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UPON

FARM PESTS,

INCLUDING

INSECTS, FUNGI, AND ANIMALCULES,

DELIVERED AT A MEETING OF THE

NEW HAMPSHIRE BOARD OF AGRICULTURE,

BY

delphus
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PESTS OF THE FARM,

INCLUDING INSECTS AND MICROSCOPIC FUNGI.*

BY DR. HIRAM A. CUTTING, LUNENBURG, VT.

INSECT PESTS.

It seems proper, as an introduction to the study of farm pests, that I should say something of the general nature of the objects of which I speak. As I first speak of the visible pests called insects, I will define them. Perhaps it would seem almost superfluous to define the meaning of the word "insect," yet I seldom find among the young a perfect understanding of the classifications of life as found in the animal kingdom. This kingdom is divided into four great classes :—

1. Animals of all kinds that have back-bones, or "Vertebrata," and then again they are subdivided into four classes ; viz., mammals, birds, reptiles, and fishes.

2. Animals made up of segments or joints, "Articulata." These are again subdivided into—

"Insects," a term from the Latin that signifies "cut into," which expresses that peculiar segmented form. They generally have six legs when adult.

"Arachnida," as spiders, mites, etc., having eight legs.

* This lecture was illustrated by nearly two hundred colored drawings, two by two and one-half feet in size, several of which have been engraved for this work.

"Crustacea," as crabs, lobsters, etc., with from ten to fourteen legs.

"Myriapoda," as thousand-legged worms, or those having more than fourteen legs.

"Annelida," or true worms without legs, as the earth-worm.

3. Animals with soft bodies, called "Mollusca." These are without distinct joints, and have no internal or external skeleton.

4. Animals that radiate from a central point like stars, called "Radiata."

But we will return to our special class. Insects are further known by having their bodies divided into three distinct parts, as follows: The head, containing the organs of sense; the thorax, which bears the organs of locomotion; and the abdomen. They also undergo a series of molts or changes, and usually exist in four distinct stages, known as the egg; next as the "larva," or masked or hidden form, usually so unlike as not to be known by its appearance, though an active stage of its life; then, as the "pupa" or "chrysalis," which is an inactive state; and lastly, as the "imago," or perfect and usually beautiful insect.

To sum up, an insect is a thirteen-jointed, six-legged animal, divided into three distinct parts, as above described, and may be with or without wings; with an external skeleton, and undergoing transformations, breathing through little breathing-holes in its sides, known as "spiracles," which lead to air tubes, answering to our lungs, and known as trachea.

This short explanation shows how we may best prepare ourselves to fight this common enemy. If we can in any way stop their breath, by dust or any viscid substance that stops the spiracles by filling them, we drown them as we would drown in water. With many, this method is very effective, as breath is much more necessary than food. In fact, to the adult insect food is not always necessary, while breath ever is.

But our insect is further classified:—

1. "Hymenoptera," meaning clear or membrane winged, as flies, bees, etc. Some insects of this order have mouths fitted for biting and sucking, with a complex structure, as the honey-bee.

2. "Coleoptera," meaning sheathed or covered wings. These are known as beetles, and go through a complete transformation. The "Colorado potato-bug" is a beetle of this class.

3. "Lepidoptera," meaning scale wings, or wings with microscopic plumage, as butterflies and moths; transformations also complete.

4. "Hemiptera," or half-winged. The insects of this order are known as bugs. Some have no wings, or only rudimentary ones, while others are winged and feed upon plants only.

5. "Diptera," meaning twice-winged or two-winged. This order is very troublesome to man, and is found everywhere upon the earth's surface where inhabitable; the mosquito, gnat, wheat-midge, cabbage-maggot, onion-maggot, etc., belonging to this order.

6. "Orthoptera," or straight wings, meaning straight-winged insects, including grasshoppers, locusts, etc.

7. "Neuroptera," or nerved-winged insects, their wings resembling net-work, as the dragon-fly.

Many of this order are beneficial, and few really injurious, to man.

The time was when any person that attempted the study of the insect world was derided and laughed at; the derisive term of "bug-hunter" was applied to him, and every person supposed that to run after and catch bugs was the insane idea in his life.

More than a century ago, the Swedish authorities became greatly alarmed at the fearful destruction of the timber in their dock-yards by a minute boring-beetle. They at length applied to that renowned "bug-hunter," Linnæus. He told them that the perfect beetle, that laid the eggs for the borer, only appeared in the month of May, and if they would submerge their timber that month, they would be free from its ravages. The government did this, and by this simple and inexpensive method saved their timber, and at the same time brought the "bug-hunter" into respect as an entomologist, a term from the Greek, meaning "one who discourses upon insects," or treats of them and their habits.

In Prussia and Germany the rudiments of entomology are

taught in their common schools, and I would ask if, in a country where the damage from insects is variously estimated from one hundred million to one billion of dollars per annum, and the extermination of insect pests becomes almost imperative, it is not worth while for us to look about us for the necessary information to intelligently fight our foes?

In a letter before me, I am asked, "What is science good for, if scientific men are baffled by one little insect which they cannot devise means to exterminate?"

Science is not baffled, but, like Hercules in the old fable of the Wagoner, can help you and will help you, only when you help yourselves. I may now hear you ask, How may we help ourselves? or, How can New Hampshire alone help herself? We may safely calculate that the insect ravages in New Hampshire for one year will exceed three millions of dollars. Now is it too much to say that a concerted action on the part of all agriculturists would decrease this damage one-half? Did science have full control of our legislatures, law would require and enforce the necessary concert of action; and while agriculturists would groan under imaginary tyranny, they would reap the reward. As agriculturists control the legislature, ought they not to take their best interests under consideration, and do something for themselves?

Concerted action is the only way to combat insect foes, and the law must protect this concerted action from the thriftless ignoramus that don't care for himself or neighbors. The fact is, that the ravages of hostile insects represent a condition of war, and it is only by organization, and appropriate weapons, that they can be conquered. The proper subjects for consideration are the materials to be used, and the best time to make the attack in force, and the weapons to be employed. It is entirely useless for us to fold our arms and exclaim, "It is the will of God!"

It is to lead the farmer to realize his position, and to show him how easy it is to study natural history for his personal benefit, that I presume to stand before you to-night. I will first introduce to you the ten-lined potato-beetle.

Fig. 1.

TEN-LINED POTATO-BEETLE,—COLORADO POTATO-BEETLE.
Doryphora Decemlineata. SAY.

a, a, eggs; *b, b, b*, larvæ of different ages; *c*, pupa; *d*, perfect insect; *e*, right wing-cover enlarged; *f*, leg enlarged.

This bug, so called, is, strictly speaking, a beetle, and is known to naturalists under the name of *Doryphora decemlineata*. It was first described by Thomas Say, who was then with Long's exploring expedition to the Rocky Mountains. The specimens from which his description was written, were collected in the region of the upper Missouri, and it was found there quite common. Its food in its native place was the wild potato, so common to this mountainous region.

As civilization advanced toward this far western section, carrying the cultivated potato within its reach, this insect acquired the habit of feeding upon it; it even seems to thrive upon the cultivated potato better than upon the wild ones, and, as a result, its numbers vastly increased. In 1859, it had spread eastward to a point one hundred miles west of Omaha city, in Nebraska. Prof. Riley says that in 1861 it had invaded Iowa, and during the next four years it had reached the Mississippi River. In 1864 and 1865, it crossed that river, invading Illinois, from which time it has gradually but surely spread over all the Middle and Northern States.

The first account of its destructive propensities was published in the *Prairie Farmer* for August 27, 1861. From this time until the present, frequent reports and descriptions have been published.

In 1874, it was found upon the sea-coast in New Jersey, but it was in 1876 that the advance guard invaded New England.

Like other higher species of the Coleoptera, it passes through a complete metamorphosis, but, unlike many other beetles, it confines itself during its entire life to the same species of vegetation, and, unhappily, selects as its first choice the potato. This beetle, however, is not, like many of our pests, an importation, but an original native, of the Far West. Its name would indicate Colorado as its birthplace, but historical facts, as I have before stated, would indicate upper Missouri. Yet Prof. Riley thinks it also existed in Colorado. It, however, seems true that this beetle committed severe depredations in Nebraska and Kansas before it was ever seen by the farmers of Colorado, and when it infested that section the people there considered it of eastern origin; but its exact birthplace does not matter.

That it is a great lover of the potato-plant is certain; yet it can exist upon other food when potatoes fail, but first selects the tomato and other plants nearly allied in properties to the potato-leaf; but such plants are seldom attacked until the potato-fields are fully devastated. The eggs of this beetle are deposited, to the number of seven or eight hundred, by each female, at intervals during from twenty-five to forty-seven days, on the leaves of the potato, in regularly arranged clusters of from twenty to sixty eggs each. They are of an orange color, and always on the under side of the leaf. In a week after they are deposited they hatch into larvæ, which feed upon the foliage about two weeks, though some fix the period at seventeen days. When full grown they descend to the ground, where they change into a pupa state near the surface. The perfect beetle appears in a little less than two weeks, pairs when about one week old, and a week later commences the deposit of eggs, as before described. From two to four broods may be hatched in a season. The statements of the time are, however, liable to vary, being longer or shorter, according as the weather is more or less favorable to their development.

The mature beetle, as its name indicates, has ten lines of black lengthwise of its wing-covers, five on each side, the ground being a medium yellow. It has several black spots upon its head and thorax, also six legs, and pink gauze wings under the striped wing-covers. It passes the winter in the perfect beetle state, burrowing in the ground beneath the frost, coming out in the spring, just in season to lay its eggs on the young potato-plant.

The statement is sometimes made that the mature beetle does not feed, and that they infest the potatoes as soon as they break through the ground to lay eggs only. This is untrue. The beetles do feed, not as ravenously as the larvæ, but coming upon the young plant just as it breaks ground, it has little to eat to spoil the crop, and if in abundance it will certainly do so, as the crop of larvæ from the eggs come on so soon that what they leave is at once appropriated by them. It is at this stage of the crop that the farmer needs to be on the alert; though more numerous later in the season, when the tops are mature, they do very little damage.

Bad as these beetles are, they are not as bad as popular opinion makes them. Their first onset is the most severe, and farmers accustomed to give up to imaginary evils will talk about the extermination of the potato. Of that there is no danger from this cause. In Iowa, in 1870, the beetles were very abundant, so much so that they swarmed over barns and outhouses, and also entered dwellings so that you could hardly sit down or walk without crushing them; yet the crop of potatoes was the largest ever known, and they were retailed in the streets for twenty-five cents per bushel. This abundant crop was raised by every one planting in anticipation of high prices, thus bringing the opposite result.

By some this beetle is considered poisonous, but from no just cause, as it can be picked from the potatoes day after day, by whole families, with no bad results. Large quantities of them in a state of putrefaction, like all other animal matter, are disagreeable, and doubtless unhealthy, and they should never be left to putrefy, but be burned or destroyed with boiling water and then buried. As they are voracious feeders, they may be

killed with poison like Paris green, mixed with flour, and dusted on the potato-leaves. A much better way is to brush them off into a tin "catcher," made on purpose, to encircle half the hill.

We have much in New England to favor us in our persecution of this pest, by way of its natural enemies.

ENEMIES OF THE POTATO-BEETLE.

The lady-birds, — *Coccinella 9-notata* and pupa (Fig. 2), *Hippodamia 13-punctata*, larva and pupa (Fig. 3), — destroy multitudes.

The eggs of the lady-birds are very much like those of the potato-beetle in color, but are smaller, and not so many in a cluster, but always laid in close proximity to those of some other insect. As soon as they hatch they commence their war of extermination, and, as they are voracious feeders, they follow it up almost unceasingly. This lady-bird is about two-thirds the size of the potato-beetle when fully grown, of a yellowish red color, with two or more black markings on each wing-cover,

being shorter and more thick-set than the potato-beetle. In fine, they are about the size and the shape of a half pea. (See Figs. 2 and 3.) There are several varieties, but all are the friends of the farmer, and should have special protection.

So of the many-banded robber, *Harpactor cinctus* (Fabr.) (Fig. 4). It is ever actively on the lookout for food, and woe to the potato-beetle that falls into its sharp claws.

So of the spined soldier-bug, *Arma spinosa* (Dallas) (Fig. 5; a, its beak); c, the beak of the *Enschistus punctipes* (Say), which closely resembles the *Arma*. Doubtless, both species do a great work, as they are wholesale depredators, not alone upon the potato-beetles, but upon many farm pests.

There is also a parasitic fly (Fig. 6), *Tachia*, that not only destroys myriads of the larvæ of the potato-beetle, but also those of many other pests. The marks at the bottom of the cut denote its actual size.

There is also another deadly foe in the *Philonthus*, which Dr. Packard found to creep even into his hatching-cases and kill not only enough for food, but all; just as the weasel or mink will kill more chickens than they need for food. This beetle is black, with short wing-cases, and is, perhaps, the most terrible enemy of the Colorado beetle. It is a member of the family *Staphylinidæ*.

There are, perhaps, no natural enemies that will entirely kill them out, and so, like the farmers at the West, we are inclined to Paris green. It is, however, much more dangerous here than there. All know it is a deadly poison, and not rendered inert by being eaten by the beetles. Showers wash it from our hill-sides, together with the dead beetles, into our streams, where it kills the fish and doubtless poisons the water, so that cattle are more or less injured by it. On level land it can be used with much greater safety. If used at all it should be dusted on the leaves when wet with dew, while the beetles are in their larval state, or mixed with water at the rate of one tablespoonful of the green to a pailful of water. When applied dry it is better to mix with ten parts of flour, by weight; and great care should be taken not to inhale the dust, as it is very poisonous. When in solution it must be almost continually stirred, or the green will sink

in the bottom of the sprinkler, as it is not soluble in the water.

Prof. Riley, of Missouri, says that quite as good results may be obtained in using the ingredients from which green is made as from the finished article. The Paris green costs, say thirty-seven and one-half cents per pound, and the demand is often so great that it cannot be obtained just when wanted, especially in back towns. The following directions for making green, from Brande's Chemistry, are practical: Dissolve two pounds of sulphate of copper (blue vitriol, costing fifteen cents per pound, or thirty cents) in a gallon of hot water, keeping it in a stone jar. Dissolve in another large jar, one pound of common white arsenic (costing about six cents) and two pounds of saleratus or pearl-ash (costing sixteen cents) in forty-four pounds of hot water, stirring well till thoroughly dissolved. These articles, costing fifty-two cents, will make about five pounds of Paris green, which would cost \$1.88.

This can be kept in solution and mixed in proportion of one part of the first and five of the last solution, as they are needed. The green immediately begins to precipitate in a fine powder, and is much more convenient for use in solution than the dry article. Prof. Riley says that Paris green can be in this way used without danger; and all agree that in solution, or mixed with flour when dry and dusted on, it is the unfailing remedy.

Dr. Leconte advises the use of large atomizers, for not only the destruction of the potato-beetle, but of all insects that can be killed by a solution. This idea is worthy of consideration, and it may doubtless prove invaluable.

When this beetle first came among the farmers, all birds, like themselves, were suspicious of it, and it has often been reported that no bird would touch them. Such is not true. Ducks will devour them greedily. Turkeys and all fowls soon learn to like them for food, and chickens frequently take them in preference to any other insects. The crow not only takes the beetles and larvæ from the vines in great numbers, but late in the season digs for the beetles in the ground, and captures thousands of them. The rose-breasted grosbeak and many other birds have also a great liking for them. Skunks, toads, and snakes, even,

prey upon them ; then our winters are more severe than the winters West. Jack Frost creeps deeper into the ground, and must overtake many of the ten-liners that supposed themselves safe from cold.

Fig. 7.

Fig. 8.

Fig. 10.

Fig. 9.

THE BLISTERING BEETLES. *Cantharidæ*.

These beetles are also great eaters of the potato-plant. For several years they have done great damage in New England, but only in special localities. They have not become general. Those most injurious are the striped Cantharis, *Lytta vittata* (Fabr.) (Fig. 7), the margined Cantharis, *Cantharis marginata* (Olivier) (Fig. 8), the ash-colored Cantharis, *Lytta cinerea* (Fabr.) (Fig. 9, *a*, male), and the black Cantharis, *Lytta marina* (Leconte) (Fig. 9, *b*) ; *c* and *d* show the magnified antennæ of the male and female, rendering it easy to distinguish them. These beetles, while they will make short work of the potato-leaves, when abundant, are not very fastidious about their food. They will eat beets as soon as potatoes, and also pig-weed, or almost any kind of green leaves when the potatoes and beets fail.

There is another species, being a species of oil-beetle, *Meloe*

angusticollis (Fig. 10), which when plenty are a great foe to potatoes, tomatoes, beets, and various other vegetables ; but they are vulnerable to insect enemies, and so are only now and then abundant. They may be killed by Paris green as the potato-beetle, but cannot be picked off, as they are too spry for the fingers.

Fig. 11.

Fig. 12.

STRIPED SQUASH-BEETLE. *Diabrothica Vittata*. FABR.

1. Back view of the grub that eats the root and stalk. 2. Side view; both magnified. The marks show the actual length. Beetle natural size.

This beetle appears on cucumber and squash vines as soon as they are through the ground, and frequently they penetrate through the cracks made in the ground by the swelling and sprouting of the seeds of melons, cucumbers, or squashes, and, biting off the young sprout, destroy the plant before it is out of the ground. These beetles need little description. The cut shows the beetle in outline, and he is well known by the yellowish stripes upon his wing-covers. Their subsequent work, also, when the leaves appear above the ground, is well understood, but the biting off the young sprout, thus preventing the development of leaves, is frequently not known, and the seeds are thought to be poor, or other causes are assigned for their non-appearance above ground.

The gardener watches his plants until he thinks them beyond danger from this beetle, and then is surprised to see them wilt

and die without apparent cause. No wound or injury is found above ground, and so the destruction is looked for in the root. Here we soon discover the true cause of death, for the roots are found to be pierced here and there with small holes. In fact so many are found, that the root presents a corroded appearance. Upon closer examination the authors of the mischief are easily detected, either in the root or lurking in the corroded furrows. They are little whitish worms, about the length of the lines beside the enlarged view of the worms in this figure.

They are, as found, about the thickness of a good-sized pin. The head is blackish, brown and horny, and there is a plate of the same color on the last segment of the worm. These are the young of the beetle, or "striped bug," which was so troublesome on the leaves earlier in the season, and the eggs from which they hatched were laid low down on the stalk at that time. In this masked stage of worm life they do more damage than when in the beetle form on the leaves. When the worms are full grown, which is about a month from the time they hatch, they forsake the root, and retiring to the earth, by continually turning around they form for themselves a little cavity, or minute cave, with solid earthy walls, in which they throw off their skin and become a pupa. This pupa is much shorter and thicker than the worm; they remain inactive for about two weeks, taking no food. At the end of this time they throw off their skin again, and the perfect beetle is seen, still however in a soft condition, incapable of movement. Remaining in its cell till these soft parts have acquired solidity and strength, it breaks through the walls of its little house, and working itself slowly through the soil, appears in the light of day a perfect beetle. We have two generations each year, the second remaining in its dormant or pupa state through the winter. This generation, doing little damage, is not often noticed. Many vines not killed by the worm are so much injured that their value is nearly destroyed.

Covering the vines, with a box covered on top with muslin, has been considered the only sure remedy, though powdered charcoal, lime, and sometimes ashes can be used with benefit. In many cases, however, the material sprinkled on the leaf is as bad as the beetle. If a handful of shavings be burned near the hills

in the evening, many of them will fly into the flames. After various experiments I have become satisfied that covering the hills with common newspapers is much the best means to be used; besides, you get an accelerated growth of the plants. Just as soon as the seeds are planted, or, at any event, a day or two before the plants appear, open a newspaper to its full size, and spread it over the hill, letting it lie close on the ground, and fasten it in place by hoeing the dirt on the edges, so that no gust of wind can disturb it. The plants thus covered will grow at least a third faster than those not covered, are safe from the beetle, and, what is more, safe from the egg that produces the worm, or masked stage of the pest. The plants kept covered until the danger is past are more healthy in every way, producing blossoms several days sooner than those not covered. It is seldom that once covering will not answer all purposes, but should one be torn off from any cause, it can easily be replaced. I have tried different colors of paper, and find white or blue paper best adapted to the purpose. Other colors seem to give a pale green or sickly appearance to the plants. Newspapers are easily obtained, and are just as good as clear white paper. It will be seen, also, that this is a protection against late frosts, and I believe that every person who tries this method of protection will ever use it with entire satisfaction.

TENT-CATERPILLAR OF APPLE-TREES. *Clisiocampa Americana*.
HARRIS.

What farmer in New Hampshire is not familiar with the web nests of this caterpillar, glistening in the rays of the spring sun, before the trees are in blossom? Yes, before the leaves are one-half grown, these little white web nests speak volumes. They tell of a negligent, slovenly farmer, whose spare hours are got rid of as useless time, and the pests of his orchard revel in his neglected trees, among which the caterpillar holds conspicuous place. This small white glistening web, if unmolested, soon spreads over several branches, and the caterpillars strip the tree of its leaves, to the great damage of it, if not entailing death, which is ever liable to occur from this cause alone.

This caterpillar is well known to all, yet all do not understand

Fig. 13.

All natural size; *a*, larva full grown, side view; *b*, larva full grown, back view; *c*, cluster of eggs on a twig; *d*, cocoon.

Fig. 14.

its habits. The eggs are laid by a night-flying moth (Fig. 14). Its color is a dull, yellowish brown, or something inclined to the reddish tint; it is unusually thick-bodied and hairy. Its wings are characterized chiefly by the front wings being divided into three nearly equal parts, by two transverse whitish or pale yellowish lines, and by the middle space being paler than the rest of the wing, in the male, while it is often the same color as the rest, or even darker, in the female.

Riley says the color is very variable in the Western States. Dr. Fitch notices great variations, but in this section I do not find the variations very great, and think all will readily recognize the moth from the foregoing description.

The moth here described lays her eggs in the night, when she may be found hovering about the tree, in August, or, in the

southern part of the State, doubtless in the last part of July. She lays her eggs in oval rings, round the smaller twigs, as seen in Fig. 13, *a*. These rings contain some three hundred eggs each, and are covered over with a mucilaginous coating which answers the double purpose of keeping out the water, and serving as food for the young when they hatch, to give them sufficient strength to crawl down the limb to the first fork, where, by crawling back and forth, they weave from a spinneret in their mouths the tent in which they live. From this tent they sally forth twice a day for food, eating voraciously. On an average, each caterpillar will eat two apple-leaves a day, and no tree can long live under such a vital drain. As the weather gets warm, when they return from a meal, instead of going into their tent, they go to rest upon the outside, as *a* and *b*. Those coming in later and finding no room, will crawl over the sleepers, spinning all the time, until they are covered, and another story is added to their tent.

Thus from time to time it is increased with their growth, until their food gives out, or their caterpillar life is spent, when they lose their social habits, and wander off to find other food, which they are seldom able to do, or find suitable places in which to spin their cocoons. These are light-colored, with a tinge of yellow, and may generally be found attached horizontally to the under side of fence-rails, or other protected places. They remain in these about three weeks, when such as have not fallen a prey to the ichneumon-fly, as many do, come forth to lay their eggs, as before described. The question so often asked is, How to destroy them? I will first tell you how you ought not. Some flash gunpowder on their nests; others burn them with a torch; while some put on kerosene and burn; and others saturate with oil to kill them. All these methods are destructive to the trees, and should never be employed. Upon a moment's reflection it will be seen that the easiest and quickest way is to cut off the twig containing the eggs.

As they are laid in July or August, there is a long period in which the farmer may destroy them; and as they are found upon small twigs, near the end of a branch, they can be found with a little careful looking, and cut off. After the leaves have fallen,

on a frosty morning the eggs may be readily seen as a dark band on the twigs, as the frost does not so readily adhere to them. When you cut them off always burn them. If this method is neglected, watch your trees when they first hatch, and with a stick remove the entire nest early in the morning, or just at night, — as they feed, and are consequently scattered over the branches, both in the middle of the afternoon and the middle of the forenoon, and some stragglers are absent all day. If they are still neglected, as they should not be, there is no sure way to rid your trees of them but to put on gloves and clean them off with your hands. You can kill by crushing, or have an attendant with a pail of hot water, and put in such branches as you can cut away, or do not crush. Every tent found, whether on orchard or forest tree, should be destroyed.

The black cherry (*Cerasus serotina*), so common throughout the State, is a favorite tree with this caterpillar. If I could have my way in the matter, as they are a useless tree, I would cut them all down, or else pass a law fining the owner of premises where the caterpillars' nests were not destroyed. Concerted action would soon put an end to its ravages; and the thousands of bushels of apples annually destroyed, together with damage to trees for the ensuing crop, would well repay the amount of time and labor necessary for their extermination.

Where apple-trees are overrun, it will feed upon the plum, thorn, rose, willow, common red-cherry, poplar and white-oak, and even sometimes upon witch-hazel and beech trees. But it will ever be found in the greatest numbers upon the black-cherry and apple trees.

FOREST TENT-CATERPILLAR. *Clisiocampa Sylvatica*. HARRIS.

This caterpillar (Fig. 15), the representation of which is a back view, is often erroneously called the "army-worm," and may sometimes be seen in vast numbers, marching along a hard road in the hot sun, or crawling in great numbers along the railroad track. When closely examined it will be found to resemble the apple-tree tent-caterpillar, and is often confounded with that also. The following difference, however, will be apparent : —

Fig. 15.

Fig 16.

a, eggs; *b*, female moth, natural size; *c*, enlarged view of egg from top; *d*, enlarged view of eggs from side.

The eggs, as may be seen from the above cut, are distinguished from the common tent-caterpillar by being of uniform diameter in the entire mass, which is docked off squarely at the ends. They are usually composed of about four hundred eggs, the mass being of a creamy white color. These eggs are deposited in circles around the twig, and with each egg is deposited a brown varnish; the second circle is closely fitted into the first, so the eggs stand like rows of cells in honey-comb. In this section, the eggs are deposited in July, or the first of August, the larvæ are quite fully formed by the time winter commences, and the warm days of spring bring them into being, even before there are any leaves on the trees; and it is a singular fact in their nature, that they may not only be frozen, but they actually exist for two or three weeks without food, standing any amount of inclement weather, waiting for the leaf-buds to develop into leaves, which they then eat with hearty relish. As soon as they are born they commence spinning a thread wherever they go, yet as the web is beneath them, close to the bark of the tree, it is often overlooked. They live more or less in company, like the common tent-caterpillar, but go through four successive molts before they arrive at maturity, and at such times huddle in bunches, remaining for a day or two inactive. At their fourth

molt, they quite unwittingly court destruction by collecting in masses upon the trunks of trees, often within a few feet of the ground. After this molt, it may be seen (as before mentioned,) wandering about to find a suitable place to form its cocoon. Why it wanders in such places, and then takes up with a leaf that it can draw together, or several leaves all combined to cover it, we can hardly tell. It, however, frequently spins its cocoons under fence-rails, boards, or any sheltered protection.

The cocoon is much like that of the common tent-caterpillar. Three days after its completion, the caterpillar again casts its skin, and becomes a chrysalis, of a pale reddish brown color, dusted all over with a pale powder, and densely clothed with short and yellowish hairs. In a couple of weeks more, or usually in this State from the first to the tenth of July, the moth issues, being of a brownish yellow, and having two oblique transverse lines across the front wings. It is quite like the moth of the common tent-caterpillar. The most marked difference is, that the transverse bands upon the front wings are darker in this, and lighter in the other species.

There is one noticeable fact about this pest; that is, that for several years we see few, if any, of them, and then there is a year or two of great plenty. The reason of this is, that our insect friends, and we fortunately have many that live upon this caterpillar, gain ground upon it, and come near exterminating it; but, with a dearth of food, they die out also, and the caterpillar then gains again, to become a prey to his persecutors.

By their aid we get along nicely, only now and then a year, when we have to kill them to save our trees. If you jar the tree or branch upon which they are feeding, they will spin down a few inches, and may then be picked off. At their fourth molt, they may be killed as they congregate upon the leeward side of trees, as before noticed; but, as they have already eaten up the foliage, it is not so necessary to kill them as it was earlier, yet always kill them when you can. If you search your trees for eggs in the winter, and destroy them, you will never have much trouble.

When one tree is denuded of foliage the caterpillar travels to another and ascends it. This can be prevented by putting tar

or printers' ink upon a band about the trees not infested. The cocoons may also be sought for and many killed.

Fig. 17.

WEB-WORM. *Hyphantria Textor*. HARRIS.

All natural size. *a*, caterpillar; *b*, chrysalis; *c*, moth.

One of the most common and destructive of our insect pests is the little caterpillar known by the name of the "fall web-worm," or perhaps more commonly as the "web-worm." The web of this, which at first look seems an insignificant caterpillar, frequently, in the months of July and August, covers the limbs of many trees—a web enclosing leaves seared and dead, from the ravages of this pest. They are more often seen upon elm and apple trees, but other trees are not exempt; and often, towards the end of summer, most of our fruit and shade trees show the ominous web enclosing dried leaves. The eggs from which these caterpillars proceed, are laid by the parent moth in a cluster upon the end leaf of a branch. When these eggs hatch, they are generally on the third or fourth leaf from the end of the twig, as since the eggs were laid the limbs have usually extended their growth to that extent.

As soon as they hatch they begin to spin. To provide a shelter for themselves, they cover the top of the leaf with a close web, which is the result of their united labors. They feed in company beneath this covering, devouring only the upper skin and pulpy portions of the leaf, leaving the veins and lower side untouched. The leaf withers, and they enlarge their web, taking in other leaves, first to the end and then downward on the branch, and taking in other branches,—frequently destroying the entire amount of foliage on the tree.

When fully grown, this caterpillar measures a little more than one inch in length, having a body rather more slender than other similar feeders, very sparsely covered with hairs of a grayish color, intermingled with a few that are black. The general color of the body is greenish yellow, dotted with black. There is a brown-blackish stripe along the top of the back, and a bright yellow stripe on each side. The warts from which the hairs proceed are black on the back and rusty yellow on the sides. The head and feet are black. Of course their age has much to do with the distinctness of the markings, and the adult worm only will be found perfectly marked.

In the last of August, or more generally in the month of September, they leave the trees and disperse, wandering about, eating a little of almost all plants they happen to find in their way, until they find a suitable place for concealment, where they make their thin, almost transparent cocoons, composed of a slight web of silk intermingled with the cast-off hairs from their bodies. If this place is not found they bury themselves just beneath the surface of the ground, where they spin as before, and remain in all cases through the winter in this latitude ; but farther south they are said to be two-brooded.

The pupæ are transformed to moths in the ensuing June or July. These moths are white and without spots in New Hampshire, but at the South are said to possess rudimentary spots upon the first pair of wings. The fore legs are tawny yellow, and their feet blackish. Their wings expand about one and one-fourth inches. The antennæ and feelers do not differ from those of other moths ; but the females have two rows of minute teeth beneath the antennæ, which is a distinguishing feature.

From the foregoing description of its habits and transformations, it is evident that the time to exterminate these destructive insects is when they are first hatched from the egg, or while but few leaves are involved. This can be done at any time of the day, as they do not go about the tree for food, like the tent-caterpillars, but are always on the leaves covered with the web. If you carefully pick the leaves, it is sufficient ; or you can cut off the branch affected, if you choose. In any event they must be destroyed, and the surest and best method is to burn them.

Take a basket into your orchard, gather in it all the leaves on which the web is found, take them to your stove and burn them. Close attention to your premises for a few years will almost entirely rid you of this pest. On no account delay, as, if you do, they will slip through your fingers and very much increase your labors the next season. If they are neglected until they cover more than you desire to prune away, kill as you do the tent-caterpillar.

Some consider this the second brood of the tent-caterpillar, but from the foregoing account it will at once be seen how widely they differ. It hibernates in the pupa state, they in the egg state ; it appears in midsummer and fall, they in the spring ; its moth is pure white, theirs reddish brown ; its eggs are deposited on the leaf and are hatched in a few days, theirs are deposited on the twig, so as to pass the winter on the tree ; this feeds solely upon the soft part of the leaf under its web, they devour the whole leaf always on the outside of their tent. It will thus be seen that the only time and best manner of extermination must be as above given.

Fig. 18.

CODLING-MOTH. *Carpocapsa Pomonella*. LINN.

a, apple eaten by larva ; *b*, spot where egg is laid and the young worm enters ; *c*, cavity made by larva ; *d*, chrysalis ; *e*, larva full grown ; *f*, moth with wings folded ; *g*, moth with wings expanded ; *h*, head and first joint of larva (enlarged) ; *i*, cocoon.

This insect is, doubtless, found everywhere, where apples are raised. In the month of June, in this State, the night-flying moth comes from his silken cocoon, which was hid under some bit of bark, or sliver, on the fence near by. After pairing, the female may be seen in the dusk of night flitting around the apple-tree, laying her eggs in the blossom-end of the little apples.

There are two broods each season. The first brood is very small, but the second is fifty to one of the first, or even more.

The worm when young is whitish, with usually an entirely black head, and a black shield on the top of the first segment. When fully grown it acquires a flesh-colored or pinkish tint, especially on the back, and the head and top of first segment, as at *h*, become more brown. It is sparsely covered with very minute hairs, which take their rise from little elevated points, of which there are eight on each segment. The cocoon is invariably of a pure color on the inside, but is disguised on the outside by being covered with minute fragments of whatever substance the worm happens to spin to. The chrysalis is yellowish brown, with rows of minute spines upon its back, by the aid of which it is enabled to partly push itself out of its cocoon, when its time to issue as a moth arrives.

The moth is a beautiful object, yet from its habits not being known it is seldom seen in this State ; and the apple-grower, as a general thing, knows no more of the insect that gives him so many wormy apples than he does of men in the moon. Its fore wings are marked with alternate, irregular, transverse, wavy streaks of ash-gray and brown, and have, on the inner hind angle, a large, tawny-brown spot, with streaks of bright bronze or gold. As apples are raised in almost all sections of our country, and wherever apples are raised this insect is a dreadful pest, it becomes us to be well acquainted with its habits, and I shall therefore speak more at length of it than of most other insects.

Riley says, that in Missouri, as well as elsewhere, it is mostly two-brooded ; the second brood of worms hibernating in the larval state, inclosed in their snug little silken home, under some fragment of bark or other protection. The spring weather that causes our apple-trees to burst into blossom, releases this

imago from its pupal tomb, and though its wings are at first damp, they soon dry under the rays of the sun that waked them into their full existence, and they seek their companions. They soon pair, when the male dies, and the female deposits, as before stated, thousands of tiny yellow eggs. As the fruit begins to form, the egg hatches, and the worm develops in the little apple. In from one month to six weeks it has become full grown. Eating its way out, as may be seen in the plate, it leaves the apple, and, spinning its cocoon in some crevice, changes in about three days to a chrysalis, and issues in about two weeks as a moth, same as before, only this time they do not always lay their eggs at the calyx, as they are often found now to enter at the side of the apple. This brood causes the wormy apples in the fall of the year. This second brood always passes the winter in a larval state, either as a worm in the apple, or as a cocoon, and it makes no difference with the time of its maturity whether it goes into its cocoon in September or any time in the fall, or not until spring. Neither does it matter whether it is in a warm room, or frozen, as in proper time, — that is, when the trees are in blossom, — it comes forth to propagate its kind.

Riley says that when in a warm room they are active enough in winter, and will always fasten up any cuts made in their cocoons, though the cuts may be often repeated. These active worms perfect themselves at the proper season, just as well as those that have had a dormant stage, so we may conclude that the dormant stage is not a necessity with this insect.

As this pest destroys millions of dollars' worth of fruit every year, of course it is worth our while to do all in our power to rid ourselves of it. This is a somewhat difficult thing to do, but a great deal can be done to mitigate the evil.

Various authors recommend catching the moth with plates of sweetened vinegar or sweetened water, to be left standing about the trees in spring-time. A few may thus be caught, but at least twenty of our friends may be caught, and usually are, to one of our enemies, so that method is useless.

The first crop of worms, as I have before said, is much the smaller, and as the development within the little apple prevents the full development of the apple, it withers and at length drops

off, usually before the worm leaves it. If this apple could always be destroyed, of course the worm would reap the same destruction. Hogs in orchards in sufficient numbers would do this, by eating all the little windfalls, but hogs are not always at hand. A much better way is to spread a large cloth, prepared for the purpose, beneath the tree, just as the first apples begin to fall, and then by jarring the tree most can be jarred off, and then boil them. This operation, repeated once in three or four days, for, say three times each season, will destroy almost all the first brood, and prevent further trouble that year.

No definite date can be given for this treatment, as some years the season varies many days; watching the fruit, and gathering as directed, as soon as the first signs of exit of the worm can be found, or as soon as they begin to fall, will be sufficient direction.

Another method, as given in the *Country Gentleman*, June 15, 1871, is also valuable. The writer recommends knocking them off with a pole. He says: "Two men with poles usually knock off the wormy specimens about as fast as one boy can gather in a basket." I suspect that this would usually be done too late, as after the worm has eaten its way out of the apple, thus showing the wormy ones, they might as well remain, for the worm is what we want to destroy, not its home. The exudations referred to are not indications of the presence of the worm, but, on the contrary, are sure indications that it is *not* there. I will observe that the gathering of the withered fruit in New Hampshire would probably always need to be in the month of July, and, to do good, must always be before the exit of the worm. If this is not done, cloths laid in the crotches of the branches to shelter the worms and entice them to build their cocoons, wisps of hay or straw wound round the trees, folded or twisted paper bands put around the trees, or any attachment that will afford shelter to the worm and entice it to spin its cocoon, in such a way that it can be destroyed, is beneficial. These bands or cloths, after the cocoons are formed, should be burned, so as to make the destruction sure. They should first be placed about the trees about one month after the tree is in full blossom, and from this time to the time the apples are picked they should

be kept in order, being examined every week, and if cocoons are found they should be at once destroyed, and new bands put in their places, or if but a few they may be crushed, and the old protectors remain.

In a letter received this season, I am asked the philosophy of the hay or straw bands. I can only say, with Prof. Riley, that the straw or hay bands simply afford an enticing shelter for the worm when seeking for a place to build its spun-up house. The hay band is just the thing wanted, as it affords the requisite shelter, and in ninety-nine cases in a hundred will be accepted. There are many patent traps for the same thing, but I am at least safe in saying that none of them are any better than the straw band ; many not half as good.

Of the second crop of wormy apples, which are found so often in the barrels that find their way to market, I can only say that a careful examination in early spring of the barrels and the cellar in which they are kept, and the careful killing of all the cocoons that are found, will do much towards preventing the early brood. Though they have a few natural enemies, they are not in such abundance as to allow the orchardist to depend upon them in the least, and so I need make no mention of them.

Fig. 19.

ROUND-HEADED APPLE-TREE BORER. *Saperda Bivittata*. SAY.

Figures all natural size. *a*, larva full grown; *b*, pupa; *c*, perfect beetle.

This is a native American, born and bred in the mountains; feeding upon the wild crab, mountain ash, and various other trees. It comes out of the trunk, usually in June, and always by night,

in its perfect state. Resting by day, in the night-time it flies from tree to tree for food and companions. Though they feed upon the bark of branches where it is tender and succulent, they lay their eggs on the bark at the foot of the tree, where the young, as soon as hatched, commence to burrow in the bark. For the first year, they live mostly in the bark, but, towards the last of the season, advance into the sap-wood. Frequently, in young trees, the bark over them will crack and allow their castings to fall out, and thus they may be detected. They remain in the trees three years. As the time comes for their exit, they eat their way to the bark, thin that somewhat, and go into the pupa state, to emerge perfected in about four weeks. Fifty years ago, large, thrifty, long-lived apple-trees were exceedingly common, and were grown with comparatively little effort on the part of our ancestors. This borer in the apple-tree was then entirely unknown to the farmer, and the first specimen ever seen was found and described by Thomas Say, in 1824; and it was not till some time after, that its destructive powers became evident in the apple-tree. Yet it is to this borer, almost entirely, that the short and precarious life of the apple-tree is due.

All understand this borer to be a dreadful pest, but how to deal with it is the question; and to show more fully its habits, and how it may be exterminated, I will briefly review its history. The eggs when laid, as before mentioned, soon hatch, and the tiny worm, differing from the adult in no essential point but size, eats into the bark, and then follows between the bark and wood, sometimes entering the sap-wood low down towards the root the first season. While eating its way in lengthy furrows beneath the bark, the bark sometimes cracks, and the castings of the worm tumble out, revealing its presence. When such is the case, they may be killed with a sharp wire, or carefully cut out with the point of a knife. If left alone they will remain inactive through the winter, to commence their work again early in the spring. The second season they spend mostly in the sap-wood, or near the bark, getting two-thirds their size, and this year doing their greatest damage, as five or six of them will frequently girdle or nearly girdle the tree, making death sure; they again winter low down in the body of the tree, and eat the next

season deeply into the wood, sometimes quite through the tree, finishing its gnawing work at the commencement of the third winter. At the close of its work it extends its passage invariably to the bark, and thinning that somewhat, stuffing the upper end with wood, like sawdust, and below with soft wood fibres, it rests from its labors, remaining motionless as before through the winter. The following spring it casts off its skin, becoming a pupa ; rests in this condition about three weeks ; and then, as a beetle, gradually gets strength, and after nearly two weeks more, cuts its way through the sawdust piled against the bark, and then the bark, to issue through a round hole as an adult beetle, ready to propagate as before. The time from its entry to its egress, is about one month short of three years.

Few ever take the trouble to hunt for this beetle, and as it flies in the night, lying concealed during the day, it is not often seen in the adult state. As will be seen in the cut, it has two stripes its entire length, and is rather handsome.

There is still another species, called the flat-headed species, as the head of the larva is flat, but, as it is never very abundant and is of small size, it seldom does much harm, and the same treatment is destructive to both species.

The best remedy is to prevent the successful laying of eggs, which may be done by smoothing and then soaping the bark. If such is done near the ground only, they will lay their eggs at the juncture of the largest limbs, or higher up on the trunk, so scraping and soaping must be thorough. If the borers are really in the trees, there is no way except to kill them, or cut them out one at a time. A small piece of whalebone is the best to kill them with, by pushing it into their holes. A piece of wire will answer. When the bark is killed over them it is just as well to cut them out. The application of the soap is necessary in May. Either soft or hard soap will do, but if hard soap is used a thin piece had better be crowded down into each principal crotch of the tree, so that the rain may wash it down the trunk. Do this, of course, after having washed the tree with strong suds.

Fig. 20.

THE CURRANT-WORM. *Nematus Ventricosus*. KLUG.

a, a, a, different stages of growth; *b*, a single segment of the caterpillar magnified.

Fig. 21.

Adult specimens enlarged. The marks at the side represent the actual measurement with wings spread. *a*, male; *b*, female.

This worm is so common and so well known in New Hampshire that it needs no description. It affords an excellent example of the wonderful rapidity with which an important insect

may increase and flourish in this country. It was imported from Europe in 1860, into nurseries, in Rochester, N. Y. Since that time it has not only spread eastward throughout New England, but to the Far West. It is a dreadful pest to the currant and gooseberry bushes, and in sections where it has been left to do its work unchecked such fruits are numbered as things of the past.

Though near fifty species of the *Nematus* are natives of this country, this little foreigner has forced himself so disagreeably to our notice that we almost forget the ravages of the native varieties.

Though the worm is so well known, the fly that causes the mischief is seldom noticed. The female is of a bright honey-yellow color. The head is black, with all the parts below, as well as between, the origin of the antennæ, except the tip of the jaws, a dull honey-yellow. The antennæ are brown-black, often tinged with reddish above, except toward the base, and beneath, entirely dull reddish, except the two basal joints. They are four-fifths as long as the body; the third joint, when viewed sideways, is four times as long as wide; the third, fourth, and fifth joints slowly diminishing in length. On the thorax are four conspicuous black spots and other smaller ones. The legs are bright honey-yellow; the hip joints whitish, with the extreme tips of the hind shanks, and the whole of the hind toe joints are blackish brown. The wings are glossy, with dark veins, and expand a little over one-half inch. It is stated in the *American Entomologist*, that in Europe she is known to lay eggs which have not been fertilized, and from them young caterpillars are hatched. It is probable, however, that they do not have the power of again propagating the race, and that the eggs hatch and the worms eat it just as likely as in the case of the silk-worm and other moths, as well as of some insects, including the honey-bee.

The male (Fig. 21, *a*) is rather smaller and is black. The head is dull honey-yellow. The antennæ are brown-black, often a little reddish beneath, except toward the base; they are as long as the body; while longer than in the female, they are also somewhat flattened out. The under side of the thorax and

abdomen are honey-yellow. I have given this minute description of the fly, as, if seen and killed, hundreds of the worms may be saved. The eggs are laid about the 20th of May in New Hampshire, in regular rows, along the under side of the veins of the leaf, at the rate of about two a minute. The embryo escapes from the egg in from four to ten days, and immediately commences feeding. They continue their work upon the bushes until they are bare of leaves, and then, whether fully grown or not, go down into the ground and form little black pupæ, varying in size according to the way the worm is fed. Emerging in about two weeks, they lay their second brood, which pass the pupa state in the ground, as before, but do not emerge until the following spring. The fly lives about nine days.

For their destruction, we first look to the birds. While a few only will catch the fly, none are found to eat the worm. Thus we are deprived of our most powerful ally. We never half realized the good done by insectivorous birds until we have an enemy they disregard. Among the natural enemies of this pest are three kinds of ichneumon-flies, of which one is an egg parasite. From this aid three-fourths of the eggs are destroyed; but the other fourth give us much trouble.

The first method of destruction is to pick off the worms and destroy them. This, if there are but few bushes, can be done quite easily, and is really the most practicable method.

The next in use is to dust on the leaves powdered white hellebore, from a muslin bag. Used in this way, it is not sufficiently poisonous to render dangerous the use of the fruit. This is recommended by Walsh and Riley.

A solution of a pound of copperas to six gallons of water has been used with success. It blackens the leaves, but does no injury to them. Suds made of carbolic soap may be sprinkled on from a common sprinkler. Any dust that touches them is lodged in the spiracles, or breathing-pores, and soon produces death. Dust from the road, dried fine plaster of Paris, or any finely pulverized substance will answer. The Grafton fertilizer, which was finely pulverized quartz, was the best material I ever saw for killing them. It possessed the requisites of great fineness and perfect dryness, so it would make a dust easily.

Gum aloes are, when fine, equally penetrating, and less dangerous than the white hellebore.

By a little attention in time this pest can be easily stayed, by any of the means spoken of, but *The Boston Journal of Chemistry* says this worm can be immediately destroyed by the use of carbolate of lime. This is certainly less costly and more agreeable to use than the hellebore, so to those that must buy something to use, instead of using road-dust, I would recommend it. With two or three applications the work would be done.

Fig. 22.

Fig. 23.

Fig. 24.

CABBAGE-WORM. *Pieris Rapae*.

Fig. 23, butterfly of the cabbage-worm, male. Fig. 24, female. The female is distinguished from the male by having two round spots, rarely three, on the wings. The body of this butterfly is black above, with white wings. *a*, cabbage-worm; *b*, chrysalis.

This worm, the product of the rape-butterfly, is the great pest of the cabbage-grower, and doubtless the worst of all our imported insects. It was imported from England to Quebec in 1857, as it is supposed, with a quantity of cabbages; but it was so sparse that none were seen until 1859, and so rapid was its increase that in 1864 it had extended at least forty miles in every direction from Quebec, and it was estimated that it caused

a loss of the cabbage crop that would have sold for at least two hundred and fifty thousand dollars.

In England and Europe, it is *the* butterfly everywhere common ; its larva is the dread of every cook, as she expects to cook several with every cabbage, notwithstanding her utmost care. Its chrysalides are so abundant in the winter-time that they seem present upon everything that affords them the least protection ; even upon the doors of dwellings in constant use several may often be found. America had two native species, which sometimes appeared upon the cabbage, but they were content with the outside leaves ; but while this important species riddle the outside leaves, they secrete themselves in the head also, and render it necessary to pull the same to pieces before cooking, and then you are not sure, for many times they appear cooked with the leaf. The color is so near that of the leaf upon which they feed that they are ever liable to appear as unwelcome visitants. The use of the cabbage among all is rapidly decreasing from this cause. It has already spread over large sections of the country, being taken in Vermont in 1866, in Maine in 1868, and around New York and Boston in 1870. It is now almost as wide-spread as the cabbage is cultivated.

The butterflies have their bodies black above, with wings white, as may be seen in the cuts.

The female may be distinguished from the male by having two round spots, rarely three, instead of one as in the male, upon the front wings. Underneath both sexes are alike, and have two spots on each front wing, but none on the back ones, which are usually yellowish, yet sometimes with a greenish tint. They vary much in color, but the above general description will be sufficient to enable one to recognize them, as the first impression will be white or nearly so, and the slight variations of tint, from yellow to green, will not be likely to much confuse.

This butterfly deposits its eggs upon the leaves of the cabbage, usually upon the under side. They are exceedingly beautiful when magnified, having a delicate tint, variable as in the butterfly, and seemingly etched with a beautiful network of lines. The larva, as seen in the cut at *a*, is pale green, finely dotted with black, with a yellowish stripe down the back, and a row of yel-

lowish spots along each side in a line with the breathing-holes. As the stripes and spots are somewhat obscure, some farmers do not notice them, and think they have another variety, which is possible, as we have two native species that sometimes feed upon the cabbage, but they are sparse in numbers, and seldom seen in New Hampshire.

When about to transform, it leaves the plant upon which it feeds and takes shelter under the rails of fences, in stone-walls, or any place convenient, and changes to a chrysalis, which, though variable in color, is usually pale green, speckled with minute black dots, as seen at *b*.

The second brood pass the winter in this condition, this species, like our native ones, having two broods a year.

The first remedy that occurs to most when they see their cabbages destroyed, is to quit raising them, and starve them out. This cannot be, as they feed upon several plants, and even upon the willow, when other food is not at hand.

The first method of attack is to cover the young plant with mosquito-netting, held off from the leaves by sticks, usually four of them, set in the ground, and a piece of netting pinned on. This is done in various ways, according to the tact of the person doing it, and, when properly done, prevents the eggs being laid upon the leaves, and so the cabbage grows in security. This costs, besides the labor, from one to two cents for each cabbage.

If this is not done, picking the eggs is the next method. They can be easily found, and, if attended to often, they may all be destroyed. Children can easily do this, and are usually led to do it by the promise of a small reward for any certain number found. When the butterflies are seen about your garden they can easily be caught in a net, as they are slow, lumbering fliers, and easily killed, thus crushing hundreds of eggs without hunting for them.

If the eggs have not been destroyed, poultry, if in numbers, will pick off most of the worms, as they are considered by fowls as a sweet morsel, very desirable. But we can not fully depend upon them to do the work, though they will help greatly. As they get into the very heart of the cabbage-head, hand-picking

will not amount to much more, but yet it will decrease their numbers so that cabbages can be raised.

Paris green or white hellebore will, of course, kill the worms, but should never be used, as it will lodge in the growing head and endanger the lives of those making use of the cabbage. Dust sprinkled on it is also effectual, but will leave grit in the head so as to injure it for eating, yet is without danger.

Carbolic soap-suds are destructive to them, and if not too strong will not injure the plant. Fine sawdust impregnated with carbolic acid is one of the best things for their destruction. Superphosphate of lime, fine salt, ashes, and lime have all been used with effect, yet nothing of the kind is sure to kill all the worms. Close attention to the plant, or perfect protection by netting, as first spoken of, is the only way to secure a crop of cabbages.

If, as estimated, at least half a million dollars' worth of cabbages were destroyed by it around New York City alone, last year, and an average of two hundred and fifty thousand dollars' worth are annually destroyed around Boston, Montreal, and other cities, it shows beyond question, that we have, in spite of our warfare upon it, an implacable foe.

We have thus far but one insect that lends us substantial aid. This is a species of chalcid-fly, and so rapid has been its work that of one hundred and ten chrysalides, collected by F. W. Putnam, of Salem, Mass., at least two-thirds were infested, and brought forth chalcid-flies instead of cabbage-butterflies. In most sections, however, this help has not yet arrived, but will become general, doubtless, in a few years.

By placing boards elevated a few inches from the ground about your cabbages, the worms will select these places for their change to the chrysalis state; and as those infested by the chalcid-fly can be easily distinguished by the livid and otherwise diseased appearance of the body, and left to produce flies, while the healthy are destroyed, you can aid your friends and destroy your enemies. If the chrysalides are all found healthy, you can make a general destruction.

Fig. 25; Tongue.

Fig. 26; Larva.

COMMON HOUSE-FLY. *Musca Domestica*. LINN.

This fly, in fact, needs no introduction, as it is well known everywhere, so I do not as much as give its portrait.

There is, however, in the study of the proboscis and tongue-like organ, as seen in the cut above (Fig. 25), much for study. The maxillæ are minute, and their palpi (*mp*) are single-jointed, and the mandibles (*m*) are comparatively useless, being very short and small compared with the lancet-like jaws of the mosquito. But the structure of the tongue itself (*labium*, *l*) is most curious. When the fly settles upon a lump of sugar, or any other eatable substance, it unbends its tongue, extends it, and the broad, knob-like end divides into two broad, flat, muscular leaves (*l*), which thus present a sucker-like surface, with which the fly laps up its food. These two leaves are supported upon a frame-work of tracheal tubes, which act as a set of springs to open and shut the muscular leaves. These, it will be seen from the magnified cut, end in hairs projecting externally. Thus the inside of this broad, fleshy expansion is rough, like a rasp, and so is easily employed by the insect in scraping or tearing delicate surfaces. It is by means of this curious structure that the house-fly occasions much injury to the covers of books, or any polished surface that owes its polish to albuminous material. It is by means of these, also, that it teases us in the heat of summer, when it alights upon the hands or face, to sip the perspiration as it exudes from, and is condensed upon, the skin.

Doubtless all have noticed that house-flies are more numerous

about barns, but few trace the transformation of the fly. Where the house-fly comes from, is often asked, yet seldom answered, as its habits have not been much observed. The barn and its vicinity are usually its birthplace, and about such places may be seen in June, now and then, stray flies, the remnant of last year's brood, that have in some sheltered nook survived in a dormant state the cold of winter. The excrements of the horse are the most desirable on which to deposit its eggs, and yet they may, for want of that material, deposit them on other refuse of the barn, and sometimes even on sand or loam that is made rich by the wash of the buildings. The eggs hatch almost immediately, producing a maggot, fleshy, smooth, and shining, about one-third of an inch in length, and yellowish white (Fig. 26). After feeding for some time it goes into the pupa state, shortening up as in *a* (Fig. 26). It is a reddish brown case, two-thirds the length of the maggot, and, as seen in the cut, thicker and stouter. In this transition case it remains from six to ten days, — according to the warmth of the weather, — emerging therefrom a perfect, full-grown fly. I have frequently called the attention of the farmer to the pupa case, asking him what it was. He almost invariably answers that he supposes them undigested oats that have passed his horse; and in several instances they were dosing horses for indigestion, having taken these pupæ for the signs of such. From inquiry thus, I have concluded that most farmers notice the pupa cases, but do not understand what they are. I have never known the house-fly to lay its eggs upon meat, or anything about the house, though they sometimes do about a sink-spout, or other places where slops are thrown out. With a little concerted action among our population, the house-fly might be greatly decimated in numbers. All barnyard fowls are fond of the larva and the pupa also, and, if yarded where they have full access to their breeding-grounds, will greatly aid in their destruction. As fowls are given to much wandering, they will seldom eat the pupa unless shut up in a yard where the manure from the barn is thrown, or where it usually lies; as the dirt in such locations is rich enough in the necessary larval food to produce them if no manure is at hand.

We will now turn our attention to microscopic pests.

MICROSCOPIC PESTS.

At the present time, every one who possesses any love of nature, or even a love simply for marvelous things, desires some knowledge of the minute mysteries of nature. To follow out the peculiar character of animal or plant when too small singly for the human eye to study, requires a microscope. At the prices they are now sold for, they are within reach of almost every one. With our microscope complete, wherever we search, be it our own dwellings, the meadow or the upland, the grasses or the forest, the ruin crumbling into dust or the sands of the seashore, even in the waters of our marshes, rivers, lakes or ocean, there may be discovered plants and animals which are unknown to our unaided vision, yet endowed with organs perfectly adapted to their respective necessities ; and with regard to the latter, often, if not always, for their enjoyment. Even in the aqueous vapor and dust of the atmosphere are germs of living beings, both animal and vegetable, though the latter much predominate, that the microscope alone enables us to contemplate with any satisfaction.

It is true that when near sundown a beam of sunlight struggles through the thick foliage of a forest, or enters our room by means of some small aperture, we can see, floating in that beam of light, numerous particles of apparent dust, yet what its form, or its ultimate destination, our unaided eye could never inform us. It is the microscope alone that gives us aid, and that shows us countless spores, or seeds to reproduce minute vegetation, as well as plants actually flourishing in the atmosphere. Also the germs of animal life are often, yes, very often, there ; and, judging from analogy, we find thus an easy method to propagate by germ various diseases in the human family ; and that such is often true is beyond reasonable doubt, though such germs have never been fully identified. In our limited survey of those wonders of life and organization, which are thus revealed to us, it is natural to first turn our attention to the vegetable kingdom. And the largest number, as well as the most interesting, of the peculiar plants thus revealed in all their beauty, yet perhaps

the most difficult to understand, on account of their varied appearance and intermediate forms, are the

FUNGI.

Their sudden appearance and growth, their ephemeral nature, and the multiplicity of their forms, have always been a source of trouble to investigators, and even the most indefatigable of modern mycologists have been able to lift but partially the veil which hangs over the life and development of these organisms. Almost every one, however, supposes that there can be no doubt as to what a toadstool, a mildew, or a mold is, and some may even correctly call them fungi, but many others are entirely unacquainted with that Latin word which denotes them. Rust on grain, and smut on Indian corn and other cereals, are also familiar to farmers ; but a vast multitude of other all too numerous fungi are known only to the botanist by name, and only to the mycologist in their habits and structures, and to him only after long and patient study. In fact, it is to the researches of many eminent men and women, in Europe, Great Britain, and in this country, both among the dead as well as among the living, that the structure, habits and mode of growth, relation to the various departments of industry, injurious effects and general utility of these smaller fungi in nature, are collected and known. As plants, although of a low order of organization, they are of great interest as mere objects of beauty ; but to attain a full comprehension of this fact we must have recourse to the microscope, as the peculiar portions of these structures are beyond the reach of unaided vision. No one that has not had his eye upon them, aided by magnifying power, could possibly conceive that the little specks of brown or black, seen on the brilliant ripening foliage of the maple in September and October, or on the skins of apples, pears, and other fruit ; on the dry stalks of plants or straw, on old decaying matter, on the buildings and fence-rails, on the panes of the window, or the bodies of diseased insects, like bees and house-flies,—in fine, on almost everything,—are receptacles of exquisitely sculptured and carved seed-vessels, called *spores* ; often beaded thread-like strings of pearls ; again,

consisting of myriads of the most fantastic shapes that the genius of man could imagine, but could never imitate.

A subject so broad and so varied, one which can be investigated at any season of the year, inviting the naturalist, more especially the botanist, forth from earliest spring to latest autumn, to search for forms of beauty on every living or ripening leaf and fruit, and in winter rendering the evening lamp more attractive in studying the collected treasures of the summer's gleanings ; even if such collections have not been made, the barn with its harvested treasures is at hand, and from that may be taken specimens which can never fail to interest as well as instruct every thoughtful person in some way or other ; and would ever be of the greatest interest, if presented in an agreeable manner, and shown with regard to their reference, or connection, with the industrial pursuits of society.

Not only is such study of interest to the botanist, whose specialty is the study of fungi, but it possesses more than ordinary interest to the husbandman whose crops often lie at the mercy of some of this class of parasites, and to his family, as their welfare often depends upon these minute organisms. Even a slight acquaintance with a few of these wonderful little plants, would render the walk for exercise or pleasure ten times more valuable, and often remunerative. Who, even without special thought upon the subject, has not noticed along the roadside early as June, where blackberry-bushes are found among weeds and grass, that their leaves were powdered underneath with rich golden dust, which might be shaken from little orange cups? Many times from children, and often also from the middle-aged and old, has come the query as to what it was. On other bushes also, when yielding fruit, even, to tempt women, men, boys, and maidens ; yet would they turn aside, because the dust was ominous, but in what way or from whence it came none knew.

Those dusty-looking lilac-bushes, so dusty ere the close of summer that no rain could wash them clean, or ever will, so long as that peculiar white egg-mold riots on the upper surfaces of their leaves.

The crystalline drops of permanent dew, on some refuse matter, often attract attention as they glisten in the sun, but few stop

to examine and see the white threads in countless numbers that permeate them. Though such things often attract attention, they are soon forgotten when we know nothing about them, and no one is there to tell an anecdote from their history. Cunningly, wisely, and full of secret hidden meaning, a thousand forms of lower vegetable life look up into our faces, while we, with repressed curiosity and not quite willing, tread them under our feet. How few even ever stop to think that they are leaves in the great book of nature, and consequently worthy the reading, and that to every one who will study those pages and translate the hieroglyphics, that the time and trouble of deciphering would be richly rewarded by the knowledge obtained.

"How thankful I am to you," said a friend, "that you have told me so much about the lichens in our pastures. They are now a great source of happiness to me; formerly I detested them."

"The best lectures on botany," said a well-known and highly appreciated educator, "are lessons upon every plant we meet." Yes, within reach of all of us is study for a life-time, and we may thus not only please ourselves, but by and by be considered benefactors. With an intention to introduce a few of these little parasitical growths to the attention of the reader, and to make plain and easy what at first seems so obscure and mysterious, I will bring forward some of the more common species, and, explaining by word and figure their form and habits, endeavor to interest you to such an extent that you will be willing at least to acknowledge their power for good or evil, and know where to find your enemy, when pet plants, or fields of grain, grasses, or potatoes, are likely to fail under the evil so wide-spread and fatal.

CLUSTER CUPS.

M. C. Cooke, the great English writer on fungi, divides them into six families. In one of these families the spores are the principal feature. This family is called the "dust fungi" (*Coniomycetes*). Of course it contains many groups, called families or orders, which are analogous to the natural orders of

flowering plants. Without enumerating any of the various characteristics of these orders, I will select one typical plant. The spores are inclosed in a distinct peridium (covering for the seeds). This is a cup-shaped excrescence on the infested leaves. This order is called *Æcidiiacei*. They are always developed on living plants, sometimes on the flowers, fruit, or stems, but usually on the leaves; occasionally on the upper surface, but almost always on the under side of the leaf.

The different species are distributed widely over the entire world. They may be found on every continent, and on almost every island. When examined they look like minute cups upon the leaf, and hence we call them "cluster cups." Besides the generic name they have also added a specific name, generally derived from some plant they are known to infest; but this must not lead the student to suppose that one species is only found on that particular plant, for most of them infest many plants, yet some, of course, to a greater extent than others.

We must therefore look to the actual differences in the fungi, not in the plants they infest.

The leaf may be truly said to be the lung of the plant. Through the stomata (minute holes) on the under side of the leaf, the plant obtains nourishment from the atmosphere, which is as necessary to them as our breath is to us.

Anything that clogs or injures the stomata of any plant directly injures the growth of that plant. This little fungi, when the plant has become infested, breaks through the epidermis, destroying many of the breathing-pores (stomata), and also draws its own nourishment from the life-juices of the plant it infests. Before it breaks through the under surface of the leaf, the infested leaf, if closely examined, will appear to be covered with little elevations or pustules, paler at the apex; these soon become ruptured, and the fungus pushes its head through the opening, at the same time bursting by radiating fissures. The teeth thus formed resemble those of the peristome of some mosses. All around the orifice the teeth, or fringe, become recurved, and the orange spores (fungi seed) are exposed, crowded together within. At first, and in fact while contained in the

peridium (cup), these spores are connected together as a string of beads, but when dispersed they are scattered singly about the orifice, often mixed with colorless cells arising from the partial breaking up of the teeth, or fringe, of the peridium. Let us now for a moment examine the manner in which these cups are distributed upon the leaf. They are scattered without any apparent order over the under surface, with now and then one upon the upper surface, but they nowhere touch each other, unless at the margins of the leaf, but then they are never joined, only crowded. Generally there is a space greater than the width of the cups between them. The leaf is not thickened by their growth, and the upper surface gives you no indication of what is going on beneath. If a leaf be taken fresh, and the epidermis from the under side be stripped off, as it is often easy to do, the orifices through which the fungi have burst will appear in irregular holes, and the fungi will be left rooted still upon the leaf, showing that they are not confined to the surface, and thus we see why the damage is so great to the plant upon which they subsist.

The spores in this species are orange in color, but variable both in size and form, though the majority are comparatively large. Each of these spores is capable of reproducing its species, and if we compute two thousand cluster cups as occurring on each leaf, and many leaves have double this number, and supposing each cup to contain two hundred and fifty thousand spores, which again is much below the actual number, then we shall have not less than five hundred millions of reproductive bodies on one infected leaf, to furnish a crop of parasites for the plants of the succeeding year. As we thus so soon reckon by millions, our figures and capacities fail in appreciating the myriads of spores which compose the orange dust produced from one infected cluster of plants. Nor is this all, for it is found that one of these spores is not only capable of producing a plant, but is in itself a bundle of vegetative spores, which are exceedingly minute, and yet, small as they are, they have the capability to produce fresh crops of cluster cups.

Naturally enough, our reader will ere this be debating in his

own mind how these spores, which we have seen are shed in such profusion, can enter the tissues of the plants which give subsequent evidence of infection, as I have described ; in fact, how the yellow dust with which the atmosphere may be filled to-day can inoculate the young plants of next year. If one or two of these spores are sprinkled upon the cuticle which has been removed from the leaf, as we have before indicated, it will be seen that they are very much larger than the stomata, or breathing-pores, which stud the cuticle ; hence it is clear they cannot gain admittance there. There remains but one other portal to the interior of the plant, and that is through the extremities of the roots. Here another difficulty arises ; for the spores are as large as the cells through which they would there have to pass. This difficulty is, however, much lessened when we remember that these spores are a bundle of infinite particles, each particle of which is probably capable of infecting a plant. Even under this consideration, there is much need of an active imagination, to invent hypotheses to cover the points upon which we as yet know nothing definite.

"The Rev. M. J. Berkeley proved many years ago that the spores of bunt, for example, may be caused to infect all the plants the seeds of which had been placed in contact with them." But this did not prove that the seeds absorbed them, as it is probable they did not, but they would adhere to the seed and thus be conveyed to the ground, where infection to the sprout would be probable. Much has been done to elucidate this mystery, but much remains a mystery still. No spores have ever been seen traversing the tissues of growing plants.

The stems and leaves of violets, sweet-scented and scentless all alike, are often distorted and ruined altogether by a variety of cluster cups ; the stinging nettle does not escape ; the hardy dock, the useful currant, the wild geraniums, alike feed with their juices fungi of this description.

It has long been a popular belief in England (says F. B. Hough in his report on Forestry), that the barberry-bush (*Berberis vulgaris*) has some agency in the propagation of rust in wheat and other grain, and the researches of botanists have

somewhat tended to confirm this belief. The spores from grain-rust (*Puccinia graminis*) are said to find their way to the leaves of the barberry, germinate, and form cluster cups on the under surface of the leaves, and the spores from these in turn germinate on the grain by alternate generation. The fact that rust sometimes appears in fields where there are no barberry-bushes capable of bearing the intermediate form, appears to indicate that there are other plants having the same capability of bearing the intermediate growth. The clearing off of barberry, or other plants or bushes, near wheat-fields, has, it is claimed, been productive of good results; and if it should be proved beyond doubt that there is a direct relation between this and grain-rust, the use of the barberry as a hedge-plant, as well as that of other bushes, should be discontinued. Cooke, on the other hand, says that while this statement long ago had credit among the people, it has no foundation in fact, as the genera are distinct and perfect in themselves; while some others, perhaps equally eminent, claim intermediate and spurious forms. Professor Ærsted, it is said, has recently determined their identity as one and the same plant. In this figure (Fig. 27), *a* shows a leaf of the barberry, with cluster cups upon it (*Æcidium herberidis*); *b*, a portion of the leaf magnified; *c*, the same fragment seen side-wise.

The leaves of the pear show other species, and very singular and curious clusters of excrescences occur on the leaves of the apple-tree and mountain ash, and are also very prominent on the leaves of the quince-tree, and especially of the wild

apple-tree of the West, consisting of large peridia, pointed at the tops, and so swollen below as to bear a rude resemblance to urns, the edges split into long, contorted threads. They are a

Fig. 27.

species of *Restelia*. The *R. lacerata* is seen in Fig. 28, *a*,

Fig. 28.

natural size, living on the leaves and fruit of the hawthorn; *b*, a portion magnified. The spores are also of a light orange color, but the plant, by comparison, or even by comparison of the cuts, may be seen to widely differ in its appearance. The fir and pine also suffer, as they are often attacked by the *Periderminum*, which changes the foliage, and spoils the effect of their branches, rendering them unsightly. Unfortunately but little

is known of this fungus, but it is well worthy of attention from those that are interested in the minute aspects of nature, and those who can recognize the hand

"That sets a sun amidst the firmament,
Or molds a dewdrop, and lights up its gem."

But we must not stop for reflection, but slightly notice another class. The spores of the smaller fungi have thus far been spoken of as seeds, but this is not strictly true, and several novel and interesting points for consideration and inquiry arise.

If we should place some of the yellow dust, which fills the cup-shaped peridia, in a drop of water, and prevent its evaporation by covering it with a watch-crystal, or any other glass would do as well, we should find in a few hours that each particle of the dust had swollen, and bursting at some point had given out a little thread, at the apex of which it is crowned with delicate curved appendages, which soon become connected by lateral threads, thus forming a kind of latticed network, and from the sides of these filaments little cells sprout, which in turn germinate and reproduce the plant. Those of our readers who are familiar with the early stages of the ferns, can trace a striking analogy in the process.

In many of the smaller fungi the spore is present in another form, constituting what is termed the spermagone (pustules and

depressions like pockets), often in shape of a minute dot near the peridium, and sometimes on the other side of the leaf. In fact it may be like a little blister filled with threads, throwing off little curved bodies called spermatia (germinating filaments), which escape through an orifice provided for the purpose.

Before the nature of these singular objects was known, spermagones were mistaken for distinct kinds of fungi, and many species were thus described. In the *Peridermium Pini*, before spoken of, they are white, few in number, and are developed not only in the spring, but sometimes re-appear in the autumn upon the same leaves that produced them at the commencement of the year. The evident effort of nature, then, in this process, is to produce an ultimate condition of fungal life, which shall be sure to continue indefinitely the presence of the parasites upon the leaves and other parts of the higher plants. And this is done with certainty by the mycelium, a system of the most subtile threads, which can enter the tissues by attacking the seed when sown, and whose persistence of vitality enables it to endure the most trying circumstances unharmed. So vitalized indeed is the mycelium, that any fragment of it will vegetate and grow after long periods of desiccation. And its luxuriance of growth is in nowise dependent on any higher development, such as, were it the stems and leaves of a flowering plant, would be necessary to cause it sooner or later to push forth blossoms and fruit.

This wonderful vitality is taken advantage of in the cultivation of the edible fungi, such as the mushroom for example, where lumps of dry earth permeated by the mycelium, or "spawn," as it is called, are planted in prepared soil and a good crop realized. It is familiar to nurserymen, and all those who cultivate trees for shade or otherwise, that they often languish and die, owing to their roots reaching spots deep in the ground, where decayed wood or other vegetable remains are filled with this subtile fungal spawn, which inoculates the tree with the destructive fungus, causing its death. Fortunately, the awakening and full vigor depends much upon the atmospheric condition, else we should live in fear that every plant would be blasted. From this cause fungi of every form are often regarded

as meteorological phenomena, and wet and foggy weather are complained of as harbingers of various fungoid evils.

MILDEW OR RUST.

Peculiar hot and damp days will be dreaded by nearly all on account of "mildew," but "mildew" is one of those loose terms that represents no definite idea, or a very different one to various individuals.

Talk of mildew of grain to a farmer, and he tells you of the rust which appears in lines or irregular spots upon the wheat-stalk, indicating *Puccinia graminis*, which is known to him and generations before him in many sections as mildew.

Talk to a New England housewife of mildew, and she will describe a minute species of fungus which attacks damp linen, as true mildew, and will ask if you know what will remove the spots occasioned by it.

Ask the hop-grower of New York about mildew, and he will point out a species of mold that infests the hop-vine, but which differs as much from the mildew of the South as does the mildew of linen. The librarian will tell you of mildewed books and papers, and the housemaid of mildewed cellars, — all meaning a fungous growth, but as wide in their significance as the poison-hemlock and hemlock-tree.

Mildew in England means in literature but one thing, and that is the rust upon wheat and other grain, known scientifically as *Puccinia graminis*.

But let us look into the history of this pest. In view of a clearer understanding of this peculiar pest, so long supposed to be several separate species, and which under the present light of science seems fast merging into one, we will suppose a fine day in June dawns upon our resolve to learn of mildew, or rust, and we stray away from the village to gain the chance to examine a wheat-field. Having reached the field, there is no appearance of anything but a healthy crop; we walk into it perhaps fifteen or twenty yards before we find a single fungus of which we are in quest. But let us look closely down at the green leaves at the very bottom of the wheat-plant, and we are soon

rewarded, as we shall find one or two that look rusty. The surface seems powdered with red ochre, and to have grown sickly under the operation. Pluck it carefully, and examine it with low magnifying power ; a pocket lens will do. Already the cuticle of the leaf is traversed with numerous longitudinal cracks or fissures, within which and around which you discern an orange powder, to which the rusty appearance on the leaf is due. Further examination reveals also portions in which the cuticle is distended into yellowish elongated pustules, not yet ruptured, and which is an earlier stage of this same disease. This is the rust of the New England agriculturist, the *Trichobasis rubigo vera* of the botanist, or the first phase of the mildew.

To know more of this parasite we must take it to our microscope, and by careful manipulation we shall find that the vegetative system of this, as well as of all similar fungi, consists of a number of delicate simple or branched threads, often intertwining and even uniting one to the other by little branchlets. These threads, as we have before explained, are called the mycelium ; they penetrate the intercellular spaces and insinuate themselves in a complete network among the cells of which the leaf or other diseased portion of the plant is composed. We may regard the whole mycelium of one pustule, or spore-spot, as the vegetative system of one fungal plant. At first it might have originated as several individuals, which afterward become combined as one, for the production of fruit, and by their combined effort a cluster of fruit, or spore-spot, is produced.

In the first instance, a number of minute, transparent, colorless cellules are developed from the mycelium ; these enlarge, and are filled with an orange-colored endochrome, and appear beneath the leaf as yellowish spots. As a consequence of this increase of bulk, the cuticle becomes distended in the form of a pustule over the yellow cellules, and at length, unable to withstand the pressure from beneath, ruptures in irregular, but more or less elongated fissures, and the yellow bodies, which I will call spores, break from their short pedicels and escape ; to the naked eye presenting the appearance of an orange powder.

On the first of August we will again visit our wheat-field. Rusty leaves are more common than before. A little careful

examination, and here and there we shall find a leaf or two with decidedly brown pustules intermixed with the rusty ones. If we remove from the browner spots a little of the powder by means of a sharp-pointed knife, and place it in a drop of water, and cover it with a thin glass, and place it under our microscope, a different series of forms will be observed. There will still be a portion of one-celled yellow spores, but the majority will be elongated, mostly with short stalks, and either decidedly two-celled or a tendency to be so.

These two-celled spores are another form of the mildew called *Puccinia graminis*, which may be produced in the same pustules and from the same mycelium as the rust previously described, and is generally considered at the present time to be the same fungus. Other grain and various other plants are likewise affected.

Fig. 29.

Fig. 29 represents at *a*, wheat-straw infected with this rust; *b*, cluster of spores magnified; *c*, single spore magnified 300 diameters.

This rust is so common and so much alike on all plants, that this plate will answer to represent the fungus wherever found.

Let us now for the third time visit our wheat-field. It is ripe, or else much damaged, possibly destroyed, by the fungi.

On the straw we shall find black lines, or blackish spots, from the size of a pin's head to an inch in length; this is the mildew, rust, or *Puccinia*,—it matters not what name it is called,—in full maturity, and when once seen it is never forgotten. Botanists may dispute about its intermediate stages; may give it different names when found on other plants,—

but it still remains the great pest of the husbandman. There are no lingering doubts in the minds of agriculturists, botanists, savans of science, or laborers, that the rust is not injurious, because the most casual observation shows it in the sickly condition of all plants affected through the season.

The manner of impregnation is unknown, or, if known, is in

dispute. Some believe, as the stomata or breathing-pores of the plant are open in damp weather, that the infinitesimal germs enter these pores and gain a foothold, and push their rootlets into the cellular tissue of the plant. Others think they enter from the ground through the roots, and others still do not believe that they enter the plant at all, but that the seeds are poisoned by the touch of their spores. Be it as it may, we well know that it exists, and of course desire to have as little damage from it as possible. Observation has shown that rich land, or that manured by old manure, is much more likely to have the grain crop injured than land not so rich, or manured by green manure or some of our fertilizers. This should teach care in the preparation of our land. Some claim that an admixture of sulphur in sowing, and others that if it is sifted on the leaves, is a preventive. Careful experiments have shown all such remedies useless. Ashes are good to produce a healthy condition of the crop, while they have no effect upon the fungi.

The state of the atmosphere conducive to very rapid growth, is usually liable to develop the pest. We believe that all straw infected to a large extent should be burned, and all grasses and weeds standing around such fields should share the same fate. In this way the principal danger might be avoided.

Another instance of the two-formed condition of the smaller fungi can be traced in the delicate condition of moldiness which frequently covers the leaves of the lilac, the grape, the fruit of the gooseberry, and various other plants. It looks like strings of beads made of colorless cells. In this condition it is known and described as *Oidium*.

Fig. 30, *a*, tufts of conidia of the *Oidium Monilioides*; *b*, portion of grass leaf with same species of blight, the spores being the self-same beads and egg-shaped bodies, whence the generic name, but careful observation will show us that this is not its perfect condition; and when, later in autumn, these threads become more compact, and are surmounted on their horizontal surfaces by shining black

Fig. 30.

capsules, or perithecia, each of which is filled with elegant elliptical and elongated cells, and each in turn containing several spores, we shall find in *Erysiphe* that we have arrived at the conclusion of the dimorphism of this fungus, so injurious in its effects.

The famous grape mildew, so destructive to the grapes of Europe, and known as *Oidium Tuckeri*, is also only an imperfect form of some common *Erysiphe*; so of the grape fungi of New England, as well as of various other fungal plants.

Even the cluster cup first described is quite likely to turn out but one form of the rust, on some other plant. Some, as I have before said, even now suppose it identical with the *Puccinia*, and with good reason.

SMUTS.

Another of the fungal diseases of grain, long and widely known among agriculturists, is here called smut. Different names have been given it in different localities. In some it is "dust-brand," in others, "bunt-ear," "black-ball," etc. All the names refer to the blackish, sootlike dust with which the infested and abortive heads are covered. This fungus in New England does not generally excite much alarm among the farmers, yet it often injures the crop. Perhaps it is not so extensively injurious as rust, yet it destroys every infested head of grain upon which it establishes itself, and is also thought to be poisonous to people, or animals, that feed upon it. In Johnson's work on the grasses of Great Britain, he says "that diseased wheat examined by Sir H. Davy, when good, had an average of .955 parts of nutritive matter to 1,000: sometimes from disease, or smut, rust, or mildew, it was reduced as low as .210 in 1,000." The consequence of using such diseased wheat for food would be a step towards starvation, even though no greater evil resulted. It is, however, well known to be highly prejudicial to health; and the higher standard of living among the poorer classes of our population, compared with those of some continental countries, is the only cause of their exemption from the dreadful diseases resulting from the use of bad grain. That such diseases might occasionally prevail among them here, from similar

causes, under a more restricted diet, is evident from a record in the *Philosophical Transactions* for the year 1762. The case in question occurred in the village of Wallisham, about fifteen or sixteen miles from Bury, St. Edmond's, Suffolk, and the report of it was forwarded to the Royal Society by Dr. Wollaston, attested by the Rev. Mr. Bone, the curate of the parish, and is abridged as follows :— Some of the wheat belonging to a farmer in the neighborhood, being laid or beaten down by bad weather, and diseased, the grain much damaged in consequence, it was collected and threshed apart from the remainder. Being unfit for the market, it was sold at a low price to any of the farm laborers, and other people of the village, who would purchase. The sale of this wheat commenced about Christmas, and to one poor family, whose chief and possibly sole support it was for some time, the result was most alarming and unparalleled. It appears that the consumption of this poor wheat by the father, mother, and five children, was about two bushels in a fortnight ; the same being eaten in the form of bread and puddings, both of them very indifferent in quality.

But to poverty, cheapness and sufficiency of food are always irresistible inducements, and this unwholesome fare was continued without intermission until the mother and her children were attacked within a few days of each other with a gangrenous disease. The first indication of the disease was intense pains in the lower limbs. It first occurred on the tenth of January, and was thought to be rheumatism, but when this pain subsided it was followed by numbness and insensibility of the parts which terminated in mortification. The condition of the family at the time Dr. Wollaston made his report to the society is here subjoined :—

" Mary, the mother, aged forty. Right foot off at ankle ; left leg mortified, a mere bone but not off.

" Elizabeth, aged thirteen. Both legs off below the knee.

" Sarah, aged ten years. One foot off at ankle.

" Robert, aged eight. Both legs off below the knee.

" Edward, aged four. Both feet off at ankles.

" An infant, aged four months. Dead."

The father was not attacked until about a fortnight after his

wife and children, and in a slighter degree. In his case the pain was confined to two fingers of his right hand, which turned blackish and withered. Another laboring man in the same parish, who had eaten of this bread, suffered from numbness in both his hands for upwards of a month. They were constantly cold, and his finger-ends peeled ; one thumb he says remains without any sensation.

In several instances where bread made from the same wheat was eaten in the farmer's own family, as well as by other persons, no prejudicial effects were noticed, probably in consequence of such bread being used only occasionally, and as an adjunct to other and more wholesome food. The nature of the disease with which the wheat was affected does not appear to have been fully ascertained, but the circumstances are well authenticated. It is of course possible that the want of proper nourishment in the wheat may have had a share to do with the disease ; but smutty and mildewed grain has always been considered unhealthy to man, and many cases of disease in animals have often been traced to this cause.

With such examples before us, too great caution cannot be used regarding the use of grain and flour of suspicious character.

These fungi, like many of the others that infest our fields and gardens, belong to the family in which the spores are the distinctive feature, and is regarded as fixed in the genus *Ustilago* (or smut of grain), and the specific name *segetum* (standing). So we have the name *Ustilago segetum*, or the smut of standing grain.

Another kind of smut known in this country is *Ustilago magdis* (the maize smut). It is even more common than the other, as no corn-field is without more or less of it. It forms a peculiar thickened and abnormal growth, that is full of the characteristic black spores represented as magnified four hundred diameters in Fig. 31.

Fig. 31.

The spores in this fungus are very numerous, simple, deeply serrated, springing from delicate threads or in closely-packed cells, ultimately breaking up into a powdery mass. A species of this smut affects some grasses slightly in this country, but in France it frequently affects grass

to such an extent as to produce disastrous consequences on the hay-makers, such as violent swellings of the head and face, with poisonous irritation over the whole system. Threshers are sometimes thus affected in this country, when at work on smutty oats, although not all are equally affected.

The spores of this species are so immense in number, that it would seem impossible to guard corn or other grain against its ravages, but it seems like others of this class — they are quite easily destroyed, and in that way are kept in check. They adhere to the grain in threshing, but if the grain is washed with clean water, and then with a solution of Glauber's salts, and while still moist dusted with quicklime, these spores will be destroyed, and the rust spores also, and the crop will be improved, as the caustic soda is set free by the sulphuric acid of the salts combining with the lime, and converting it into sulphate of lime (plaster of Paris) which is beneficial to the young sprout, while the caustic soda is fatal to the spores of rust and smut.

Other washes, as of chloride of lime, at the rate of one ounce to the gallon of water, or of aqua ammonia in same proportions, are probably also beneficial to kill the spores, and aid germination of the grain. Experience has also taught us that a wet season is much more prolific of fungi than a dry one; and thick-sown grain than thin-sown.

The direction of the wind when grain is sown is of no effect, notwithstanding old people, many of them, think that an east wind is deleterious.

THE ONION SMUT.

This fungus, called by Prof. C. C. Frost, of Brattleborough, Vt., *Urocystis Cepulæ*, since its first appearance in New England in 1870 has caused much damage to that crop. It is thought to be allied to the rust on Indian corn, but not exactly the same. The damage caused to single towns in Massachusetts from this smut alone is estimated at several thousands of dollars. There is as yet very little known about the development of this fungus. It has never been known in Europe, and is supposed to originate from some of our wild species of onions, and of course is as yet

but imperfectly known here. It changes the onion to the peculiar dark sooty powder so well known as smut, and the infected onions at once cease to grow ; and though the black may often be peeled off apparently with one or two of the layers of the onion, they are not considered healthy, and great loss is entailed to those raising them. As the spores doubtless remain in the ground, and nothing put on the ground would be likely to eradicate them, the only known help is to change the locality, giving the onions ground on which they have not been previously raised, and using the onion-bed for other purposes, or for such crops as the spores would not injure.

After a time, perhaps four or five years, the old beds might probably be again planted, as doubtless the spores would have lost their vitality.

As this smut at the present time is principally confined to Massachusetts and Connecticut, with a little care on our part, it will be a long time before New Hampshire will materially suffer from this fungi.

Should it appear among us, it should be at once stamped out by burning over the land, and not trying to raise onions on it for at least four years, as a trial would not only be useless but would endanger whole townships by the increase of the spores.

It should as much be the law to stamp out by legal proceedings such pests, as to keep small-pox out of our towns, as the diseases resulting to the human family are none the less to be dreaded because slow and insidious in their workings.

Those who desire to know more of this disease we will refer to the Massachusetts Agricultural Report for 1876-77, where it is fully described.

WHITE RUST.

The idea we have thus far of rust and smut is, that it is dark colored, or like the rust of iron ; but as I speak of white rust that opinion must be overthrown, as the white rust of the cabbage, turnip, and all similar plants is one that the gardener has often to contend with. I bring it in to show that fungi must be looked for in every place and under all colors. This white rust

is called *Cystopus candidus*. It is represented in Fig. 32 as it occurs on shepherd's-purse, *a* showing the fruit with the rust upon it; *b*, portions of the cabbage-leaf with the same species upon it; and *c*, conidia of the same. (See Cooke's treatise on fungi.)

Upon the leaf of the cabbage it appears as engraved, in white patches; the leaves become deformed and swollen or blistered, even before we can make out fully the cause of the mischief outside. These blistered pustules have a minute system of

Fig. 32.

branching threads, which traverse the pulpy parts of the leaves, and which threads, insinuating themselves between the cells that constitute the pulp, take their nutriment at the expense of the growing foliage.

It is after the pustules assume the white color and are visible on the skin or cuticle that the reproductive parts termed conidia can be detected. (See Fig. 32.) From the multitudes of these beads or spores forming the white powdery dust, the term *conidia* is applied, which means dust-like. Other plants, besides, are often affected, as the water-cress, pepper-grass, radish, and even the weed purslane does not escape its ravages. Its mode of vegetation is one of peculiar interest, in fine one of the most curious phenomena of plant life, and indicates in this low order of vegetation a relation to higher structural forms, not only in plants but even in animals. Thus, if a few particles of the white dust be immersed in a drop of water, and examined under the microscope, they will be seen to rapidly absorb water, and swelling, a large and obtuse papilla resembling the neck of a bottle is produced, and a seeming empty space is formed in the contents of each spore. As these disappear, the whole granular substance becomes separated by fine lines into five to eight por-

tions each, with a small, faintly colored, empty space in the center. These portions are so many zoöspores. These are soon expelled one by one, and soon afterwards begin to move, being provided with seeming fins or fringes by which they are enabled to swim about like an animalcule ; but they are only buds endowed with motion, same as many other plants have. These of course are capable of infecting plants, as we have seen.

The prodigal provision of nature is here, as everywhere, especially in its lower orders, signally manifested, when we are told that the immense number of zoöspores capable of being produced from a single infected plant is almost beyond calculation.

It is easy for a million of conidia to be developed from one such plant, each producing five to eight zoöspores. It can scarcely be considered marvelous that the white rust should be so common on plants favorable to its development, the marvel being rather that any escape.

THE POTATO DISEASE.

Mold is a word in common use, and all will tell you what mold is, yet each will perhaps tell you of a different kind. This very numerous family are called *Hyphomycetes* ; that is, fungi that grow by throwing out delicate threads.

Of course there are several distinct groups.

To the common eye, unaided by the microscope or observation, mildews, moldiness, and similar microscopic plants would be readily confounded. But the mildew is a much more highly developed fungus, and though apparently as dangerous, is not so to the same extent. The egg-mold (*Oidium*), which covers and suffocates the young gooseberry, or the grape, readily yields to agents which will destroy it, and set free from its threads the swelling fruit ; but the potato-mold, for instance, is the inception of the potato-rot, which is so dreaded. The "molds," then, as Russell says, "are fearful parasitic plants, which riot on the tender tissues of other plants and eventually cause their death." There are in this country as many as ten known fungi infesting the potato. It is on this account that those attempting to describe the potato disease have differed so widely from each

other, while all have brought up some facts. The true potato-mold, causing so much mischief, is now generally admitted to be the *Peronospora infestans*, and were it not for its effects it would be regarded as a thing of beauty. Were the flies or insects, which are so liberally endowed with eyes, and quite unconcerned about crops, — to investigate, the leaves of the potato would be quite a pretty set of objects to examine, presenting white, many branched, and beaded twigged plants, with egg-shaped seed bodies on the tips of the branches. These vegetable growths issue from the stomata (breathing-pores) of the leaves, choke up the internal and external passages, and prevent a healthy action from being maintained. Soon the leaves become paler, or yellow, then discolored spots appear, and the stems are covered with dark patches ; even the stalks become filled with clotted substances, and sooner or later putrefy, and lastly the tuber suffers, and the rot rapidly increases.

It was towards the close of the summer of 1845 that the world awakened to what they supposed a new disease in the potato crop ; and one which threatened its entire destruction. Early in September its ravages in Ireland threatened starvation to the people. It extended to Scotland, England, and the continent, and rewards were offered for detection of the cause ; and a host of observations were made with no valuable results.

It is only by long years of patient study that nature's works are found out, and it will be longer still before any sure preventive will be reached. There are, however, some things that tempt this fungous growth that is so destructive ; as close planting, damp land, weeds that shade the crop, etc.

As there are some differences of opinion in relation to the actual condition of the potato, favorable or otherwise, to the rot, I copy from the observations of others.

“ Some eminent chemists, such as Dr. Lyon Playfair, believe that the potato-plant when healthy, is not subject to attacks from fungi. In a lecture delivered by the doctor before the Royal Agricultural Society of England, December 9, 1845, he remarked that ‘ much had been said and written with regard to the source of the disease, and since minute fungi had been assigned as its cause, potatoes, apples, and other fruits had been

inoculated with fungous spores, and had become diseased ; but if there was not some previous disease in the potato itself, how was it that some varieties of potatoes escaped while growing in the immediate vicinity, while others were attacked? ” The disease, he believed, arose from structural or chemical causes.

When a decayed potato was examined it was found that the diseased spots were always in the region of the spiral vessels whose function it is to carry air into the tissue of the plants. He believed the disease originated in the oxidation of the tissue. The Rev. M. J. Berkeley, the leading mycologist of England, on the other hand, contends that the fungus *Botrytis infestans*, or, as now classed under the new genus, *Peronospora infestans*, will attack the healthy tubers ; but the question arises just at this point, What means have we of ascertaining the perfectly healthy structure, and chemical state of tubers? Every farmer plants what he deems sound tubers, yet in the majority of cases, since 1845, the crop during very moist seasons has been more generally affected than it was prior to that date.

The severity of attacks of fungi on plants will depend in some cases on the density of their organic structure and the solubility of their nitrogenous matter. The nitrogenous principle of potatoes, for example, is soluble in water ; that of turnips nearly insoluble. The former, therefore, ferments more readily than the latter. The leaves of a healthy peach-tree, when placed in a moist atmosphere at about 75° Fahrenheit, resist fungoid fermentation for months, while those of a peach-tree affected with the “ yellows,” placed under the same general conditions, will quickly ferment and become covered with the fruit of the fungous mucor. The first possess an antiseptic property, the second are deficient in it. If two blocks of wood, one of boxwood and the other of soft pine, are placed in a fungoid solution, the first will resist the action of the mycelium for a long time because of its density, while the second will quickly decay. The first absorbs very little water, the second a great deal. A certain amount of moisture is always necessary to the growth of fungi. The presence of an excess of water is highly favorable to the growth of the common molds and some other forms of fungoid plants.

In years previous to the noted potato-rot of 1845, the average

amount of water found in healthy potatoes, according to Professor Playfair, was 72 per cent; that of unhealthy tubers since that date, 80 per cent. The tendency to ferment is therefore increased. It was observed by Professor Playfair, in his lecture alluded to, that a peculiar state of the weather had been observed all over the north of Europe where the disease had been seen, as well as in America. The wide-spread use of the potato as an article of diet, especially among the laboring classes throughout Europe, must have led to the extensive planting of diseased potatoes in 1846, because healthy seed could not be found. Indeed, Professor Playfair, in his second lecture of the 10th of December, 1845, recommends "the planting of diseased potatoes as seed rather than none." He further states that there was no prospect of obtaining healthy seed from abroad, and that he had permission of the late government authorities for stating that this was the result of their consular returns. The unavoidable adoption of this advice tended to establish hereditary disease in after years, whether it arose from chemical, structural, or fungoid conditions.

If a healthy potato is so dug out on its opposite ends that it will resemble a double egg-cup, and placed erect on one end for about six days in an atmosphere at the temperature of 70° Fahrenheit, its under cavity will become covered with mildew, and its fruit will appear in the form of blue mold, *Penicillium glaucum*. In this case the inverted cavity will retain the moisture, and as a consequence slight fermentation will ensue, the fungus deriving its nutriment from the potato; but the upper surface, although fully exposed to the floating germs in the atmosphere, will not sustain a fungous growth, in consequence of the free evaporation of the moisture from it. This form of fermentation should not be confounded with that produced by the fungus of potato-rot, *Peronospora infestans*. The chemical action of the blue-mold fungus is slow, and its odor is simply that of sour paste, while the destructive action of the potato-rot is very rapid, producing a higher state of decomposition and very offensive odors. The mycelium and fruit of each fungus also differ essentially from each other. Both forms of fungus produce oxidation of the cellulose structure, but with very different results. Consequently

potato-rot consists of more than the "mere decay of the tissue by its absorption of oxygen." The purely fungoid theory, on the other hand, will not account for the many exceptions pointed out by those who favor the chemical theory; since it may be shown that as the chemical constitution and density of any vegetables vary, so will the genus and species of fungi be found to vary with the proximate principles of the plants on which they subsist.

If there is truth in these remarks, the value of sound, hearty seed is one great preventive. Farmers should therefore exercise great care in their selection, and never plant a diseased tuber. Yet to my mind the fungus is the chief mischief, and so plenty of room, good care, and, I might add, early planting, should go hand in hand with the selection of seed. Russell says entire destruction by fire of all diseased tops should be imperative.

THE BRISTLE MOLD.

One more species of mold, known as the "buttercup-blight," is so common and so peculiar in its growth, that I can not pass it by.

Fig. 33.

a, conceptacle of *Erysiphe communis*;
b, sporangium of the same highly magnified.

It is represented in Fig. 33. Its varieties are all known as bristle mold, and attack damp paper or books; damp specimens in the collections of our botanists are frequently nearly ruined, and like other fungi they are dreaded pests.

RAPID GROWTH OF FUNGI: YEAST-PLANT.

Yeast is a well-known substance to all housekeepers, but all do not know that it is a plant that thrives on sugar or nitrogenous matter. When the plant is examined under the microscope it is found to be composed of myriads of minute cells, about one twenty-four-hundredths of an inch in diameter. During the progress of fermentation these cells rapidly increase in number,

until all the material necessary to their growth is used up. Its rapid growth, and the evolution of carbonic acid gas from such growth, makes it convenient for the housewife to raise her bread. She prepares her material, puts in her seed, which is some of the spores of the plant either dry or in fluid, and they immediately commence their growth.

The cells grow together in chains, and when stirred they sometimes appear like threads, which are in reality bundles of the fibers of the yeast-plant.

If the yeast is not used in this condition, the plant nourishment is soon used up, putrefaction commences, and with it comes a swarm of animalcules, countless as they are minute, and voraciously devouring all in their way, until they also die from want of food, changing the yeast frequently to a mass of animal and vegetable putrefaction. This soon subsides, and vinegar is the result.

This can be more fully exemplified by milk-yeast, which sooner, as every housewife knows, passes through its various stages, and sometimes is not baked until the putrescence is such as to be hardly endurable to many persons.

With this example of fungous growth before their eyes, who can wonder that the various fungi in the State of New Hampshire alone cost the agriculturist many millions of dollars. They blight his fruit-trees from the seed ; they blight his grain crop more or less every year ; they blight his fruit from the blossom to its end, pursuing it with a determined hate ; they mildew his beans and peas ; they impair his corn and potatoes ; they poison his hay, and disease his cattle ; they destroy his loved ones, often with insidious disease, and then rot out his store-houses, his dwelling, and even fastening upon himself, claim him at last as fit ground on which to ripen their spores for deadly work on others. No pest is so deadly, none so insidious in its workings, none so varied, meeting us everywhere and under almost all conditions. Insignificant in themselves, their very obscurity gives them the best chances to do us injury.

They have their enemies, — countless animalcules feed upon their various forms, yet no family is rendered extinct. The very atmosphere we breathe is often hazy with the spores of various

fungi. The only wonder is, why anything, or any condition of plant or atmosphere, can hold the various families of fungi in check. Some suppose them of spontaneous growth. Why is there need of such a supposition, when their minute spores capable of producing their like cannot even be excluded wherever the atmosphere is present? The wonder is quite the other way, for it is a wonder that they don't destroy more than they do.

ANIMALCULES.

It is but a step from the microscopic plant to the animal. The variety of form peculiar to microscopic life is truly wonderful. It is so different from what we have been accustomed to meet in our visible world that we are at once struck with its peculiar varieties. The number of these creatures exceeds all human calculation. In every pond and ditch, and almost every puddle, in vegetable infusions, in paste and vinegar, on honey, sugar, and all sweet substances, on almost every leaf and flower, even on those fungi only visible through the microscope, and in rivers, seas, and oceans, these creatures are found in such numbers and varieties as to almost exceed belief.

"The shapely limb and lubricated joint,
Within the small dimensions of a point,
Muscle and nerve, miraculously span
His mighty work, who speaks, and it is done,
The invisible in things scarce seen revealed
To whom an atom is an ample field."

Of these wonderful creations, I will only bring forward a few examples.

THE MITE FAMILY.

Comparatively few naturalists have studied up the habits and peculiarities of the mite family. But few of our readers in natural history text-books learn from their pages anything definite in relation to them, either regarding the affinities of these humble creatures, their organization, or frequently singular meta-

morphoses. We shall, therefore, only mention a few typical forms which we have had the pleasure of examining.

Mites are lowly-organized *Arachneds*. This order is divided into four families; viz., the scorpions, spiders, harvestmen, and mites; the scientific name of which is *Acarina*. They have a rounded oval body, without the usual division between the head and abdomen observable in spiders; the head, thorax, and abdomen being merged in a single mass. When mature, there are four pairs of legs, and the mouth part consists, as seen in the adjoining figure of a young tick, of a pair of maxillæ (*c*), which, in the adult, terminate in two or three jointed feelers; a pair

Fig. 34.
Young *Ixodes Albipictus*.

of mandibles (*b*), often covered with several rows of fine teeth, and ending in three or four larger hooks, and a serrated labium (*a*). These parts form a beak, which the mite can insinuate into the flesh of its host, upon the blood of which many species subsist.

While very many of the mites are parasitic on animals, some devour eggs of insects. The *Nothrus* (Fig. 35) destroys millions of the eggs of the canker-worm, and it is said that it also sucks the eggs of the chinch-bug.

A few of this species are injurious to man, as the *Sarcoptes*, that burrows under the skin of filthy people, causing a disease once so common, — the itch. The cheese-mites, that swarm over the cheeses in our cities, and sometimes in the country, have six legs when young, but eight after a molt. I have scraped a full pint of them off a single cheese in Boston, and, putting my hand into the mass, I could distinctly feel the animal heat produced by aggregate millions of living, burning furnaces, the same as from higher organizations.

Fig. 35.

The harvestmen, known in this section as "daddy-long-legs," almost always have numerous parasites belonging to the mite family. They also live parasitic on various water insects, and on the gills of the fresh-water mussel.

These species are very minute in size. Some species have been found in the lungs and blood vessels of various animals.

THE SUGAR MITE.

Many people have been startled by statements sometimes read, or that they have heard from authoritative sources, as to the immense number of mites (*Acarus Sacchari*, Fig. 36,) found in unrefined or raw sugar, but those statements generally fall below rather than above the truth.

Fig. 36.

Dr. Hassel, who first discovered them, found them upon sixty-nine out of seventy-two samples, and found sixty or seventy mites to one grain of sugar, in most of the samples. Mr. Cameron counted five hundred on ten grains, which would be one hundred thousand to the pound. This would really be quite an adulteration, but, under favorable circumstances, that is, with warmth and moisture, I have seen one-half the bulk, at least, animal life. This would, however, only be the case upon small lots of sugar. When in barrels, their number is frequently immense, but they are much more plentiful at the top of the barrel, or nearest the light, though light is in no way necessary to their production.

The disease known as "grocer's itch," is undoubtedly due to the presence of this mite, which may now and then work its way under the skin of the hand.

Plentiful as these mites are on the damp brown sugars, I have never detected them on dry white sugar, though I almost always find them on figs, dates, honey, if grained, and often on the comb when not; in fine, they may be found on all sweet substances that are sufficiently exposed.

They are a jolly, playful race of beings, and seem to live and eat for enjoyment; when frightened they play dead, curling up their legs, and remaining inactive for some time.

Another singular mite, and of the lowest order, burrows in the skin of dogs, and also in the diseased follicles of the human face, and more especially the nose of man. (See Fig. 37.) It is a long, slender, wormlike form, with eight short legs, though like many other mites it has but six in the larval state. Washing the face in water to which has been added one teaspoonful of strong aqua ammonia to the quart, will usually remove them.

Fig. 37.

WATER ANIMALCULES.

Perhaps no class of objects that are visible to us only through the microscope engage our attention so often, or amaze us so much, as the various forms and peculiar habits of the water animalcules.

For the first time it is an amazing spectacle to view an assemblage of dissimilar forms in a drop of stagnant water. They are from one thousandth to one ten-thousandth of an inch in diameter, and I once saw them so crowded that the spaces between them were not much larger. Several hundred forms have been studied and described, but I shall only mention three or four of the more common species. Remember, while pond or river water will contain now and then specimens, that it is stagnant water alone that is crowded, and the pure spring-water of New Hampshire never contains any animal life.

The motions of these creatures are varied, I might say almost endless, in variety ; but amid their diversified gambols all have the power of avoiding obstacles in their course, and their neighbors, which are in such close proximity to them. Some species are far more common than others, but the more uncommon varieties may frequently be obtained in midsummer, by exposing a decoction of any dried leaves to the sun for three or four days ; such exposure must be in the open air. A few species I will describe.

The *Rotifer*, or wheel-bearing animalcules, are so termed from the appearance of certain wheels, often seen rapidly rotating in various situations on the anterior part of the body near the

mouth. We say wheels, because they were so considered by early microscopic observers who could not account for the motion in any other way ; but an improvement in instruments has shown that it is an incessant muscular action, giving an apparent rotation ; but that wheels could revolve in any part of an animate body, would be quite inconsistent with the laws of animal organization. These wheel-shaped muscles are used to aid in the motion of the animalcule and in supplying its food. They are entirely subservient to the power of will, as they can stop the motion instantly or increase it as they choose.

Their body, though so small, in one species, is shielded by a shell into which this rotating apparatus can be drawn at will. It is by the whirlpool, formed by the before-described rotations, that its food is drawn into its mouth as a vortex, where it is masticated by three tiny teeth, and swallowed into a prepared receptacle where it is ground by muscles working vigorously on each other. Minute and curious as these organs are, the animalcule is so small that like all other microscopic creatures they are transparent, and with a moderately high magnifying power this can be seen as the workings of a steam engine made of glass.

This species enjoy sunshine, and on dark, cloudy days are only found at the bottom of the pond or ditch in which they reside.

Again another of this same species, called *Tardigrade*, have so great a tenacity for life that they may be put upon a glass slide and dried for days, yes, for months or years, and then at once resuscitated by a drop of water. Dr. Carpenter, one of the most renowned microscopists of Europe, states that their tenacity of life goes even further, as he has kept them in a vacuum for thirty days with sulphuric acid and chloride of calcium, thus causing them to suffer the most complete desiccation that the chemist can effect, and yet they have not lost their capability of revivification. For this reason they have been styled the resurrectionists, and it seems for good cause. This wonderful power of resuscitation, and the fact that the rapidity of their reproduction, as estimated by Prof. Erenberg, being from the egg at the rate of seventeen millions per month, is cer-

tainly sufficient for their remarkable appearance in almost every situation, and under almost all circumstances.

It has been supposed by some that they were the result of spontaneous production, but from what I have said you can see there is no necessity for such a conclusion. The many curiosities connected with the life and introduction of the Rotifer, into almost all places, of course will excite the amateur in microscopical investigation to search for them. That he may not be disappointed, I will state that in the leaf-cells of the *Spagnum*, generally known as bog-moss, there is a very curious departure from the ordinary type of vegetable growth. Instead of the usual cell-tissue their leaves contain spiral fiber, loosely coiled in their interior, and in the membranous covering of the stem there are nicely rounded holes, or apertures, by which there is free communication with the interior, as well as with each other. These natural caverns are appropriated by the Rotifer, and used as dwellings. It is here you are sure to find them at home.

Another species, called *Aurelia*, are covered with cilia, or minute hairs around the mouth in a circle ; by their agitation animalcules much smaller are drawn into their mouths and devoured.

Again the *Hydra*, which may be found in ponds and rivulets adhering to the leaves of aquatic plants, or twigs and sticks that have fallen into the water, is a wonder among wonders.

It may be subdivided many times and yet every part will in a few hours become a perfect *Hydra*. This name is given them because they have many long arms, which were supposed to resemble the heads of the fifty-headed water-serpent, called *Hydra*, which fabulous history informs us was destroyed by *Hercules*, in the lake of *Lerna*. They are by no means vegetarians, and have the capability of swallowing creatures as large as themselves.

In the ordinary mode of multiplication little budlike protuberances are developed on their external surface, which are soon observed to resemble the parent in character, possessing a digestive sack and mouth.

For a time, however, this cavity is connected with that of the parent, but at last the communication is cut off, and the young

Hydra quits its attachment and goes in quest of its own maintenance.

A second generation of buds are, however, frequently seen on the young before quitting its parent, and I have counted as many as eighteen in different stages of development on one original stock. Again, in taking its food, it sometimes happens that the same morsel will be seized upon by two Hydræ, when a struggle for the prey ensues, in which the strongest gains the victory. Sometimes each will begin to swallow the same morsel, until the mouths of the pair come in actual contact, when, if the morsel does not break, the larger deliberately swallows his opponent, sometimes partially, so as to compel the discharge of the food by the smaller, but frequently the entire polyp is engulfed. But Hydra is no fit food for Hydra, and his capacity for endurance saves him from a living tomb, for after a time, when the food is sucked out of his mouth, the sufferer is disgorged with no other loss than his dinner.

Yet perhaps the greatest curiosity is in the reproduction of its parts. Split one open, and the separate parts will soon take food, and in twenty-four hours are as perfect as ever.

Strange as it may seem, all these processes can be watched with unerring certainty, and so interesting are the developments, that I always dislike to close the scene, though aching eyes will at length gain the mastery.

TRICHINA SPIRALIS.

As the *Trichina Spiralis* is an animalcule liable to infest man to his injury, and often a disease of swine, rendering the pork dangerous to the consumer, I have selected it as of peculiar interest. It is a small spiral worm, like a pin-worm, which has ever been found now and then in muscles of various animals. It is supposed by some to originate in the rat, and to have been from them spread over the country as they gained a foothold, as it is often found in their muscles, and frequently in those of cats that devour them. How it comes to infest pork is uncertain, but probably by their food, as a hog is none too particular upon what it feeds, and might eat portions of rats or any other dead animal.

The immature parasites, as seen in muscle under the microscope, are worms about one twenty-fifth of an inch in length, spirally coiled up within globular, oval, or lemon-shaped transparent cysts, which, according to the length of time they have been formed, are more or less covered with calcareous matter.

From various experiments, I have been led to believe that after they are completely covered with this calcareous concretion, sealed as it were in a stone sarcophagus, that they are destroyed; such flesh containing them will not contaminate other individuals, as I have fed young rats with it without effect, when they were always contaminated when fed with diseased meat in which the cysts were not calcareous, though the cysts themselves are to be considered rather as abnormalities, developed some little time after the larvæ have reached their destination, as hundreds of specimens have been seen to co-exist entirely free from cysts.

Fig. 38 shows the *Trichina* when thus incased in the muscles (magnified).

The number found in any one subject varies, but Leuckart estimated that one ounce of cat-flesh which he observed must have harbored more than 300,000 parasites. Even if we assume that the forty-five pounds of muscle which an ordinarily healthy man possesses were infested with only 50,000 *Trichinæ* to the ounce, they would still contain more than thirty millions.

Fig 38.

The adult *Trichina* magnified is shown in Fig. 39.

Fig. 39.

The sexually mature male *Trichina*, according to Cobbold, is about one-eighteenth of an inch long, while the adult female is one-eighth; the body is rounded and slender, and the head very narrow and sharply pointed. The mode of reproduction is viviparous. The muscular parasite, when introduced into the alimentary canal of man or animal, is set free in the process of digestion, and in two days' time reaches the adult

condition. Leuckart states that in six days more the female brings forth a numerous brood of minute, hairlike larvæ; these soon begin their wanderings by piercing the intestinal walls, after which they proceed through the system till they reach the muscles, into which they penetrate; here they develop so that in two weeks more, that is, in about three weeks from the time the infested food was taken, they present the appearance of the ordinary muscular *Trichina Spiralis*, as shown in Fig. 38.

The sexually mature worms probably produce more than one brood of young; they have been found alive in the intestines eight weeks after the infection of the flesh in which they were contained. The larvæ remain in the muscles they have reached, and shortly become incysted as heretofore mentioned. Smoking the meat does not kill the parasites it contains; brine, if very strong and long applied, probably does; thorough cooking certainly does. Time also has its effect on them, though they are endowed with wonderful vitality. In some healthy subjects who died from accident, the larvæ and their inclosing cysts have been found to have undergone calcareous degeneration; but it is probably months, and even years, before death of the parasite occurs; in illustration of which, Virchow states that in one case he found them alive eight, and in another thirteen and a half, years after infection.

When a person is infected, which infection usually takes place from eating partially cooked sausages or raw bacon, in three or four days there is lassitude, depression, sleeplessness, loss of appetite, and fever. Then there supervenes excessive pain in the muscles, especially of the limbs, contractions of the knee and elbow, swelling of the limbs with apparent pneumonia, and frequently mania with death.

On post-mortem examinations, the muscles are found crowded with the parasites, and to be in a state of fatty degeneration. If they recover, after three or four weeks of the same symptoms, with less severity, convalescence commences, and in six or eight weeks more the patient is quite well, and the incysted *Trichinæ* seem to give him no further trouble. The virulence of the attack seems to depend considerably on the number of parasites introduced into the patient's stomach, yet the previous constitu-

tion and strength of the patient have much to do with final recovery.

The true safeguard is to eat no pork unless thoroughly cooked ; yet microscopic examination will reveal the disease, even if ever so small a section of a muscle be examined, and it should be incumbent upon all butchers here as in Germany, to make such examination, and they should be punished here, as there, for selling Trichinous meat.

For this time I will present no further microscopic wonders. What I have said is sufficient to show you, that around us all exist immense fields of study, easy of access, and yet pregnant with wonderful facts, with but few of which we are as yet conversant.

“ Has any seen
The mighty chain of beings, lessening down
From infinite perfection to the brink
Of dreary nothing ? ”

Until we have, let us be ever ready to grasp truth, wherever found, and lend idle hours to investigation.

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