}$ cents per tree. These trees stood close to the street and near a water supply. They are very large trees, having a great amount of leaf surface. This should give one a fair idea as to the cost of spraying the largest trees.

[1] Journal of Economic Entomology, vol. 5, no. 2, April, 1912, pp. 170–171.

FIG. 170.— *English elms killed by leaf-beetles and -miners*

FIG. 171.— *English elms sprayed and recovering from attacks of beetles and miners*

A careful and detailed record was kept of the actual cost of spraying four hundred and thirty-five trees. Most of these trees were large and all stood near the street and near the campus water supply. The cost of spraying these trees once was $133.37, or 30.7 cents per tree. On the average, each machine sprayed 36¼ trees per day of eight hours, or 4½ trees per hour, or a single tree about every 13⅓ minutes. The average quantity of liquid used for each tree was approximately 18⅙ gallons. With the bordeaux nozzle, or with any nozzle throwing a coarse stream, considerable liquid is sure to be wasted. Nevertheless, the writer thinks it is not wise to try to be too economical in the use of the spraying material. Both the upper and undersides of the foliage should be covered, even if some material goes to waste in getting about among the branches.

During the season of 1912 the beetles were not so abundant nor so injurious. They appeared considerably later in the spring than in 1911. No beetles were seen on the trees until May 17 and they were not abundant until May 22. Spraying was begun on June 13 and finished on June 22. This was a little later than usual, it having been decided to spray but once because of the scarcity of beetles and because of the thorough spraying in the preceding year. It cost $218.90 to spray the trees in 1912, an average of 41⅓ cents per tree. Since only one application was given, the work was done somewhat more thoroughly than before and considerably more liquid was used. The men on the towers were paid $2.50 a day, an advance of 50 cents over the amount paid in 1911.

Powdered arsenate of lead, at the rate of 1½ pounds to 50 gallons of water, was used on one hundred and twenty-six trees. It gave as good results in controlling the beetles as did the paste, and mixed a little more readily with water. It was slightly more expensive than the paste.

COST OF SPRAYING SHADE TREES IN OTHER LOCALITIES

It has been shown that in the work at Cornell University the cost of spraying each tree was about 30 to 41 cents when one application was given. It is probably safe to say that the shade trees of most towns and cities could be efficiently sprayed at this cost. It must be remembered that the trees on the Cornell University campus were being sprayed by an entomologist who was anxious that the work should be an unqualified success, at least so far as controlling the beetle was concerned. Great pains were taken to coat all parts of the trees, especially the topmost and the inner branches. In order to do thorough, careful work, much time and material must be consumed. Undoubtedly the trees were more thoroughly sprayed than are average trees. It would be easy to cut the cost of spraying one fourth or one third by slighting the work.

The trees on Cornell Heights in the city of Ithaca, New York, were sprayed in 1912 by contract at 22½ cents each. These trees, which are not very large, range from 20 to 30 feet in height. Individual trees in the city of Ithaca are sprayed, by contract for the season, at a cost ranging from $1 to $2 per tree, depending on size, distance from water supply, and other conditions. It often becomes necessary, in the case of these individual trees, to use special care in order to prevent the spraying material from being sprinkled on the houses. Moreover, many of the trees in Ithaca are very large, and all such trees must be climbed in order to reach the top.

Some figures showing the cost of spraying elm trees are given by Dr. E. P. Felt.[1] He reports Dr. J. B. Smith as saying that the elms on the college campus at New Brunswick, New Jersey, were sprayed at odd times by the janitors. It took two men, with a force-pump and ladders, about one hour to spray a single tree. Including the poison used, the cost was about 56 cents per tree. In the city of New Brunswick the trees were sprayed at a contract price of $1, it being understood that they were to receive three treatments if necessary.

Considerable data are given by Mr. Kirkland,[2] of Massachusetts, on the cost of spraying trees, mostly woodland trees. In general the cost is 20 to 45 cents each for spraying trees averaging 35 to 60 feet in height.

Doctor Felt states that the trees in Albany, which present a wide range in size, were sprayed during the season of 1898 at the low cost of 15 cents per tree. He reports later[3] that the trees in Lansingburg, New York, were sprayed at a cost price to the contractor of about 23 cents, while in Troy the same contractor charged 50 to 60 cents for individual trees here and there throughout the city.

In Albany the trees were sprayed in 1901 at an average cost of 22 cents each when 5 pounds of Bowker's disparene to 100 gallons of water was used. The average number of trees sprayed each day by each outfit was forty.

The city of Saratoga Springs sprayed its maple trees in 1900 at an average cost of 17¼ cents per tree. These trees were sprayed for the forest tent-caterpillar, and the spraying did not require so much time and material as would have been needed for the elm leaf-beetle.

PROPER TIME FOR SPRAYING

The first spraying should be done just as soon as the leaves are three fourths grown or larger, and as soon as the characteristic feeding-holes

[1] Bulletin 20, New York State Museum, 1898, p. 22.
[2] Third Annual Report of Superintendent for Suppressing the Gipsy and Brown-tail Moths, 1908, pp. 140–159.
[3] Seventeenth Report New York State Entomologist, 1901, p. 739.

of the beetles appear. The beetles come from their winter hibernating places in early spring as the leaves are beginning to push out, and in a few days they begin to eat holes in the leaves (Fig. 172). *This is the time when the first spraying should be done.*

This time will vary with the earliness or lateness of the season. In 1911 the first spraying was begun on May 16, while in 1912 spraying was not begun until June 13. This, however, was a few days later than the work would have been begun had it been purposed to make two applications. In making the first application no particular attention need be paid to coating the undersides of the leaves, since the beetles eat holes entirely through the foliage.

FIG. 172.—*Adult beetles eating leaf in spring*

The second spraying should be done as the eggs begin to hatch, which will be about three weeks after the first application. In 1911 the second spraying was begun nearly four weeks after the first, but probably it should have been begun somewhat earlier. In making this application special pains should be taken to coat the undersides of the leaves. The grubs of the beetle work on the lower sides of the leaves almost entirely, and in order to kill the insects before they have done serious injury the poison should be on the underside.

The first injury noticed by the grubs is likely to be in the tops of the trees, although the grubs have been seen seemingly as abundant and injurious on the lower branches as higher up. Nevertheless, the writer would emphasize the importance of reaching the topmost branches with the spray. If a few grubs are left in these branches they will eventually transform and furnish a crop of adult beetles for succeeding years.

The writer would also emphasize the necessity of spraying early for beetles and for grubs. If the beetles or a large percentage of them are killed, not many eggs will be deposited; while the grubs are much more easily killed when young than when two thirds or three fourths grown.

AMOUNT OF POISON TO USE AND NUMBER OF TIMES TO SPRAY

As already stated, the trees were sprayed twice during the first season of the work and the mixture used was 3 pounds and 3½ pounds, respectively, of paste arsenate of lead to 50 gallons of water. The brand of arsenate

of lead used contained about 15 per cent arsenic oxid. When powdered arsenate of lead was used, the proportion was 1½ pound to 50 gallons of water.

Other experimenters recommend the use of 4 pounds of paste arsenate of lead to 50 gallons of water. A. F. Burgess, who has had much experience in combating the gipsy moth and the elm leaf-beetle, says that "the cheapest and most satisfactory remedy for the gipsy moth and the elm leaf-beetle consists in thoroughly spraying the trees with arsenate of lead, using 10 pounds to 100 gallons of water, as early in the spring as there is sufficient foliage to hold the poison." Mr. Burgess's aim is to use a large amount of arsenate of lead and to spray but once. The writer thinks this is a good practice to follow after one year of thorough work. If the elms in a town or city have been neglected and allowed to suffer for several seasons from the ravages of the beetle, the writer thinks it would be desirable to give two sprayings the first season of treatment, using in each application 3 to 3½ pounds of poison to 50 gallons of water. Thereafter, probably one thorough spraying after the leaves are fairly well out, using 4 to 5 pounds of arsenate of lead to 50 gallons of water, would suffice. That practice has been followed and has satisfactorily controlled the beetle.

To summarize, it would seem that 3 to 5 pounds of arsenate of lead to 50 gallons of water, with two applications the first year of the fight and one thereafter, are sufficient.

LIFE HISTORY AND HABITS OF THE ELM LEAF-BEETLE

Appearance and work of the beetle

The insect is about one fourth of an inch long. In general it is yellowish or brownish yellow in color, with a dark line along each side of its back. Its color varies somewhat, and the over-wintering beetles are often so dark-colored that the brownish yellow almost disappears and the dark lines are hardly noticeable. In its normal coloring it is quite likely to be confused with the common striped cucumber beetle, although it is considerably larger.

When the beetle first awakens in the spring from its long winter sleep it flies to the elm trees just bursting into leaf and takes its first meal by eating small, irregular holes through the young, tender leaves (Fig. 172).

Story of its life

In the fall of the year many of the full-grown beetles, when searching for snug crannies in which to pass the winter, find their way into dwelling-houses, congregating especially in attics where they are often found by

the score. Housekeepers are sometimes alarmed when they see so many of these beetles crawling on their windowpanes, walls, and ceilings, thinking that probably here is another household pest. Fortunately, so far as the writer is aware, these insects do not injure household articles of any description. Other individuals hide under loose pieces of bark on trees, in cracks in fences and telegraph poles, in outhouses, sheds, and any other sheltered places that they are able to find. Here they remain in a quiet, inactive condition through the long winter months. With the warm days of spring the beetles awake and begin crawling about on the walks and on the windowpanes.

As soon as the leaves of the elm begin to appear the insects fly to the trees for their first spring meal. After feeding for some time they deposit their conspicuous orange-colored eggs (Fig. 173) in clusters of five to twenty-five on the undersides of the leaves. The egg is flask-shaped, and stands upright with its larger end attached to the leaf. The eggs hatch in five or six days during hot weather, but in cool weather this period may be prolonged several days. The grubs eat ravenously, increase rapidly in size, and complete their growth in fifteen to twenty days. When full-grown they either crawl down the trunk of the tree or drop from the ends of the branches. At the bases of the trunks many of the larvæ transform into the yellow pupæ (Fig. 176). Sometimes they are so numerous that the pupæ lie an inch deep about the foot of the tree. Other larvæ undergo transformation in crevices of the bark, especially if the trunk of the tree is rough; others go to gutters; while still others seek shelter in crevices of the sidewalk and wherever they can find hiding-places. The quiet, inactive pupæ lie motionless for six to ten days and then transform into adult beetles, thus completing the life round of one generation.

Observations on the life cycle and number of generations at Ithaca

During the last week in April in 1911 the beetles became active and were especially evident on the windowpanes of dwelling-houses. By May 2 the elm trees were blooming and the leaf buds were beginning to show green. By May 11 the trees were beginning to come into leaf rapidly and some were fairly well in leaf. The beetles were present at this time on the leaves and were eating ravenously. On May 16 eggs were found on the leaves; they were probably deposited a few days earlier. On May 18 eggs were found in some abundance on the English elms. On May 22 the first eggs were hatching; during the succeeding two weeks the eggs were hatching in abundance. By June 18 a few larvæ were found pupating, and from that time into the first week in July

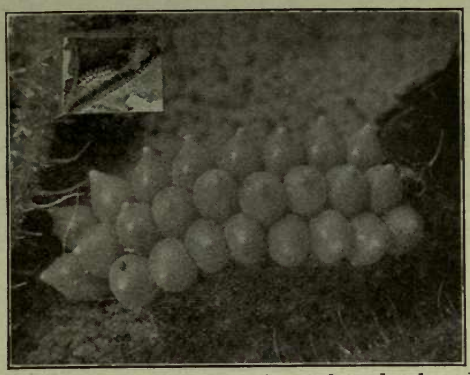


FIG. 173.— *Eggs, natural size, and much enlarged*

FIG. 174.— *Young grubs eating leaf*

FIG. 175.— *Grubs nearly grown*

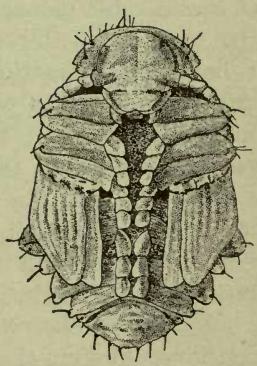


FIG. 176.— *Pupa of the elm leaf-beetle*

the larvæ pupated in abundance. Several adult beetles were observed emerging from scores of pupæ at the bases of trees on July 8.

On July 17 many beetles were noted on the leaves of the elms, but no eggs were found. On July 20, however, H. H. Knight discovered a bunch of twelve eggs that had been deposited by a beetle found in the field on July 8. This beetle had been confined in a cage in the insectary. On July 27 and July 30 Mr. Knight found an abundance of eggs of the second brood on some English elms in the city of Ithaca. Some of these eggs were already hatching, which showed that they had been deposited several days earlier. By the first week in August the eggs of the second brood were hatching in abundance. The English elms, on which the eggs were found, had been practically defoliated by the first brood, not having been sprayed; these trees had put forth a growth of new leaves. By September 1 many larvæ had left the trees and a few pupæ were found at the bases of the English elms. Most of the pupæ of this second brood were destroyed by the fungus *Sporotrichum globuliferum*. It is possible that there is a partial third brood in Ithaca in favorable seasons, such as that of 1911, for example. The history of the beetle was not followed in detail further than the first week in September during that season, but in the latter part of September the writer noted what were apparently nearly full-grown larvæ on elm leaves. These were possibly the larvæ of the third brood.

Doctor Felt[1] has noted a partial third generation under favorable conditions in the vicinity of Troy and Albany.

In 1912 the conditions were very different from those in 1911, for the beetles appeared much later in the season. In fact, they appeared so late that it was thought they were not coming in any abundance and would do no great harm. They came late in the season, however, and did considerable damage where no spraying was done.

In 1910 the writer stated, "Our observations show that in Ithaca we have one generation, with a possible second, the latter, however, being so small as to cause no serious damage."[2] The observations on which this statement was founded were made in 1910. The season of 1910 was similar to that of 1912, in which the beetles appeared late. In 1910 and 1912 the second generation was apparently small and did little damage, especially on the American elms where these observations were made. This is a fair illustration of the absurdity of drawing general conclusions and deducing general principles regarding the activities of an insect, from observations carried on during only one season. Moreover, it would seem that these insects, at least in Ithaca, are much more

[1] Bulletin 20, New York State Museum, 1898, p. 13.
[2] Circular No. 8, Cornell University Agricultural Experiment Station, 1910, p. 4.

abundant on English elms and that they pass through their life cycle somewhat faster on these trees than on American elms. Therefore, observations confined to individuals occurring on American elms might lead to conclusions concerning the rapidity of development and number of broods different from those resulting if individuals occurring on English elms were observed.

THE ELM LEAF-MINER

(*Kaliosysphinga ulmi* Sund.)

The Scotch and English elms and the Camperdown elms are subject to the attacks of the larva of a small sawfly, which mines the tissues of the leaves. Up to 1911 no adequate or effective method of control of this miner had been found, so far as the writer is aware.

CONTROL MEASURES

Recalling the penetrating power of certain contact insecticides, it occurred to the writer that possibly the larvæ might be killed in their mines in the leaves before they caused much injury. It was with a rather forlorn hope, however, that a fine, small Scotch elm, which had been badly injured by miners in previous years, was sprayed in the spring of 1911.[1]

FIG. 177.— *The European elm sawfly, much enlarged*

The material applied consisted of "Black-leaf 40" tobacco extract, diluted at the rate of 1 pint to 100 gallons of water, with 9 pounds of laundry soap dissolved and added to the mixture. It was the intention to use but 8 pounds of soap to 100 gallons of the mixture, but by mistake 9 pounds was added. The application was made in May, 1911, just as the tiny mines had begun to show in the leaves. The effect was certainly surprising. Many of the sprayed leaves were examined during the succeeding few days and every larva was found dead. Each one had evidently been killed at once, the mines on the sprayed leaves not having been perceptibly enlarged. The contrast later in the season between the topmost branches, which could not be reached, and the lower branches was very marked (Figs. 178 and 179). The leaves not sprayed were almost completely mined and became withered and most unsightly.

In 1912 these experiments were repeated on a much larger scale, there being several English elms on the university campus that had been badly injured for several years. A row of such elms extends along a stone wall bordering University Avenue. These trees were set by the founder of the University, Ezra Cornell. They had suffered severely from attacks of the leaf-beetle and the miner. Some of them had been so badly injured that they had been cut out, while those remaining bore many

[1] Journal of Economic Entomology, vol. 5, no. 2, April, 1912, p. 171.

dead branches and were in a weak, dying condition. These trees were sprayed thoroughly with "Black-leaf" tobacco extract, 3 gallons to 200 gallons of water, with 10 pounds of fish-oil soap and 8 pounds of arsenate of lead. "Black-leaf" tobacco extract contains only 2.7 per cent nicotine and is usually diluted at the rate of 1 gallon to 70 or 80 gallons of water. In these experiments the mixture was slightly stronger than this, because of the necessity of thorough work.

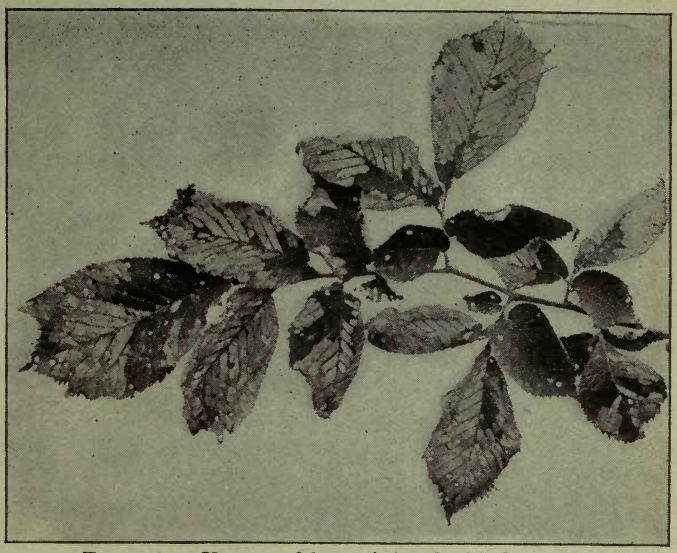


FIG. 178.— *Unsprayed leaves infested with the miner*

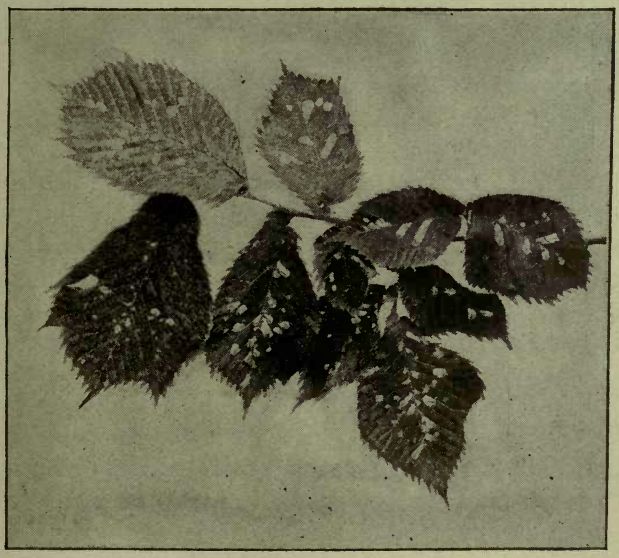


FIG. 179.— *Sprayed leaves from the same tree*

Owing to difficulty with the pump and the engine there was a delay of a day or two in getting to these trees, and some of the larger larvæ were not killed so soon as had been expected. The tobacco must have worked on them slowly, however, for the trees made better growth than they had before in some years, and looked in the fall

as though they had taken a new hold on life (Fig. 171). A row of the same kind of trees of about the same age, not far from these, nearly all died during the summer and were cut down (Fig. 170). It is evident that the "Black-leaf" extract does not work so fast as does the "Black-leaf 40."

Eight other trees were sprayed on May 28 with "Black-leaf 40" (which contains 40 per cent nicotine), at the rate of 1 pint to 100 gallons of water, with 5 pounds of fish-oil soap and 3 pounds of powdered arsenate of lead added. These trees, which had been badly injured by the miner in preceding seasons, were in good condition at the end of this season. All the young miners and many of the older ones were killed at once in their mines. Here and there, where the leaves had not been thoroughly coated with the mixture, some of the larvæ that were larger and older at the time of spraying escaped.

One Camperdown elm was sprayed thoroughly. It was low and the leaves could be coated thoroughly on both sides. The miners were completely held in check on this tree.

On the whole, the work showed that this pest of the European elms can be held in check if taken at the proper time. The trees must be sprayed early, *just as soon as the tiny mines begin to show in the leaves.*

The "Black-leaf 40," 1 pint to 100 gallons of water with 5 pounds of soap, seems to be more effective than the "Black-leaf." One great advantage of these tobacco extracts is that the arsenate of lead may be added for the leaf-beetle, thus obviating the necessity of a separate spraying for each insect.

It might be well to say that "Black-leaf 40" is a tobacco extract manufactured by the Kentucky Tobacco Product Company, Louisville, Kentucky. It may be bought from that firm direct, or it may be procured from several distributing agents in the State. It is sold by the Leadley Drug Company, Batavia, the Rex Company, Rochester, and the Parsons Drug Company, Albion. The price is $12.50 per gallon or $1.85 per pint. When it is diluted at the rate of 1 pint to 100 gallons of water, however, it costs no more than lime-sulfur or other contact insecticides.

LIFE HISTORY OF THE ELM LEAF-MINER

The adult insect is a small, shining black sawfly about one eighth of an inch in length. The wings expand about one third of an inch. In the latter part of May the sawflies may be seen on the leaves of the elm. They are not shy and can often be picked up with the fingers.

The tiny, milk-white eggs are thrust by the female into the tissues of the leaf from the upper side. They hatch in about one week and the

young larvæ begin their mines at once. The majority of the eggs are probably deposited, in most seasons, in the middle of May.

The larvæ grow rapidly, and by July 1 all have practically completed their growth and gone into the ground under the tree. Here they burrow downward an inch or less and soon make a thin, brown, papery cocoon in which they hibernate until the next May. Apparently they pass the winter as larvæ, changing into pupæ in the spring. Thus there is but one brood a year.

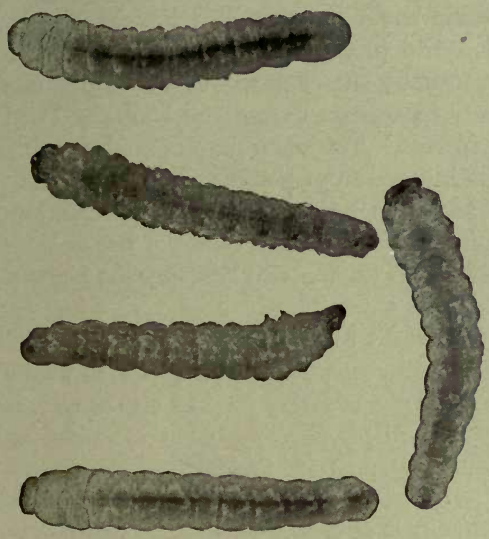


FIG. 180.— *Larvæ of elm leaf-miner, much enlarged*

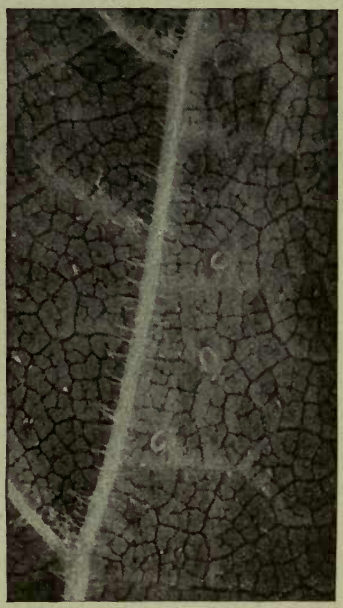


FIG. 181.— *Three eggs of elm leaf-miner stuck in leaf. Much enlarged*

NATURE OF INJURIES CAUSED BY THE ELM LEAF-MINER

The work of this miner becomes very conspicuous in June. The leaves become blotched and blistered by the mines of the larvæ. Several miners usually attack a single leaf and their mines eventually coalesce and form large, whitish blisters (Fig. 178). Often the inner tissues of nearly the whole leaf are mined out, forming a blister over the entire area of the leaf. The leaves then wither and turn brown and the tree looks as though it had been scorched by fire. Unless the leaves are wholly mined they remain on the tree. Small trees are often almost defoliated, especially small Camperdown elms. A half dozen small English elms standing in a group on the campus have been most seriously injured for several seasons.

JUDICIOUS PLANTING AS AN AID IN THE CONTROL OF THESE PESTS

In view of the wide and serious injury to shade trees by many different insects, it becomes pertinent to discuss some general principles of control of such pests. In the first place, it is unwise to depend almost entirely on one species of tree for shade or ornament. The very existence of the American elm, for example, in the eastern United States at least, is threatened by two serious pests, the elm leaf-beetle and the leopard moth. Probably the elm leaf-beetle could be controlled if every owner of elm trees would spray. It is quite probable that the leopard moth cannot be controlled and that eventually the elms will succumb to these two pests. The trees have already disappeared from the Harvard Yard as a result of the ravages of these insects. The sugar maples are becoming more and more subject to serious injuries from borers. Many fine trees are dying each year and there seems to be no help for the situation. The graceful white birches are going one by one as a result of the ravages of the bronze birch borer, while the hickories are hard beset by the hickory bark-borer.

With these facts in mind, it is important to give careful and thoughtful consideration of the question of the wise selection and planting of shade trees. A city in which the streets are planted only to elms and maples is likely to be without shade trees in the near future. The wide planting of one kind of tree over considerable territory forms ideal conditions for the increase and spread of an extended outbreak of an injurious species of insect. On the other hand, if adjacent streets are planted to different varieties of shade trees an outbreak of any single pest can be checked and controlled much more easily. Elms and maples can well be supplanted in many cases by oaks, especially the pin oak and the red oak, or by the ginkgo tree — a handsome but rather slow-growing tree, and one remarkably free from pests. The Norway maples make fine shade trees, and so do the linden, the horse-chestnut, and the American ash.

JANUARY, 1906. BULLETIN 234

CORNELL UNIVERSITY

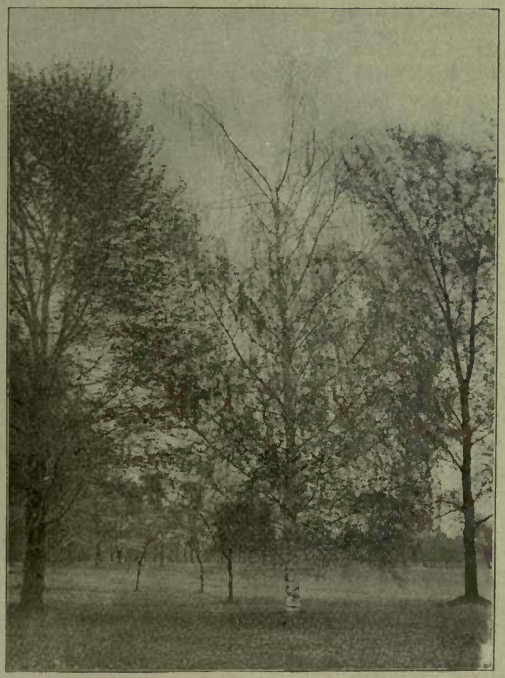
AGRICULTURAL EXPERIMENT STATION OF THE COLLEGE OF AGRICULTURE

Department of Entomology

Walter Mulford

THE BRONZE BIRCH BORER:

AN INSECT DESTROYING THE WHITE BIRCH



An infested birch in one of the Buffalo Parks.

By M. V. SLINGERLAND

ITHACA, N. Y.
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THE BRONZE BIRCH BORER

Agrilus anxius Gory

Order COLEOPTERA; family BUPRESTIDÆ

The birch trees with their graceful habits, their slender, often pendulous branches, and their picturesque trunks are conspicuous features of any landscape. The European white birch in its various weeping and cut-leaved forms has been extensively planted in American city parks and private lawns. Its artistic beauty, with its silvery stemmed branches and fluttering leaves "floating at the discretion of the winds" makes the white birch a constant source of delight both in summer and winter. As compared with the elm or maple, the white birch is considered a short-lived tree, but they frequently survive to grace a landscape for thirty years or more.

It is with much regret, therefore, that this Experiment Station finds it necessary through this bulletin to announce to lovers of these beautiful white birches that a deadly insect enemy has recently appeared which is fast destroying these trees in city parks and on home grounds. Hundreds of the finest specimens of these graceful trees in Buffalo, (see frontispiece) Ithaca and other cities and towns of New York have succumbed to this enemy within the past eight years. About half of the score of white birches on the Cornell University Campus (Fig. 34), some of them over thirty years old, have been killed by the insect within three years; and several of the remaining trees are infested and will not survive more than a year or two. These facts demonstrate the seriousness of the situation, and demand that city authorities and private owners of these valuable trees acquaint themselves with the details of the work and life-habits of this insect so that remedial measures may be promptly and judiciously applied.

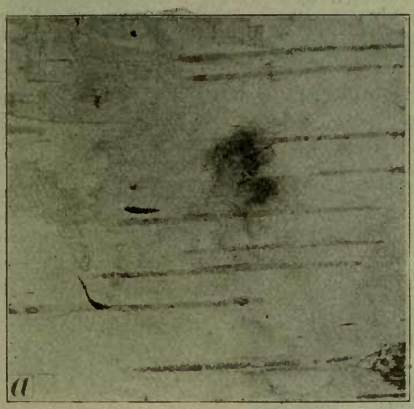

FIG. 30.—*a, Characteristic rusty brown spots on bark over the borer in autumn, natural size; b, birch branch showing the peculiar ridged effect over the burrow of borer, reduced in size.*

INDICATIONS OF THE INSECT'S PRESENCE

The presence of this insect in birch trees is not easily determined until it has been at work for a year or more. The first intimation one usually has of its presence is the dying of some of the top branches of the tree. This is well shown in the frontispiece and in Fig. 34. This dying of the tops of the trees has been very characteristic of the work of this pest wherever I have seen it in New York. The whole tree often succumbs in another year or two. Rarely the trees might begin to die at the top from a condition known as "stag head" caused by lack of moisture and food materials. A careful examination should readily locate the borer if it is the culprit. Some have tried to save a tree by pruning out the dead branches or top, but without avail for by that time the whole tree usually is infested.

Sometimes one can determine in autumn whether a tree is infested by this insect, even before any branches have been killed. Characteristic reddish or rusty brown spots or discolorations, as shown at *a* in Fig. 30, often occur on the white bark of the trunk and larger branches at the point where the insect is preparing to hibernate and transform in the wood beneath. Usually the insect can be easily located by cutting through the bark and into the wood beneath these rather conspicuous spots.

Another peculiarity which characterizes the work of the insect is the ridge which often develops in the bark over the burrow on the branches, as shown at *b* in Fig. 30.

Thus, while the insect works in rather an obscure manner, it indicates its presence in the above described characteristic and sometimes conspicuous ways. Unfortunately, however, it is usually then too late to save the tree, but much can be done to prevent further infestation of other trees.

CHARACTERISTICS OF THE ENEMY

This destroyer of white birches is a small, slender, olive-bronze colored beetle nearly half an inch in length (7.5–11.5 m m.), as shown in Figs. 31 and 35. * Its general color and the fact that it works mostly in birch trees suggested the good popular name of Bronze Birch Borer for the insect. However, it is not in this adult or beetle stage that the insect is destructive. It is injurious only during its life as a larva or grub when it is a borer.

* Chittenden (Bull. 18, U. S. Div. of Entomology, p. 47) technically describes it as "of moderately robust form, subopaque, olivaceous bronze in color. The last ventral segment is oval at the apex; the punctuation of the prothorax is transversely strigoso—punctate, and its posterior angles are carinate in both sexes; the first ventral segment in the male is broadly grooved; the second more deeply, the groove being narrow and smooth (see *b* in Fig. 31). The serration of the antennal joints begins with the fourth joint. The elytra bear each a rather vague longitudinal costa and the scutellum is transversely carinate". The popular name of the insect was first suggested in this account by Chittenden.

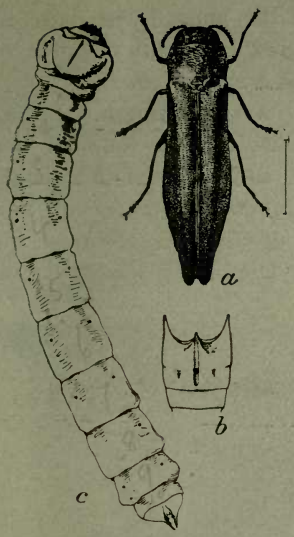

FIG. 31.—*The Bronze Birch Borer. a, female beetle; b, first abdominal segments of male from below; c, grub or borer. All enlarged about three and one-half times. (From Bull. 18, U. S. Bureau of Entomology).*

The borer (Figs. 31 and 35), is a slender, flattened, footless, creamy white grub about three fourths of an inch long when fully grown. Its small head with dark brown mouth-parts is retracted into the wide, flattened first thoracic segment giving it a flat-headed appearance. The other segments of the body are not so wide, the second and third thoracic being the narrowest. The caudal end of the body ends in two brown, horny, forceps-like processes with bidentate inner margins. It is this slender creature which is responsible for the killing of the trees. It may be found in autumn by cutting into the trees beneath the rusty-colored spots described on page 66 as occuring on the bark (Fig. 30 *a*). These grubs make tortuous or zigzag burrows in the sap-wood around and across the trunk and branches of infested trees, as shown in Figs. 36*a*, and 32.

WORK OF THE INSECT

This borer attacks white birches of all sizes from nursery trees to stately monarchs more than a quarter of a century old. All parts of the tree, from branches a quarter of an inch in diameter to the main trunk, may be infested The top branches are always first attacked and killed, then the infestation spreads into the other branches and trunk.

The tiny borer, hatching from an egg laid by the adult or beetle on the bark, begins a narrow mine or burrow through the bark. The burrow is extended in a tortuous or zigzag direction along the branch, getting wider as the borer grows, and running mostly in the sap-wood just beneath the bark, but sometimes going for a short distance deeper into the wood, even to the centre of the branch. The borer packs the burrow behind it with its excrement and wood particles which

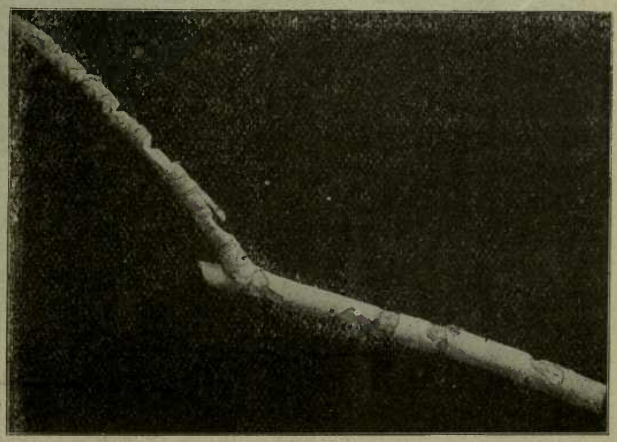

FIG. 32.—*The burrow of a single borer as it zigzagged around and through this 2-foot branch for a distance of over 5 feet. Much reduced.*

turn dark brown in the first or smaller portion of the mine. The flattened grub makes a shallow burrow that gradually widens to an eighth of an inch. Many of these zigzag, packed burrows are shown at *a* in Fig. 36.

It is difficult to follow a burrow throughout its whole length. Larsen (Mich. Acad, Sci., 3rd. Rept. 1902, p. 48) states that he followed one "through its winding course a distance of 1 foot and 7 inches in a length of branch of 4 inches, now near the bark, now deep down in the wood; now running upwards in the branch, now running downwards. Neither the beginning nor the end of this burrow was found. The branch was somewhat

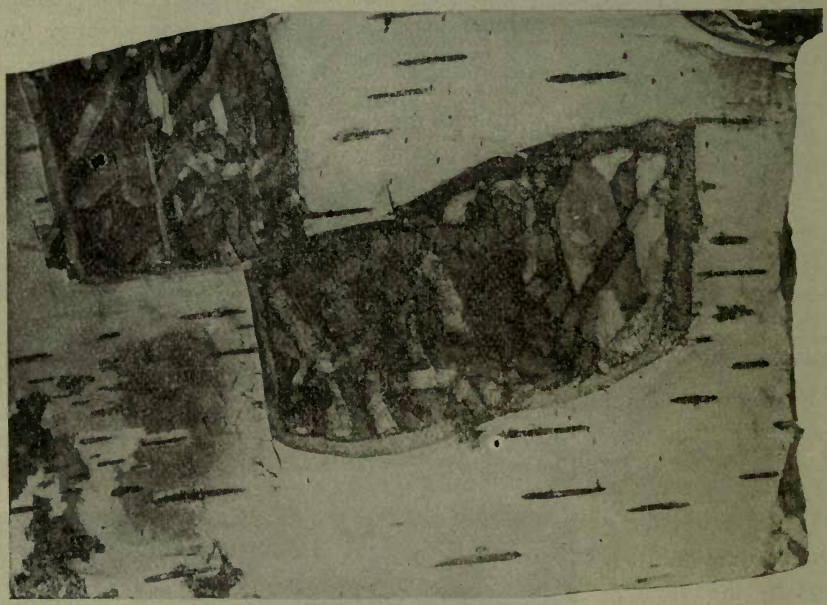

FIG. 33.—*Portion of trunk of infested white birch, showing no injury apparent until the bark is removed and the numerous burrows of the borer revealed. Natural size.*

less than an inch in diameter. Another burrow was traced upwards in a branch of about half an inch in diameter a distance of about 18 inches, then doubling upon itself ran downwards parallel to the upward course". I followed the burrow shown in Fig. 32, from the point where the grub had formed its hibernating and transforming cell in the wood back to the starting point on a branch about an inch in diameter and two feet long. The course of the burrow is shown in the figure, but one can get from the picture but a faint notion of the numerous turnings and zigzaggings of the burrow as it extended along and around the branch. Eight times the borer tunneled its way through the wood to the centre of the branch or farther, once working along for about four inches near the centre. This burrow, the work of a single borer, measured a little over five feet in length, and it was evidently all made between June 1st and Oct. 1st. Surely this is a remarkable piece of work

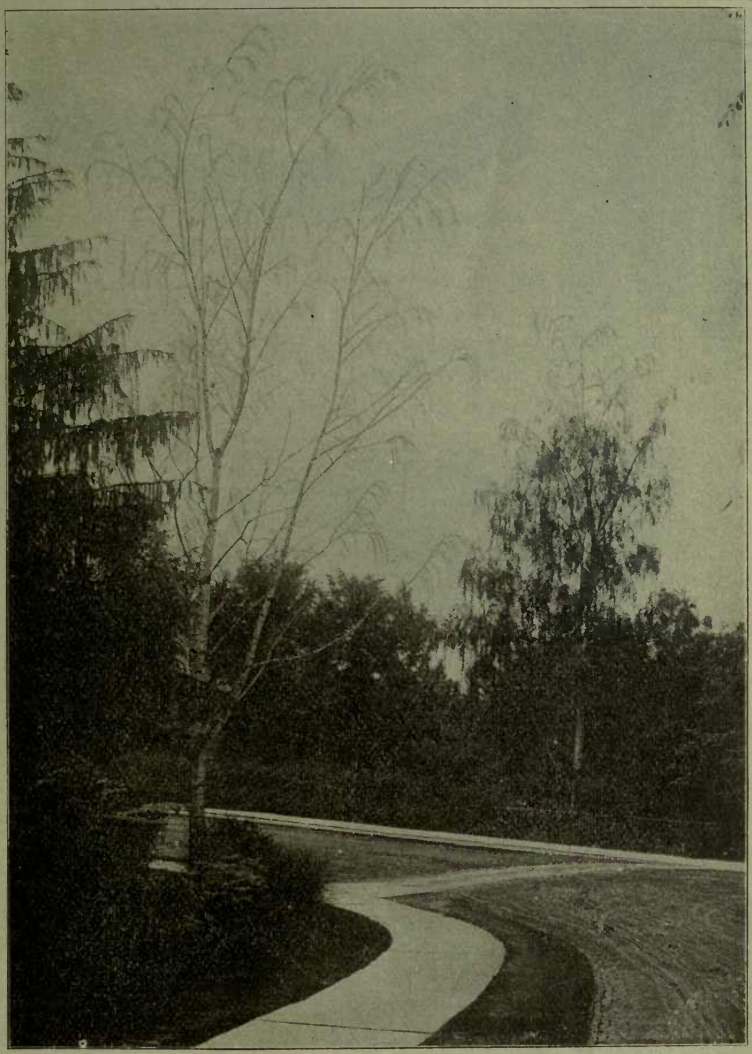

FIG 34.—*On the Cornell University Campus. The white birch tree in the foreground was killed by the bronze birch borer and the other birch tree across the road shows the characteristic work (top branches dying) of the insect.*

FIG. 35.—*a, The bronze birch borer beetle, natural size in lower corner; b, the grub or borer, natural size above.*

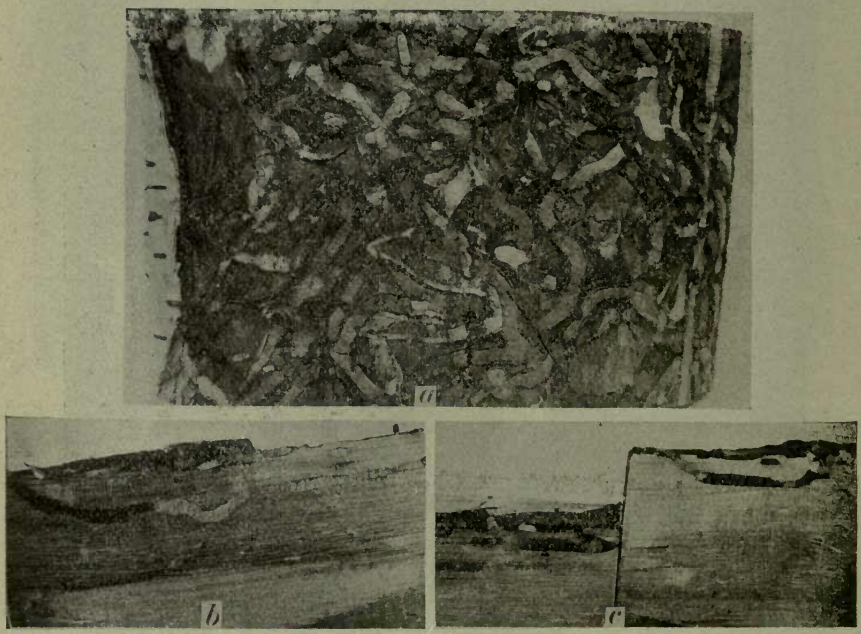

FIG. 36.—*a, Portion of trunk of white birch with bark removed to show how the burrows of the borer sometimes zigzag across each other; b, shows a burrow extending through the wood; c, hibernating and transforming chambers in the wood a short distance beneath the bark. All figures reduced slightly.*

and must have kept the little creature chewing nearly every moment of the four months.

Oftentimes on the trunk and larger branches the burrows of several borers zigzag across each other in interminable confusion, as shown at *a* in Fig. 36. Yet it is a remarkable fact that even in this case where the infestation was very severe, there were no indications on the bark of the trunk of any injury beneath, or that the tree was infested by a borer; this fact is well shown in Fig. 33, where small portions of the bark were removed and the numerous burrows of the borer revealed. The burrows mostly extend through the growing wood just beneath the bark, and often the effort of the tree to repair the injury results in a woody growth over the burrow that causes corresponding ridges to appear on the bark (Fig. 30, *b*). Sometimes a burrow can be traced for several inches by these ridges on the bark. The next year's growth of the tree may cover an old burrow with wood, and burrows have been found thus buried under three annual rings of woody growth, showing that the tree might overcome some of the injury were it not for renewed attacks by the pest. Sometimes the burrowing of the borers weakens the limbs to such an extent that they break from their own weight.

HISTORICAL NOTES

Scientific name.—The first record in the literature of this Bronze Birch Borer concerned its scientific name. Like many other American insect pests, this borer was also named in Europe. One of the adults or beetles found its way into the collection of Dejean, a Frenchman, who published lists of the beetles he had. In the third edition of his *Catalogue des Coleopteres* (p. 63) issued in 1836, he listed this birch borer, giving it the name of *Agrilus anxius*. But the honor of naming the insect is now credited to Gory, another Frenchman, who first published in 1841 a description of it and courteously used Dejean's name (Hist. Nat. des Coleopteres, Monog. des Buprestides, Vol. 4, p. 226). Dejean recorded the insect from Boreal America.

In 1859, the insect was first recorded in American literature by Le Conte, and was then described under two different names as *Agrilus gravis*, from Lake Superior and New York, and *Agrilus torpidus* from Lake Superior and Illinois (Trans. Am. Phil. Soc., XI, p, 247); he recorded *Agrilus anxius* from Massachusetts. The former names fell as synonyms of Gory's earlier name of *anxius* when Dr. Horn monographed the genus *Agrilus* in 1891, (Trans. Am. Ent. Soc. XVIII, p. 277–366.

Early economic records.—Dr. Lintner was the first to record anything about the habits of the insect. In 1883, he collected 62 of the beetles "which were observed alighting from their flight in the bright sunshine, and running actively in jerking motions, over the bark upon some cut poplars piled by the wayside" in the Adirondack Region of New York. He suggested that the larva was probably a borer in poplar (37th. An. Rept. N. Y. State Mus. Nat. Hist. p. 50.; the same account occurs in Lintner's 5th Rept. p. 281). In 1884, Harrington took specimens of the beetles on willows in Quebec (Can. Ent. Vol. XVI, p. 101), and in 1889, Blanchard recorded it as occurring on the foliage of poplar sprouts in Massachusetts, and he took a few specimens on the summit of Mt. Washington, N. Hamp., "whither they had flown from below" (Ent. Am. Vol. V, p. 32).

The first notice of this borer attacking birch appears to be that of Schwarz who mentioned the insect in 1890, in connection with the work of a Scolytid beetle, *Xyloterus politus* (Proc. Ent. Soc., Wash., Vol. II, p. 78) at Detriot, Mich., where two silver birches were killed. The same year Cook (3rd An. Rept. Mich. Expt. Sta., p.119), bred the insect

from galls which were quite common in Michigan on a willow (*Salix discolor*). Davis describes these galls (Insect Life, IV, p. 66) as an oval swelling of the live branch in which the borer tunnels "an oval gallery downward from the gall, sometimes in the pith, but oftener indiscriminately through the wood, and makes its exit often an inch and a half below." This work in willow is so different from that of *Agrilus anxius* in birch, that I was inclined to doubt the identity of the two borers, but an examination of one of Cook's specimens convinced me that they are probably the same insect, and Mr. E. A. Schwarz confirms this. As the specimen was a female, it was impossible to determine it definitely.

In 1896, Jack reported (Garden and Forest for 1896, p. 269), that "some of the foreign birches in the Arboretum and other localities about Boston have been killed by the attacks of boring larvæ" which were doubtless this Bronze Birch Borer. About the same time the white birches in the parks of Buffalo began to die from the attacks of this pest, and during the past six years the insect has killed hundreds of these beautiful trees in Buffalo, Rochester, Hornellsville, Ithaca and doubtless other cities in New York; and similar destructive work is reported from Detroit and Ann Arbor in Michigan, from Chicago, and from Guelph, London and Hamilton in Canada. It is still continuing its ravages in some of these cities, slowly spreading from tree to tree, as practically no well directed effort is being made to check it.

A good summary of previous records of the insect and an account of its work in Buffalo was given by Chittenden in 1898 and 1900 (Bull. No 18, new series, U. S. Div. of Entomology, p. 44–51, and Bull. 22 of the same Division, p. 64–65). In a paper on "A Disease of the White Birch" read in March, 1901, before the Michigan Academy of Science (3rd Rept. of Mich. Acad. Sci. 1902, p. 46–49) John Larsen gave an excellent account of many original observations on the work and habits of this insect. Professor Lochhead well summarized the records in 1903, (28th An. Rept. Ontario Agr. Coll. & Exp. Farm for 1902, p. 22–23).

The Distribution and Destructiveness of the Insect

This bronze birch borer is an American insect and is widely distributed throughout the northern United States and Canada. It has been recorded from New Hampshire and Massachusetts westward through Connecticut, New Jersey, New York, Pennsylvania, Virginia, Quebec and Ontario in Canada, Michigan and Illinois to Colorado. Thus far it has been reported as injurious only in Massachusetts, New York, Michigan, Illinois and Ontario in Canada. But doubtless many white birches in other States have been killed by the insect, the real cause being unknown or unrecorded.

In New York state this borer now occurs in destructive numbers in St. Lawrence County, and in the following cities: Buffalo, Rochester, Ithaca, Hornellsville, and probably others. The beetles have been taken in other parts of the State, and it is liable to appear in destructive numbers wherever white birches are used as ornamental trees.

In Europe two similar borers (*Agrilus betuleti* Ratz. and *Agrilus viridis* L.) are destructive to birches.

The fact that the bronze birch borer often kills large trees in three or four years is sufficient evidence of its very destructive character. Within a few years many white birches in Chicago, Ann Arbor, Detroit, Buffalo, Ithaca and other cities have been killed by the insect. A tree usually succumbs within two or three years after the first top branches die.

In 1895, M. F. Adams, a keen observer of insect life, discovered that

the common white birches in Buffalo's parks were injuriously infested by a borer. By 1898, several trees had been killed, the cut-leaved varieties also were being attacked, and the culprit was found to be the bronze birch borer. I saw in Delaware Avenue Park in Buffalo on May 11, 1899, at least one hundred magnificent white birches, some of them veritable monarchs nearly two feet in diameter at the base, all dying from the work of this borer. In August of the same year, Mr. Adams reported that from one spot in one of Buffalo's parks he could see fourteen black and yellow birches, but twelve of them were dead, all killed by this borer. Chamberlain reported in 1900, (Scientific American, Vol. 82, p. 42), that the result of the work of this insect is that "nine-tenths of Buffalo's white birches are either dead or dying and the rest will soon follow. Several hundred have died, including about 50 in Forest Lawn Cemetery the present season. Even the dead trees were not burned, and the pests were allowed to multiply at will."

I have seen over half of the white birches on the Cornell University Campus and many of those scattered about Ithaca's lawns killed by the insect within the past three or four years. And unless the vigorous, prompt, and judicious measures now being enforced on the Campus are carried out throughout the city, Ithaca's white birches will soon be dead monuments to the industry and destructiveness of this little enemy.

Food-Plants or Kinds of Trees Attacked

This insect seems to confine its work almost entirely to birch trees. The only exception yet recorded is discussed on page 72 where it was found making gall-like swellings on a willow. The European white birch (*Betula alba*) and its cut-leaved weeping variety (*pendula laciniata*) have suffered most from its ravages. In the outbreak in Buffalo, the former or *alba* was first attacked, the infestation then extending to the cut-leaved variety. But I have seen a case in Ithaca, where a cut-leaved birch was killed before a tree of the whole-leaved form only a rod or two distant showed any signs of being infested.

Several trees of the American black (*Betula lenta*) and the yellow (*Betula lutea*) birch have been killed by the insect in Buffalo, and it is also recorded as attacking the paper or canoe birch (*Betula papyrifera*).

However, there is no record of any kinds of birches having been killed by the insect in forests or woodlands. It seems to have confined its destructive work to the more valuable individuals and groups of these beautiful trees set in parks and private lawns.

The beetles have been taken on poplars cut and piled by the roadside, on poplar sprouts and trunks, and on willow, but there is no evidence that the insect was breeding in poplar. Larsen put a number of the beetles in a cage and supplied them with fresh leaves. "When only birch leaves were supplied they fed very sparingly. Some elm leaves were then put in with the birch and they fed greedily upon these. This led to further experiment and various sorts of leaves were used. They fed upon almost any leaf of soft texture. But their favorite food was willow, poplar and aspen leaves with preference

strongly marked in the order given. It seems from this that the beetles upon leaving the birch feed on other trees until the time for reproduction."

THE LIFE AND HABITS OF THE INSECT

The chain of evidence regarding the life-story of this bronze birch borer is not yet quite complete, but from the records and from my observations and investigations most of the details can be supplied.

Hibernation.—All the evidence I have, shows that the insect always passes the winter as a full-grown grub or borer curled up in a long, narrow cell or chamber, which it makes in the wood not far from the bark. I have failed to find smaller borers in uncompleted burrows in autumn. One of these hibernating cells is shown at *c* in Fig. 36. Most of the borers may be found in these cells early in October; Adams reports finding some as early as July 14th. Some of them can be easily located by cutting into the tree beneath the characteristic rusty colored spots (Fig. 30, *a*). The grubs rest in the cells in a peculiar manner with the cephalic third of the body bent around lying close to the remainder. They are very sluggish when removed from the cells. Early in the spring these hibernated borers shorten up, straighten out in their cells, and thus prepare for transforming.

Transformation and habits in spring.—During the latter part of April or early in May, depending upon weather conditions, the grubs transform in their hibernating cells into the adult insects or beetles (Figs. 31 and 35). A day or two before transforming the pupæ turn to the dark bronzy color of the beetle.

In making its hibernating and transforming chamber in the wood in early autumn, the borer also extends its burrow up to the bark, so that in the spring the newly-transformed beetles only have to squeeze their way out of the cell and eat their way through the bark. Larsen records that the emergence of the beetles is rather a laborious process, as some were found "with the forward parts of their bodies protruding for hours making long rests between efforts to free themselves." Several of the peculiar shaped *exit* holes of the beetles are shown in Fig. 37. Eleven exit holes have been counted in an area only two and a half inches in diameter.

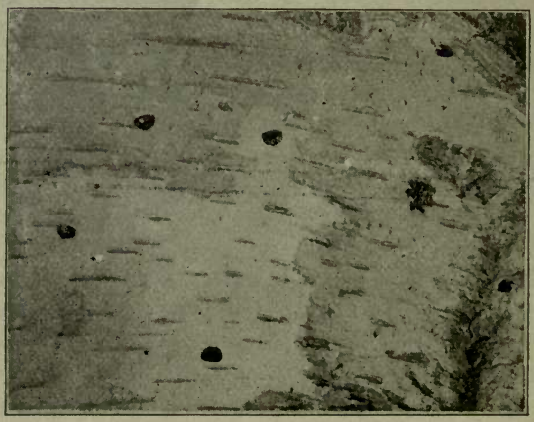

FIG. 37.—*Exit holes of the bronze birch borer beetles in the bark. Natural size.*

The date of emergence of the beetles in the spring is of much importance in connection with methods for controlling it, and it varies somewhat with climatic and other conditions. Sometimes a few of them emerge as early as May 1st, but my observations and breeding notes in New York, indicate that most of them do not appear until

from May 15th to June 1st, or even later. In 1900 Adams reported that none of the beetles had emerged by June 3rd. The beetles feed on tender foliage, evidently preferring other trees like the willow and poplars, as Larsen has shown.

Egg-laying.—I have not seen the eggs of this bronze birch borer as I could not induce the beetles to lay eggs in my cages, but Larsen was more fortunate and obtained evidence that they were laid in crevices of the bark. He states that beetles "confined in a glass jar were found to be depositing eggs on June 8th, and for a week or more afterwards. Pieces of fresh limbs were supplied, but the insects did not deposit their eggs upon these, but moved about feeling for crevices with their long prehensile ovipositor and having found a place, such as between the glass and the lower part of the cork or under a piece of wood, from five to ten or more eggs were put in one place. Copulation had gone on for some time before this. Great activity was exhibited during the copulation and egg-laying. No observations were made on the development of the eggs." It is unfortunate that the eggs were not described.

As further evidence that the eggs are laid several in a place in crevices or rough places on the bark, is the fact that the burrow I followed from end to end, as described on page 68 and shown in Fig. 32, began at a rough place where a twig had been broken off. And Larsen found that "in one place in a slight swelling on the bark were several small openings, less in diameter than a pin. From these openings burrows were traced. The burrows are at first very small and lie close under the bark and are filled with dark granules." Adams wrote me of a similar observation made in Buffalo early in June, 1899. He "detected the beginnings of the burrows by a slight circular discoloration on the outer bark."

Thus the evidence indicates that after feeding for a few days, the beetles mate and the eggs are laid early in June in rough places on the bark of the birches, first on the upper branches and later on the trunk.

Work of the borer.—The beginning of the newly-hatched borer's burrowings in the bark in June have just been described in the preceding paragraph. And its later work as it industriously tunnels its way, zigzagging around and through the branches has been described on page 68. Beginning early in June, the borer must work almost incessantly to be able to dig such a tunnel in less than four months, or before October 1st.

Length of the life-cycle.—Although no one has followed this birch pest through its whole life, all the recorded evidence and all my observations indicate a yearly life-cycle.* I have just made a careful examination of much of the infested portion of a large white birch, and I found nothing but full-grown grubs or borers and exit holes of last year's generation. There were no indi-

* Most of the species of *Agrilus*, both European and American, whose life-history has been fully worked out, require two years to complete a life-cycle or generation. This is true of *Agrilus viridis* and *Agrilus sinuatus*, both European species, the latter now an American pest also. But our native *Agrilus bilineatus* and *Agrilus ruficollis* seem to have a yearly life-cycle.

cations of small or half-grown borers, as there would be if the insect required two seasons to develop.

NATURAL ENEMIES

Were it not for the ubiquitous English sparrow, doubtless the woodpeckers would help considerably in reducing the numbers of this bronze birch borer. The sparrows have largely driven the woodpeckers out of city parks and private grounds. During most of its life, or for about eleven months in a year, the borer is just under the bark where the birds could easily get at it. Adams observed one of the common woodpeckers, probably the hairy woodpecker, feeding quite extensively upon the grubs in Buffalo.

The pest does not escape from parasitic enemies. While examining some infested branches of birch in January, 1899, I found several borers that had been killed by parasitic grubs. The parasite had spun a tough, semi-transparent cocoon inside the skin of its host. Later the adult parasite was bred and it proved to be the interesting little creature shown much enlarged in

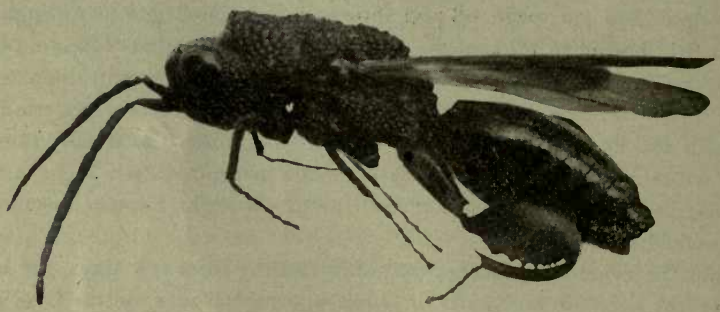

FIG. 38.—*Phasgonophora sulcata. The interesting little parasitic enemy of the bronze birch borer. Much enlarged.*

Fig. 38. It is a Chalcid fly known to science as *Phasgonophora sulcata* Westwood (Griffith's Animal Kingdom, Insects, Vol. II, p. 432). Note the wonderful development of the hind legs, the purpose of which is unknown. Chittenden also reared the same parasite from this borer and from the flat-headed apple-borer infesting a Japanese redbud tree. The parasites issued about two weeks after the beetles. Dr. Howard writes me that the parasite has been taken in Texas, California, Washington, D. C., Illinois, South Carolina, Canada, Florida and Oregon, thus showing a very wide distribution. Doubtless this interesting little enemy aids materially in holding this bronze birch borer in check. But in most localities it has not yet reached that point where it is numerous enough to cope with the pest to the extent that man need not employ artificial agencies to prevent the destruction of his beautiful white birches.

REMEDIAL SUGGESTIONS

This bronze birch borer is practically invulnerable against man's usual insecticides. Nearly all of its life is spent as a borer under the bark out of reach of insecticides. The fact that the beetles feed for a few days on tender leaves would suggest spraying the trees in May with a poison, but apparently they do not eat the birch foliage to any extent, preferring that of willow, poplar, or elm. Thus it is very doubtful if it would materially check the insect to spray the birches with a poison.

On account of the possibility that the beetles might be prevented from emerging or from laying their eggs, several applications to the bark have been suggested, such as a poisoned whitewash, a mixture of hydraulic cement and skim milk, covering the trunks with a paper wrapping, and a resin-oil wash. Adams treated about forty trees in Buffalo with a resin-oil wash (5 pounds resin dissolved and 1 gallon raw linseed oil poured in) with no satisfactory results. As the insect infests all parts of the tree, from branches half an inch in diameter to the trunk, it would be difficult to so cover the bark as to allow no place for egg-laying, or to put on such a coating as to prevent the exit of the beetles. I doubt the practicability and effectiveness of such methods against this birch borer.

Some have tried to save their trees by cutting out the top branches that were dead or dying, but in every case the trees finally succumbed. This pruning may sometimes delay the inevitable death of the tree for a year or more. *I doubt if a tree can be saved after it is once infested to the extent that the top branches are dying. Better sacrifice the whole tree at once and thus prevent the spread of the pest to neighboring trees.*

This brings me to the only practicable and effective method of dealing with this borer. That is the heroic one of cutting down and burning the infested tree, trunk and branches, before May 1st, thus destroying the whole crop or generation of borers in their hibernating quarters under the bark. As soon as the top branches are killed (as shown in the frontispiece and in Fig. 34), do not delay a moment, but cut and burn the tree, as its death is inevitable within a year or two.

But this is much more easily said than done, as any one can testify who has tried to persuade owners of private grounds or park authorities to apply the method in time. Sentiment and the forlorn hope that the tree may revive or last a few years more, often results in an infested tree remaining as a leafless eyesore on the landscape for a year or more after it is dead and all the beetles have been allowed to emerge and spread to other trees. It seems to be almost impossible in many cases to get individuals or city authorities to act promptly. Often after one succeeds in getting an infested tree cut down in time, it will not be burned promptly, but left where the beetles can readily emerge, so that practically nothing is accomplished in checking the pest.

A determined effort is now being made to save the remaining white

birches on the University Campus. This autumn all the infested trees showing dying tops are being removed and promptly burned. In cities and towns where this insect is killing the white birches, there should be enacted an ordinance compelling the authorities to promptly cut and burn in autumn, winter, and surely before May 1st, the infested trees in the parks, and if possible requiring owners of private grounds to do the same. The mere enactment of such an ordinance will not often accomplish the desired result. Public opinion must be behind such a measure to enforce it. Ithaca, Buffalo, Rochester and other New York State cities are now face to face with the problem of checking this pest or of losing their white birches. Civic Improvement Societies could render efficient aid in such work.

Briefly then, *there is no known way of preventing this bronze birch borer from attacking white birches, and the only practicable and effective method yet found for checking its ravages is to promptly cut and burn the infested trees in autumn, in winter, or before May 1st. There is no possibility of saving a tree when the top branches are dead, as shown in the frontispiece and in Fig. 34. Cut and burn such trees at once and thus prevent the spread of the insect.*

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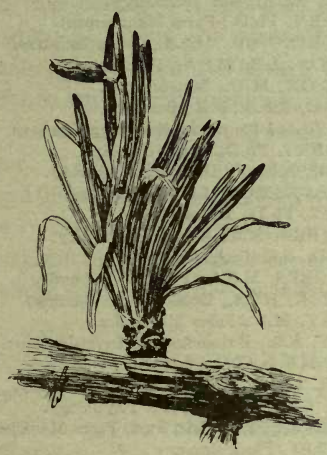
CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Entomology

THE LARCH CASE-BEARER



By GLENN W. HERRICK

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THE LARCH CASE-BEARER

(*Coleophora laricella* Hbn.)

Order, *Lepidoptera* Family, *Elachistidae*

GLENN W. HERRICK

Many of our favorite ornamental trees are subject to the attacks of various pests, which in some cases, notably on the elms, white birches, and hickories, prove very serious. In fact, there is scarcely a shade tree that has not one or more enemies with which to contend. The larch, which is widely used as an ornamental tree and is much admired for its soft, green, feathery foliage, has struggled for years with the larch saw-fly and with the larch case-bearer. Although these two pests were first discovered in this country at about the same time, yet the case-bearer has not attracted much attention until within the last ten years. For several seasons the larches used for ornamental purposes on the campus of Cornell University have been rather seriously injured by the small larvæ of this case-bearer. Opportunity has thus been offered to observe the habits, injuries, and life history of this interesting insect during the past two years. The writer was fortunate in finding an apparently satisfactory method of controlling this pest on trees used for ornamental purposes, but the method would not be practicable for trees in a forest.

HISTORY OF THE LARCH CASE-BEARER, AND INJURIES CAUSED BY THE INSECT

The larch case-bearer is a European insect and has been known in Europe for many years, it having been originally described in 1827 by the German worker, Hübner. In Europe, especially in Germany, it is a serious pest to the forest larches and the Germans have given it considerable attention. The insect found its way to England and Scotland when the larch was introduced into Great Britain. Later it reached America.

Doctor Hagen was the first person to definitely record the presence of the insect in this country. He found it on twigs sent to him from the private grounds of Henry Watson in Northampton, Mass., in 1886. It was found on specimens of the European larch (*Larix europea*) that had been planted along an avenue. These trees were thirty years old and had never been affected before, so far as had been noted. The pest had evidently not been introduced with the trees, but had come in later from

NOTE.—D. E. Fink, student assistant, gave valuable aid by his observations in the field during the summer of 1910.

some other source. J. G. Jack, writing in Garden and Forest in 1896, says that the insect had been known in the Arnold Arboretum at Cambridge, Mass., for many years. It is quite possible that this case-bearer reached America earlier than 1886. It has evidently spread slowly in this country.

In 1905 Dr. James Fletcher recorded the insect at Ottawa, Canada, where it was working on the European larches. He says that "the numbers of the larvæ upon the trees at Ottawa in May last were not large enough to have any serious effects upon either the growth or appearance of the trees; but I regret to find this autumn that the small cases of the larvæ are enormously more abundant than they were last spring."

Dr. C. Gordon Hewitt writes under date of March 29, 1912, that this species infests both the native tamarack and the European larch in eastern Canada, and that during the past two years it has been exceedingly abundant in certain localities, especially in the provinces of New Brunswick and Nova Scotia. He says, "The most serious depredations of this insect which I have witnessed were in Nova Scotia where considerable areas of tamarack had been attacked; the destruction and shrivelling up of the foliage gave the trees a characteristic light-brown color, quite distinct at a distance from the appearance produced by the defoliations by the larch sawfly, *Lygaeonematus erichsonii*."

Doctor Fletcher quotes an account of Rudolph Japing, Forest Assessor, Muenden, Hanover, Germany, concerning this pest, in which the latter says, "The injury to the trees from these insects can be very great, especially in the spring. The growth stops and the trees become feeble and are thus susceptible to canker, which often follows the damage done by the insect. The larch case-bearer is mostly found on trees from ten to forty years old."

Cecconi says that he has observed the invasion to begin generally at the topmost part of the trees and to extend gradually toward the base. Young trees and the most vigorous ones are preferred, while the old trees and those isolated are generally spared. He calls attention to the great numbers of the larvæ in the larch forests of Bellino, Italy, in 1904. He says that from nearly eight hundred grams of dry branches (that is, withered) sent to him in May and taken from the breeding cage about the end of August, he obtained more than six thousand moths.

The insect is also becoming a pest of considerable importance in the forests of the northeastern United States. Miss Patch observed the case-bearers over a period of two years in Maine. She found them rather widely distributed on larches in the forest, and committing serious injury. She says, "Although minute, they have been present in such enormous numbers that larch trees have often been, during the past three seasons,

eaten bare of green early in the spring. . . . Small larches in the vicinity of Bangor and Orono which have been subjected to an attack of at least three seasons died this summer from no other apparent cause than the presence of great numbers of the case-bearers which kept the needles eaten off. Many large larches infested by this insect look yellowish and unhealthy."

The case-bearer has been present on larches in the vicinity of Ithaca for several years and undoubtedly has done considerable injury. The small green leaves are devoured in early spring as fast as they push out, and on many trees the green tissues are eaten out and the leaves left pale and bleached in early spring (Figs. 14 and 15). Badly infested trees show the effects of the work of this insect and fail to make their normal growth. Many of the branches are killed outright.

The records of this department show that complaints of injury have been received from Franklin county, New York. The author has also found the case-bearer in abundance on larches in the Adirondacks in the vicinity of Cranberry Lake. The work of the insect was apparent on the trees, but was almost overshadowed by the much more serious injuries of the larch sawfly (*Lygaeonematus erichsonii*).

Doctor Felt records the case-bearer in the vicinity of Albany, N. Y., where he has seen it at work for several years on ornamental larches.

THE NAME

The larch case-bearer belongs to that large group of moths commonly known as the Tineids. These moths are all small and have narrow wings fringed with very long, slender scales. Although small, some of them are really very beautiful, surpassing many of our larger moths in brilliancy and richness of coloring. Since this species of insect infests only the larch, and since the larva always lives in a case, it has very properly been given the name "larch case-bearer." Its scientific name, *Coleophora laricella*, is also very appropriate. The word "*Coleophora*" means bearing a sheath, and the word "laricella" refers to the larch — the ending "ella" meaning small. Hence, we have a small case-bearer living on the larch.

The following is the history of its scientific names: In 1827 Hübner, a German worker, named the insect *Tinea laricella* and figured the moth and the larva. Seven years later, Treitschke, another German entomologist, put the insect in his genus *Ornix*, and added the termination *pennella* to the specific name *argyro* because he thought all species belonging to this genus should end with *pennella*. Four years after, Duponchel put the insect in the genus *Gracillaria*, and in 1839 Zeller placed it in the genus *Coleophora* and retained Hübner's specific name *laricella*. Under the last name it still remains.

Synonymy of Coleophora laricella

1827 *Tinea laricella* Hbn., Samm. Europ. Schmett., V, fig. 427.
1834 *Ornix argyropennella* Treit., Schmetterl. Europa, X, part III, p. 221.
1838 *Gracillaria laricella* Du., Histoire Naturelle des Lepidopteres, etc., XI, p. 586, pl. 311, fig. 3.
1839 *Coleophora laricella* Zell., Isis, p. 208.
1840 *Tinea laricella* Ratz., Forst-Insecten, part II, p. 244

DISTRIBUTION AND FOOD PLANTS

The larch case-bearer is a European insect and is rather widely distributed over Europe, being especially abundant and injurious in Germany. It has been reported as injurious in Italy, France, Switzerland, and Finland. It very probably exists in other countries on the Continent. It is also widely distributed in Great Britain, probably having been introduced on the European larch, the larch not being indigenous to the British Isles.

As has been stated, the case-bearer probably reached this country by being introduced on the European larch. It is now certainly widely distributed in the northeastern United States—New York and New England. Doctor Felt records it as present on larches in the vicinity of Albany, N. Y., and Doctor Fletcher recorded it in the vicinity of Ottawa, Canada, in 1905.

The food plants of the insect evidently consist of the European and American larches. The latter tree is known in the United States as the tamarack, or hackmatack, and sometimes, although erroneously, the juniper.

It is said that the Japanese larches are not attacked by this case-bearer. Cecconi records it as attacking the *Larix leptolepis* in Italy.

LIFE HISTORY

The larch case-bearer has an interesting life history and most interesting habits. It passes a very protected life, for while young it lives in burrows within the larch leaves and later it fashions a case in which it ensconces itself and which it never leaves as a larva. Undoubtedly this case serves to protect the tiny larva from extreme weather conditions, if not from insect enemies.

Hibernation

By a strange instinct the larvæ migrate in the autumn from the deciduous leaves of the larch upon which they have been feeding, and securely fasten themselves in their tiny cases to the branches. Here instinct tells them they will be safe from falling to the ground and will be accessible to their food supply in the early spring.

When the larvæ enter hibernation in the fall they are very small and only about one fourth to one third grown. Their cases at this time are long and slender, for each case is merely a piece of a mined leaf from the larch. The cases are nearly cylindrical, for, although the leaves of the larch are flat, the body of the larva evidently fills out the hollow leaf and makes it cylindrical. The outer, or free, end of the case is usually slightly contracted and fully closed with a sheet of silk. The other end of the case is securely attached to the branch with a copious supply of silk. Some of the cases lie flat along the branch, while others project at various angles as shown in Figs. 5 and 12. Very often the cases occur in

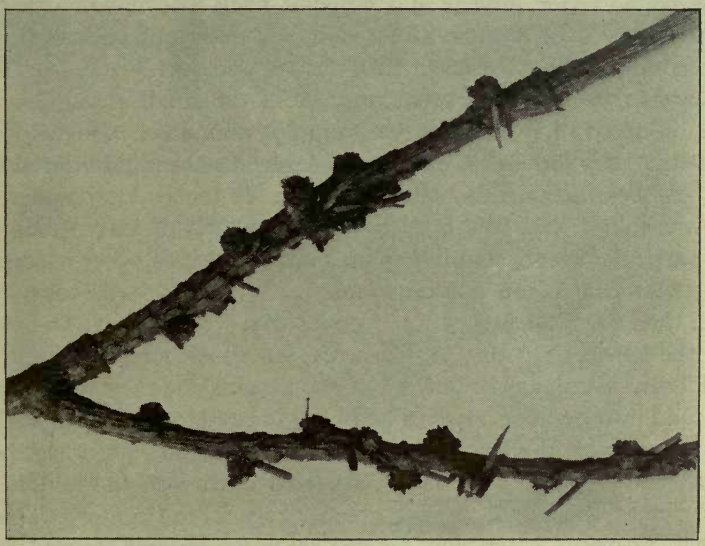

FIG. 5.—*Hibernating case-bearers, natural size*

bunches of four or five clustered in the axil of a bud. The winter cases vary considerably in length, measuring all the way from one eighth to one sixth of an inch.

In the fall of 1910 the majority of the larvæ did not migrate from the leaves to the branches until the latter part of October. On October 24 most of them were still actively feeding on the leaves, but a few had moved down to the branches. By October 31 the great majority had established themselves in their winter quarters. Here they remained until the following April, nearly six months, in a perfectly quiescent condition.

The case-bearers in spring

As soon as the buds of the larch begin to put out in the spring, the case-bearers wake from their long winter's sleep and migrate to the buds (Fig. 11).

In the spring of 1910 the larvæ had begun migrating to the buds by April 15, but in 1911 they were about ten days later owing to the retarded opening of the buds. Before leaving its place on the branch the larva sheds its skin. The cast skins, with the dark-colored skeletons of the head, can be found among the tangled silk on the twigs where the case-bearers were fastened during the winter.

The young larva attacks a leaf in an interesting manner. It eats a tiny hole through the epidermis of the leaf and mines out the inside tissues of the leaf as far on each side of the entrance opening as it can reach. During this time it does not let go its hold of the case, but remains attached to it by its posterior prolegs and wriggles back into it when disturbed. Attacked leaves soon assume a bleached, whitened appearance (Fig. 10), and when deserted by the larva they shrivel and curl.

One larva must attack a great number of the small young leaves, for in cases observed in 1910 the larvæ were not abundant enough to do the damage that they did unless each case-bearer attacked and injured several leaves. As bearing on this point, a branch six inches long was selected and it was found that this branch bore 24 whorls of leaves; one whorl, at this particular stage, containing 54 small leaves and other nascent ones in the center that could not be counted. If 54 leaves be taken as the average, then the branch bore 1,296 leaves that were of a size to be attractive to the larvæ. On this branch were ten case-bearers. These larvæ had evidently begun at the bottom of the branch, for they were now near the tip, and every leaf of any size had been injured except those in the last whorl. Moreover, the larvæ had injured the outside leaves first because these were largest, and now they were going down into the middle of the buds to get at the small growing green leaves in the center. These ten larvæ had probably eaten and injured over a thousand leaves.

About the first thing that a case-bearer does after it reaches the fresh buds in the spring is to enlarge its old winter case. This it does by slitting the case lengthwise on the underside and then inserting a gore of silk. The buds are not far enough out at this time so that the larva can obtain leaves for enlarging its case. In the spring of 1912 the case-bearers first began migrating to the buds on April 21, a warm, sunny day. They lived on the growing buds for nearly ten days before they were able to find leaves long enough to cut off and fasten to their cases over the slit already made and filled with silk. In addition to this enlargement in diameter of the case, it is also now increased in length by the addition of silk to the anterior end. The new leaf is usually cut longer than the old case, so that on the underside of the case the leaf extends the whole length (Fig. 9). At this period in the life of the larva it destroys many leaves, for it passes from one to another as has been already pointed out. Cecconi

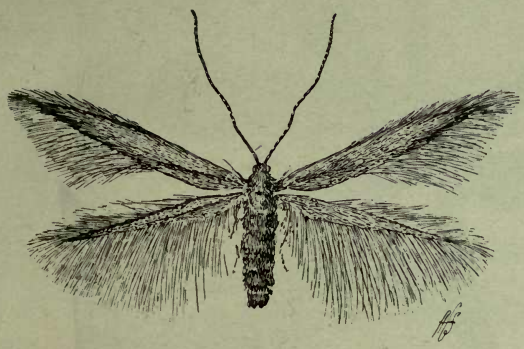

FIG. 6.—*The female moth, much enlarged*

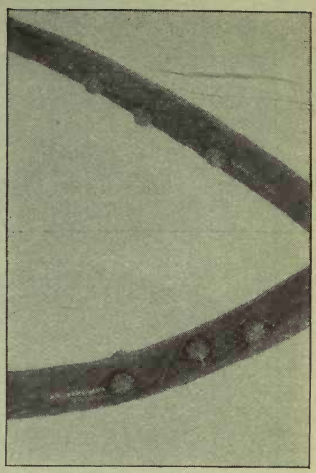

FIG. 7.—*Eggs on larch leaves, enlarged*

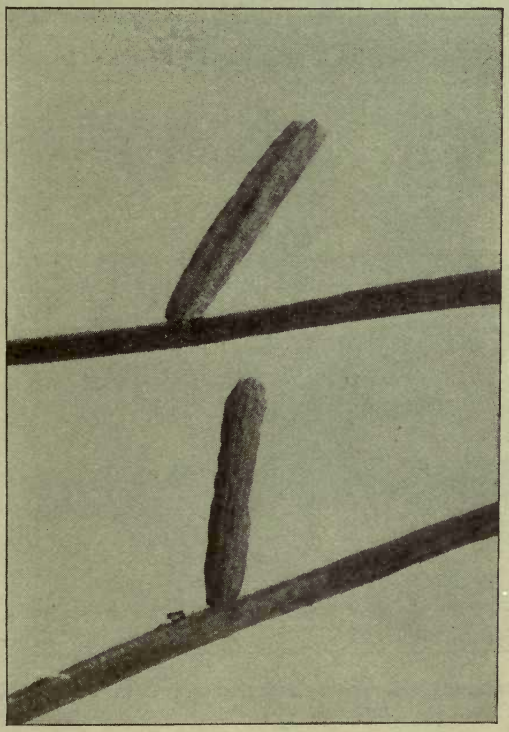

FIG. 8.—*Young larvæ in cases just formed in autumn. Enlarged*

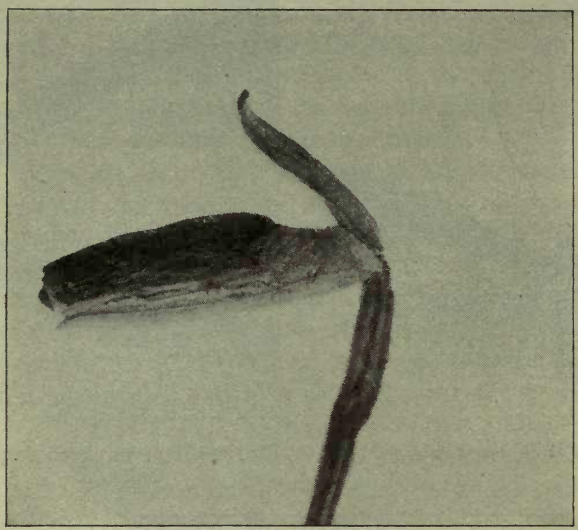

FIG. 9.—*Full-grown larva in case, much enlarged*

FIG. 10.—*Work of larva on leaf*

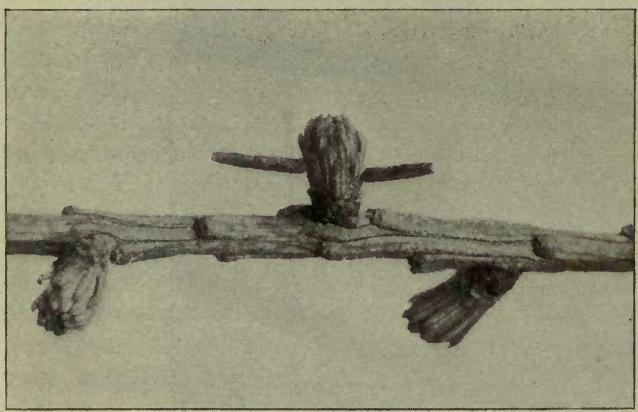

FIG. 11.—*Over-wintering larvæ getting their first meal in the spring. Enlarged*

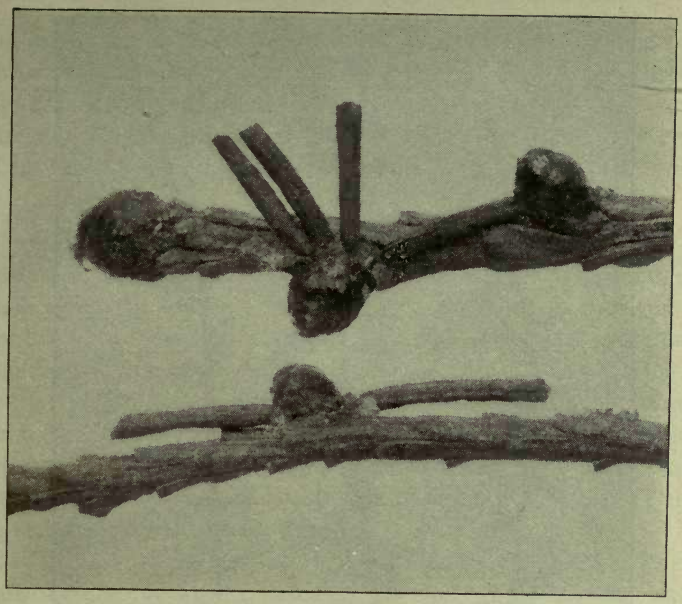

FIG. 12.—*Hibernating case-bearers on branches in winter. Enlarged*

FIG. 13.—*Full-grown larvæ in position for pupation. Enlarged*

FIG. 14.—*Badly injured branches at right and left, with normal branch between*

FIG. 15.—*Badly injured buds at left, normal buds at right*

says that when the larvæ have consumed all the needles on one branchlet they lower themselves down to others by means of a silken thread. He also noted that they devoured the flowers of the larch.

Apparently the larva lives in this enlarged case during the remaining time of its growth and pupates within it.

The larva

The larva is dark reddish brown and, when full-grown, about one fifth of an inch in length ($4\frac{1}{2}$ to 5 mm.). The head is black, and the thoracic shield is black but divided along the middle. The last segment of the abdomen bears a black plate on the dorsal side. The anterior pairs of prolegs are small and each one is furnished with a circle of minute hooks; while each of the posterior prolegs bears a half circle of strong hooks pointing forward, by which the larva clings most tenaciously to its case. The end of the caudal segment of the abdomen is beset with strong chitinized setæ pointing straight caudad.

The favorite locations for the larvæ to attach themselves when ready to pupate seem to be at the bases of the short side branches and in the center of the leaf whorls. In Fig. 13 is shown a cluster of four pupæ at the base of a short side branch. The pupal stage lasts fourteen to twenty days. The pupa is small and brownish black, with no characteristic markings.

The moth

The moths were appearing by May 24 in 1911 and were abundant from that time on. The moth is small, silvery grayish brown in color, with no conspicuous markings. Both pairs of wings are narrow, especially the hind wings, and fringed with long, slender scales (Fig. 6). The wings expand about one third of an inch. The moths are active during the daytime and when at rest they alight on the stems or leaves, with the wings closely folded along the body and the antennæ projecting straight forward.

Within a few days the moths pair, and in a week to ten days from emergence begin laying their eggs.

The egg

The eggs are small, but plainly visible to the unaided eye, and in shape they resemble an inverted teacup. Each egg is conspicuously marked with twelve to fourteen ridges radiating down the sides from the apex. The eggs are conspicuous objects on the green leaves of the larch, being cinnamon-rufous in color and standing out clearly in contrast to the green. They seem to be laid indiscriminately on the upper and under sides of

the leaves (Fig. 7). The great majority of the eggs, in the vicinity of Ithaca, are deposited during the first part of June. In 1910 an abundance of eggs was found in the field on June 10. The time will vary somewhat, however, in different years.

The summer habits of the larva

When the larva hatches from the egg it bores directly through the floor, or bottom side, of the eggshell, and thence through the epidermis of the leaf into the inside. Mr. Fink demonstrated this habit of the larva very clearly, for he found specimens in the act of entering the leaf in this manner. Mr. Fink and the writer were puzzled by not finding any openings in the leaves through which the larvæ had entered, until they found individuals entering directly from the egg. The larva, being exceedingly small, mines very slowly at first; but after a few weeks the light-colored mine, with the dark body of the miner showing through, is seen. The light-colored eggshell clings to the leaf for many days, but if it is tipped over one may find the opening through the epidermis to the mine.

The larvæ live within the leaves of the larch, gradually enlarging their mines until September. The leaves as they are mined appear russeted. As the tiny miner grows and enlarges its burrow, it packs the empty part of the mine with excrement. During 1910 the miners began to emerge from their burrows in the larch leaves and to make their winter cases during the first half of September. Sometimes these cases were made of the old leaves in which the larvæ had lived all summer, but often they were made of newly mined leaves. When the larva gets ready to form its winter case it cuts off the end of the leaf in which it has lived all summer. The larva then cleans out the burrow, goes to the lower end of the mine next to the base of the leaf, and cuts off enough of the mined leaf to make its case. The mine of the larva is large enough to allow its occupant to turn around with ease and whenever occasion demands. The larva is very neat in its habits, for it backs up from time to time in its work, protrudes the posterior end of the body, and ejects the excrement outside. Occasionally one finds a case still bearing the eggshell of an egg laid nearly three months previously. The inside of the case is lined with a very thin, delicate layer of silk.

Some of the larvæ, as already noted, make cases out of new leaves. After the middle of September one often finds naked larvæ wandering over the leaves of the larch. These are the ones that have left their old mines and have gone in search of new leaves to excavate for their winter cases. When a suitable leaf is found the larva mines it out and makes the case in the same way as described above.

After making their winter cases the larvæ feed for three or four weeks before entering hibernation. They migrate from the leaves in normal seasons during the latter part of October.

The larvæ during this period of their lives may attack more than one leaf. One would infer from Ratzeburg that as soon as the larva emerges in September from its summer mine it builds its winter case and goes into hibernation without more injury. Cecconi points out that in Italy the larva feeds on the leaves before going into hibernation, and may mine quite thoroughly more than one leaf after having made its winter case. There is undoubtedly considerable injury done by the larvæ at this period of their lives. The leaves of the larch are, however, so large and so abundant that this injury does not become conspicuous as a usual thing.

Number of broods

As the life history just detailed indicates, there is but one brood in a year. This is similar to the life history of the cigar case-bearer and of the pistol case-bearer on apples.

NATURAL ENEMIES

The larch case-bearer is subject to the attacks of a number of parasites, especially in Europe. Two or three parasites have been bred at this station, but not in large numbers. As yet, not enough material has been obtained for determination. J. C. Crawford very kindly examined the few that were obtained here, but could place them only provisionally until he had more specimens for examination. He says, " One is a species of *Pteromalidae*, apparently belonging to the tribe *Pteromalini*; the second is a species of the genus *Pachyneuron*; the third is a *Tetrastichine* and probably of the genus *Tetrastichus*."

The following parasites are recorded as having been bred from this insect in Europe; *Bracon guttiger* Wesm., *Microdus pumilus* Ratz., *Campoplex nanus* Gr., *Anaphes*(?), *Entedon arcuatus* Frst., *Entedon laricinellae* Ratz., *Pteromalus laricinellae* Ratz., *Campoplex tumidulus* Gr., and *Campoplex virginalis* Gr.

METHODS OF CONTROL

No practicable method of control is known for this case-bearer on forest trees over large areas. It can be controlled, however, on trees used for ornamental purposes. An account is given below of experiments at this station with arsenate of lead and the lime-sulfur solution. The concentrated lime-sulfur solution, diluted at winter strengths, proved very effective in killing the case-bearers while in hibernation.

Arsenate of lead

From success obtained with arsenate of lead in controlling the closely allied cigar case-bearer and pistol case-bearer on apples, it has been suggested that the larch case-bearer could be controlled by the same method. It must be remembered, however, that the pistol case-bearer, at least, eats much larger quantities of the foliage. That is, it is not so exclusively a miner as is the larch case-bearer. Moreover, the cigar case-bearer, in its mining and making of new cases, seems to devour more actual leaf surface and thus, presumably, obtain more poison than would be the case with the larch case-bearer. In order to test this method, however, five larch trees well infested with the case-bearers were sprayed with arsenate of lead at the rate of 2½ pounds to 50 gallons of water. These trees were thoroughly sprayed on April 25. The buds were just starting to grow well and the case-bearers were just coming on them from their winter quarters.

The trees were examined from time to time, but no appreciable diminution in the numbers of case-bearers could be noted.

On May 5 the trees, with one exception, were carefully and thoroughly sprayed again. At this time the leaves were of fair size and the case-bearers were abundant.

The trees were observed throughout the season, but no difference in the amount of injury could be seen between these and many others untreated.

In looking over the trees shortly after they were sprayed, the poison was found to be invariably gathered in small globules at the bases of the leaves. The leaves of the larch are small, narrow, and glossy. The poison does not seem to stick to the narrow needles and consequently does not become well distributed over the surface of the leaves. It is possible that a small quantity of soap added to the mixture would enable the poison to spread and stick better.

Laboratory experiments with arsenate of lead gave very inconclusive results.

In the light of experiments at this station, the writer would not feel justified in recommending the use of arsenate of lead for control of the larch case-bearer.

Lime-sulfur

From experience gained in controlling the bud moth on pecans and the ribbed cocoon-maker on apples by spraying the trees in the dormant season with lime-sulfur, thus killing the hibernating larvæ and pupæ, it seemed possible to do the same with the larch case-bearer. Accordingly, on April 7, 1911, before the buds had begun to swell and before the larvæ had left their winter positions, a badly infested tree was sprayed

with lime-sulfur at scale strengths. The lime-sulfur was the homemade concentrated, and tested 29° Beaumé. It was diluted 1 to 7 and the tree thoroughly coated from top to bottom. The next day there was a heavy fall of snow. The subsequent three or four days were clear and sunny.

On April 27 an examination of the trees showed that the buds had started and that on the unsprayed trees the larvæ had moved to the leaves. On the sprayed tree, however, not a larva had left its winter position. On May 5 the writer examined many larvæ and found only two alive. The others were dried up and dead. In subsequent examinations the writer was unable to find that a single larva had moved from its hibernating position to the leaves.

Lime-sulfur is evidently a simple and effective remedy for the larch case-bearer. Probably the best results will be obtained by applying the mixture to the trees just as late as possible in the spring before the buds start growing. There is evidently no injury to buds or tender wood at this time if the mixture is used at scale strengths, say 1 gallon to 8¼ gallons of water when the concentrated solution tests 33° Beaumé. The mixture should be applied thoroughly to all the branches, and the tree should be completely covered with the solution.

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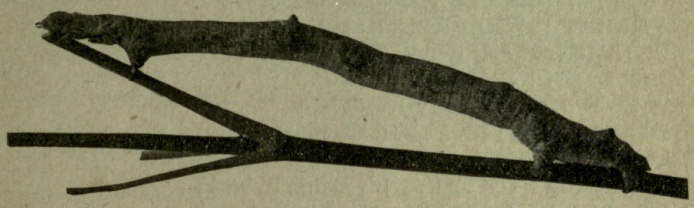
Department of Entomology (Extension Work)

THE SNOW-WHITE LINDEN MOTH



By GLENN W. HERRICK

ITHACA, N. Y.
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THE SNOW-WHITE LINDEN MOTH

Ennomos subsignarius Hübn.

Order, Lepidoptera; superfamily, Geometrina

A half century ago the snow-white linden moth was a conspicuous insect in some of our Eastern cities and its caterpillars were very abundant and exceedingly injurious to shade-trees. From 1857 to 1870 the shade-trees of Brooklyn, N. Y., and Philadelphia, Pa., were annually subjected to defoliation by this insect. To check its increase, the English sparrow was introduced from Europe, and so well did this bird do its work that for nearly a half century we have heard almost nothing about this insect as a shade-tree pest. During this time there has been an occasional reference to it as a forest-tree despoiler, but it was not until 1907 that it again appeared as a serious pest, in New York State at least. During that year it seriously injured forests in the Catskills and the Adirondacks. In 1908 and 1909 it was again very abundant and seriously injurious, and now in 1910 it promises to be as prevalent as ever. During the last two years, in rearing large numbers of the moths the writer has been able to find but one single specimen of a parasite. It may be that the absence of parasites is the main reason for the great abundance of this insect. At any rate, we must conclude that the environments, climatic conditions, and other factors have been especially favorable for this insect during the past four or five years. Just how long it will continue in its present abundance, how widely it will spread, and whether it will eventually become a pest to our fruit-trees and ornamental plants, are questions the answers to which we shall await with much interest and considerable anxiety.

THE NAME

This insect has masqueraded under several names during its career with the scientists. It was first named in 1806 by Hübner, who called it *Eudalimia subsignaria*. About a half century afterward, T. W. Harris, in a paper in Hovey's Magazine of Horticulture, says, "This species not having been scientifically described or named before may be called *Geometra niveosericearia*, the snow-white silky Geometer." In 1857, Guenee placed it in the genus *Ennomos*. Four years later, Mr. J. B. Jones, in a communication to the Entomological Society of Philadelphia, referred to it as *Geometra niveosericearia*, and also gave it

the common name of "measure-worm," although it had no more claim to this particular appellation than many other caterpillars of the same family. Packard, in a discussion of the insect in 1869, gave it Guenee's old name again, *Ennomos subsignaria*, but in a subsequent and more extended discussion in 1876 changed it to an entirely new genus, *Eugonia subsignaria*. Finally, in 1891, Dr. J. B. Smith, in his "List of Lepidoptera of Boreal America," listed it under the name, *Ennomos subsignarius*, and under this it has since remained.

Dr. Lintner, in 1882, first proposed the common name of snow-white linden moth because of its snow-white color and its chief depredations, as he then supposed, on the linden tree. It was soon found however, that it attacked other trees quite as seriously and extensively as the linden, but since the name was as appropriate as any, it has clung to the insect to the present day.

HISTORY OF THE SNOW-WHITE LINDEN MOTH

Early history.—The snow-white linden moth was first described in 1806 and has been known to science ever since; but it was not until about 1860 that it began to attract attention in this country as a serious pest. In 1855, T. W. Harris discusses the abundance of the larvae in the city of Brooklyn and says that a correspondent writes that the "worms" were first seen in the city "ten years ago," since which time they have appeared at the regular season every year. In 1861, Dr. J. B. Jones wrote a report on the measure worms which infest the trees of Brooklyn, with suggestions for treatment. In the same year, the citizens of Brooklyn became so excited over the increase of this measuring worm that the Common Council seriously discussed a resolution compelling the destruction of all linden trees on the streets of the city. In a subsequent examination, however, the caterpillars were found on so many other varieties of shade-trees that it was seen that no permanent good could be accomplished by the destruction of the linden trees and the resolution was laid on the table indefinitely. In 1881, Mr. Grote wrote that, when he lived in Brooklyn in 1857, this measuring worm was so abundant "that the horse-chestnuts, elms, and maples, the latter especially, became completely defoliated, and the brown measuring worms used to hang down and cover the sidewalks ultimately to the great discomfort of the passers by." It is said that this condition continued until the introduction of the English sparrow, which is considered to have destroyed the caterpillars and held the pest in check.

In 1880 the pest was discovered in Georgia. Professor Comstock reported the caterpillars as destroying forests of hickory and chestnut

and doing much damage to fruit-trees. Since that time we have heard mention of the insect only now and then until within the last three years.

Later history.—On July 6th, 1909, we received from a correspondent at Cooks Falls, N. Y., the following letter concerning this pest: "Last year there appeared in this community a worm somewhat similar to the common apple tree worm and known locally as the 'beech' worm from its habit of eating the leaves of the beech tree. We thought it would die out over winter, but have been disappointed in this hope. It is again eating the foliage of the same trees it stripped last year and is threatening large tracts of very valuable timber land. While it appears to prefer the beech leaves it quite often attacks maple, birch, etc. As our interests in timber land are considerable, we write to enlist your aid in determining what species of worm this is, and how its ravages can be stopped." In response to this appeal, the writer made a personal inspection of the infested area and found a fine forest of beech, maple, and other wood, over five hundred acres in extent, literally stripped of leaves by the larvae of this moth. The owner said that they were so numerous that the dropping of the excrement sounded like rain pattering on the leaves. The undergrowth was almost as bare as it would be in winter. The young beeches had suffered more severely than any other trees and most of them were entirely bare of leaves. Hundreds of empty pupal cases, partly rolled-up in eaten leaves, were hanging to the trees. The caterpillars had covered a certain area on the top of this particular mountain and part way down one side. The line limiting their injuries was clear and evident to the eye long before we reached the actual area. For two successive years this forest had been denuded and the larvae were just as abundant this year (1910) as ever.

On July 9, 1909, a correspondent at Arena, N. Y., about twenty miles from Cooks Falls, wrote that the caterpillars "are working mostly on beech, ash, birch, and maple. In fact, nothing comes amiss to them. In driving through the town of Hardenburgh, Ulster Co., I noticed the trees were literally stripped of their foliage and a fence running in the woods was so loaded with them (caterpillars) you could not see the rails. They hang by webs on the trees, and looking through the forest appears like looking through smoke or a fog." This same correspondent wrote on May 16th, 1910, nearly a year later, that the trees were again "literally covered with the very small caterpillars and that if nothing can be done to check them the Catskills are doomed." The pest is evidently widely distributed, for there are reports of its injuries in Ulster Co., Sullivan Co., and also in the forests of the Adirondacks.

In his report for 1908, Dr. Felt says that the Forester, E. S. Woodruff, reports the beeches on a tract of over two square miles as completely defoliated. The caterpillars seem to attack the beeches first, but finally spread to the birches and maples. (Fig. 54).

One of the most remarkable phases of this pest were the flights of great swarms of the snow-white moths in cities and towns throughout the eastern part of the State and in New Jersey. In New York City the effect was compared to a snowstorm in mid-summer. Myriads of the moths fluttered about the electric lights. Dr. John B. Smith

FIG. 54.—*Caterpillars of the snow-white linden moth on maple*

says that on the evening of July 17th, Newark, Elizabeth, and Paterson, N. J., had the same experience. On the morning after the flight, however, nothing remained except great numbers of snow-white wings without bodies, showing the work of the English sparrow, and probably of other birds and destroyers. These flights are remarkable since the presence of the caterpillars had not previously been noticed in these towns and cities. It seems probable that the moths must have flown long distances from the feeding places of the caterpillars in the forests. During the latter part of July, 1909, Ithaca and several other cities

in the central part of the State experienced similar flights of myriads of the spruce bud moths. These moths could not have bred in such numbers on ornamental spruces in the near vicinity of the towns invaded but must have come from some forested areas, perhaps at long distances from the towns invaded. Thus we have an undoubted second instance of a moth which has certainly flown long distances from the feeding places of its larvae.

THE DANGER AS A FRUIT PEST

The first reference to this insect as a fruit pest that the writer finds is by Thomas in his Second Illinois Report, in which he says that he twice found the larvae on apple trees, though not in large numbers, and had reared them to the perfect insect on the leaves of this tree. In 1880, Comstock, quoting a correspondent, says that the larvae were damaging fruit-trees in Georgia. In 1882, Dodge, in the Canadian Entomologist, quoting from the same correspondent in Georgia, writes that the "apple trees in June last were as destitute of leaves as in midwinter, the fruit growing to the size of marbles and falling off."

In 1904, Garman writes of this insect as an important pest of the apple tree in Muhlenberg Co., Kentucky. It was especially injurious in 1903 but not so serious in 1904, due probably to the work of parasites. Again, in 1908, Garman treats of this pest as a serious one on apple trees and says that this species "is sometimes very common locally and may defoliate whole orchards at times." In his 23rd Report, Felt says very significantly, "It would not be surprising if a number of outbreaks, hitherto attributed to our more common canker worms, were in reality the work of this species."

It is quite evident that we have in this insect a possible future fruit-tree pest of considerable importance. It apparently used to be confined to the shade-trees of our cities but it has now almost entirely deserted these for our forest-trees. It would not be at all surprising in view of the history of this insect if the future should see it migrating from the forest-trees to our fruit-trees and becoming a serious pest.

DISTRIBUTION

Evidently this insect is widely distributed over the Middle and Eastern United States, and it occurs in Canada. It has been recorded from Nova Scotia to Georgia and westward through Michigan, Kentucky, Iowa and Colorado. In New York State, the moths have been reported from Delaware, Ulster, Sullivan, Rensselaer, Albany, Columbia, Saratoga, Schenectady, Herkimer, Fulton and Oneida Counties, and from the northeastern part of the State in the Adirondacks.

FOOD PLANTS

The larvae infest a great variety of forest-trees, apparently somewhat preferring beech and maple. They have been found on elm, linden, chestnut, hickory, ash, apple, birch, and others.

THE LIFE HISTORY AND HABITS OF THE INSECT

This insect requires nearly a year to pass through its life history. It is said that in Georgia the eggs were laid on the leaves as though there might be a second brood or generation in a season. It would seem from a study of the insect in New York that this must have been due to the carelessness of the female moths and can hardly be taken as an evidence of a second brood. At any rate, there is only one brood in New York State each year; and this is fortunate. If this pest could pass through its life history and produce a generation every two or three months, our forests would surely be doomed to destruction.

The eggs of the female moth are laid on the under sides of the branches —as often on the upper branches of the smaller trees, at least, as on the lower. In a rather hasty search, the writer found the eggs laid on the beech only. However, a correspondent at Arena, N. Y., has sent many eggs deposited on maple. The eggs are always deposited at an oblique angle to the surface of the bark and lean against each other like a pile of leaning bricks. They are laid in masses of 20 to 100 or even more, and are stuck so securely to the branch that in 1909 the writer found still adhering to the trees the empty shells of quite as many old egg masses of 1908 as there were new ones of 1909. The eggs are deposited on the branches in the latter part of June and first part of July, and remain unaffected by snow, rain, or extremes of temperature until the following April and May, nearly a year after deposition.

The eggs are about one twenty-fifth of an inch in length, barrel shaped, often more or less flattened on the sides, light olive when first deposited but later becoming darker in color, with a conspicuous ring at the free extremity. They occur in irregular masses, long and narrow if the branch is small but spread out if the surface is large (Fig. 55).

Eggs brought from Cooks Falls in August, 1909, were placed outdoors under natural conditions and began to hatch May 2nd, 1910. Eggs sent from Cooks Falls on May 11th, 1910, had not hatched, and the writer found that the caterpillars on the mountain at Cooks Falls had appeared two to three weeks later than at Ithaca or at Arena, N. Y., the difference probably being due to the higher altitude and lower temperature. Eggs at Arena, N. Y., brought into the house in

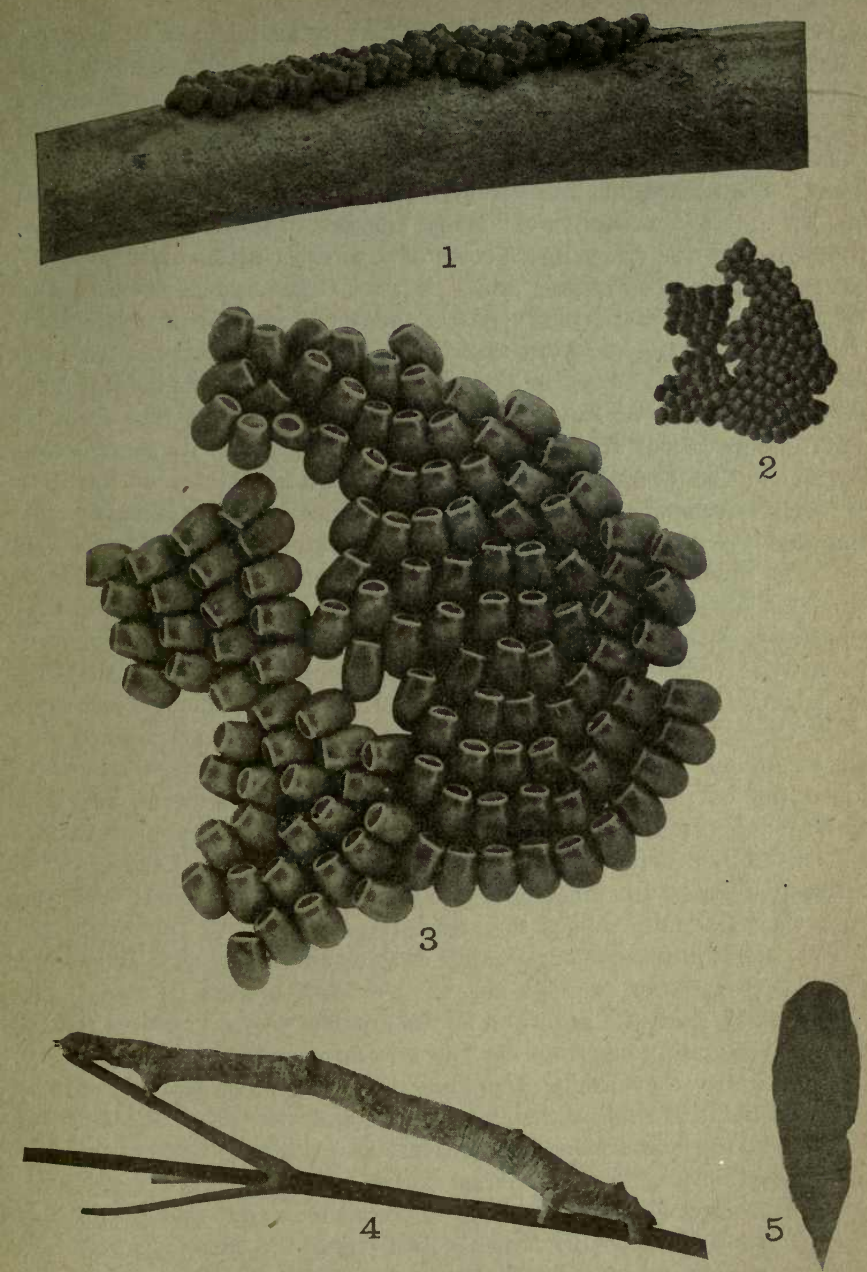

FIG. 55.— *The snow-white linden moth: 1, egg mass, side view; 2, eggs enlarged; 3, eggs much enlarged; 4, larva enlarged; 5, pupa enlarged*

February, moistened and placed by the stove, hatched and the caterpillars, which were fed on leaves of Abutilon, apparently throve finely but were not reared to maturity. Other eggs from Arena placed outdoors under natural conditions hatched at Ithaca as early as April 23rd.

The number of eggs that may be deposited on a single tree is very great. The number in six average clusters ran as follows: 93, 21, 44, 40, 89, and 67, respectively. Many clusters contain more eggs than the highest of the foregoing. Scores of such egg clusters exist on many of the trees in the infested area. Messrs. Graef and Weibe say that they removed at least 60,000 eggs from one small maple tree in Brooklyn.

It is probably right to say that the eggs of this moth begin to hatch in the latter half of April, and in high altitudes probably not much before the middle of May. When a caterpillar first emerges from the egg it is only about one-tenth of an inch in length and its general color is green. The head, last abdominal segment, and sides of the body are light green while the back is a darker green. In general, when the larva is viewed from above, the two ends of the body appear light green in color with the part between a darker olive green.

The young larvae begin at once to eat the green tender leaves. On May 3d, the writer placed six caterpillars, just out of the egg, on fresh tender maple leaves, each caterpillar on a leaf by itself, to watch its habits of eating. By the morning of May 5th each one had eaten holes through its leaf, varying from pinholes up to good sized shot holes. In one leaf eighteen such holes had been eaten, which shows something of the voracity of the tiny larvae. Observers who have had the opportunity to watch these larvae in the forest say that at first they climb to the top of the tree and to the ends of the branches where the leaves are presumably younger and more tender. As they grow they gradually ravage the entire tree.

The caterpillars vary considerably in color and markings. In general, after the first molt they become dark reddish brown, in many cases almost black, with the head and last abdominal segment red or reddish brown and quite conspicuous. The larvae resemble the twigs of the tree on which they are feeding, and like other "measuring worms" have the habit of holding themselves erect and motionless like a broken twig. The six larvae reared on separate maple leaves and receiving an abundance of food were without exception of a beautiful pale rose color with three distinct tubercles on the abdomen, as shown in Figs. 54, 55. Many of the caterpillars received from the infested forest trees were of a light green color throughout and in marked contrast with the darker ones. Full grown caterpillars that have had all the food

they want become a little over two inches in length, but when they are crowded and the food supply limited they are often less than two inches long. During their growth the larvae molt five times or even six times. Graef and Weibe record only three molts.

The caterpillars of this moth have the three pairs of true legs attached to the thorax, but only the last two pairs of abdominal legs are present, thus leaving the middle of the body unsupported. Hence, instead of walking like many other caterpillars do, they move with a looping gait and have been called "looping" caterpillars or "measuring worms." Moreover, they have the habit of spinning a silken thread and letting themselves down by it from the branches when the tree is suddenly struck or jarred. Frequently they drop half way down to the ground and remain quietly suspended in the air for a few moments, after which they ascend to the branches above. It is said that during their great abundance on the shade-trees in Brooklyn in the sixties much annoyance was caused by this habit of dangling in the faces of pedestrians. The following remarks of a committee from the Brooklyn Horticultural Society anent this phase of the insect are interesting: "It would seem to be entirely unnecessary for the committee to urge upon those who have been constrained to traverse our streets in the latter part of June and the early part of July, the great importance—they might almost say the necessity—of devising and accomplishing *some* plan for removing the worms which dangle before their faces, are dropped upon their clothing, or are crushed by their feet at every step. Certainly no gentleman, no lady, can need to be convinced that carrying these worms from house to house, brushing them out of the face and hair, or stopping at the corners to pick them off with the fingers—at the risk of crushing them in the experiment—is not a part of the privilege which one looks for in becoming a resident of a city like this."

Six caterpillars that emerged from eggs May 3rd began spinning their cocoons May 30, July 1, 2, 3, 6 and 7, respectively, and changed to pupae about three days after commencing the cocoons. It should be understood that these larvae were under exceptionally favorable surroundings so far as food was concerned. The cocoons are very flimsy affairs and usually are made by turning over the edge of a ragged leaf and lining the inside with a thin net-like layer of silk (Fig. 56). Graef and Weibe say that the insects pupate on the trunks and branches of trees, on fences, railings, lamp-posts, or almost anything they can reach.

The pupa is about five-eighths of an inch long, sometimes more, sometimes less. It is blunt and rounded at the anterior end but strongly pointed at the posterior extremity and terminates with about six small,

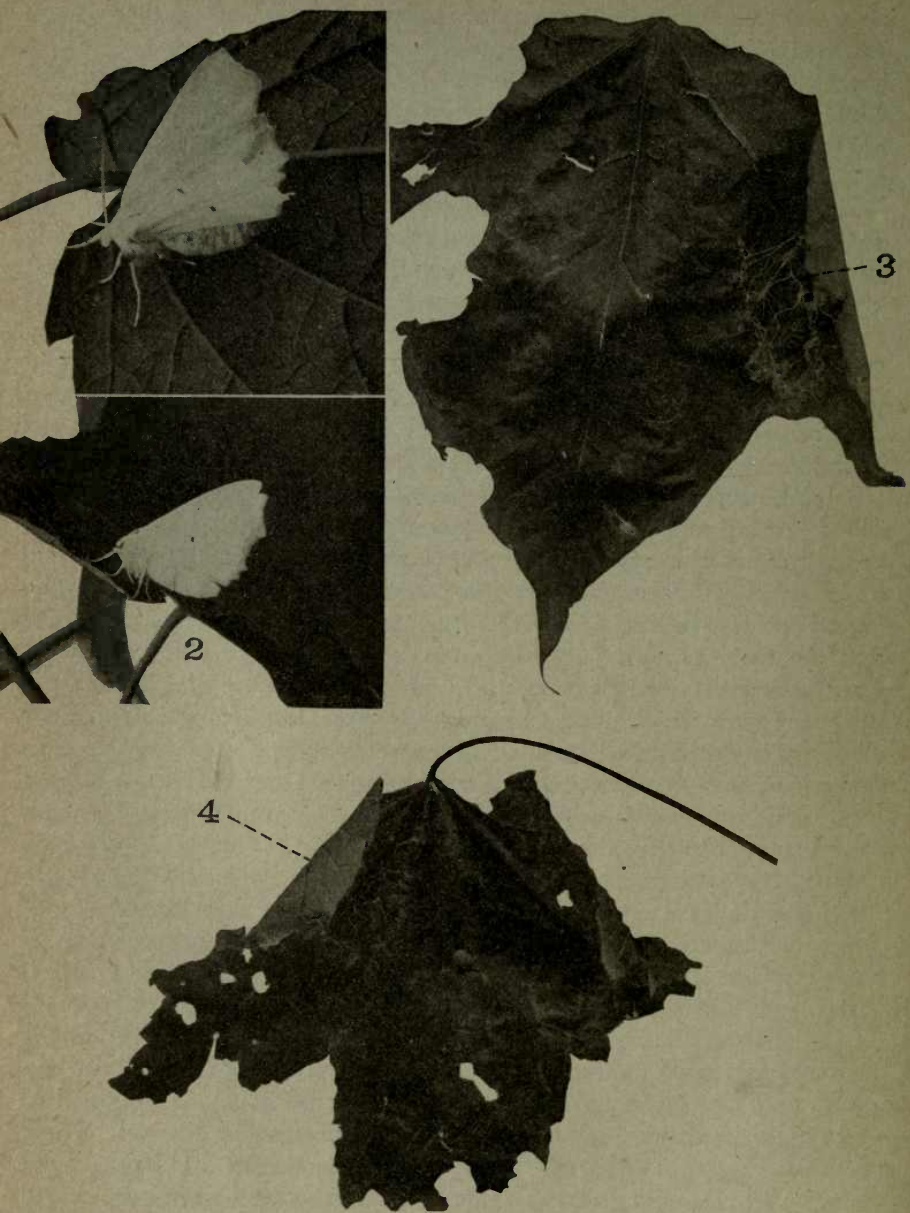

FIG. 56.—*The snow-white linden moth: 2, moths from nature; 3, lace-like cocoon; 4, pupa under the rolled edge of a leaf*

chitinous hooks that securely fasten the pupa to the network of threads lining the cocoon. The pupa is of a pale brown color flecked with numerous black dots which in some places run together. The six pupae, under observation, occupied 13 to 16 days for their transformations to adults.

The moths are pure white, and the females are somewhat larger than the males and have thread-like antennae, while the males possess feather-like antennae. The front wings of the male and the female are angulated, those of the female more prominently. Packard says that the hind wings of the male are entire. In a long series of bred specimens, many males show notched hind wings while some are entire in outline. The hind wings of the female are noticeably and quite regularly notched. (Fig. 57).

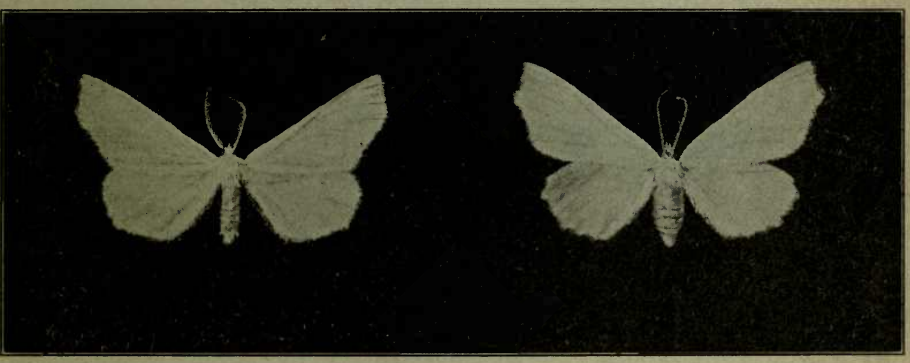

FIG. 57.—*Male moth at left, female at right*

From the eggs brought to Ithaca from Arena and Cooks Falls we find the moths appearing from June 16 to July 1st. From caterpillars obtained from Cooks Falls in 1909 we find the moths appearing July 18 to July 25th. At Arena, N. Y., in 1909, the larvae were found pupating about July 1st and the moths appeared about the middle of July. It would seem, then, that the adult moths appear from the middle of June to the last of July, depending upon the season, altitude, and other factors. The eggs are deposited within a few days after the moths emerge, thus completing the life cycle.

NATURAL ENEMIES

What the natural checks of this insect are we are unable to say at present. It is evident that some unfavorable conditions have operated

to hold it in check for the last fifty years, and it is equally evident that for the past three or four years these forces have been partly or wholly inoperative.

The testimony regarding the activity of the English sparrow in exterminating this pest in cities seems to show rather conclusively that this much-disliked bird did actually bring about the destruction of this insect. Nearly every writer on the snow-white linden moth makes acknowledgment to the sparrow and declares that the cities owe their freedom from this insect to that bird. We take pleasure in again calling attention to this little-known meritorious work of the English sparrow.

Mr. William H. Broadwell in describing the visitation of the snow-white linden moths at Newark, N. J., on the night of July 17th, 1908, as "a July blizzard," has the following to say regarding the work of the sparrows in destroying this insect: "Early the following morning, under the lamps, the wings were on the ground as thick as apple blossoms after a storm, showing that the sparrows had not forgotten why they were brought over to this country some forty years ago." Mr. Grote, in a paper from which we have already quoted, after discussing the great abundance of the measure worms in Brooklyn, says further, "The advent of the English sparrow changed all this. The naked brown larvae of *subsignaria* disappeared before them."

FIG. 58.—*A parasite (Pimpla conquisitor) of the snow-white linden moth*

In 1880, Mr. G. H. French of Carbondale, Ill., bred five males and seven females of a minute Hymenopterous parasite, *Macrocentus iridescens*, from two caterpillars, which he took to be *Ennomos subsignaria*, found on an elm tree. We have not been fortunate enough to find this parasite present in any of the caterpillars reared by us. We have, however, bred one single specimen of a common parasite, *Pimpla conquisitor* (Fig. 58), from the pupae of the snow-white linden moth. Since only the one specimen has been obtained from the scores of pupae we have had, it will be seen that this parasite is not abundant enough yet to be of any great service as a check. Mr. Harris says that *Chalcis ovata*, a small parasite, has also been reared from the pupae.

It may well be that the great and wanton destruction of birds is one cause of the abnormal abundance of this insect. If one bird is so efficient in the control of this pest, as the evidence shows it to have

been, then why may we not legitimately expect a great deal of our native birds in this respect? Undoubtedly one of the most efficient and feasible means for the control of this insect in our forests will be the better protection of our native birds.

METHODS OF CONTROL

In the control of this pest in shade-trees, spraying with arsenate of lead, 3 pounds to 50 gallons of water, would probably be very effective. If it ever becomes injurious to apple trees in this State, the same method of control would have to be followed. The trees should be sprayed early while the caterpillars are small, as the poison will be much more effective then.

As we have already noted, the caterpillars have the habit of suddenly dropping to the ground in great numbers when the trees are jarred. On small trees, hundreds of the caterpillars may be jarred on to sheets and then destroyed. Unfortunately, the young larvae are not so susceptible to this kind of treatment, and if one waits until they become large much of the damage will already have been done.

The masses of eggs are very conspicuous objects and could easily be found on the branches and scraped off. In the case of small trees much good could be accomplished in this manner. On large trees it would be more difficult to collect the eggs.

In forests there seems no practicable way of controlling this pest. In case of the particular forest area mentioned at Cooks Falls, the wood is being grown for the manufacture of certain wood chemicals. In this instance it may be best to cut off the present growth of timber and use it for the distillation products before it dies as a result of the annual defoliation to which it has been subject for the past two years.

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NOVEMBER, 1910 CIRCULAR No. 8

Walter Mulford

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Entomology (Extension Work)

THE ELM LEAF-BEETLE

GLENN W. HERRICK

FIG. 1.—*An adult elm leaf-beetle.*

About 1834 there was introduced into the city of Baltimore, from somewhere in Europe, a small inconspicuous beetle whose food plant at home had been the European elms. It attracted no particular attention until about four years later, when it came into prominence as a serious enemy of the elms in this Maryland city. Since that time it has gradually extended its territory until now it is found as far north as Massachusetts and New York and westward to Ohio and Kentucky. In New York State it is destructive in the eastern and central sections, and very likely will gradually extend its activity until it covers the greater part of the State.

THE APPEARANCE OF THE BEETLE, AND ITS WORK

The insect is about one-fourth of an inch long. In general, it is yellowish or brownish yellow in color, with a dark line along each side of its back (Fig. 1). Its color varies somewhat, and the over-wintering beetles are often so dark colored that the brownish yellow almost disappears and the black lines are hardly noticeable. In its normal coloring it is quite likely to be confused with the common striped cucumber beetle, although it is considerably larger.

FIG. 2.—*Adult beetles eating leaf in the spring.*

When the beetle first awakens in the spring from its long winter sleep, it flies to the elm trees just bursting into leaf and takes its first meal by eating small, irregular holes through the young, tender leaves (Fig. 2). After feeding a few days, the orange-colored eggs are deposited on the leaves and these in a few days more hatch into the tiny black and yellow grubs (Fig. 3). These grubs are the chief culprits. They work on both surfaces of the leaves, although mostly on the under sides, and eat so ravenously that in a few weeks nothing remains of the leaves except a bare network of veins. The effect on the leaves is serious, for they turn brown, curl, and finally fall from the trees. If the trees are vigorous enough and the season is propitious, a second crop of leaves is put out, but these may meet the same fate as the first.

Fig. 3.—*Young grubs eating leaf.*

EXTENT OF ITS INJURIES

It was estimated that in 1898 1,000 fine elms were killed in the city of Albany and that in Troy the conditions were even worse. Similar conditions obtained in dozens of other towns in the Hudson Valley and along the Mohawk River. The writer has been told that a majority of the magnificent elms in Harvard Yard have been destroyed within the last two or three years by the attacks of these small pests. There is danger that through inaction and apathy the splendid elms of our own City and Campus will suffer a like fate. Some of them are now probably past any effort to save them.

Undoubtedly the elm leaf-beetle must be regarded as the most serious pest to shade-trees in this State. It probably destroys more shade-trees, certainly more elm trees, than all other insect pests combined.

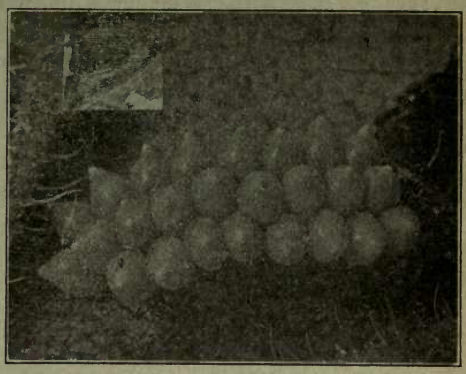

FIG .4.—*Eggs natural size, and much enlarged.*

STORY OF ITS LIFE

In the fall of the year many of the full-grown beetles, in searching for snug crannies in which to pass the winter, find their way into dwelling houses, congregating especially in the attics where they may often be found by the score. Housekeepers are sometimes alarmed when they see so many of these beetles crawling on the window panes, walls, and ceilings of the rooms, likely thinking that here is another household pest. Fortunately, so far as the writer knows, these insects do not injure household articles of any description. Other individuals hide away under loose pieces of bark on trees, in cracks in fences and telegraph poles, in outhouses, sheds, and in any other sheltered places they are able to find. Here they remain in a quiet, inactive condition through the long winter months. With the warm days of spring, the beetles awake and begin crawling about on the walks and on the window panes.

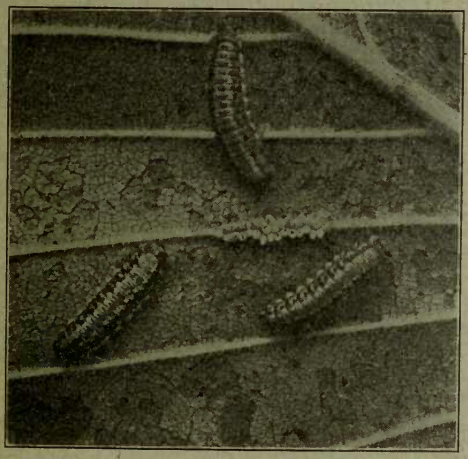

FIG. 5.—*Grubs nearly grown.*

As soon as the leaves begin to appear, the insects fly to the trees for their first spring meal. After feeding for some time they deposit their conspicuous orange-colored eggs (Fig. 4) in clusters of five to twenty-five on the undersides of the leaves. Each egg is flask-shaped and stands upright with its larger end attached to the leaf. The eggs hatch in five or six days during hot weather, but in cool

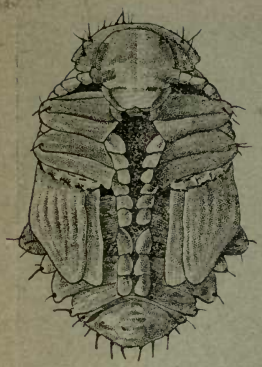

FIG. 6.—*Pupa of the elm leaf-beetle.*

weather this period may be prolonged several days. The writer found that in Ithaca, last year, the majority of the eggs were laid during the first three weeks of June. By June 20th the young grubs were appearing in force. The grubs eat ravenously, increase in size very fast, and complete their growth in fifteen to twenty days (Fig. 5). When full grown they either crawl down the trunk of the tree or drop from the ends of the branches. At the bases of the trunks many of the larvae transform to the yellow pupae (Fig. 6). Sometimes they are so numerous that the golden pupae lie an inch deep about the foot of the tree. Others transform in crevices of the bark, especially if the trunk is rough, others go to the gutters, while others seek shelter in crevices of the sidewalk and wherever they can find hiding places. The quiet, inactive pupae lie motionless for six to ten days and then transform to the adult beetles, thus completing the life round of one generation. Our observations show that in Ithaca we have one generation, with a possible second, the latter, however, being so small as to cause no serious damage.

METHODS OF CONTROL

The elm leaf-beetle can be controlled effectively only by spraying the trees with an arsenical poison, preferably arsenate of lead, at the rate of three or four pounds to fifty gallons of water. (See Fig. 7 for

FIG. 7.—*Sprayed elm at right, unsprayed at left.*

sprayed and unsprayed trees.) In order to be most effective, two sprayings each year should be given, especially during the first season. If the work is well done the trees may not need another application for a year or two.

The first spraying should be made while the leaves are unfolding and expanding, to kill as many of the adult beetles as possible before they commit injury or lay their eggs. The second spraying should be made about the second week in June in this locality, to kill the young grubs as soon as they begin to feed. Since they feed mainly on the lower surfaces of the leaves the poison mixture should be applied as much as possible to the undersides of the leaves.

FIG. 8.—*Hand-spraying outfit.*

SPRAYING APPARATUS

Low and medium-sized trees can be sprayed very well with certain hand-spraying outfits, like the one in Fig. 8. A high step-ladder with an extension rod to which the nozzle may be attached will facilitate the work greatly. A nozzle capable of throwing a fine or coarse spray will probably be best.

For large trees a power spraying outfit will be necessary. There are several makes of gasoline power sprayers on the market that can be bought for $250.00 to $300.00 (Fig. 9).

FIG. 9.—*Power-spraying outfit.*

COST OF SPRAYING

Available data on this subject show that it costs twenty-five to sixty cents for a single application to a large tree if the work is done privately. If the work is performed on a large scale by a contractor it can be done more cheaply. If one can contract to have his trees sprayed twice in one season for fifty cents a tree,

for large trees, it would seem to be a reasonable price. If the trees are small, they should be sprayed for less.

Figures 2, 3, 4 and 5 are from photographs by M. V. Slingerland. The drawings were made by Miss Anna Stryke.

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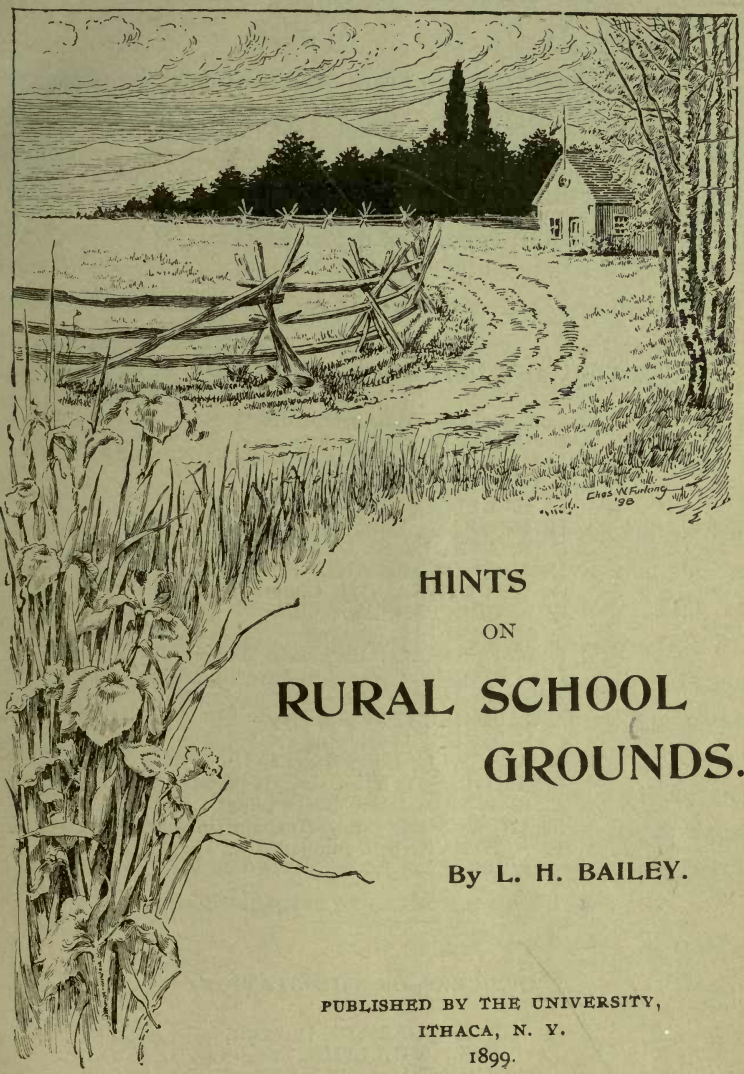
Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

HORTICULTURAL DIVISION.



HINTS ON RURAL SCHOOL GROUNDS.

By L. H. BAILEY.

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L. ANDERSON, Dairy Husbandry.
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I. P. ROBERTS, Director.
E. L. WILLIAMS, Treasurer.
EDWARD A. BUTLER, Clerk.

CORNELL UNIVERSITY, January 2, 1899.

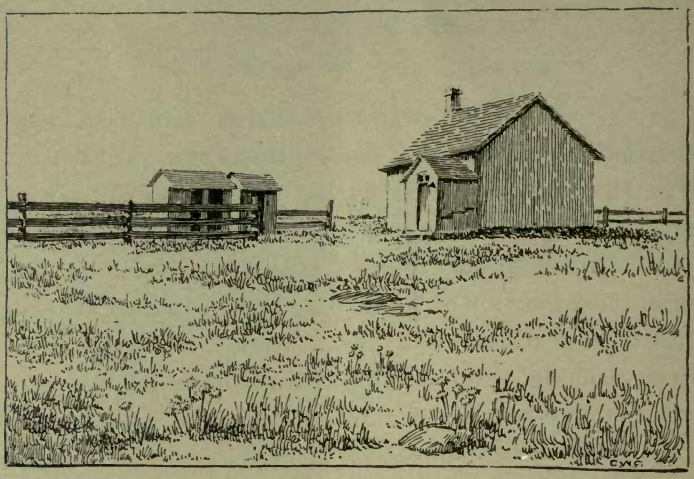
HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: In the effort to extend the teaching of nature and to popularize farming subjects, we have found the nature-study leaflets to be invaluable. These leaflets are now so well established in the estimation of New York teachers that we are obliged to print them in editions of 25,000. These afford subject-matter for direct teaching. But the surroundings of the child should also be such as to interest him in rural subjects. The home and the school premises should supplement the explicit work of the teacher.

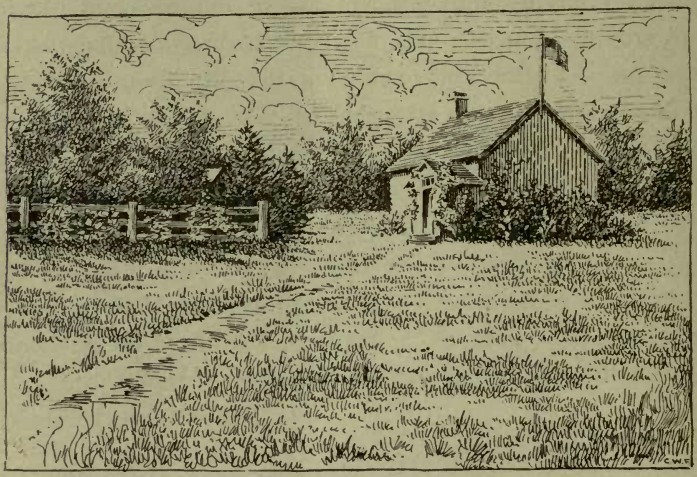
We have endeavored to provide suggestions for the improvement of home surroundings in a number of bulletins; and we hope that more will follow. For many years, Professor Bailey has been studying the problem of the improvement of rural school grounds, but it is only now that he has felt that the time is ripe for a distinct movement in this direction. This bulletin is the first move. It strikes at one of the greatest evils connected with the education of the farmer's children. We hope to follow up the movement, and eventually to give suggestions for the interior of the schoolhouse.

These recommendations are the result of long study of trees and shrubs as adapted to New York State, and of the principles of landscape gardening. The report is submitted for publication as a bulletin under Chapter 67 of the Laws of 1898.

I. P. ROBERTS, Director.



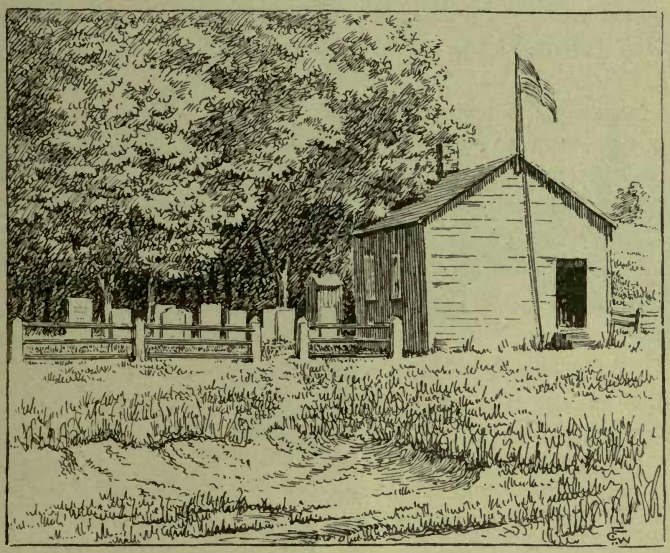
21.—*Where children are taught. An actual example, in one of the most prosperous fruit-growing sections of New York.*



22.—*A suggestion in planting.*

HINTS ON RURAL SCHOOL GROUNDS.

One's training for the work of life is begun in the home and fostered in the school. This training is the result of a direct and conscious effort on the part of the parent and teacher, combined with the indirect result of the surroundings in which the child is placed. The surroundings are more potent than we think; and they are usually neglected. It is probable that the antipathy to



23.—*The beginning and the end,—schoolhouse and graveyard. In eastern New York.*

farm life is formed before the child is able to reason on the subject. An attractive play-ground will do more than a profitable wheat crop to keep the child on the farm.

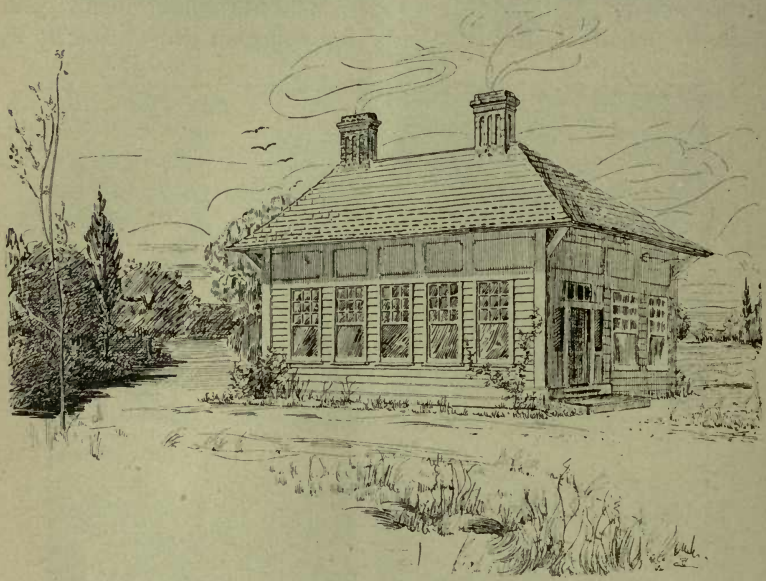
a. THE FACT.

Bare, harsh, cheerless, immodest,—these are the facts about the average rural school ground. Observe Fig. 21.

Children cannot be forced to like the school. They like it only

when it is worth liking. And when they like it, they learn. The fanciest school apparatus will not atone for a charmless school ground. A child should not be blamed for playing truant if he is sent to school in a graveyard. Observe Fig. 23.

It would seem that land is very precious. Very little of it can be afforded for a school ground. A quarter of an acre of good land will raise four bushels of wheat, and this wheat may be worth three or four dollars a year. We cannot afford to de-



24.—*A suggestion for a simple little schoolhouse.*

vote such valuable property to children. We can find a bit of swamp, or a sand hill, or a treeless waste. The first district school I taught was on a heartless hillside. The premises had two or three disconsolate oaks, and an old barrel was stuck in the top of one of them. The second school was on an island in a swamp. The mosquitoes loved it.

The school building is generally little more than a large box. It has not even the charm of proper proportions. A different shape, with the same cost, might have made an attractive building. Even a little attention to design might make a great

difference in the looks of a schoolhouse; and the mere looks of a schoolhouse has a wonderful influence on the child. The railroad corporation likes to build good-looking station-houses, although they have no greater capacity than homely ones. I asked an architect for a simple plan of a cheap school house. He gave me Fig. 24. Plans for the improvement of shoolhouses may be obtained of the Superintendent of Public Instruction, Albany.

The following sentences are extracted from the "Report of the Committee of Twelve on Rural Schools," of the National Educational Association (1897):

"The rural schoolhouse, generally speaking, in its character and surroundings is depressing and degrading. There is nothing about it calculated to cultivate a taste for the beautiful in art or nature."

"If children are daily surrounded by those influences that elevate them, that make them clean and well-ordered, that make them love flowers, and pictures, and proper decorations, they at last reach that degree of culture where nothing else will please them. When they grow up and have homes of their own, they must have them clean, neat, bright with pictures, and fringed with shade trees and flowers, for they have been brought up to be happy in no other environment."

"The rural schoolhouse should be built in accordance with the laws of sanitation and modern civilization. It never will be until the State, speaking through the Supervisor, compels it as a prerequisite for receiving a share of the public funds."

b. HOW TO BEGIN A REFORM.

We will assume that there is one person in each rural school district who desires to renovate and improve the school premises. There may be two. If this person is the school commissioner or the teacher, so much the better.

Let this person call a meeting of the patrons at the schoolhouse. Lay before the people the necessity of improving the premises. Quote the opinions of intelligent persons respecting the degrading influence of wretched surroundings; or even read extracts from this bulletin. The coöperation of the most

influential men of the district should be secured before the meeting is called.

Propose a "bee" for improving the school grounds. John Smith will agree to repair the fence (or take it away, if it is not needed). Jones will plow and harrow the ground, if plowing is necessary. Brown will sow the grass seed. Black and Green and White will go about the neighborhood with their teams for trees and bushes. Some of these may be got in the edges of the woods, but many of the bushes can be picked up in front yards. Others will donate their labor towards grading, planting, and cleaning up the place.

The whole thing can be done in one day. Perhaps Arbor Day can be chosen.

C. THE PLAN OF THE PLACE.

This is the most important part of the entire undertaking,—the right kind of a plan for the improvement of the grounds. The person who calls the meeting should have a definite plan in mind; and this plan may be discussed and adopted. The remainder of this bulletin is devoted to plans for school grounds and means of working them out. If any person is interested in this subject, he should have our Bulletin 121, on the "Planting of Shrubbery."

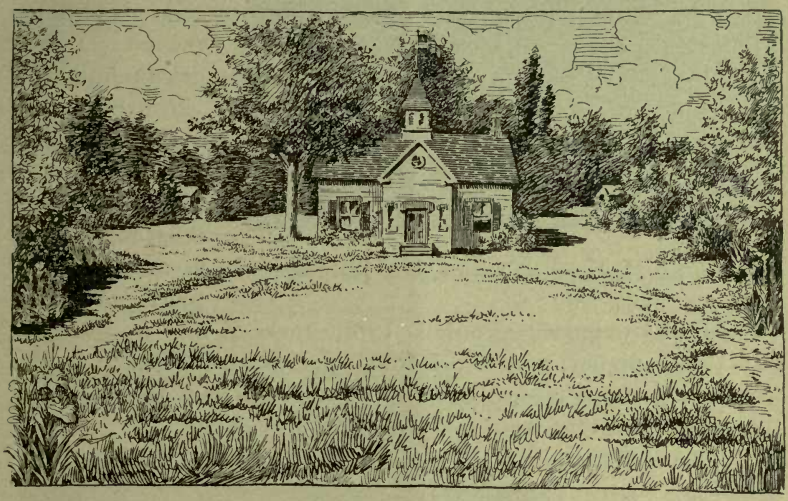
Begin with the fundamentals, not with the details.—If an artist is to make a portrait, he first draws a few bold strokes, representing the general outline. He "blocks out" the picture. With the general plan well in mind, he gradually works in the incidentals and the details,—the nose, eyes, beard.

Most persons reverse this natural order when they plant their grounds. They first ask about the kinds of roses, the soil for snowballs, how far apart hollyhocks shall be planted. It is as if the artist first asked about the color of the eyes and the fashion of the neck-tie; or as if the architect first chose the color of paint and then planned his building. The result of this type of planting is that there is no plan, and the yard means nothing when it is done. Begin with the plan, not with the plants.

The place should mean something.—The home ground should be home-like, retired and cosy. The school ground should be set off from the bare fields and should be open enough

to allow of play-grounds. It should be hollow,—well planted on the sides, open in the interior. The side next the highway should contain little planting. The place should be a picture, not a mere collection of trees and bushes. Fig. 25 shows what I mean.

As seen in the picture (Fig. 25), this style of planting seems to be too elaborate and expensive for any ordinary place. But if the reader will bear with me, he shall learn otherwise.

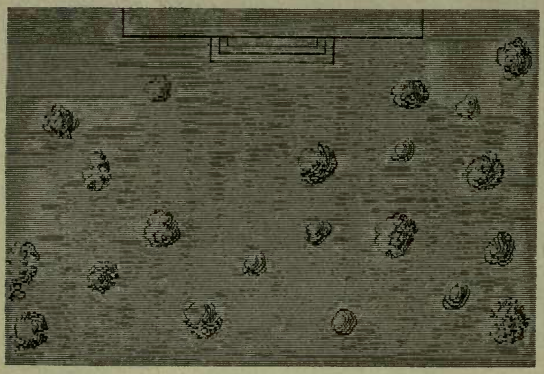


25.—*A picture, of which a schoolhouse is the central figure.*

Keep the center of the place open.— Do not scatter the trees over the place. They will be in the way. The boys will break them down. Moreover, they do not look well when scattered over the whole area. When an artist makes a picture with many people in it, he does not place the persons one by one all over his canvas. He masses them. Thereby he secures a stronger effect. He focusses attention, rather than distributes it.

The diagrams (Figs. 26, 27), taken from Bulletin 121, make this conception plain. The same trees and shrubs can be used to make either a nursery or a picture. But it is more difficult to make the nursery, and to keep it in order, because the trees grow one at a place in the sod, and they are exposed to accidents.

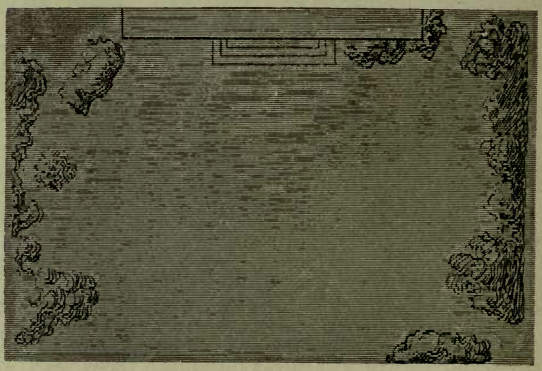
Go to the blackboard. With four lines, represent the borders of the school grounds, as in Fig. 28. Indicate the schoolhouse and the out-buildings. Existing trees may be located by small circles. Now you have the facts, or the fixed points.



26.—*The common or nursery type of planting.*

Now put in the walks. The first fixed point is the front door. The other fixed point is the place or places at which the children enter the grounds. Join these points by the most direct and simplest curves possible. That is all there is of it. In many, or perhaps most places, the house is so near the highway that only a straight walk is possible or advisable.

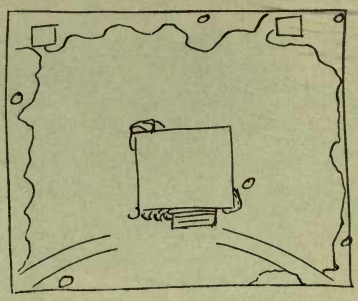
Next comes the planting. Let it be irregular and natural, and represent it by a wavy line, as in Fig. 28. First of all, cover up the out-houses. Then plant heavily on the side next the swamp or a disagreeable barnyard, or in the direction of the prevailing wind. Leave openings in your plan wherever there are views to be had of fine old trees, attractive farm homes, a brook, or



27.—*The proper or pictorial type of planting.*

a beautiful hill or field. Throw a handful of shrubs into the corners by the steps, and about the bare corners of the building.

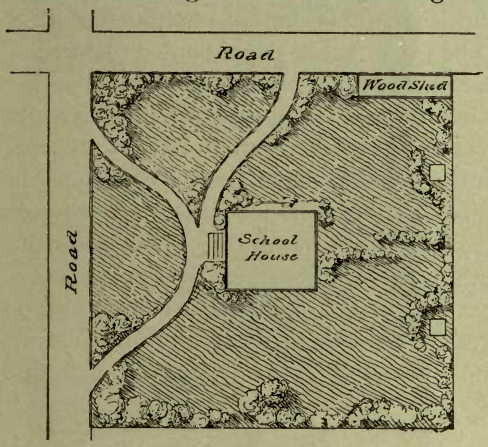
You now have a plan to work to. It has been the work of five minutes at the blackboard.



28.—*The blackboard plan.*

Sometimes the problem is not so simple as all this. There may be three entrances to the grounds and a highway on two sides. Fig. 29 is a plan made for such a place in western New York. It was thought to be necessary to separate the play-grounds of the boys and girls. This was done by a wide hedge-row of bushes running back from the schoolhouse.

An interesting case as shown in Figs. 21 and 22. It is indecent to put the two out-buildings together. But it was assumed that it would not be allowable to move them. The place is bald and cheerless. The outlay of a day's work, and no money, might cause it to look like Fig. 22 inside of three or four years.



29.—*Suggestions for the planting of a school-yard upon four corners. From "Lessons with Plants."*

Perhaps some persons object to so much shrubbery. They look upon it as mere brush. Very well; then use trees alone. But do not scatter them hit and miss over the place. Throw them in at the side, as in Fig. 30. Give room for the children to play; and make the place a picture at the same time. Three or four trees may be planted near the building to shade it, but the heaviest planting should be on the sides.

The mere planting of trees and shrubs is the smaller part of the problem.—Arbor day has emphasized the mere planting of trees. Fortunately, many of the trees do not live. They are too often put in the wrong places. If the love of trees could be combined with some purpose in the planting, the results would be much better. Fig. 31 suggests Arbor Day planting; and this is certainly much better than nothing. These four trees will be useful in their present positions, but the place will still remain bare. The great thing—the border planting—has been omitted, and the incidental thing has been done.

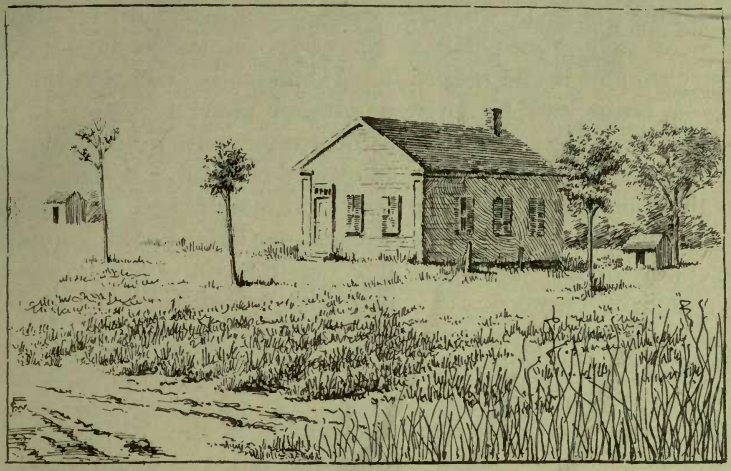
30.—*A border planting of trees.*

Observe how the long foliage-mass adds charm to Fig. 32. A row is better than mere scattered trees. But even this planting is not ideal. Heavy planting should have been made along the fence beyond the schoolhouse. There are too many trees between the border row and the house, although this is not a serious fault. A few bushes and vines would relieve the barrenness of the house; so would one or two trees close against the house on the side next the road. But this place is so much more attractive than most rural school premises that one ought not to find fault with it.

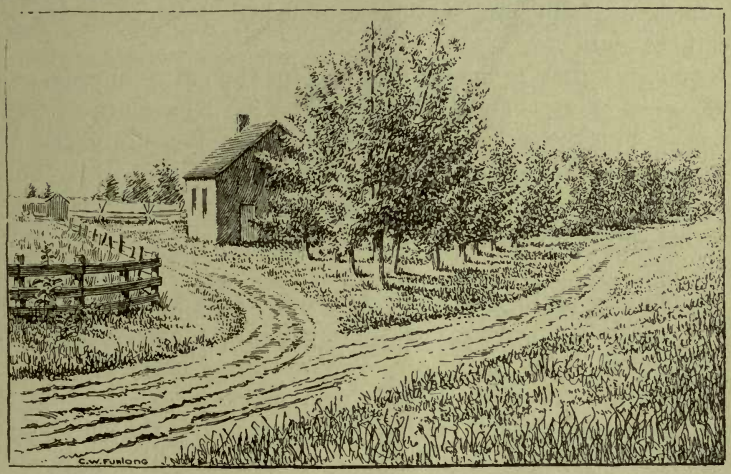
d. HOW TO MAKE THE IMPROVEMENTS.

Every effort should be exerted to do the work well in the beginning. If all preparations are thoroughly considered, and the details carried out with care, the premises should become more attractive year by year with almost no annual outlay of labor. The school grounds should be able to take care of themselves when once the place is set in order. Of course, better results

are to be expected when much labor is put on the grounds each year, but it is useless to advise such expenditure for the rural



31.—*Trees enough in the center, but the place needs a back-ground.*



32.—*A row of willows makes the place attractive.*

schools. But it is surprising what excellent results can be secured with almost no attention from year to year. The beau-

tiful garden in Fig. 34 has received practically no labor for three years except that required to mow the grass.

Making the sod.—In many cases the school yard is already level or well graded and has a good sod, and it is not necessary to plow it and re-seed it. It should be said that the sod on old lawns can be renewed without plowing it up. In the bare or thin places, scratch up the ground with an iron-toothed rake, apply a little fertilizer, and sow more seed. Weedy lawns are those in which the sod is poor. It may be necessary to pull out the weeds ; but after they are out, the land should be quickly covered with sod or they will come in again. Annual weeds, as pigweeds, ragweed, can usually be crowded out by merely securing a heavier sod. A little clover seed will often be a good addition, for it supplies nitrogen and has an excellent mechanical effect on the soil.

The ideal time to prepare the land is in the fall, before the heavy rains come. Then sow in the fall, and again in early spring on a late snow. However, the work may be done in spring, but the danger is that it will be put off so long that the young grass will not become established before the dry hot weather comes.

The only outlay of money required for the entire improvement is for grass seed. The best lawn grass for New York is June-grass or blue-grass. Seedsmen know it as Poa pratensis. It weighs but 14 pounds to the bushel. Not less than three bushels should be sown to the acre. We want many very small stems of grass, not a few large ones ; for we are making a lawn, not a meadow.

Do not sow grain with the grass seed. The June-grass grows slowly at first, however, and therefore it is a good plan to sow timothy with it, at the rate of two or three quarts to the acre. The timothy comes up quickly and makes a green ; and the June-grass will crowd it out in a year or two. If the land is hard and inclined to be too dry, some kind of clover will greatly assist the June-grass. Red clover is too large and coarse for the lawn. Crimson clover is excellent, for it is an annual, and it does not become unsightly in the lawn. White clover is perhaps best, since it not only helps the grass but looks well in the sod. One or two pounds of seed is generally sufficient for an acre.

At first the weeds will come up. Do not pull them. Mow the lawn as soon as there is any growth large enough to mow. Of course, the lawn mower is best, but there is no use of recommending it for rural school yards. Then use the ordinary field mower. When the sod is established, mowing the yard three or four times a year will be sufficient. And here is another advantage of the open-centered yard which I have recommended, — it is easily mown. It would be a fussy matter to mow a yard planted after the fashion of Fig. 26; but one like Fig. 27, is easily managed. A yard like Fig. 25 can be mown in a half hour.

How to make the border planting.—The borders should be planted thick. Plow up the strip. Never plant these trees and bushes in holes cut in the sod. Scatter the bushes and trees promiscuously in the narrow border. In home grounds, it is easy to run through these borders occasionally with a cultivator, for the first year or two.

Make the edges of this border irregular. Plant the lowest bushes on the inner edge. Fig. 33 shows how a certain yard was marked out for the planting. The whole area had been plowed, rolled, harrowed and raked. Grass seed had been sown and raked in. Then a line was drawn, by means of a rake handle, to represent the edges of the border planting. The interior or lawn space was now rolled, and the soft area along the borders was left for the planting. Five years later, the place looked as shown in Fig. 34. Imagine a schoolhouse at the end of that garden!

For all such things as lilacs, mock-oranges, Japan quinces, and bushes that are found along the roadsides, two or three feet apart is about right. Some will die anyway. Cut them back one-half when they are planted. They will look thin and stiff for two or three years; but after that they will crowd the spaces full, lop over on the sod, and make a billow of green. Prepare the land well, plant carefully; andlet the bushes alone.

The kinds of plants for the main planting.—We now come to the details,—the particular kinds of plants to use. One great principle will simplify the matter: the main planting should be for foliage effects. That is, think first of giving the place a heavy bordermass. Flowers are mere decorations.

Select those trees and shrubs which are the commonest, because

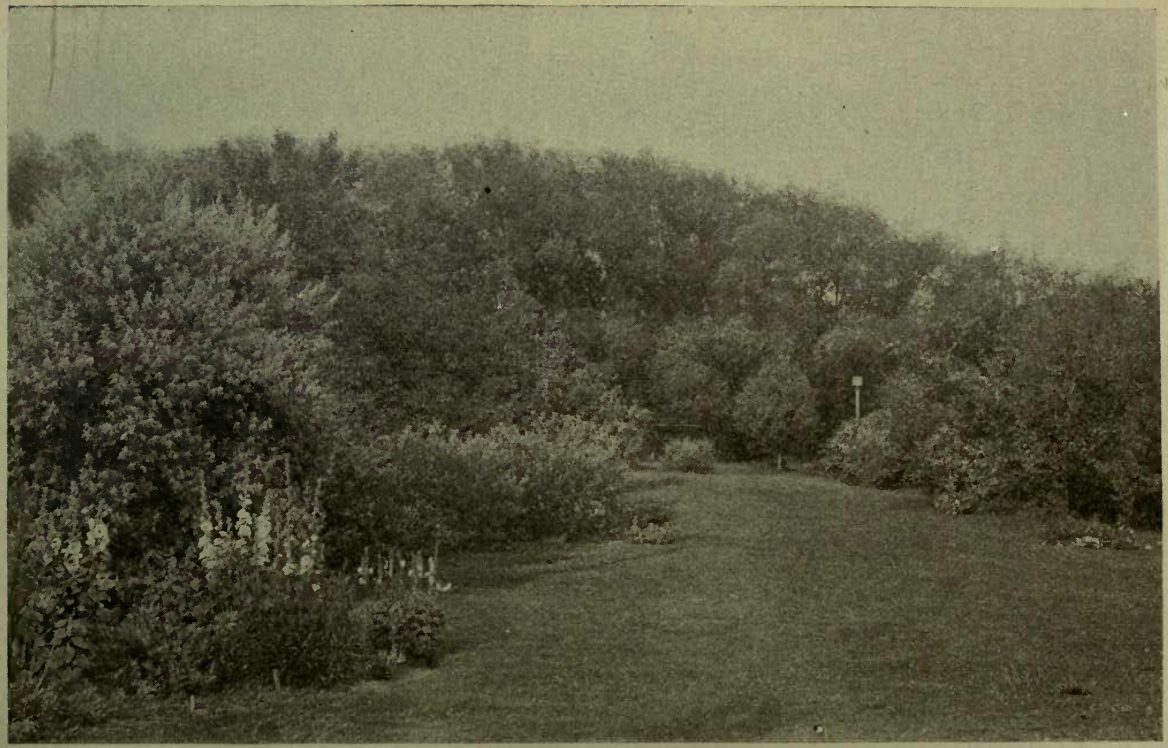
they are cheapest, hardiest and most likely to grow. There is no district so poor and bare that enough plants cannot be secured, without money, for the school yard. You will find them in the woods, in old yards, along the fences. It is little matter if no one knows their names. What is handsomer than a tangled fence-row?

Scatter in a few trees along the fence and about the buildings.

33.—*A newly made landscape garden, ready for the border planting.*

Maples, basswood, elms, ashes, buttonwood, pepperidge, oaks, beeches, birches, hickories, poplars, a few trees of pine or spruce or hemlock,—any of these are excellent. If the country is bleak, a rather heavy planting of evergreens about the border, in the place of so much shrubbery, is excellent.

For shrubs, use the common things to be found in the woods and swales, together with roots which can be had in every old yard. Willows, osiers, witch hazel, dogwood, wild roses, thorn apples, haws, elders, sumac, wild honeysuckles,—these and others can be found in every school district. From the farm yards can be secured snowballs, spireas, lilacs, forsythias, mock-



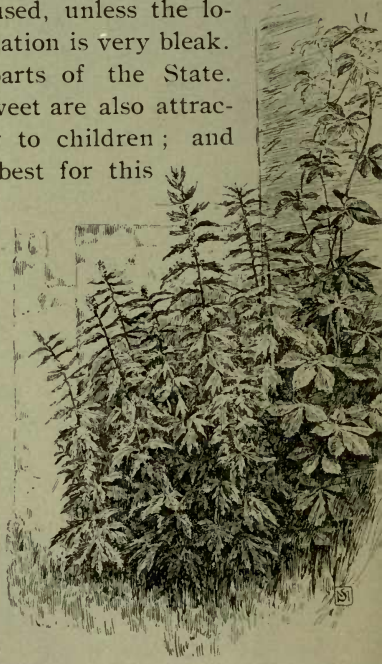
34.—*Five years' growth upon the area shown in Fig. 33. On the Cornell horticultural grounds. From our Bulletin 121.*

35.—*It is easy to make a yard as good as this.*

oranges, roses, snowberries, barberries, flowering currants, honeysuckles and the like.

Vines can be used to excellent purpose on the outbuildings or on the schoolhouse itself. The common wild Virginia creeper (shown on the right in Fig. 36) is the most serviceable. On brick or stone school houses the Boston ivy or Japanese ampelopsis may be used, unless the location is very bleak. This is not hardy in the northern parts of the State. Honeysuckles, clematis and bitter-sweet are also attractive. Bowers are always interesting to children; and actinidia (to be had at nurseries) is best for this purpose.

Kinds of plants for decoration.—Against these heavy borders and in the angles about the building, many kinds of flowering plants can be grown. The flowers are much more easily cared for in such positions than they are in the middle of the lawn, and they also show off better. Notice how striking the holyhocks are in Figs. 34 and 37. They have a background. Even a clump of weeds looks well when it is in the right place. Observe Fig. 36.



36.—*A clump of weeds in the corner the house—motherwort and Virgin creeper. How pretty they are!*

It is impossible to grow many flowers in the school ground under present conditions, for what is everybody's business is nobody's business; and then, the place is neglected all through

the summer. But the children can be taught to plant many things.

Only those flowers should be used which are very easy to grow and which have the habit of taking care of themselves. They should also be such as bloom in spring or fall, when the school is in session. Perennial plants—those which live from year to year—are excellent. Of these, day lilies, bleeding hearts, pinks, bluebells, hollyhocks, perennial phlox and hibiscus, are always useful. Nothing is better than the common wild asters and goldenrods. They will grow almost anywhere and they improve when grown in rich ground and given plenty of room; and they bloom in the fall.

37.—*A dainty bit,—flowers against a background.*

Many kinds of bulbs are useful, especially as so many of them bloom very early in spring. We propose to issue a nature-study leaflet on this subject the coming season. Think of a school yard with crocuses, daffodills and tulips in it!

Annual flowers may be grown along the borders, out of the way of the play-grounds. China asters, petunias and California poppies are very attractive, and they are easy to grow. They bloom in the fall. Phlox, sweet peas, allyssum, and many others are also useful. Consult Bulletin 161.

While the main planting should be made up of common trees and shrubs, a rare or strange plant may be introduced now and then from the nurseries, if there is any money with which to buy such things. Plant it at some conspicuous point just in front of the border, where it will show off well, be out of the way, and have some relation to the rest of the planting. Two or three purple-leaved or variegated-leaved bushes will add much spirit and verve to the place; but many of them make the place look fussy and overdone.

e. GENERAL REMARKS.

More than one-third of all public schools will probably always be in the country. They will have most intimate relations with rural life. We must make that life attractive to the pupils.

In Europe there are school gardens, and similar plans are

recommended for this country. It is certainly desirable that some area be set aside for the actual cultivation of plants by the children and for the growing of specimens to be used in the school room. However, the conditions of Europe are very different from ours. In the rural school in Germany and other countries, the school house is the teacher's home. He lives in it, or by it. The summer vacation is short. In this country, there is no one to care for the rural school ground in the long summer vacation. Teachers change frequently. It is impossible to have uniformity and continuity of purpose. In the Old World, the rural schools are in the hamlets.

We shall be very glad to correspond with any persons who are interested in improving school premises, either on the lines herein suggested, or in other directions. The improvement must come, or, one by one, the rural schools will die out for lack of pupils. In the struggle for existence, the pupils will more and more seek the more attractive schools. There must be rural schools, whether in the open country or in the hamlet; and wherever they are, they must be cheered and brightened.

A Flower Day every October would be a fitting complement of Arbor Day. Already, flower shows have been held in various rural schools. They are symbols of the harvest. We want to focalize this movement in the coming year. We call upon every citizen for sympathy and coöperation.

A revolution in rural school grounds will not come suddenly. Here and there a beginning will be made; and slowly the great work will spread.

L. H. BAILEY.

Bulletin 168. **May, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION. Walter Mulford

Studies and Illustrations

—OF—

MUSHROOMS: II.

"By the rose flesh mushrooms, undivulged
Last evening. Nay, in to-day's first dew
Yon sudden coral nipple bulged,
Where a freaked, fawn-colored, flaky crew
Of toadstools peep indulged."
Browning's By the Fireside.

THREE EDIBLE SPECIES OF COPRINUS.

By GEO. F. ATKINSON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, ITHACA, May 15, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY, N. Y.

Sir: This bulletin, the second of a series of "Studies and Illustrations of Mushrooms," is submitted under Chapter 67 of the Laws of 1898. The object of these studies is to give accurate information upon, and illustrations of, the more common mushrooms or toad-stools. This should enable interested persons to collect and determine specimens occurring from spring to late autumn. Large numbers of the edible species go to waste each year for the want of some clear and ready information to assist in distinguishing the edible from the poisonous kinds.

It is to be regretted that in the smaller cities, in suburban districts, and upon the farms, more attention is not given to learning to know *well* a few of the more common species, since the fields and woods where these plants grow are so easy of access. By careful attention to the localities and by comparison of the plants with the descriptions and illustrations given in these bulletins, a person having no botanical knowledge can identify a number of these plants. Every one has, or should have, a certain amount of leisure time which can be devoted to recreation, or relief from the every day work. Many find enjoyment and profit in combining such recreation with an interest in some observation upon nature and natural objects. Having learned to recognize the edible species, it is possible thereafter to readily collect for food large numbers of the more common ones. Some of these plants are so easily determined that children only eight years old, after seeing the photographs of two of the species illustrated in this bulletin, were able later to name the plants from freshly collected specimens, without the opportunity of a comparison with the photographs.

One not familiar with the subject should use caution in the first collections of an unknown plant. It is well in some cases

to consult some one who does know the plants, or who has the means of determining them. In such cases, the Botanical Division of this Station is ready to assist in the identification. Directions for collecting and mailing specimens are given in the present bulletin. With some attention to this subject there is no reason why, in America, mushrooms should not form as important an article of food as they do in parts of the Old World.

Professor Atkinson has made a large number of photographs of the edible and poisonous mushrooms, as well as of those wood destroying species so destructive to timber and forest trees.

I. P. ROBERTS, Director.

STUDIES AND ILLUSTRATIONS OF MUSHROOMS, II.

Three Edible Species of Coprinus.

I—The Shaggy-Mane (*Coprinus comatus*).

The "shaggy-mane," or "horsetail mushroom" (Coprinus comatus), is one of the largest plants of this genus. It is usually considered by many to surpass all the other species of the genus in those qualities most esteemed by the fungus eater. The frontispiece is from a photograph of a group of these plants growing in a lawn on the Cornell University Campus. All stages of the "horsetail" are here represented, from the tiny ones which are thrusting their heads through the turf to the old ones which present an unsightly aspect as they are melting down into inky blackness, an example of the swiftness with which it passes its ephemeral existence. A day, or at most two or three days is vouchsafed to it during which it is to lift itself up into the free air, where it may expand and mature its spores. Then it vanishes. But it has accomplished the final purpose for which it exists as an organism. Its "seed," the spores are free to be carried by the wind or other agencies of dissemination to distant places, and thus propagate the species. While the natural mode of the wide dissemination of the plant is probably by the distribution of the spores, dissemination may take place through the agency of man or other animals when the soil is disturbed.

Some of the "spawn" may be transplanted in the sod for covering new lawns, or in the fertilizer for old ones. Here food lying hidden in the soil is awaiting forage at the pleasure of the searching threads of the mycelium or "spawn," which now spreads its meshes as it extends through the earth. Here it grows for months or sometimes for years may be, laying by supplies in the shape of an increased amount of "spawn." We tread upon the soft carpet of green or recline on the sod unmind-

ful of the process of growth, absorption and assimilation in that wonderful unseen world of plant life. Suddenly some morning we see the shaggy, unkempt heads of our old friends again just risen from their long sleep which calls to mind Browning's verse,—

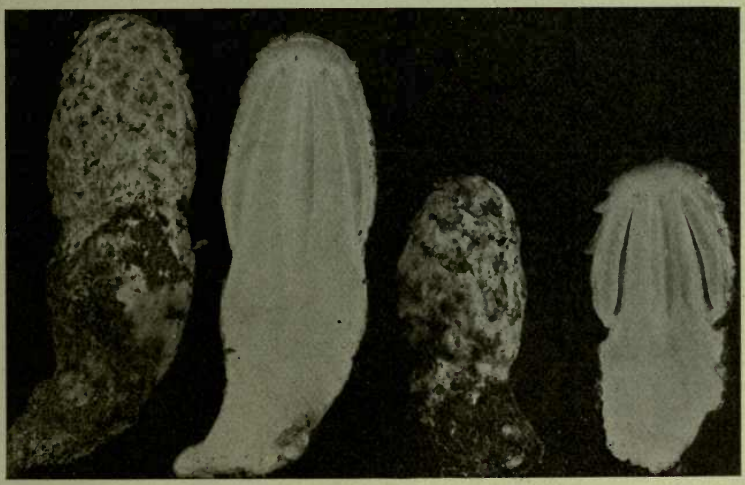
> "By the rose flesh mushrooms undivulged
> Last evening. Nay, in to-day's first dew
> Yon sudden coral nipple bulged,
> Where a freaked, fawn-colored flaky crew
> Of toad-stools peep indulged."

83.—"*Shaggy-mane*" (*Coprinus comatus*) *in lawn.*

A "mushroom growth," we say. It looks that way; as if the whole thing had grown in a single night. That is because we have not searched underneath the sod and observed the long, tedious process of growth while the cords and meshes of the mycelium have increased, and extended their lines through the moist soil. If we do search there and observe we see that sometime before the shaggy heads peep forth, tiny bodies appear on the cords of mycelium; first like a pin head in size, then as large as a pea and the size of a thimble they grow. A great deal of

growth has taken place in the formation of these tiny bodies beneath the soil. They are made up of delicate threads and the tiniest cells which have multiplied until there are countless numbers of them. Now when every thing is ready in these fungus "buttons," the tiny cells already formed, as well as new ones still forming, expand rapidly and this pushes the mushroom up into view in a single night.

In figure 84 are shown two buttons of the size when they are just ready to break through the soil. They are now quite dark

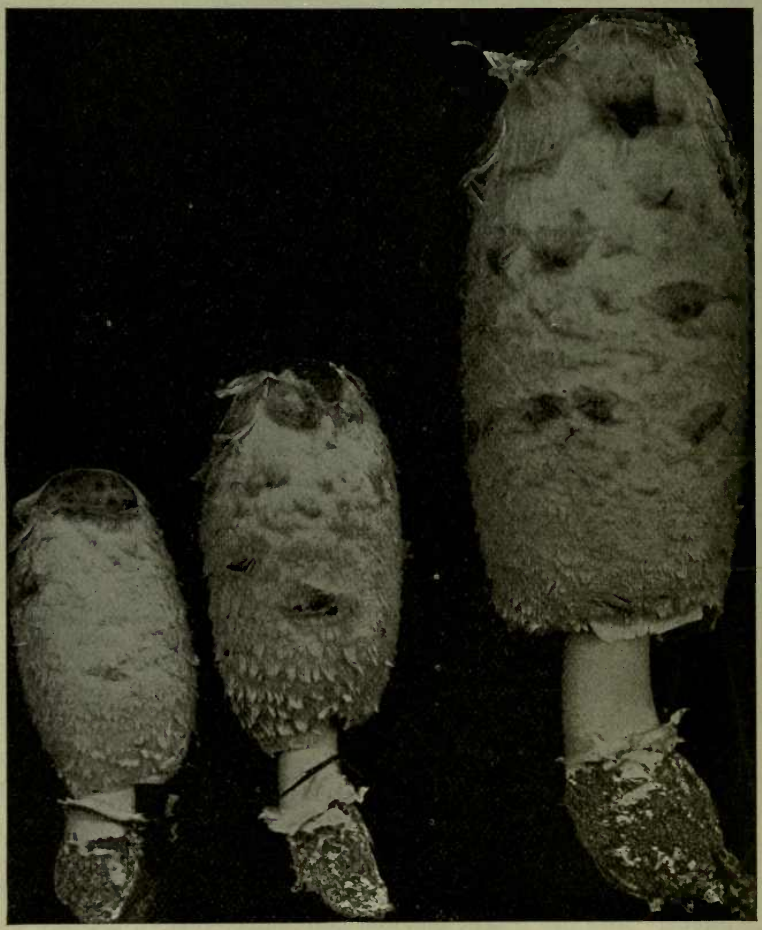


84.—"*Buttons*" *of Coprinus; two in section, showing gill slits and hollow stem.* (*Natural size.*)

in color on the outside. They appear mottled with dark and white, for the outer layer of fungus threads, which are dark brown, is torn and separated into patches or scales, showing between, the delicate meshes of white threads which lie beneath. The upper part of the button is already forming the cap or "pileus," and the slight constriction about midway shows the lower boundary or margin of the pileus where it is still connected with the undeveloped stem.

We are curious to know if the internal structure of these buttons will reveal the parts of the mushroom. We can learn this by splitting buttons through from one end to the other with a

sharp knife. At the right of each of these buttons in the figure is shown a section of a plant of the same age. Here the parts of the plant though still undeveloped are quite well marked out. Just underneath the pileus layer are the gills. In the section



85.—*Coprinus comatus, removed from soil.* (*Natural size.*)

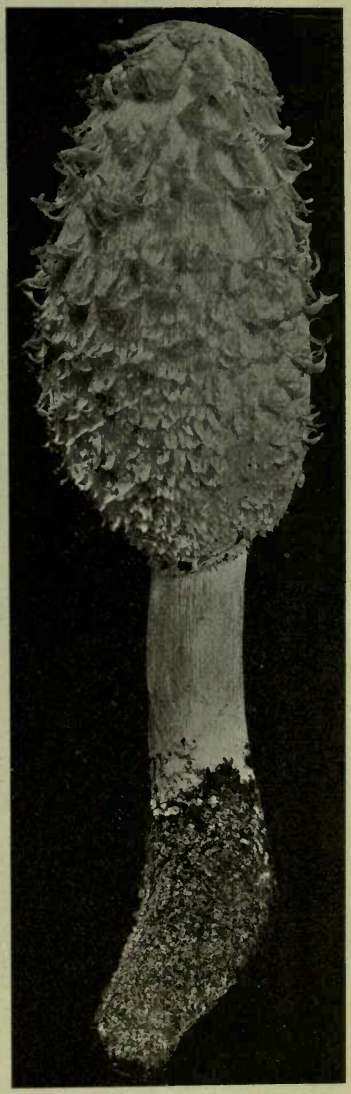
one gill is exposed to view on either side. They are long, narrow, and taper at each end. In the section of the larger button the free edge of the gill is still closely applied to the stem, while in

the small one the gills are separated a short distance from the stems showing "gill slits." Here, too, the connection of the margin of the pileus with the stem is still shown. From our first study of mushrooms (Bulletin 138) we know that this connecting layer between the margin of the pileus and stem forms the veil. This kind of a veil is a marginal veil.

The stem is hollow even at this young stage, and a slender cord of mycelium extends down the center of the tube thus formed as is shown in the sections. From the button stage the growth is quite rapid, and in a short while the plants are full grown.

Now the plants are nearly all white. The brown scales so close together on the buttons are widely separated except at the top or center of the pileus, where they remain close together and form a broad cap resting jauntily on the shaggy head. This is shown in figure 85 which is from a photograph of three plants removed from the sod.

A study of the different stages, which appear from the button stage to the mature plant, reveals the cause of this change in color and the wide separation of the dark brown scales. The threads of the outer layer of the pileus, and especially those in the brown patches seen on the buttons, soon



86.—*Coprinus comatus, well meriting the name "shaggy mane".* (*Natural size.*)

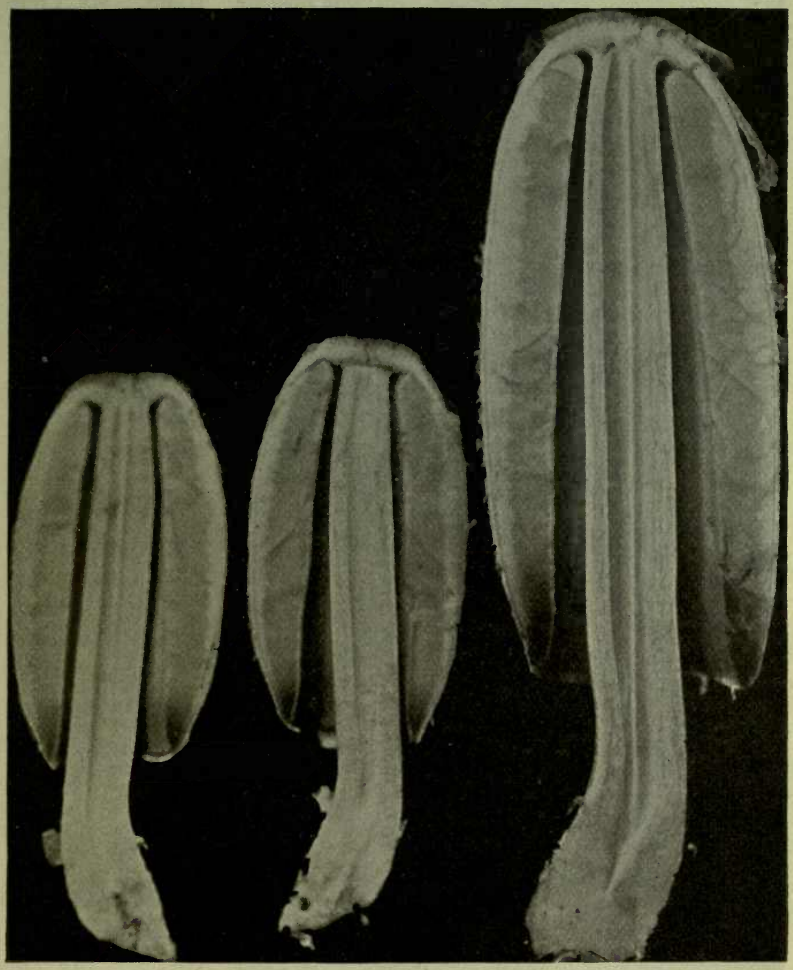
cease to grow, though they are firmly entangled with the inner layers. Now the threads underneath and all through the plant, in the gills and in the upper part of the stem grow and elongate rapidly. This pulls on the outer layer tearing it in the first place into small patches and causing them later to be more widely separated on the mature plant. Some of these scales remain quite large while others are torn up into quite small tufts.

87.—*Coprinus comatus, surface of pileus gathered in loups.* (*Natural size*).

As the plant ages, the next inner layers of the pileus grow less rapidly, so that the white layer beneath the brown is torn up into an intricate tangle of locks and tufts, or is frazzled into a delicate pile which exists here and there between well formed tufts. While all present the same general characters there is considerable individual variation as one can see by comparing a number of different plants. Figure 86 shows one of the interesting conditions. There is little of the brown color, and the outer portion of the pileus is torn into long locks, quite evenly distributed and curled up at the ends in an interesting fashion which merits well the term "shaggy." In others the threads are looped up quite regularly into triangular tresses which appear to be knotted at the ends where the tangle of brown threads holds them together as if some fairy had plaited the lock.

There is one curious feature about the expansion of the pileus

of the shaggy-mane which could not escape our attention. The pileus has become very long while comparatively little lateral



88.—*Coprinus comatus, sections of the three plants shown in figure 85. (Natural size).*

expansion has taken place. The pileus has remained cylindrical or barrel-shaped, while in the case of the mushrooms treated of in our first study the pileus expanded into the form of an umbrella.

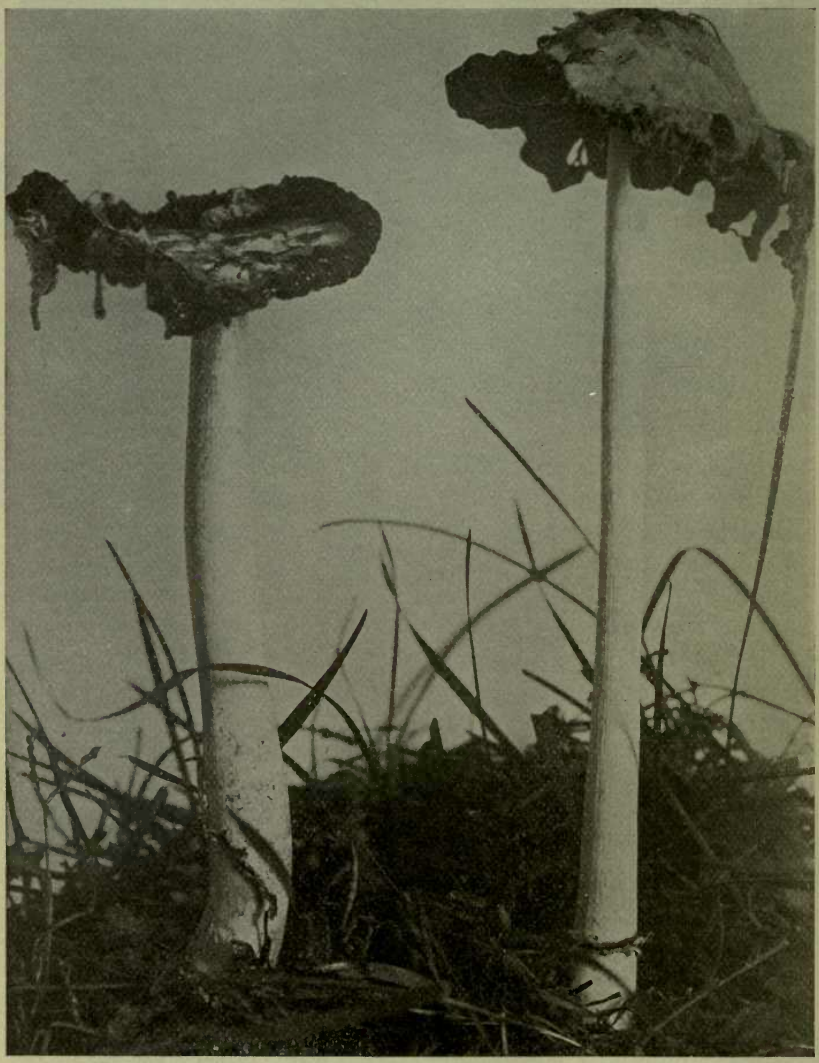
The cylindrical or barrel-shaped pileus is characteristic of the shaggy-mane mushroom. As the pileus elongates the stem does also, but more rapidly. This tears apart the connection of the margin of the pileus with the base of the stem, as is plainly shown in figure 85. In breaking away, the connecting portion or veil, is freed both from the stem and from the margin of the pileus, and is left as a free, or loose ring, around the stem. In all of the plants of our former study, the common mushroom (*Agaricus campestris*), the smooth lepiota (*Lepiota naucina*), and the deadly amanita (*Amanita phalloides*), the ring remained attached to the stem, *i. e.*, it is not a free ring in those

89.—*Coprinus comatus, early stage of diliquescence. The ring is lying on the sod.* (*Natural size.*)

species. In the shaggy-mane the veil does not form a thin expanded curtain as in the three species just enumerated. It is really an annular outer layer of the button lying between the margin of the pileus and the base of the stem. It becomes free from the stem. As the stem elongates more rapidly than the pileus, the latter is lifted up away from the base of the stem. Sometimes the free annulus is left as a collar around the base of the stem, still loosely adherent to the superficial layer of the same, or it remains for a time more or less adherent to the margin of the pileus as shown in the plant at the left hand in figure 85. It is often lifted higher up on the stem before it becomes free from the pileus, and is then left dangling somewhere on the stem, or it may break and fall down on the sod. In other instances it may remain quite firmly adherent to the margin of the pileus so that it breaks apart as the pileus in age expands somewhat. In such cases one often searches for some time to discover it clinging as a sterile margin of the pileus, so closely does its outer texture resemble the outer texture of the pileus. It is interesting to observe a section of the plants at this stage. These sections can be made by splitting the pileus and stem lengthwise through the middle line with a sharp knife as shown in figure 88. Here, in

90.—Coprinus comatus, later stage of diliquescence, pileus becoming more expanded. (Natural size).

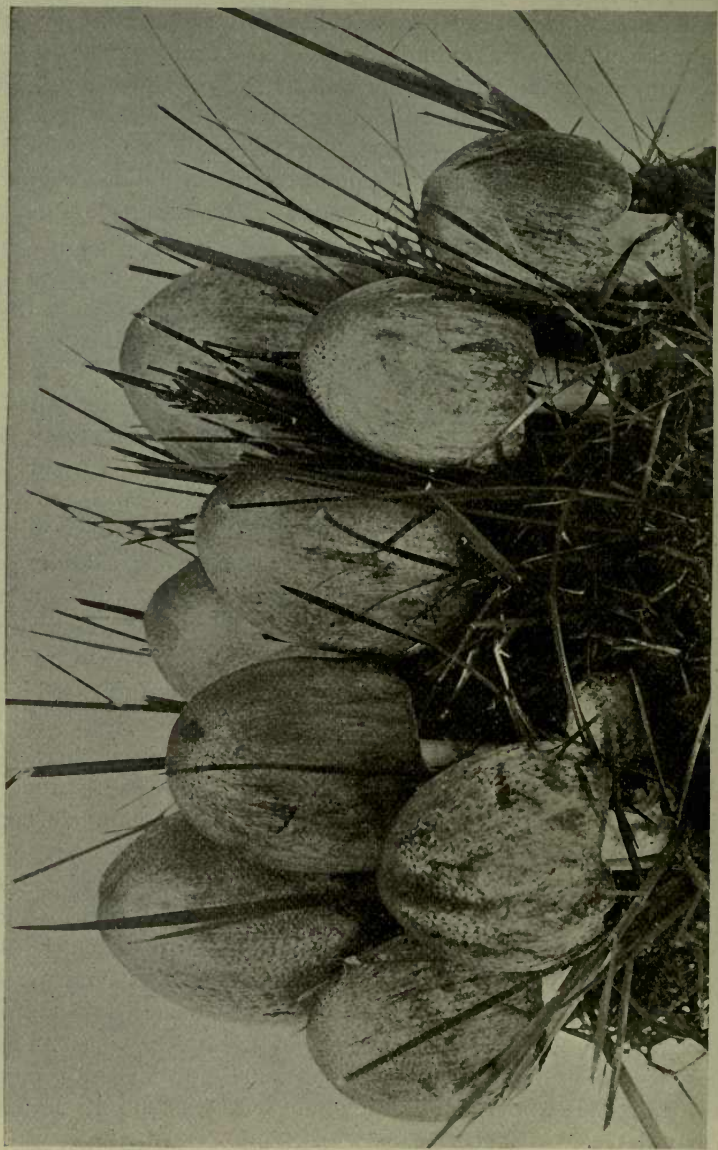
the plant at the right hand, the "cord" of mycelium is plainly seen running through the hollow stem. This cord is well seen



91.—*Coprinus comatus, drops of inky fluid about to fall from wasted pileus. (Nutural size).*

if one partly splits a stem and then gently pulls the halves apart. At the same time if the stem is held toward the light a very delicate mesh of threads, reminding one of the finest gauze, is seen extending from the cord to the wall of the tubular stem. The gills form a large portion of the plant for they are very broad and lie closely packed side by side. They are nowhere attached to the stem but at the upper end round off to the pileus leaving a well defined space between their ends and the stem. The pileus, while it is rather thick at the center, *i. e.*, where it joins the stem, becomes comparatively thin where it spreads out over the gills. At this age of the plant the gills are of a rich salmon color, *i. e.*, before the spores are ripe, and the taste when raw is a pleasant nutty flavor reminding one of the meat of fresh green hickory nuts. In a somewhat earlier stage the edges of all the gills are closely applied to the stem which they surround. So closely are they applied to the stem in most cases that threads of mycelium pass from the stem to the edge of the gills, so that they might be said to be "sewed" together. As the pileus expands slightly in ageing, these threads are torn asunder and the stem is covered with a very delicate down or with flocculent particles which easily disappear on handling or by the washing of the rains. The edges of the gills are also left in a frazzled condition as one can see by examining them with a good hand lens.

The spores now begin to ripen and as they become black the color of the gills changes. At the same time the gills and the pileus begin to dissolve into an inky fluid, first becoming dark and then melting into a black liquid. As this accumulates it forms into drops which dangle from the pileus until they fall away. This change takes place on the margin of the pileus first, and advances toward the center, and the contrast of color, as the blackening invades the rich salmon, is very striking. The pileus now begins to expand outward more, so that it becomes somewhat umbrella shaped. The extreme outer surface of the pileus does not diliquesce so freely, and the thin remnant curls upward and becomes enrolled on the upper side as the pileus with wasted gills becomes nearly flat.



92.—*The "ink-cap", Coprinus atramentarius, nearly smooth form. (Natural size).*

II.—THE INK-CAP (*Coprinus atramentarius*).

The ink-cap (*Coprinus atramentarius*) occurs under much the same conditions as the shaggy-mane, and is sometimes found accompanying it. It is usually more common and more abundant. It springs up in old or newly made lawns which have been richly

93.—*Coprinus atramentarius, scaly form.* (*Natural size.*)

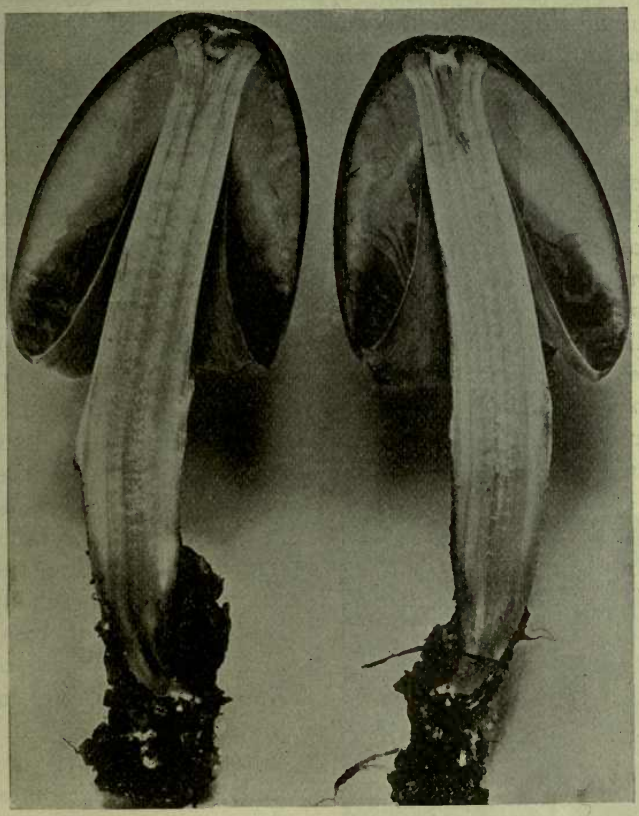
manured, or it occurs in other grassy places. Sometimes the plants are scattered, sometimes two or three in a cluster, but usually large clusters are formed where ten to twenty or more are crowded closely together (figure 92). The stems are shorter than those of the shaggy-mane and the pileus is of a different shape and color. The pileus is more egg-shaped or oval. It

varies in color from a silvery grey in a few forms, to a dark ashen grey, or smoky brown color in others. Sometimes the pileus is entirely smooth, as I have seen it in some of the silvery grey

94.—*Coprinus atramentarius; showing annulus as a border line between scaly and smooth part of stem.* (*Natural size.*)

forms, where the delicate fibres coursing down in lines on the outer surface cast a beautiful silvery sheen in the light. Other forms present numerous small scales on the top or center of the pileus which are formed by the cleavage of the outer surface here into large numbers of pointed tufts. In others, the delicate tufts cover more or less the entire surface, giving the plant a coarsely granular aspect. This is perhaps the more common appearance, at least so far as my observation goes. But not infrequently one finds forms which have the entire outer surface

of the pileus torn into quite a large number of coarse scales, and these are often more prominent over the upper portion. Fine lines or striations mark also the surface of all the forms, especially toward the margin where the scales are not so promi-



95.—*Coprinus atramentarius, section plant.* (*Natural size.*)

nent. The marginal half of the pileus is also frequently furrowed more or less irregularly, and this forms a crenate or uneven edge.

The annulus or ring on the stem of the ink-cap is very different from that of the shaggy-mane. It forms an irregularly zigzag elevated line of threads which extend around the stem near the base. It is well shown in figure 94 as a border line

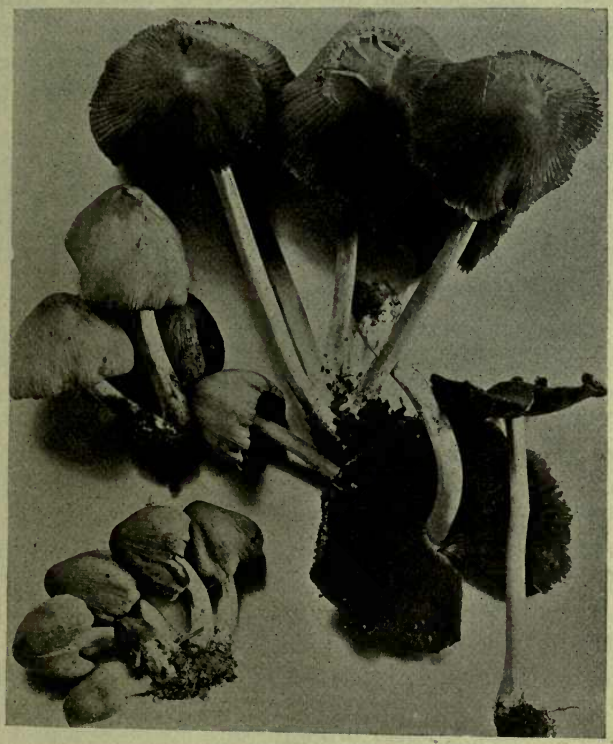
between the lower scaly end of the stem and the smooth white upper part. It is formed at the time of the separation of the margin of the pileus from the stem, the connecting fibres being pulled outward and left to mark the line of junction, while others below give the scaly appearance. It is easily effaced by rough handling or by the washing of the rains. A section of a plant is illustrated by a photograph in figure 95. On either side of the stem is shown the layer of fibres which form the annulus, and this layer is of a different texture from that of the stem. The stem is hollow as seen here also. In this figure one can see the change in color of the gills just at the time when they begin to diliquesce. This diliquescence proceeds much in the same way as in the shaggy-mane, and sometimes the thin remnant of the pileus expands and the margin is inrolled over the top.

III.—THE GLISTENING COPRINUS (*Coprinus micaceus*).

The third species described here is the glistening coprinus (*Coprinus micaceus*). It received this name because of the very delicate scales which often cover the surface of the pileus, and glisten in the light like particles of mica. This plant is very common during the spring and early summer though it does appear during the autumn. It occurs about the bases of stumps or trees or in grassy or denuded places, from dead roots, etc., buried in the soil. It occurs in dense tufts of ten to thirty or more individuals; sometimes as many as several hundred spring up from the roots of a dead tree or stump along the streets or in lawns, forming large masses. More rarely it occurs on logs in the woods, and sometimes, the plants are scattered in lawns. From the different habits of the plant it

96.—*The "glistening coprinus," Coprinus micaceus; young stage showing annulus, on the pileus the "mica" particles.* (*Natural size.*)

is sometimes difficult to determine, especially where the individuals are more or less scattered. However, the color of the plant, and the markings on the pileus, especially the presence of the small shining scales when not effaced, characterize the plant so that little difficulty is experienced in determining it when one has once carefully noted these peculiarities.



97.—*Coprinus micaceus, showing different aspects.* (*2-3 natural size.*)

Figure 96 is from a group of three young individuals photographed just as the margin of the pileus is breaking away from the lower part of the stem, showing the delicate fibrous ring which is formed in the same way as in Coprinus atramentarius. The ring is much more delicate and is rarely seen except in very young specimens which are carefully collected and which

have not been washed by rains. The mature plants are 8 cm. to 10 cm. high (3–4 inches), and the pileus varies from 2 cm. to 4 cm. in diameter. The stem is quite slender and the pileus and gills quite thin as compared with the shaggy-mane and ink-cap. The gills are not nearly so crowded as they are in the two other species. The pileus is tan color, or light buff, or yellowish brown. Except near the center it is marked with quite prominent striations which radiate to the margin. These striations are minute furrows or depressed lines, and form one of the characters of the species, being much more prominent than on the pileus of the ink-cap.

In wet weather this coprinus melts down into an inky fluid also, but in quite dry weather it remains more or less firm, and sometimes it does not diliquesce at all, but dries with all parts well preserved though much shrunken of course as is the case with all the very fleshy fungi.

Many persons who are fond of mushrooms do not venture to collect and eat other species then the *Agaricus campestris*. Many will tramp considerable distances to collect the "pink gilled agaric," and pass by on the street, or perhaps in their dooryard, a clump of coprinus sufficient for a meal. During the spring and early summer the *Agaricus campestris* is not to be had in the open, while these three species of coprinus usually grow in abundance, though the shaggy-mane is usually more abundant in the autumn than in the spring.

During the autumn of 1898 the common "pink gilled mushroom" (*Agaricus campestris*) was very rare in the vicinity of Ithaca. This has led a few to search for other forms. Two of my friends during October brought into my office a peck basket filled with mushrooms, and wished to know if they were "good to eat." Nearly all of the plants were the "ink-cap" (*C. atramentarius*), there were four or five of the shaggy-mane (*C. comatus*), and a single "glistening coprinus" (*C. micaceus*). All of them good to eat and collected in a single dooryard. One of these gentlemen had never before ventured to partake of any other species than the *Agaricus campestris*.

During the early summer of 1897, while collecting a "mess"

of *Coprinus micaceus* from a large tuft growing around the base of a stump on one of the principal streets of Ithaca, a passer-by halted, probably for the charitable purpose of giving some information which he thought might save my life. "Them's toad-stools ain't they?" "Yes," I replied. "Well, I thought so," said he. Thereupon I ate one of the "toad-stools" raw, and received from him a look of mingled pity and despair as he passed on.

All of these three species have a somewhat nutty flavor, that of fresh hickory nuts when eaten raw, but they are more palatable when properly prepared for the table. The *Coprinus micaceus* need only be rinsed to remove from the caps any adhering particles of soil. The other two species may be peeled if it is desired to remove the outer and tougher layer of the pileus, or this may be done by gently scraping. The shaggy-mane peels well by starting at the margin of the pileus and with the fingers stripping off the outer layer. The ink-cap peels more readily by first splitting the pileus in halves and then starting the strip at the top of each half. It is sufficient, however, to gently scrape the surface of the pileus to remove the coarser outer fibers and whatever soil may adhere.

To those who are not acquainted with any of the species of coprinus and wish to extend the range of species collected for table use these three species are commended. The shaggy-mane is perhaps the most delicious of the three, but the other two are much more abundant usually. By a careful comparison of the species growing in lawns, and along streets with these descriptions, and especially with the illustrations, there should be no trouble in identifying them. While the camera here has not at present succeeded in reproducing all the colors, this series of photographs illustrates well the habit, texture and specific characters of the plants, and the color values in black and white are quite faithfully represented. It is doubtful if any hand coloring has yet succeeded in producing such perfect imitations as these photographic studies of the shaggy-mane and ink-cap. That they accurately portray the habit and specific characters of these plants I am convinced by the experience of my little boy of eight years. While selecting the illustrations for this study one evening, I

showed him the photographs, told him the names of each and the parts of the mushroom. The subject was not mentioned again until a week later when I brought in a few specimens of one of the species. "What is the name of this?" I said. "That's the shaggy-mane," he said. "What part is this?" "That's the cap." "And this?" That's the ring." "And this?" That's the stem." "Now, father," he said, "where's the ink-cap?" At another time he was able to select the ink-cap from among a miscellaneous collection.

While the *Coprinas micaceus* usually grows on decaying wood, or roots, etc., underneath the soil, the shaggy-mane and ink-cap grow in rich soil in grassy places, especially such as have been quite recently manured. This latter peculiarity of growing on manured ground, or on dung, so characteristic of a number of the species of the genus, suggested the name "*coprinus*," from the work "*kopros*," meaning dung.

A large number of the species of the genus, practically all the large fleshy ones (some of the smaller also) diliquesce into an inky fluid. In the delicate or membranous ones, usually quite small species, the pileus splits in radiating lines above each gill in such a way that the gill itself is split downward, thus giving to the pileus a fluted appearance.

In bulletin 138 the writer suggested the formation of mycological clubs as a medium for the exchange of information among interested persons in a given community. At that time there was already in existence among others, the Boston Mycological Club, New York Mycological Club and the Philadelphia Mycological Center. Since that time there have been organized the Washington Mycological Club, Chicago Mycological Club, and others.

CORNELL MYCOLOGICAL CLUB.

A mycological club has recently been organized at Cornell University, with a somewhat broader work in view. It is called the "Cornell Mycological Club" and is under the supervision of the members in the Botanical Department. Its purpose is to study the fungi, to propagate information concerning them among its members, and to encourage the growing popular interest in those

groups of economic importance, to which belong especially the edible, poisonous and parasitic fungi.

The rules governing the club are such that they admit to membership any person interested in its aims and work. No other qualifications except the payment of the small annual fee of twenty-five cents, are necessary, and any person sending name and enclosing the fee will be placed on the membership roll. This small fee is to be used in necessary expenses incurred relating to executive matters of the club, as determined by the Executive Council. With this small fee it will not be possible at present to publish a bulletin of information. It is hoped, however, that it will lead eventually to some medium of communication among members, by which a knowledge of the numerous local fungus floras may be obtained, and that this information as well as other matters of interest may be regularly communicated to members.

It is purposed to make the club a center to which persons interested in the study, and in becoming acquainted with the fungi, may appeal for aid in the determination of species they collect. To this end a few general directions are given here for those who desire to know how to put up specimens properly for mailing, so that they will not be broken or ruined in transit.

HOW TO MAIL FLESHY FUNGI.

Fresh "mushrooms," or "toad-stools" if of medium or large size, should be wrapped separately in tissue paper, or if the plants grow in tufts the paper can be worked in between the individual specimens unless the tuft is a compact one. A sufficient amount of paper should be used to give support to the expanded parts of the plant, and so arranged that delicate structures on the surface will not be rubbed away. The plants should then be packed quite firmly, but not crushed, into a tin box, or a light but strong wooden box. If they do not quite fill it more paper can be added, so that they will not jostle about, or they become badly broken. Pasteboard boxes are apt to become broken and ruin the specimens.

In collecting the mushrooms do not break off the stems, but pry the stems out of the earth carefully in order to preserve all

the characters on the lower end of the stem. Also use care in handling the stems so that the "collar," when present, and the delicate scales, be not rubbed off. The corky or woody fungi growing on trees, logs, stumps, etc., may be wrapped in the same way. In all specimens from logs or trees, the name of the wood should be given when that is accurately known. When the name of the tree is not known a portion of the wood and bark, or some leaves, nay accompany the specimen. The corky or woody fungi may be dried before mailing if desired. To dry the fleshy fungi requires considerable care, and usually artificial heat, for they must be dried quickly, not burned or roasted, though careful notes upon the characters of the plants while fresh, should also be made before they are dried, in most cases.

An extemporized oven for drying may be made of tin, with holes in the sides for ventilation. In this the plants can be placed in paper boxes while they are drying. The oven may then be placed above a stove, or a lamp may be placed underneath it. Shelves above a stove where warm air is constantly rising is a good place to dry the plants. The best place that I have ever used is the brick work around a large steam boiler, the plants, or boxes containing them, being placed directly on the brick work. Parasitic fungi on leaves of plants should be dried between absorbent paper under some pressure to keep the leaves from shriveling and curling.

Dried specimens of the mushrooms can be wrapped in tissue paper for shipment. It is better in most cases, however, if the plants are shipped away for determination, to send them in a fresh condition. At least some duplicates are desirable in a fresh condition, since fresh material is often necessary for determination of the species, especially with doubtful species, and in the case of many genera.

When fresh material is mailed, if the sender will use foresight in putting it up and mailing just in time for a mail train which makes good connections through, specimens will usually travel several hundred miles and arrive in a good condition.

Specimens sent by mail require, according to the present postal regulations, 1 ct. per 2 ounces in weight, and the package should be marked "plants." Wherever it is desired to

send by express, the sender should pay the express charges, except where good material prepared and named for the herbarium or museum is contributed, or where the sender is certain that the material is of value, as in the case of some rare specimens. In all cases where a list of the plants is desired in return, the sender should enclose a number with each specimen, so that the names can be given to correspond with the numbers. All desirable material will be preserved and kept in the herbarium here where it will be available for comparison and for study. For this reason the locality and date of collection and other notes of interest should accompany the specimens. After one has had some experience in the collection of these plants and in noting the important characters their specimens will be of more value. It is possible in this way for collectors to aid us in bringing together material from different sources which should assist in making these studies and illustrations of mushrooms more comprehensive and of wider usefulness.

From students of the fungi who have duplicate material in any of the groups, the Botanical Department will welcome contributions to the herbarium. Such gifts are certain to be of great usefulness at a center where students come for research. Not only is this branch of botanical study, as well as others emphasized, it is important to consider that mycological study here contributes to, and is supplemented by, other fields of research in related departments, as well as in the work of the Experiment Station, and in that of the newly organized College of Forestry.

Specimens may be sent to either of the following addresses:

PROFESSOR GEO. F. ATKINSON,
Botanical Department,
Cornell University, Ithaca, N. Y.

or,

CORNELL MYCOLOGICAL CLUB, Ithaca, N. Y.

Persons desiring to join the Club should send name with the annual fee enclosed, to either of the above addresses. The fee should *not be sent in postage stamps*, but preferably in a postal note when in so small a sum, unless the "quarter" is enclosed

in a mailing card for the purpose. The cost of sending will be reduced where several from the same locality choose to send names and fees in a single letter. The exact address should also be given for each person, with the street number where necessary.

Those wishing to take up the study of the fungi would find it profitable to attend some school where suitable opportunities are offered for beginners. A course in mycology* (devoted especially to the mushrooms) will be given during the summer of 1899 in the Botanical Department of Cornell University.

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* Besides the course in mycology, courses in general morphology and physiology of plants, as well as a course in ecology are offered in the summer school especially for teachers. The catalog of the summer school can be obtained by addressing, The Registrar, Cornell University, Ithaca, N.Y. A full year's course in mycology is given during the regular annual session of the University as described in the annual Register.

NOTE.—The author was asissted in making some of the photographs illustrating this bulletin, by Mr. H. Hasselbring, and Mr. B. F. White.

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