BULLETIN UNIVERSITY OF MONTANA.
No. 17.
BIOLOGICAL SERIES No. 5.

Lectures at Flathead Lake

A Series of Lectures delivered at the University of Montana Biological Station at Flathead Lake, by the Staff of Instructors, Session of 1902.

UNIVERSITY OF MONTANA, BIOLOGICAL STATION, BIGFORK, MONT.,
UNDER DIRECTION OF MORTON JOHN ELROD.

University of Montana, Missoula, Montana, U. S. A.
1903.

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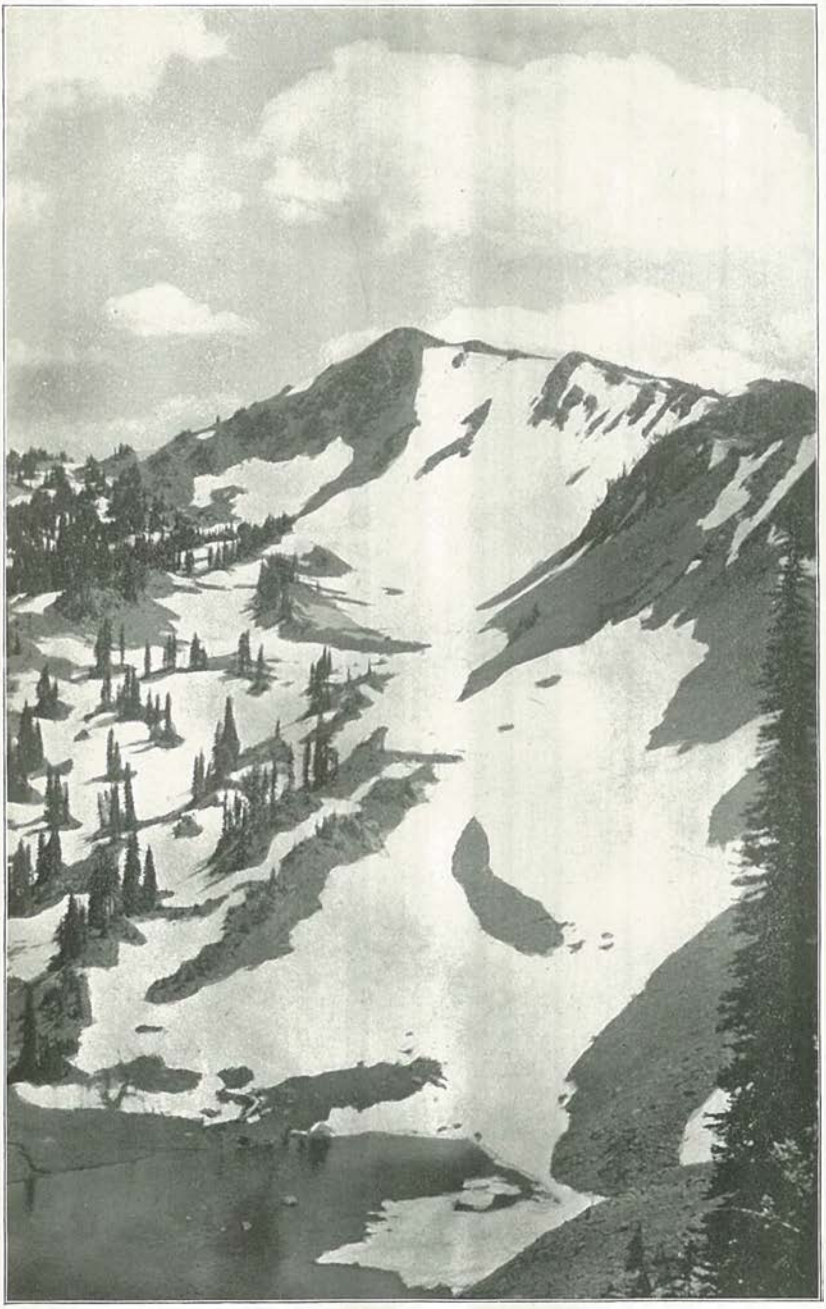

MacDougal Peak, Swan Range, from the ridge, showing snow field with ice. Note how the timber seeks the drier ridges. Photo by M. J. E., August, 1902. The view is south. Altitude of summit, 7725.

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LECTURERS AT THE UNIVERSITY OF MONTANA BIOLOGICAL STATION, 1902.

Morton John Elrod, Professor of Biology, University of Montana; President, Montana Academy of Sciences, Arts and Letters; Director of the Station.

Harry Nichols Whitford, Assistant in Botany, University of Chicago, and Collaborator in Bureau of Forestry, United States Department of Agriculture.

Perley Milton Silloway, Principal Fergus County, Montana, Free High School, Author of "Some Common Birds."

Maurice Ricker, Principal Burlington, Iowa, High School, Member Iowa Academy of Science.

INTRODUCTION.

The material presented in this bulletin consists of a number of lectures or talks delivered at the University of Montana Biological Station in the summer of 1902, by the station staff. Not all the lectures are given. Many of the illustrations, such as photographs, charts, and drawings, have of necessity been omitted, owing to the expense of reproduction. The lectures on protective resemblance and mimicry were illustrated by numerous colored drawings and charts, the work of Mrs. Maurice Ricker. But few of these can be reproduced, and they only in black and white. While the absence of numerous illustrations is to be regretted, it is thought the material presented will be of sufficient aid to warrant publication.

The lectures are given for a double purpose.

1. They should be of great service to teachers of the state in nature-study work. Several are prepared expressly for this purpose. Some of those treating of particular features of the locality may by slight modification be made to apply to other localities. There has been an urgent demand for just such information as is here presented, and the publication of the lectures will answer many inquiries that have been received.

2. They will put before the people of the state some of the results of original work carried on at the station. This is all the more desirable since nearly all the observations in a new locality must for a time be new, and hence deeply interesting. It is hoped they will show in part the wide field open for research, and encourage the attendance of many who are seeking such a place for study.

Since the lectures or talks were delivered to audiences of whom many were unacquainted with the subject and with technical terms the simplest language has been used, thereby making them of greatest service.

M. J. E.

Missoula, Mont., April 27, 1903.

The Physiography of the Flathead Lake Region.

Morton John Elrod.

The first thing one must do in a new locality is to become familiar with 'the lay of the land.' The surface geography and geology of a region must first be understood if one is to seriously discuss the botanical or zoological life. The character of the soil determines to a large extent the general character of the vegetation, and the surface irregularities will indicate the nature of the zoological life. In a region where roads, fences, houses, and similar works of man are absent, a knowledge of the country is all the more important in order to get over the country. Since much of the country is as yet unexplored the physiography of the region will be especially interesting to those working at the station.

The views here given are based on the observations of the past four years. Later study may require that they be modified in part, but it is believed the observations will aid very much in working out the exact changes that have taken place in this section of the state. The glaciation of the region offers a good field for detailed work.

The Mission and Swan ranges of mountains, in northwestern Montana, lie parallel with each other, extending north and south in general direction. The Mission range is about seventy-five miles long, ending as a range at the Biological Station. The Swan range extends twenty-five or thirty miles farther north. Both ranges were made by faulting. The stronger throw was at the southern end of the ranges, where the high peaks, reaching 10,000 feet, are found. Between the two ranges the Swan river flows toward the north. It enters Swan lake, still between the ranges, far down the side. From Swan lake the river flows still northward for a few miles, then winds around with a big bend and turns westward through a new channel to its inlet into Flathead lake. That portion of the Swan range which extends north of the Mission range borders directly on the valley north of Flathead lake, rising abruptly from the plain, without foothills.

The formation of the ranges gave to the western side of each an abrupt and steep face, intersected with many ravines and canyons, with more gradual slopes on the eastern sides. The western base of the upper end of the Mission range is washed by Flathead lake, which for the greater portion of the distance meets the mountains with abruptness. There is little level or tillable land between, and often scarcely room for a wagon road.

South of Flathead lake a large valley, Mission valley, extends southward for thirty-five miles. North of the lake is another large valley which continues northward to the British boundary. On the western shore a spur range of the Kootenais shuts in the waters of the lake. The outlet of the lake is through a new channel, with a series of rapids, a

foaming river of wondrous beauty, untouched by man's intervention, with only a trail along the bank and an occasional Indian path to the water's edge for fishing purposes. The lake is about thirty miles long. At its widest portion it is perhaps seventeen to nineteen miles. For the greater portion the width is no more than eight or ten miles.

Two rivers enter Flathead lake. Flathead river flows into the northern end near the center. Swan or Bigfork river flows into the northeast corner, past the site of the laboratory. See Fig. 4. Flathead is much the larger of the two, has a much larger drainage area, and carries into the lake much more sediment. The delta made by the river extends into the lake for more than a mile. Beyond this the lake drops off abruptly to deep water.

The preceding brief statements give the skeleton of the region to be covered in the work of the future, of which the present lecture is the smallest part. Let us consider briefly the agencies that have been at work in remodelling the surface, with the results as revealed by a rather superficial study.

When the mountain ranges were first upheaved their faces were abrupt and perpendicular. The valleys were deep and angular troughs between the ranges, rather than level valleys. It is believed that Flathead lake and the valleys to the north and south were formed by a slip in the faulting process, by which the western portion fell, leaving the mountain ranges as an abrupt border for a comparatively level plain. Evidence for this may be seen in the numerous photographs taken in the two ranges, which show plainly the stratification of the rocks, their slope and dip, and the configuration of the mountain range.

Immediately after this upheaval various agencies began the work of tearing down the ranges, and fashioning them and the valleys into their present forms. The agencies at work have been the wind and air, water, frost and ice, and the vegetation. Vegetation, as also animals, was absent at first, and came gradually, after the disintegration had been sufficient to afford a foothold.

The process of disintegration has continued from the first to the present, and continues now. It will continue until the entire mountain ranges are levelled. The rocks were alternately hot and cold, wet and dry. The small crevices were filled with snow and ice, which made them larger. Larger and larger they became, until pieces, large and small, tumbled from the face of the cliffs. Disintegration was slow or fast according to the nature of the rock. The smaller portions were washed down into the troughs between ranges, filling them up. While the larger channels between ranges were filling up the smaller gorges and ravines at right angles to these and between peaks were being ploughed deeper and smoother by the melting snows from above. The summits were being penetrated by the percolating waters, and the entire mass in some cases rent in pieces by the expanding ice. In some cases the faces of the cliffs fell away until the entire mountain tops fell, leaving the present summits a mass of boulders, still being slowly worn away by the wind and water. This is evidently the case with McDonald peak of the Mission range, as may be seen by the photographs taken at the western summit.

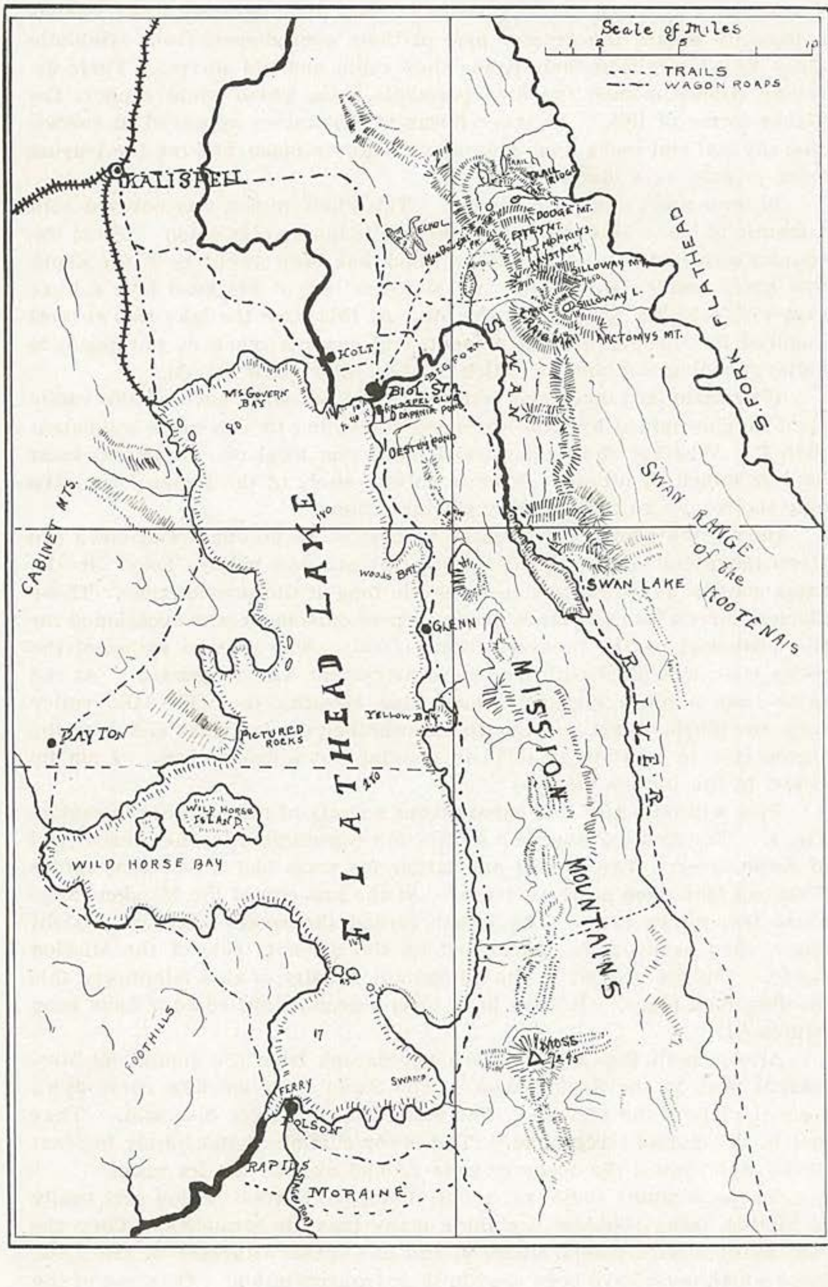


FIG. 4. Map of Flathead Lake and adjacent region.

Lichens were probably the first forms of vegetable life to appear. These probably aided in the process of rock disintegration. As lichens apparently secure the greater part of their nourishment from symbiotic algae growing within their tissue they could and did thrive. Their decaying tissues formed the first vegetable loam which could support the higher forms of life. As other forms of vegetation appeared in succession the soil and rocks were held more firmly in place, making the tearing down process very much slower.

In later times came the ice age. The whole region was covered with a mantle of ice. How deep the river was is mere speculation. From the country adjacent to the laboratory which has been swept by it the depth was many hundreds of feet. At the lower end of Flathead lake a huge dam 450 feet high was left by the ice. At this time the lake was several hundred feet deeper than at present, and covered much of the northern valley, flooding the land on which the laboratory now stands.

How many advances and retreats of the ice mass covered the valley must be determined by more extended study, and by one more competent than I. Whether the main glacial mass was local or continental must be determined by others. From a careful study of the region I can give only the results as evidenced by glacial action.

During the glacial period large masses of ice no doubt slid down the steep mountain slopes into the wider ravines and valleys below, in the same manner as ice masses on mountain tops at the present time. These glaciers flowed into one large glacier whose movement was occasioned for the most part by the pressure from behind. The present valley of the Swan river was filled with ice whose movement was northward. At the same time a much larger ice mass was crossing the wide lake valley from the north. I am not able to say whether the ice mass slid over the frozen lake or whether it aided in gouging out a deeper bed. I am inclined to the former view.

This will be better understood from a study of the map of the region, Fig. 4. The first ice river had a direction represented by the present bed of Swan river. The second and larger ice mass had a direction across Flathead lake from north to south. At the low end of the Mission range these two forces met. The larger turned the smaller first at a right angle, then back on its course, but on the opposite side of the Mission range. On the ground in the immediate vicinity of this laboratory this meeting took place. It must have been a grand sight could it have been witnessed.

Also consult Fig. 5, which is a photograph from the summit of MacDougal peak in the Swan range. The Swan river ice flow came down from the left in the picture. The main flow was from the right. They met in the middle foreground. The lower summits immediately in front of the lake toward the observer were ground over by the ice mass.

On the summits southeast of the Biological Station, which may easily be visited, large boulders, weighing many tons, lie stranded. They are well marked with glacial grooves, and are silent witnesses of the great force which must have been used in their transportation. On some of the summits where the rock strata are undisturbed may be seen deep and

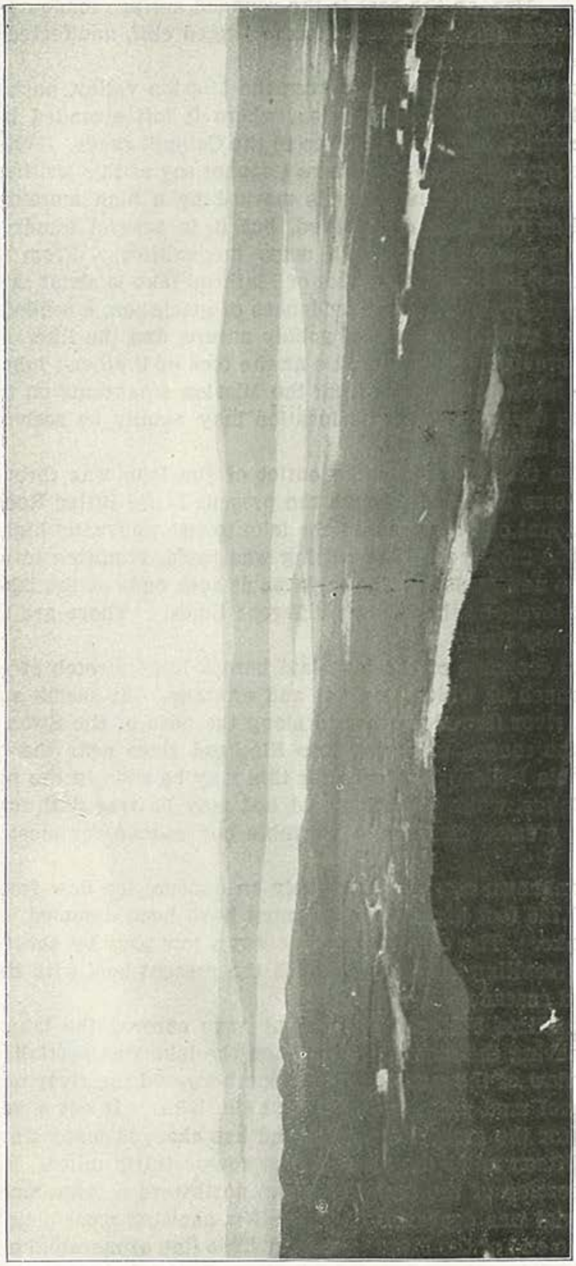


FIG. 5. General view westward from the summit of MacDougal Peak. In the foreground is the wooded plain. Echo Lake is on the right, Rost Lake in the middle foreground, Swan River on the left. In the distance is Flathead Lake. The point of land extending into the lake is the delta of Flathead River. Photo by M. J. E.

perfectly plain grooves in the rocks, showing plainly the direction of the ice movement. Also, on the east is the rounded surface made as the ice was forced upward, and on the west is the jagged cliff, unaffected by the ice as it broke off and tumbled over.

The larger ice mass extended across the Mission valley, pushed over the hills south of St. Ignatius Mission, where it left stranded boulders high on the summits, and on past Arlee to the Cabinet range. Whether it passed over or through these mountains I cannot say at this writing. The southern end of the Mission valley is marked by a high moraine. Its exact height has not been determined, but it is several hundred feet. This moraine is much broken, with many inequalities. From this region to the second moraine at the foot of Flathead lake is about thirty-five miles. This territory shows many evidences of glaciation, stranded boulders, hundreds of potholes, banks of pebbly nature, and the like.

As stated previously, the moraine at the foot of Flathead lake is 450 feet above the lake. It extends from the Mission mountains on the east to the Cabinets on the west. Its location may readily be seen by consulting the map again, Figure 4.

At the time this was made the outlet of the lake was through the arm at Wild Horse bay, and through the present Little Bitter Root river. An unusual amount of water caused the lake to rise unusually high, when it overflowed the moraine. The cutting was rapid, resulting in a lower lake level and a new outlet. The terraces at both ends of the lake show the successive levels of the lake at different times. There are at least three, and possibly four.*

The partial drainage of the lake laid bare a large stretch of country to the north, much of which was flat and swampy. It seems apparent that the Swan river flowed northward along the base of the Swan range, and close to the range, emptying into Flathead river near the present town of Columbia Falls. Evidence for this may be seen in the partially filled swamp lakes, while a distinct old bed may be traced through the timber for the greater distance, a veritable bog swamp for most of the season.

By some unknown means, most likely an unusual ice flow from MacDougal peak, 7,725 feet high, the river must have been dammed, causing a temporary lake. The overflow was across a low pass by short cut to Flathead lake, resulting in a new channel, the present bed, with its beautiful rapids and cascades.

In the earlier time Flathead river must have entered the lake immediately after leaving the mountains. When the lake was partially drained by the overflow of the moraine at the southern end the river meandered over the level mud plain until it found the lake. It cut a very tortuous channel for the greater distance, and has changed many times. In a distance of fifteen miles the river course covers thirty miles.

By the recession of the main ice sheet northward a large amount of morainal material was deposited in the valley, showing most plainly in a line north of the end of the Mission range. This line of morainal material

* This view is confirmed by Eliot Blackwelder, from the University of Chcago, who visited the region in 1902.

How to Study a Bird.

NATURE-STUDY LESSON.

Perley Milton Silloway.

The prime object of nature-study is the training of the powers of observation in such a manner that they shall minister to the higher intellectual faculties. It is not an end, but a means, whereby the observer obtains a stronger grasp upon the larger relations of life. Nature-study does not consider the probable destiny of the pupil as a botanist or a zoologist, but as a student of life in any or all of its relations, assuming that all Nature is simply environment which is to react upon the mind and develop its noblest faculties. Life is everywhere about us, and nature-study aims to teach anyone to see, hear, and appreciate that life, whether manifested in animal or plant. Hence the essential method of studying a bird is to cause anyone to see, hear, and appreciate the bird, and to consider its relationships as a part of the vast domain of Nature.

The primary step in the study of a bird is identification. The bird must be recognized, and to make recognition successful the object must be seen under circumstances which admit of definite observation. If the bird is a new one, a rapid inventory of the essential features of its description must be taken, and a fair idea gained of its size, form, color, and markings. The idea of size may be comparative, as somewhat larger than a chipping sparrow and smaller than a robin, or about as large as a pigeon. Attention must be given to the bird's form, or the general outline of the body. It may have elongated neck and short legs, like the geese; it may have both long neck and long legs, like the herons and cranes; it may be rather stoutly built, like most of the sparrows; or it may have a comparatively large head, like the flycatchers.

The prevailing colors must be noted, as general color of the upper parts, lower parts, head, wings, and tail. Then any striking markings should be carefully observed, as these markings are generally the quickest and surest means of identification. For instance, suppose we see a bird of black plumage, somewhat smaller than the robin, rather stoutly built, with prominent white bar on the wing. Upon reference to our book of descriptions, we learn that our new acquaintance is the lark bunting. Suppose we meet a blackbird, somewhat larger than our common friend of the feed-lot, with prominent yellow and white markings; we easily learn that our new friend is the yellow-headed blackbird. All these features in the foregoing descriptions should be promptly jotted down in a note-book, to be used when a key can be consulted.

The actions of the bird at the time of observation are especially important, for they often serve as a key to the family or group to which the bird under observation belongs. There are peculiar characteristics

of certain groups of birds, as the flirting of the tail by the smaller flycatchers, the deliberate folding of the wings by the plovers upon alighting, the teetering of the body by the smaller sandpipers when standing or walking, and similar actions which will occur to your own mind.

The special appearance of any bird is a great help in recognizing or identifying it. It may assume some characteristic attitude that will have a likeness to pictures we have seen or may see, and thus we are aided in determining the name of the bird. Suppose we are collecting on the shore of Daphnia pond. Among the rushes we see (though it will take sharp eyes to see it) a slender, brownish bird of rather large size, with elongated neck and head pointed upward in meditative attitude. We remember that we have read of the bitterns assuming this posture, and we form an idea which readily aids in identification,.

In connection with the description and appearance of the bird we are studying, we should learn to note its movements that seem to characterize the species. The kingbird and other flycatchers will be seen to leave their perch, fly outward and upward irregularly, try to capture a passing insect, turn in air, and quickly alight upon the same or another convenient perch. The sparrow hawk will often hover in air, maintain its place by continued fluttering of the wings, and then swoop down upon its prey, or else continue its quartering flight. We notice a bird somewhat larger than the robin, with enlarged head and noticeable crest. It flies over the water with harsh rattling cry, hovers in mid-air to select a victim in the water below, and then dives head foremost. By these actions we have little difficulty in recognizing the familiar kingfisher. A small bird, not so large as the chipping sparrow, alights upon the trunk of a tree near us, and begins to ascend the bole by a zig-zag course, inspecting the crevices of the bark for lurking insect larvae. These movements aid us in identifying the little brown creeper.

Besides what we have mentioned of movements of the bird as one of a species, it is especially interesting to note what may be called the individual actions of the bird. This constitutes a higher phase of bird study than that mentioned in the preceding paragraph, but it is productive of greater results. It separates the bird in question from its group, and regards it as an individual, manifesting traits for which it alone is responsible. No other bird of the same species may go through exactly the same performance, nor exhibit its impulses of love or hate, courage or fear, anger or pleasure, in just the same manner. It is this phase of bird study that marks such naturalists as Ernest Seton Thompson, John Burroughs, Bradford Torrey, Florence Merriam Bailey, and a few others.

Early in the study of a bird the observer must become familiar with its song, call-notes, or cries. Color is generally difficult to distinguish at any distance from which ordinary observation is made, hence the voice of the bird is the means most useful to the observer in recognizing his feathered friends. In the mating and early nesting season, the songs of the birds are especially attractive, and at that time the music should be so associated with identification that thereafter the song will suggest the author. However, the song season is comparatively short, ending

in early July at its longest, with the exceptions of the song sparrow, the meadow lark, winter wren, the vireos, and a few others. Hence the calls and cries of the birds should be learned if one's observations are to be extended throughout the year. Indeed, in late July and during August, few birds are seen, as then they are strangely silent and it is only by their few calls that their presence can be detected. Many birds which haunt the bush allow only an occasional glimpse of them as they flit through their leafy retreats; such birds must be recognized chiefly by their calls. Others, like the rails, skulk among the reeds of the swamp, and the observer must know their voices if he attempts to note their presence.

The manner of flight soon becomes a matter of importance in our study of the bird. The skimming, darting, ceaseless flight of the swallows is vastly different from the whirring wing-movements of the grouse. The low, undulating flight of the sparrows is altogether a different movement from the flitting, capricious, restless evolutions of the terns and gulls. The hawks and eagles flap and soar overhead in ever-widening circles which carry them cloud-ward; the longspurs mount upward in irregular, progressive gradations, and then descend with outspread, unmoving wings, parachute-like, singing as they descend. Our friend robin speeds through the air from point to point in a straight-away course, while the catbird flits from bush to bush with labored action and flipping tail. The flight is so characteristic that it becomes an important aid to bird recognition.

If one is to know much about a bird, he should know where to look for it. To study the bittern one must go to the reedy bog. For the sandpipers we must look along the sandy shore of lake, river, or pond. The song sparrow chooses the bushes bordering the water, while the vesper sparrow resorts to meadows rank with grass. The redstart hides the beauty of its black and orange-red plumage in the depths of the swamp-woods; the meadowlark scatters its ringing melody over the open fields and meadows. Audubon's warbler revels in the depths of the high coniferous woods; the vireos chant in the lower story of the deciduous trees. The American dipper loves the vicinity of splashing falls and foaming rapids of the mountain streams; the handsome lazuli bunting prefers the edges of clearings or the telephone wires of the roadsides. Thus we see that each species has its characteristic haunts, and a knowledge of these haunts is an essential part of our study of the bird.

The migrations of a bird, the time of its arrival in a neighborhood if it is not a resident, and its departure, form a leading part of one's knowledge of the birds of any locality. Many birds can be studied only while they are loitering in a neighborhood a few days in spring or fall as they journey northward or southward in their seasonal movements. The date on which any species is seen, whether an old friend or a new acquaintance, is worthy of permanent record. When to look for a bird is as valuable knowledge as where to look for it, or how it looks. The notes regarding the time of occurrence of any bird in one's neighborhood will form a series of observations which in time may be collated into definite information of the bird's local and seasonal movements.

The study of a bird really becomes an investigation of its relationships of environment. The most important of these relationships, from an economic point of view, is the food of any species, a phase of study which opens an almost limitless field for investigation. What a bird eats is information of practical value to the rancher and horticulturist,—not what a bird eats at some particular season, but what constitutes its bill of fare for the entire period of its sojourn in the locality. Many of the birds are invaluable assistants of the agriculturist. Frank M. Chapman mentions a cuckoo whose stomach at six o'clock in the morning contained the remnants of forty-three tent caterpillars. It was found that four chickadees had eaten 1,028 eggs of the cankerworm, and four others had eaten 600 eggs and 105 female moths of the same noxious insect.

Many ranchers regard the hawks as their enemies, because they are reputed to catch up an occasional young chicken. With the exceptions of Cooper's hawk, the sharp-shinned hawk, and the goshawk, in this region, this belief is quite erroneous. It has been ascertained that 90 per cent of the food of the so-called "chicken hawks" consists of injurious rodents and vermin. A single owl in two hundred meals was known to eat 450 destructive mice and similar vermin. The great horned owl is perhaps the only exception among the nocturnal rapacious birds. Insteaa of killing the hawks and owls indiscriminately, it would be wiser for the rancher to raise a few additional chickens for the use of his feathered allies. The horticulturist can easily afford to plant a few extra trees to supply the fruit-eating propensities of some of the birds, which live chiefly on insect food during the remainder of the year. When any known bird is seen to capture an insect under circumstances such that the prey can be recognized, or when the bird is observed eating vegetable food, a note should be made of the fact, and as continued observations are made a fair estimate may be computed of the economic value of the species.

The manner of the bird's taking its food furnishes an interesting subject of study. The flycatchers capture their prey a-wing, flying outward from some post of observation, snapping down upon a flying insect, and returning to their perch. The chickadee gleans from the crevices of the bark along the branches, finding insects and larvae that other birds have overlooked. The robin uncovers the worms lurking near the surface of the soil, or finds the destructive larvae burrowing in the roots of the grass-tufts, or else boldly visits the garden and helps himself to the ripening fruit. The osprey wheels above the lake or river, hovers in air when he spies a likely victim below, dives flatwise into the water, and emerges with his finny prey. The swallows flit in rapid evolutions, seemingly on tireless wing, in quest of flying insects, and seldom taking their prey in any other manner. The manner of feeding is quite characteristic, hence it serves as an important aid in identification, besides offering the student a subject for many valuable notes.

The bird's relation to man, in the matter of companionship or association, suggests itself as worthy of consideration. The robin is known to nest in the door-yard; the raven seeks some inaccessible cliff to rear

its brood, and at other seasons it invariably shuns the presence of man. There is a noticeable difference in the dispositions of the representatives of different species, and even of different individuals of the same species in different localities, to confide in the associations of civilization. The bird student will note these differences of disposition whenever they occur to him, and make them a part of his information regarding any bird of his neighborhood.

Furthermore, the disposition of any bird regarding its companions soon becomes very manifest to the observer. He will not see the king-bird many times before its pugnacious spirit exhibits itself in sundry encounters with other residents of its domain or with unwelcome visitors to its neighborhood. No other bird ventures near the home of the humming-bird without quickly arousing the anger of the tiny owner, and the intruder is speedily reminded that he is a trespasser. Quite in contrast to these, the good-natured osprey allows the blackbirds and swallows to nest in the cavities of its bulky habitation. Some interesting scenes of bird-life are brought to the notice of the observer who looks for these incidents of the bird's associations with its neighbors. They are the real key to the inner life of the neighborhood in avian circles, and a part of that higher phase of bird-study of which we have already spoken.

In considering the relationship of the bird with others of its own species, we find that the mating affords a series of profitable and sometimes amusing incidents. More individual character is manifested at this period than at any other, and for obvious reasons the bird disregards much of its ordinary dislike of observation, frequently placing itself in situations where its actions can be easily watched. Most of the traits usually denominated as human are then displayed, jealousy and gallantry characterizing the males, while constancy and modest coyness are noticeable in the conduct of the fairer sex.

The courting and mating among some of the grouse is an instance of the amusing scenes at this season in birdland. The males congregate at a convenient place in the neighborhood, go through a series of struttings, with inflated necks and drooping, quivering wings, apparently displaying all the accomplishments of form and movement at their command, after which the most successful competitor takes the lady of his choice and the couple begin housekeeping at once.

Careful attention to the singing of any bird will disclose the fact that any performer has a variety of musical numbers in his repertoire. Our mountain song sparrow has at least half a dozen separate songs at his command, and I have known the same male to sing as many as eight different arrangements of his notes. The western meadowlark has from six to eight different songs, and with all the variations of the different songsters of this species, it is likely that twenty to thirty varying meadowlark songs could be formulated. The same song will be uttered several times, then a variation will follow for several renditions, and thus change after change may be noted. In the singing there is manifested the same individuality as in other phases of the bird's activities, so that it is possible for the attentive bird-student to identify particular birds in the neighborhood by the execution of their songs.

The nest-building of the bird, its home-keeping, and other domestic affairs, constitute the most interesting period of its annual round to young observers. Volumes have been written about the nesting time, as at that season the study of the bird presents its most fascinating side. Children are usually so interested in the nests, eggs, and young that the safety of the nest is imperiled. The teacher should make a collection of old nests in the fall, or lead the children to bring them in, studying the sites and surroundings, and thus sustaining an interest aroused when the birds were using their habitations in the earlier season. The history of the young in the nest has come to be a vital part of the study of the bird. If properly directed, children will be deeply fascinated in oberving the events which mark the rearing of a brood of young birds in their nest.

The study of a bird implies that the bird itself should be the subject of study, primarily a-field. The interest of the pupil may be stimulated until many common birds, at first unknown, will be observed, identified by the teacher's aid and by colored plates or descriptions, studied as a part of the neighborhood's wealth of wild-life, and thus a zeal for bird study aroused that will cause the observer to become a life-long friend of the birds. A bird may be observed by one of the pupils, or may be familiar to only one, but the knowledge of this one may serve as the teacher's means to introduce the bird to the entire school. Little by little the acquaintance is extended, until all become friends of the bird. Meanwhile others are brought to notice, and in a comparatively short time the majority of the pupils have established friendly relations with all the common birds of the locality. If any accessible literature concerning bird-life has been brought before the children, not only has Nature's door been opened to them, but they have made a step into the realm of literature, from which none of them will voluntarily turn back.

Introduction to Studies on the Fertilization of Plants.

Maurice Ricker.

The subject of fertilization in plants is introduced by a consideration of the life history of an oak. This tree is usually well known, as a tree. Some have shown surprise that it has a flower and thus I am able to obtain the interest and attention, so necessary in the treatment of a nature study subject To go to the complex forms of adaptation at one bound would fail to give those who are wholly without botanical training the necessary insight into the anatomy and physiology of flowering plants. This treatise is an attempt to put this necessary information into words of one syllable, as it were.

Let us begin the study of an oak with the beginning of the plant, not as a separate individual, but with the formation of the mother cell which is afterwards to give rise to the plant. Brown and Mohl about 1840 showed that all organs were traceable to the one cell from which all the others are formed. During the past fifteen years some of the foremost biologists have devoted much time to the study of the cell. They have written many volumes and worked out many interesting things, even to some interesting studies of the difficult problem of inheritance. But we shall have little time for the consideration of their conclusions. It will suffice for our present purposes to restate the proposition of the ancients, "Like produces like." A black oak tree originated from an acorn borne upon a black oak tree. Of course the exception, so firmly believed in by all small boys, of the snake being produced from the horse hair, has to be dealt with. True the boy has not proved this by his own experiment. The one he tried was planted in the wrong time of the moon or in the wrong kind of a bottle, but he always knows some one who did grow a true snake from a horse hair.

Aristotle taught that life originated from ocean slime. He was unable to find proof of any material change in species. The last great pre-Darwinian battle was fought in the debate in Paris between St.Hilaire and Cuvier less than a week before the revolution of 1830. Cuvier won, at this time, by stating authoritively that skeletons show no change in form, even of the cats buried 3,000 years before, with mummies in Egypt. He overlooked the fact that conditions of environment which might lead to change in structure had remained constant likewise during the same length of time. We may defer the discussion of change and state that black oaks come from black oaks, white oaks from white oaks, burr oaks from burr oaks—let us see how.

We readily find the small yearling oaks under the parent tree. On pulling them up we find the well known acorn. We know this acorn grew upon the tree above. If it is spring-time we find no ripened acorns

on the living limbs, but the dead branches broken by late summer winds give the proof, if any is needed.

Closer observation of the black oak reveals the little miniature acorns on the previous year's growth, in the axils of the leaves. It would require little reflection to see that these are the acorns to ripen in the fall.

In similar positions on the fresh young shoots of this spring's growth, in the axils of young leaves, may be found corresponding structures one year younger. The fleshy growth with the three reflected lips is the female flower. But 'what a flower!' I exclaimed, when I first saw it. It is devoid of the showy envelope which we associate with this word. A perfect flower is one that has both pistils and stamens; that of the oak has a pistil only, or anthers only. It is therefore an imperfect flower. A flower with both pistils and stamens and both whorls of the floral envelope—the outer one, the calyx and the inner, the corolla—is called a complete flower. Such is the apple blossom.

The sticky surfaces of the three lips are the stigmatic surfaces and the part bearing them—the stigma. The swollen attached end is the ovary. The stem connecting the stigma with the ovary, in this case quite short, is the style.

Sections of the ovary show that the exterior part is a covering for the seed like ovule. By proper methods we could go further and demonstrate the germ cell itself which is in reality the center of life and the cell from which the future oak is to spring.

Near the attached end of the ovule is a small opening into the ovule called the micropyle. By the provisions of nature no plant germ cell can divide and grow into an embryo without the introduction through this micropyle of the growing pollen tube. This pollen tube can grow only when a ripened grain of pollen produced on the anther of the same or another flower, falls upon the stigmatic surface of the pistil when it is in a receptive state. The conditions under which fertilization takes place, for this is the name given to the process just described, form an interesting chapter in plant morphology and plant physiology.

It is my purpose to call your attention to some of the wonderful adaptations in plants and animals which are evidently solely for the purpose of transferring the ripened pollen to the receptive stigmatic surface.

Let us take up the case of the oak. As was stated, the fruit bearing oak is imperfect, and consists of a pistil only. We must look for another flower,. therefore, which shall contain the stamens,. We call the pistil just examined the pistillate flower,. Let us look for the stamens or the staminate flower. In some cases we must look on another plant. When pistillate and staminate flowers are found on separate plants we have a dioecious plant. In the black oak we find the staminate flowers on the preceding year's growth in the axils of leaves. Such flowers are called monoecious.

If you examine the long catkins or aments it will be found that the stamens are borne upon a long stalk. When viewed through a lens a beautiful structure is disclosed. Each stem bears numerous flowers and each flower contains four stamens.

The drawing (Fig. 6) shows the anther on the pollen bearing part,

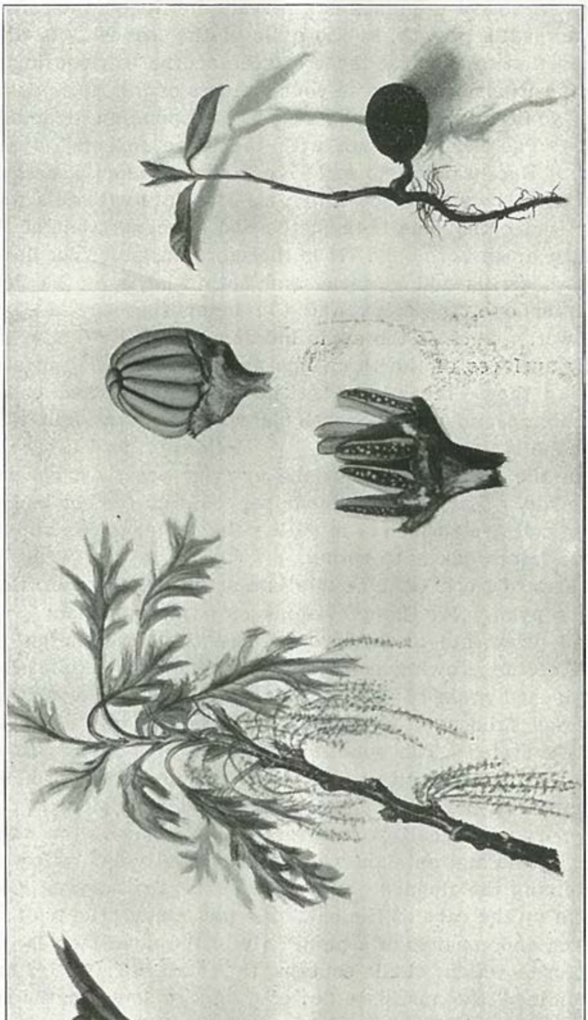


FIG. 6. The stages of the black oak. On the right, an acorn with young shoot; on the left, young acorns in the axil of a leaf above, fullgrown acorn below; branch with aments; on the right of the branch the unripened stamens above, mature stamens with pollen below. From water color drawings by Mrs. Edith Ricker.

before it has ripened and after it has dehisced or opened, setting the pollen free. The meally yellow dust that is shed so freely at the slightest touch is the pollen. Shaking the branch sets free a perfect cloud of it. It is borne off in the air like a whiff of smoke. Only one pollen grain is necessary to fertilize one ovule. Many pollen grains will of necessity, whatever be the mode of fertilization, fail to reach their intended place upon a ripe stigma. The ratio of pollen grains to the ovules must always be large. The night blooming Cereus has 250,000 pollen grains to 30,000 ovules, or about 8:1. The garden wistaria has a ratio of about 7,000 to 1 ovule. The Indian corn, pines and other wind fertilized flowers must have a much greater ratio than this.

One can see at a glance (Fig. 6) that the pollen grains of the oak, because of their position, stand little chance of falling upon the stigma of the branch upon which they are borne. It would require an upward draft of air or an insect or other animal to carry them. It would be easier to account for the transfer of the grain of pollen in this case by supposing it to have dropped gently from the boughs above. It may as well have been carried by a light breeze from a neighboring tree.

There is neither odor, nectar, edible pollen, nor showy corolla, to guide or attract a busy insect, and since all insects seem bent on business they would spend little time loafing around the oak blossom. In fact it would be a one-sided bargain for an insect to carry pollen for the oaks since he would derive no benefit to himself. Wherever a relationship is discovered between a plant and an animal it may be taken as axiomatic that the association is mutually beneficial. Darwin once staked his theory of organic evolution upon the proposition that if any organ or modification of an organ could be found in the animal or plant world that was present wholly for the benefit of another species, that he then must admit that his whole conception might be based upon false conclusions. Fifty years have passed and no one has produced the evidence.

Assuming that a pollen grain has found its place upon a sticky stigma of a pistillate flower let us see what takes place. The grain of pollen absorbs moisture and swells until it begins to grow a tube, somewhat as a seed sends down its radical. It either enters a space left between the cells or by penetrating the cells grows until it reaches the generative cell of the ovary. An interesting series of experiments has been made showing the cause of growth down the style to the ovule to be chemotaxis, or growth toward chemically attractive substance. The essential part of the pollen liquid now penetrates the ovule to the nucleus of the generative cell. There immediately follows an interesting series of phenomena of especial interest to the embryologist. In brief, the one cell subdivides many times and grows ultimately into an acorn, which one year later will be recognized as such a one as now appears on last year's growth. The season's growth increases it to the normal size and in September or October it is ripe and ready to leave the tree, and soon finds its resting place upon the ground. (The white oak and some others mature their acorns in one season. Not all the pistils are fertilized. Some of the acorns fail to grow the second year.) The fallen acorns roll about or are kicked or carried about by animals. Squirrels bury them at some

distance from the tree. A great number are eaten by animals. Many others have been stung by diptera and a little white grub has eaten the food stored up for the plant.

But here and there one in a great many has been pressed into the ground and has felt the warmth of spring. It has split its weather worn casing and protrudes its white radical. The subtle attraction of gravity causes it to turn downward and bury itself still deeper in the earth. From the split in the hypocolyl where it branches to the two cotyledons arises the caulicle or stem. This is the part we will call the tree. The figure (Fig. 6) shows an oak the second year of its growth as an independent plant, or the fourth year from its beginning as a cell.

We will not here treat further of the growth of the tree. To consider in its entirety the manner of growth to the tree again producing acorns would be a treatise on botany too long to be given here.

We have traced the growth through the stages through which, in a general way, all plants of the higher orders must go.

The Forest Trees.

Harry Nichols Whitford.

(The material contained in this and the other botanical lectures is the outcome of a series of talks given at the biological station of the University of Montana at Bigfork, Montana, during the summer of 1902. The description of the conifers is intended to be an aid to the identification of the trees for the use of those not acquainted with botanical terms. In nearly all cases the points of difference between the trees have been tried and found applicable in determining the species. In the preparation of the key and descriptions, the author has made free use of the manuals covering the region and of Sargent's "Sylva of North America.")

An attempt has been made to show why there are **prairie** and **forest formations.** In the **forest formation** itself there are places where there are no trees, and in certain situations some trees will grow where others will not. It will not be out of place to ask why these things are so. But before proceeding, it is desirable to become acquainted with the kinds of trees that are found in the state. This enquiry will be confined to that group of trees called conifers, for the others form an inconspicuous part of the forest. Not only must the trees be known, but also their habits, so that what they will do in certain situations can be predicted.

It is not always an easy thing to distinguish the different species of trees. The difficulty of recognizing young trees from one another is even greater than with older trees; for the older trees may have cones, and these are, of course, more apt to give a clue to the identification. However, even from older trees cones are often absent. The bark of trees is very characteristic, and lumbermen use this mark to distinguish trees. But hereby mistakes are often made, for the bark is different at various ages; and a tree growing in one situation is likely to have different bark from the same species growing in another situation.

The leaves perhaps are less variable in their form than the bark, and as they are more often present than the cones, they will serve as a criterion in discriminating the species. With the exception of the western larch, the leaves of the conifers to be described are on the trees the year around, so the character drawn from them can be used in the winter as well as the summer. Since the leaves even on the same tree vary in shape, often more than one character will have to be used.

A Key to the Conifers of Montana.

A. Trees with leaves in clusters, excepting those first appearing on young shoots.

   I. Leaves in clusters of more than five........1. Larix (larch).

   II. Leaves in clusters of two to five..........2. Pinus (pines).

B. Trees with leaves not in clusters.

I. Leaves scale like.
  a. Leaves four ranked, the side ones ridged, the branchlets thus appear flattened ....3. Thuya (arbor-vitae).
  b. Leaves four ranked and all ridged, the branchlets thus appear four sided ....4. Juniperus (juniper).

II. Leaves needle like.
  a. Leaves jointed from a base that remains after the leaf is shed.
    Leaves flat, petiolate ....5. Tsuga (hemlock).
    Leaves sessile, and ridged on both sides............ ....6. Picea (spruce).
  b. Leaves not jointed from a base that remains after the leaf is shed.
    Leaves short petiolate leaving a triangular scar when shed ....7. Pseudotsuga.
    Leaves sessile leaving a round scar when shed...... ....8. Abies (Fir).

The genus **Larix** is easily distinguished from the other genera by the fact that it is the only deciduous conifer in Montana. There are two species in Montana.

Western Larch (1) (**Larix occidentalis** Nutt.):

This tree is known in the Flathead valley as the tamarack or larch. The new shoots have the leaves scattered. In the axils of these leaves appear buds which develop into short branches with a cluster of leaves at the end. Each year this short branch grows slightly in length, and a new ring of wood is added. The growth in length is so little, however, that the branchlets never become long. The leaves are soft compared with the other conifers, and have a lighter green color by which they may be distinguished in the forest. In the fall they turn yellow green and drop about the middle of October. The leaves are about one and a half inches long. Compared with those of other conifers the cones are small, but are about twice as large as the eastern tamarack (**Larix laricina** (Du Roi.), Koch.) They are from one to one and a half inches in length. The bract is longer than the scale. (2)

The bark (Fig. 7) of the older trees is smooth at first, then becomes deeply ridged, and when the tree is 75 to 100 years old, it is at the base four to five inches thick. It breaks up into oblong plates and is covered with scales which break off in scroll shaped patterns. These scales are

(1) In this article the common and scientific names suggested by Sudworth of the United States Bureau of Forestry will be used. Nearly all of the western conifers have closely related species in the eastern part of the United States, and many have the same common names as their eastern relatives. It is desirable, therefore, to distinguish them by choosing a name that is not already in use. However, with these there will be given other common names that are in local use. See Sudworth, G. B., Check list of the forest trees of the United States, their names and ranges. Bull. No. 17, U. S. Dept. of Ag., Div. of Forestry.

(2) It may be well to state that the fruit of the conifers, known as the cone, is made up of closely imbricated scales. To the upper surface of each scale, two seeds are attached; on the lower surface, "bracts" are found. Usually the bracts are shorter than the scales.

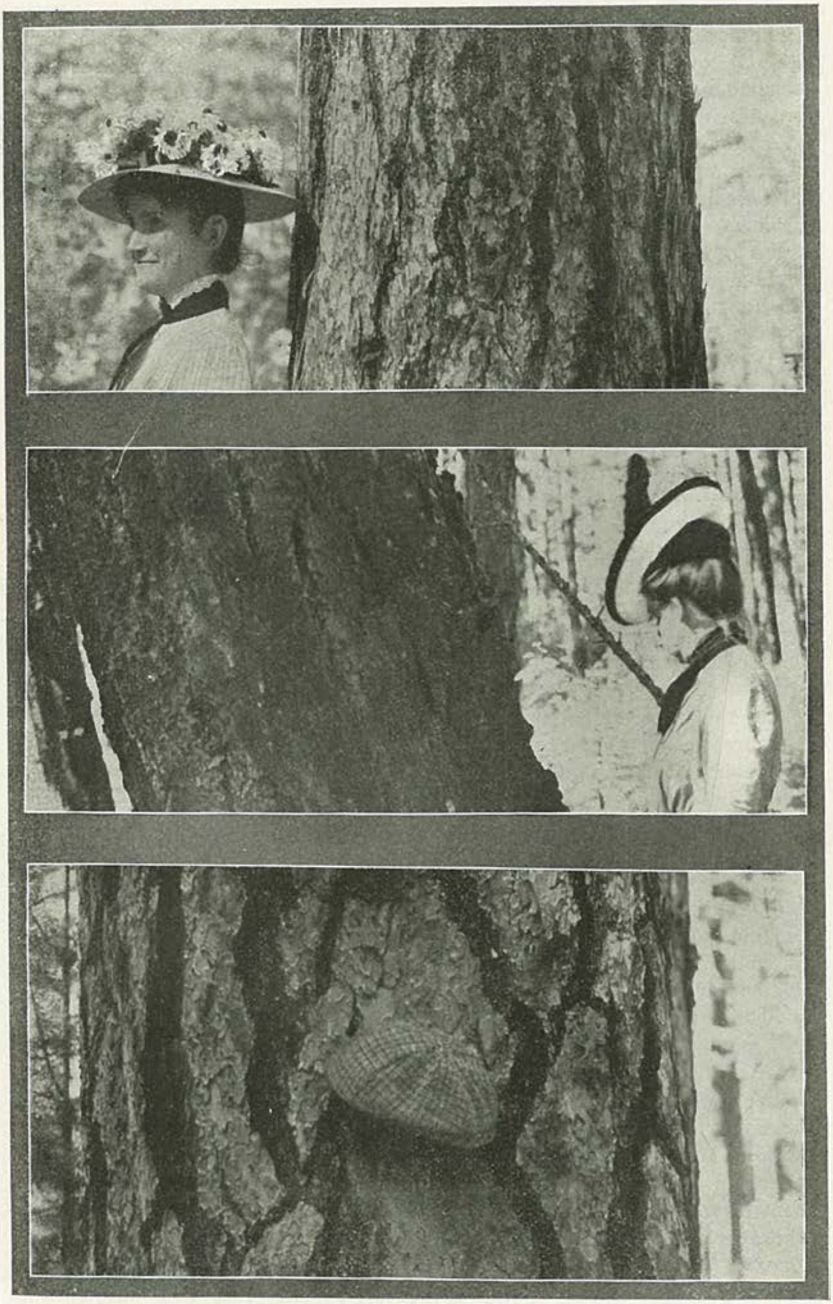


FIG. 7. Comparison of bark. Upper, tamarack. *Larix occidentalis* Nutt; middle, Douglas spruce, *Pseudotsuga taxifolia* [Lam.] Brit; lower, Yellow pine, *Pinus ponderosa* Laws.

cinnamon red in color. The thick bark enables the tree to resist fires. This is, of course, of great advantage to the tree, for since fires have become more numerous, those trees that are easily destroyed by them are first excluded from the forest. The western larch is one of the last to suffer permanent injury from fires. Those seed-bearing trees that remain after fires will re-stock the burn with a new generation of trees. The western larch requires light in its seedling stages; hence it can reproduce itself only in open places. These may be caused by fire, by death of old trees, or by any accident that will remove the trees of the mature forest. The western larch is then exceedingly intolerant of shade.

In the Flathead valley the western larch does best in soil not too moist nor too dry. This tree is said to reach its greatest development in the basin of the upper Columbia river. In the United States it is most at home in the Flathead valley, and in northern Idaho. Here it may reach the height of 200 feet, with a trunk of five to six feet in diameter, and occasionally is even larger.

Mountain larch (Larix Lyallii Par.). The mountain larch is reported to be present in a few places at high altitudes in the mountains of northwestern Montana. It does not, however, form a conspicuous element in the forest. It is distinguished from the western larch by the fact that the leaves are nearly as thick as broad. In the latter species the leaves are somewhat wider than thick. The branchlets of the mountain larch are hairy, as compared with those of its lowland relative. The height of the tree is seldom over fifty feet.

The genus **Pinus (pine)** is easily distinguished from the other conifers by the fact that the needle like leaves are in groups of two, three, or five. The first leaves that are produced on the leading shoots are scale-like. In the axil of each scale-like leaf a bud may appear which develops soon into a branch, so short and inconspicuous as to be hardly recognizable. On each of these short branches, two, three, or five leaves appear, the number being usually definite in each species.

There are five species of pine in Montana. They may be divided into two groups, viz., those that have two or three leaves in a cluster or fascicle and those that have five leaves in a cluster. The latter, known as white pines, are represented by three species in Montana, and are seldom found growing together. In the Flathead valley the **silver pine** is found only in the lower altitudes. Near the timber line is the **white-bark pine.** (Plate XLVII.) This is usually on the west side of the continental divide. On the east side of the divide at high altitudes, the **limber pine** occurs. Aside from their mode of distribution, these three pines may usually be distinguished from one another by the length of their cones. The cones (Fig. 8) of the silver pine are from five to eleven inches in length, usually not less than eight; those of the limber pine from three to ten inches, most frequently under eight; and those of the white-bark pine from one and a half to three inches. The tips of the cones of the last named species are curved inward. The length of the leaves is variable, but usually in the silver pine they are long, in the white-bark pine and the timber pine they are short; the first of the last two named having the shorter leaves.

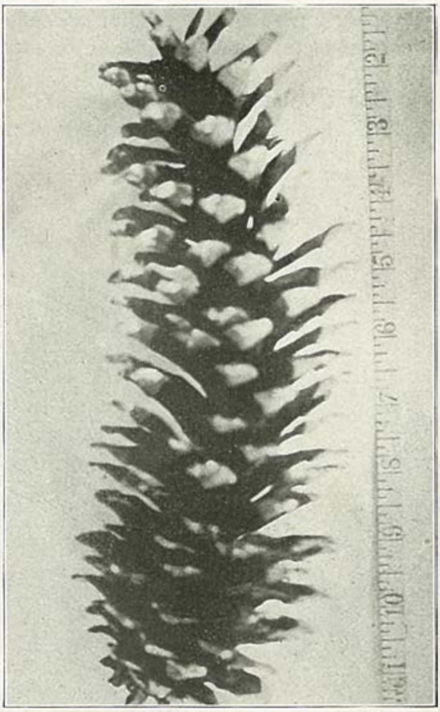


FIG. 8. Cone of Silver or White pine.

Silver pine (Pinus monticola, Dougl.): This pine is more frequently known as the white pine, or western white pine. It resembles very much the **white pine** of the eastern part of the United States. The cones of the former are much longer than those of the latter, and the leaves are more thick and rigid, and usually not so long. No tree in Montana has longer cones (Fig. 8) than the silver pine. The leaves of the silver pine are said to remain on the tree from three to four years. The trunk of the young trees has a smooth, thin, light gray bark. In the older trunks it becomes as much as an inch to an inch and a half thick, and is divided into nearly square plates which are very characteristic. When fired, the bark, is easily heated through, the cambium zone (3) is killed, and the tree thus destroyed. In contrast with the western larch the tree is slightly tolerant of shade, that is, it can exist as a seedling in the shade of other trees. In the Flathead valley it is confined to soils that are quite moist. It cannot be said to be a very successful tree here, although in favorable situations it reaches good size. Isolated trees may be

(3) The cambium zone is the active growing region between wood and bark that enables the tree to increase in diameter; in the bark and therefore outside the cambium zone is the region that conducts certain food materials from the leaves to the roots. If these regions be killed, the tree will shortly perish.

found at rather high altitudes, although it was not seen to overlap in its distribution the white-bark pine of the higher altitudes. It is said to reach its best development in the bottom-lands of streams tributary to Lake Pend d'Oreille.

The **white-bark pine (Pinus albicaulis** Engelm.): It is distinctly an alpine form. (Fig. 9.) The leaves are in clusters of five, and from one

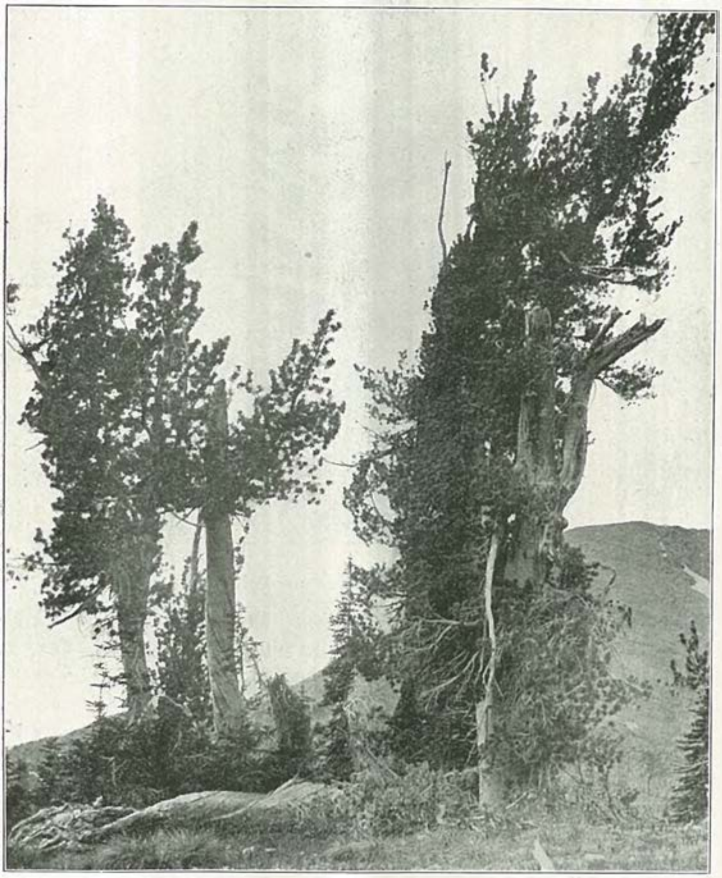


FIG. 9. White-bark pine on the slope of Sinyaleamin Mountain, at altitude of 7800 feet, showing the struggle they make for an existence. Photo by Prof. L. A. Youtz.

and a half to two and a half inches in length. They are said to persist for from five to eight years, most of them remaining on the trees from seven to eight years. The bark is very thin. It is quite smooth and is creamy white in appearance, hence the name **white-bark pine. It is** easily destroyed by fire. The white-bark pine grows on the most exposed ridges in high altitudes. It is confined to the western continental divide, where it is usually associated with the alpine fir.

The **limber pine** (**Pinus flexilis** James): The tree may usually be distinguished from the former species by its rougher bark and longer cones. It is found on the eastern side of the continental divide, usually at altitudes of from 5,000 to 10,000 feet.

The two remaining pines found in Montana are the **bull pine** and the **lodgepole pine.** They can be easily distinguished by the length of the

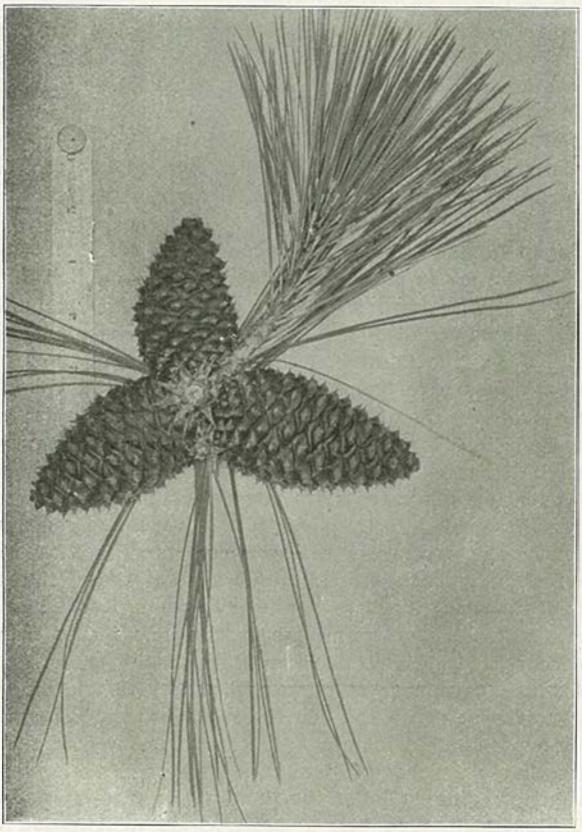


FIG 10. Leaves and cones of the bull or yellow pine. Photo by M. J. E.

leaves and the number in a cluster. The former has usually three, sometimes two, long leaves; the latter, two shorter leaves.

The **bull pine** (**Pinus ponderosa** Laws.): The bull pine, (Fig. 10) more often called yellow pine, is one of the most striking, widely distributed, and most valuable trees of Montana. The comparatively long leaves are usually in clusters of three, though occasionally two are found. They persist usually for three years. They form great clusters at the ends of the naked branches. The cones (Fig. 10) of the bull pine are three to six inches long, and often in clusters of three to five. The tips of the bracts are elongated into awnlike characteristic spines. The bark is

very striking. (Fig. 7.) In the older trees it is split up into long rhomboidal plates, covered with scroll-like yellow scales, very much resembling those of the western larch. At this stage the tree is known by certain lumbermen as the **yellow pine.** In the younger trees the bark is more ridged and rounded, and does not have the yellow color. This form goes under the name of **bull pine.** In the older trees the bark is two to four inches thick and very resistant to fires.

In the Flathead valley the tree is confined to the low altitudes, and is more abundant on the border of the prairie, though it does better in moister situations. It is, perhaps, shaded out of these places because of its extreme intolerance of shade. It needs very open places in which to germinate, and very little shade will prevent this. The bull pine and its closely related form, the **rock pine (Pinus ponderosa scopulorum** Engelm.), are found throughout the western part of America. The latter has not been reported from Montana.

The **lodgepole pine (Pinus Murrayana** "Oreg. Com."): The leaves of the lodgepole pine are in pairs one to two inches long, and remain on the trees seven to eight years. The cones are smaller than those of any other pine in Montana. The tree resembles the **jack pine (Pinus divaricata** (Ait.) Du Mont de Cours.) of the eastern part of the United States in its general appearance and some of its habits. The bark of smaller trees is smooth. On the older trees it breaks up into rectangular plates, and is about one inch in thickness. It is a tree easily destroyed by fire, but because it can produce cones at a very early age, it has a very great advantage over the other trees in gaining a foothold in burned areas. Groves of small trees six to ten years old may produce cones abundantly. Another remarkable feature of the lodgepole pine, is that the scales of the cones remain closed, sometimes for several years, thus preserving the vitality of the seeds for a comparatively long period. The seeds from cones nine years old have germinated. The heat of the fires sweeping through a forest will open cones, liberating, though not often destroying the seeds, which germinate at once, and thus give a decided lodgepole pine aspect to the new growth. In closed forests the lodgepole pine has small diameter and great length. Trees over a hundred feet tall often are no more than six inches in diameter. Where there is plenty of room for the lodgepole pine to grow the dameter is greater, and the height less. The lodgepole pine has a rather wide distribution in western Montana. It is usually confined to rather moist situations. So successful has it been in gaining a foothold after fires, that it has replaced many square miles of valuable timber. It cannot tolerate shade, however, and if fires are kept out, in several generations the forest conditions will probably be the same as before the original forest was destroyed.

The **giant arbor-vitae** and the **Rocky mountain juniper** are easily distinguished from the remaining conifers by their scalelike leaves. In the giant arborvitae they closely overlap. In the Rocky mountain juniper they do not overlap so closely.

The **giant arbor-vitae (Thuya plicata** Don.) **(Thuya gigantea** Nuttall): This tree resembles its eastern relative the arbor-vitae **(Thuya occidentalis** Linn.) very closely, both in appearance and in habits. (Fig.

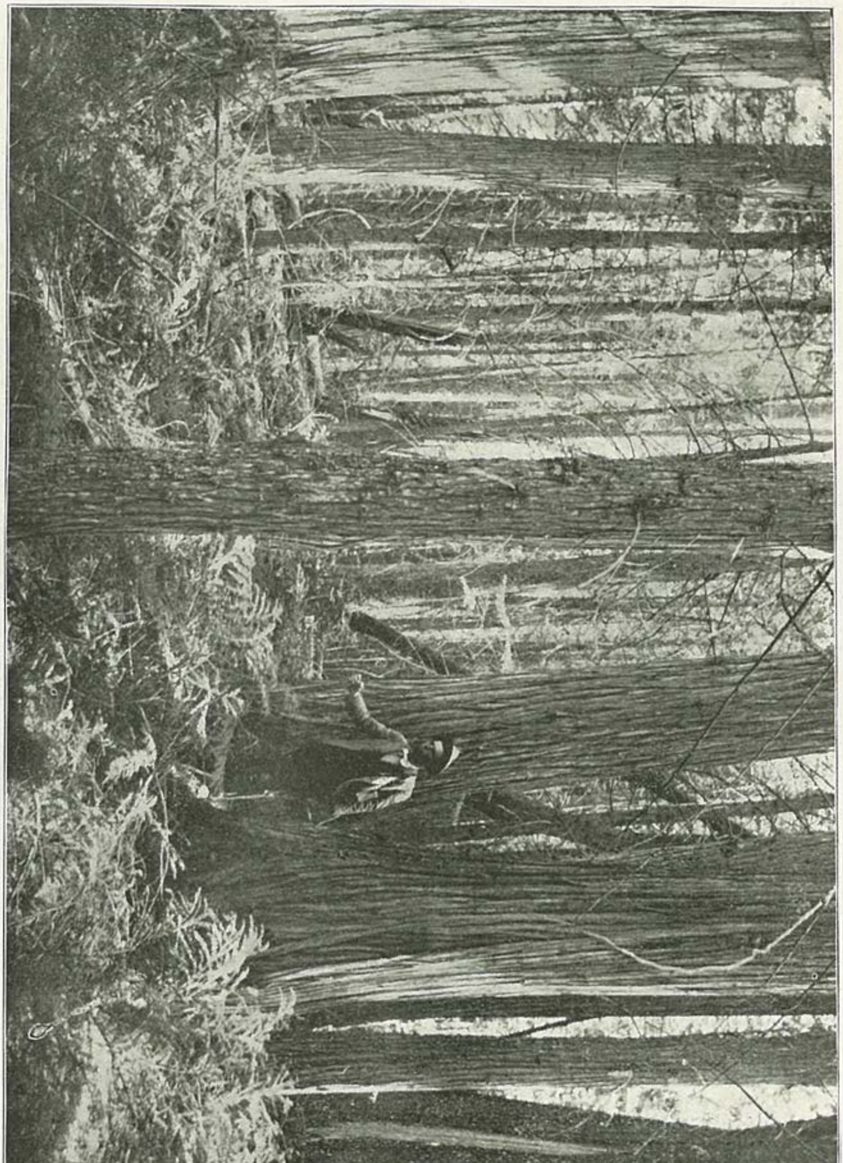


FIG. 11. Arbor vitæ forest at the inlet of Sinyaleamin Lake, Mission Mts. Photo by J. M. Hamilton.

11.) The cones are considerably larger than in the latter, and there are six scales that bear seeds, instead of four. Other common names for the giant arbor-vitae are red cedar and cedar. The leaves on the side branches are opposite, scalelike, about one-eighth of an inch long. They overlap very closely, and fall usually in the third year. The cones are one-half an inch long and ripen the first season. The bark (Fig. 11) is one-half to three inches thick, and is irregularly divided into broad ridges which have long shredded scales. The tree is said to resist fires fairly well, and can tolerate shade. It is not frequent in Montana, and is confined to moist situations on the western slopes of the Rocky mountains in

FIG. 12. Growth of young Rocky Mountain Junipers on the bank of Flathead lake, near the O'Brien mill. Photo by M. J. E.

the northwestern part of the state. It reaches its greatest development on the Pacific coast.

The **Rocky mountain juniper, (Junipers scopulorum Sarg.)**: The Rocky mountain juniper is called frequently cedar or red cedar. It resembles its eastern relative (**Juniperus Virginiana** Linn.) though the fruit is larger and matures in two years instead of one. The leaves are opposite and do not overlap so closely as in the giant arbor-vitae. The bark is about one-half an inch thick and has thin shreddy scales. The cones, commonly known as "juniper berries," bear two or three seeds. This tree is common on the borders of Flathead lake, (Fig. 12.) and is found in various parts of the state.

The **western hemlock (Tsuga heterophylla** (Raf.) Sarg.): This **tree,** commonly known as the hemlock, differs from its eastern relative (**Tsuga canadensis** (Linn.) Carr.) in having slightly larger cones with scales longer than broad. In the eastern species the scales are nearly as broad as long, and the cones have a stalk, whereas the cones of the western species are sessile. The leaves are rounded at the apex, flat, dark green above, white below, and have short leaf stalks, or petioles. The bark on full-grown trees is about one and a quarter inches thick and has rather

FIG. 13. Leaves and cones of the western Hemlock. Photo by M. J. E.

broad flat connected ridges with brownish scales. The tree, like the giant arborvitae, is very tolerant of shade. It is even more restricted in Montana than the giant arborvitae, and like it reaches its best development on the Pacific coast. (Fig. 13.)

The young trees of the **Douglas spruce, lowland fir, Engelmann spruce** and **Alpine fir** look alike to the uninitiated. The last named species is not often associated with the others, and hence is not so likely to be mistaken for it. The base of the leaf of the Engelmann spruce is woody, and remains attached to the stem after the leaf is shed, thus leaving peglike projections on the stem. The spruce can be easily distinguished

thereby from the other three trees. The western hemlock, however, has these peglike projections also, though they are not nearly so prominent. The leaf of the spruce is roundish in cross section, while that of the hemlock is more flattened. The leaves of the side branches of the lowland fir are dark green above and usually conspicuously notched at the end, while those on the side branches of the Douglas spruce are light

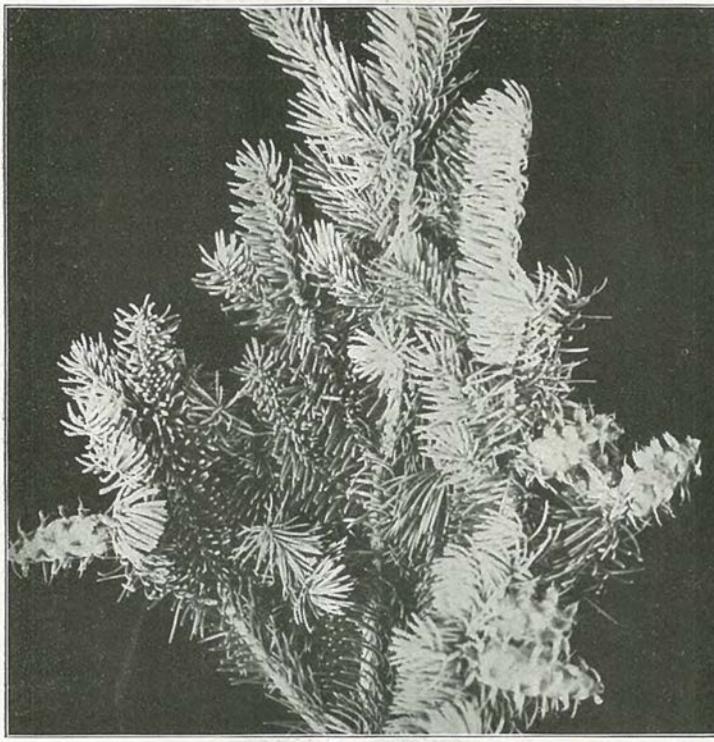


FIG. 14. Leaves and cones of Douglas spruce or lowland fir. Photo by M. J. E

yellow when young, usually dark green when older, and not notched at the end. The scar left by the former when the leaf is shed is round, while that left by the latter is more triangular in shape. The leaf of the former is sessile, and that of the latter has a very short leaf stalk. The cones of the Douglas spruce (Fig. 14) and Engelmann spruce hang down, while those of the firs are erect. The cones of the Douglas spruce have the bracts longer than the scales which easily distinguishes it from the Engelmann spruce.

The **Engelmann spruce (Picea Engelmanni** Engelm.): This tree closely resemble the **white spruce** of the east (**Picea canadensis** (Mill.) B. S. P.) Indeed the white spruce is said by some authors to be found in Montana, though others doubt its existence here. If it is found, it is difficult to distinguish it from the Engelmann spruce. The leaves on

the lower branches are usually short, stout, roundish in cross section, sharp pointed and a dark blue-green in color. They persist about eight years. The cones (Fig. 15) are about two inches long, sessile or very short stalked. At first they are horizontal but later drop. They mature at the end of the first season. The bark is thin and broken into large flaky scales. The tree on account of its thin bark, is easily destroyed by fire. It tolerates shade fairly well. It reaches its best development in moist situations, in swamps, along streams, and on moist hillsides. Outside of Montana it has a wide range in the western part of the United States and British America, usually in rather high altitudes.

FIG. 15. Leaves and cones of Engelmann's spruce. Photo by M. J. E.

The **Douglas spruce (Pseudotsuga taxifolia** (Lam.) Brit.) **(Pseudotsuga Douglassii** Car.): This tree, also known as the red fir, is neither spruce nor a fir, the name **Picea** being reserved for the former, and **Abies** for the latter. The word **Pseudotsuga** means literally "false hemlock," but the name has little or no significance.

The leaves of this tree have already been described. They remain on the tree about eight years . The cones, (Fig. 14) as already stated, are easily characterized by the fact that the bracts are longer than the scales. They vary in size from two to four inches. The bark (Fig. 7) of the tree varies greatly as the tree ages. In the older trees it is composed of large, broad, irregularly connected ridges. The bark is very thick at the base, usually from six to twelve inches, and even in excep-

tional cases two feet. By its thick bark (Fig. 7) the tree is well protected from fires. It does not tolerate shade. In this respect it may be classed with the western larch and lodgepole pine. In the Flathead valley the tree is associated with the western larch in moister soils and with the bull pine in drier soils. It does not, however, reach the dimensions here that it does on the Pacific coast, where, with the western hemlock and arbor-vitae, it forms luxuriant forests. The Douglas spruce is

FIG. 16 The Yew, showing leaves and berries. Photo by M. J. E.

distributed throughout the western part of the United States, but in dry climates it is small and stunted in growth.

The **lowland fir (Abies grandis** Lind.): This tree is also known as the white fir and the balsam fir. The leaves have already been described. On the horizontal branches they are conspicuously two ranked. They persist from eight to ten years. The cones are erect on branches near the top of the tree, and vary in length from two to four inches. The scales of the cones, as in all firs, are deciduous, the cone axis being shed later. The fruit matures in one season. The bark is smooth at first, with the characteristic balsam blisters. Later the bark splits into low

flat ridges, giving it the name of "rough bark fir" in some sections of the country. It is sometimes two inches thick, though usually thinner. The tree tolerates shade fairly well. It is not at home in the Flathead valley, though in favorable places it reaches comparatively large dimensions. Like so many of the other conifers it does its best on the Pacific coast. It is confined to low altitudes, seldom reaching above 3,500 feet.

The **alpine fir (Abies lasiocarpa** (Hook) Nutt.): This tree is also known as the balsam fir. The leaves of the lower branches resemble those of the lowland fir, though in trees growing side by side those of the alpine fir are narrower and lighter green than the leaves of the lowland fir. The cones are much alike also. The seeds have bright violet wings and can thus be easily distinguished from the pale colorless wings of the seeds of the lowland fir. The bark of the lowland fir is grayish or reddish brown, while that of the alpine fir is much lighter. The bark of the former is also much more ridged than that of the latter, which remains more or less smooth until very old age. The alpine fir, as its name implies, is a tree of the alpine regions. It does its best, however, in damp canyons, where it is associated with the Engelmann spruce. In the higher altitudes it is a companion of the white-bark pine on the exposed ridges, but is more at home in basins, occupying the places where the snow disappears first. It is found throughout the alpine regions in the western part of the United States, and reaches as far south as northern Arizona. (See frontispiece for characteristic locality for growth. On the extreme right is the tapering top of a beautiful tree.)

Daphnia Pond.

A STUDY IN ENVIRONMENT.

Morton John Elrod.

Daphnia Pond lies along the road about a mile and a half south of the laboratory. It is a small land locked pond, covering some 10 or 12 acres. It is undoubtedly of glacial origin, lying in a small pocket between two ridges of rock made by faulting. Its outlet in spring is to Flathead lake, a hundred feet lower in altitude. The pond lies in a glaciated region and is no doubt the result of glacial action. Within a few miles of Daphnia a dozen other ponds of similar nature may be found with similar origin, and offering the same field for study.

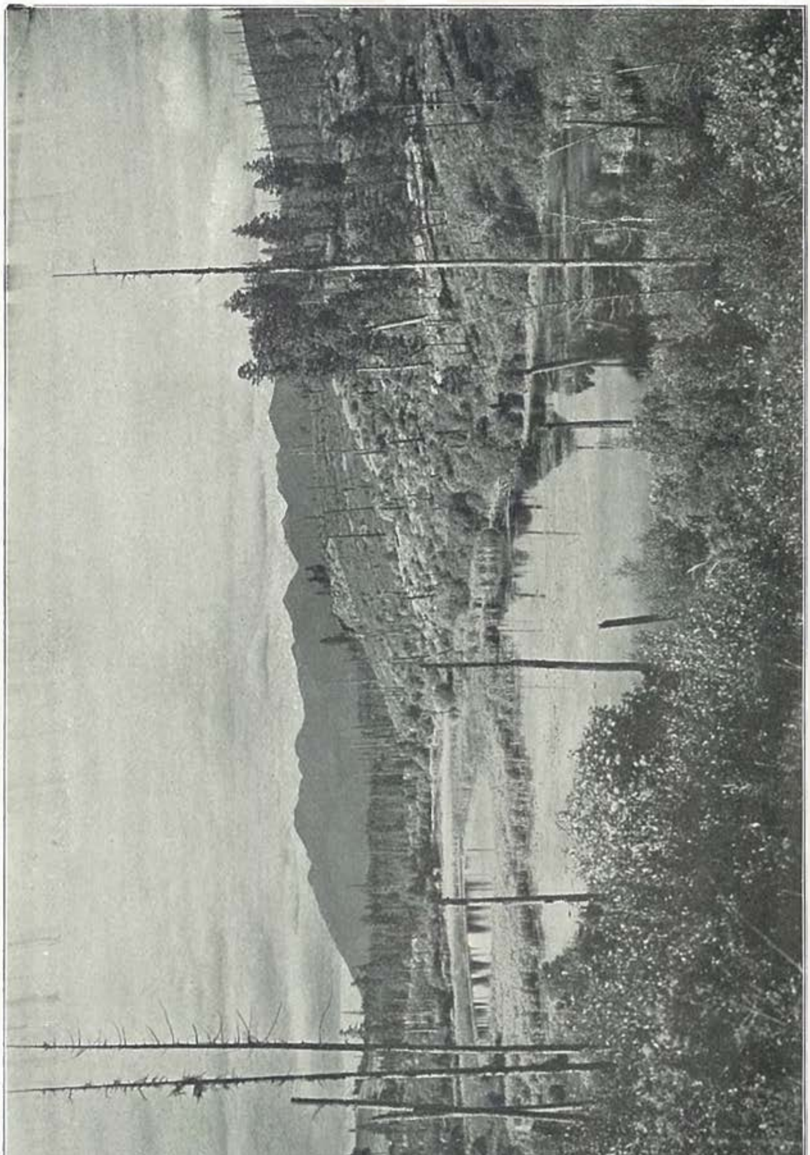
The pond is shallow at either end and 20 feet deep in the middle. The shallow places are overgrown with rushes, moss, water lilies, and other aquatic forms of vegetable life. A small place in the center has open free water. Around the banks there is the usual growth of willows, while numerous logs and dead bushes make the water difficult to reach. The bottom is largely of boulders, filled in between with mud, and overgrown with rank and dense vegetation.

The name Daphnia was given because of the great numbers of the entomostracan **Daphnia pulex** found in the pond.

Environment is a biological term having reference to the physical conditions affecting an organism. As referred to human beings we say the environment is good when the conditions are so favorable as to lead to good results. When a boy is sent to college he is in a good environment if his professors, his associates, his boarding house, and his companions all encouarge him to such effort as will bring about the best results mentally, morally, and physically.

The environment may, of course, be bad. In that case the results are not what are desired. Bad companions and associates, bad tendencies, may bring about conditions of mind and body disastrous to the individual possessing them.

According to the best information we now possess, when an organism comes into existence it has certain hereditary tendencies. These are only tendencies, and are immediately intensified or diminished by the conditions in which it is placed. In addition to these hereditary tendencies each living organism has within itself, be they few or many, some characters which are called acquired characters, which originate within the organism, and are affected the same as hereditary characters. Often these are powerfully influenced by environment, are intensified to a marked degree, and apparently modify the entire life of the species and its descendants. Hereditary or acquired characters or tendencies, affected by environment, make the species what they are.



Daphnia pond, near the station. Note the hydrophytic vegetation with open water in the middle. Swan range in the distance. The view is north. Photo by M. J. E.

Environment may mean any of the following conditions: Physical conditions, temperature and moisture, so as to make food abundant and the conditions favorable to life. In such a case the species would multiply rapidly, with little tendency to variation from the normal condition. These conditions may be such as to make food scarce, make life a struggle, and kill off the great majority of the organisms of a species. In such a case there is marked tendency to variation. Those characters or traits most useful or helpful in the struggle will be selected, and organisms differing from their ancestors in some ways will be the result.

Again: in addition to the above two cases, and modifying either, there may be the presence or absence of natural enemies, which prey upon the organisms, increasing or reducing in numbers accordingly. Where food is most abundant and enemies practically absent there is great multiplication of numbers. Illustrations of these conditions are to be seen in America in the English sparrow, the San Jose scale, the codling and gypsy moths, and other noxious insects. Where food is scarce and enemies abundant there is either great variation or extinction of species, or both. Under such circumstances the struggle is keenest and most severe, those least able to survive are killed, and the resulting and living specimens are likely to be strong and hardy, unlike their ancestors, continuing to vary in structure so long as the hard conditions exist.

Let us make application of these principles to the life as we find it in Daphnia Pond.

Vegetable Life. Trees are absent. As no trees in the region other than willow shrubs can live in water the pond must be older than any trees growing near it.

When water collects in any place it is immediately invaded by certain forms of vegetable life, water plants. In sustaining life these plants begin to fill the pond. Their roots sink into the soil to hold the plant. Their stems become so thick and matted that whatever silt is brought into the water is held, and is not permitted to run out. The pond is gradually filled in, the plants in living, slowly make living impossible, and the result is the extinction of the pond and the death of both its animal and vegetable life.

Daphnia pond admirably illustrates the method by which a pond is filled. In the center is a small space of open water, twenty feet deep. This is bordered by a fringe of yellow water lilies, whose roots are deep in the mud, and whose leaves reach up through five or six feet of water to the surface. Among these are matted masses of lower forms of vegetable life. Outside, in shallower water, the rushes and cattails hold sway, their decaying leaves and stems each year adding to the decayed vegetable material. Nearer the shore the sedges have taken hold, and formed large hummocks, sufficient to bear the weight of a man. Along shore willows have taken firm hold on the soil.

This tangled mass of hydrophytic vegetation affords abundant hiding place for various forms of animal life, and at the same time supplies food for them, as testified by their great numbers.

The glaciated ridges adjacent have in very recent years been cleared

by fires. A new vegetable growth is appearing, which may change the life materially.

Animal Life. Vertebrates are scarce in the waters of Daphnia pond. Fish are absent. This goes to prove that the pond has at no time had sufficient outflow to permit the ascent of fish from Flathead lake. Certainly fish could live in the water, since it is clear and cold, and probably has underground seepage. There is a good supply of animal food. Frogs are rather abundant, as are also garter snakes. The frogs prey upon insects, the snakes upon both insects and frogs. A dark green grass snake has also been observed. A single species of turtle has been seen, but they are rare. Among the rushes a few muskrat homes have been built, but the animals are scarce and shy.

The invertebrate life is abundant in numbers of specimens, but not in species. Three species of shells are found in the water, one on land. **Planorbis trivolvis** Say and **Sphaerium partumeium** Say are abundant in the hydrophytic vegetation. **Physa ampullacea** Gld. is rather common. **Pyramidula strigosa**, var. **cooperi** W. G. B. is found in damp places on land. It seems strange that but a single land snail has been found.

Among the entomostraca **Daphnia pulex** holds sway. So abundant is the species that the water in the open space near the center is colored a dull reddish brown. They may be taken in any quantity. Forbes reports that this species is probably a fish food. This may explain its scarcity in Flathead lake as compared with Daphnia pond. Forbes reported the species as absent from Flathead lake. It has been found by us in our studies each year up to present writing. Much less abundant, but still common, is **Diaptomus lintoni** Forbes, while in still smaller numbers is found **Cyclops pulchellus** Koch. **Gammarus**, probably two species, hide among the water lilies and rushes.

Insects are abundant. It is no doubt a breeding place for mosquitoes, although no larvae have been taken. Unidentified dipterous larvae in considerable numbers have been taken. No fewer than ten species of dragonflies have been captured on the wing. Most of these have also been secured in larval stage. Other material to be found in the pond in abundance may be mentioned; many beetles, two leeches, several case worms, many water bugs, diptera, and worms.

The vicinity of this pond is a great breeding place for birds. No fewer than forty-five to fifty migrants build their nests and rear their young within a hundred yards of the water's edge. For so small a pond this is a very good showing. On all sides the timber has been destroyed by fire. Thus most of the shelter formerly afforded has been removed. The nesting sites are confined to the low bushes along the water's edge, to those which have sprung up in the burnt area, to the dead boles left by the fire, and to the grass and reeds of the pond. Rails are heard daily as they move around among the weeds. Golden-eyes and grebes usually rear their young in the grass. Catbirds, western yellowthroats, flycatchers, chickadees, sparrows, juncos and woodpeckers, all are found. The tree dwelling warblers find a few trees near by. Kingbirds may always be noticed, noisily chattering as they leave their perches in pursuit of insects. The total number of species of birds observed in the

vicinity of Flathead lake as given by Silloway is 135. One-third of these may be found in the immediate neighborhood of this one small pond, showing the opportunity for study afforded by it.

Of the smaller microscopic life of the waters no examination has been made. Of protoza, diatoms, desmids, and the smaller worms there is no doubt a large number owing to the abundance of entomostracan life which the pond supports.

Owing to the size and character of the pond it offers an admirable site for detailed study of several forms of animal and vegetable life with respect to environment, with opportunities for experiments in changing the conditions, thus vitally affecting the lives of the inhabitants. In comparison with the waters of Flathead lake Daphnia pond teems with life, although but a short distance from the former, and insignificant in size in comparison. In the large lake there is little protection along the shore, owing to the pebbly nature, almost none in the bottom. The vegetation is confined to a few areas at either end where shallow water makes a swamp, and where vegetation can have a footing. The water is clear, cold and deep. Receiving a constant influx of cold water from the Swan and Flathead rivers, the lake does not cool rapidly save in the shallow bays where the water has little motion. In Daphnia pond, however, there is abundant vegetation. Great mats of it may be pulled out from almost any portion, from the growing green plants uppermost to the dead and decaying peat below. This mass is alive with living and crawling objects, which here find ample protection. There are no fish to destroy them while in the larval stage, hence they multiply rapidly. Among insects many have been mentioned. As these emerge from the water to the air they prey upon each other, and are in turn preyed upon by birds. A bittern was killed with his stomach full of the dragonfly **Aeschna constricta.** Kingbirds are known to prey upon them also. There can be little doubt but that many species of birds live principally upon the insects about the pond, although no examination of stomachs has been made other than as above mentioned.

Daphnia pond is commended to the students of the station laboratory as an excellent place for securing material for statistical studies in variation, for determining the relationships of hydrophytic and hydrozoic life, and for experiments on both forms of life. It offers to teachers an admirable place for securing material for class use, being one of the best collecting fields discovered in this section of the state.

Types of Nests of Birds.

TYPES OF NESTS OF BIRDS, WITH SPECIAL REFERENCE TO THE FLATHEAD REGION.

Perley Milton Silloway.

The nest-building habit of the birds is a marvel of inherited experience. Is it not remrakable that these feathered creatures of the air, roaming among the foliage of trees, bushes, or meadows for the greater

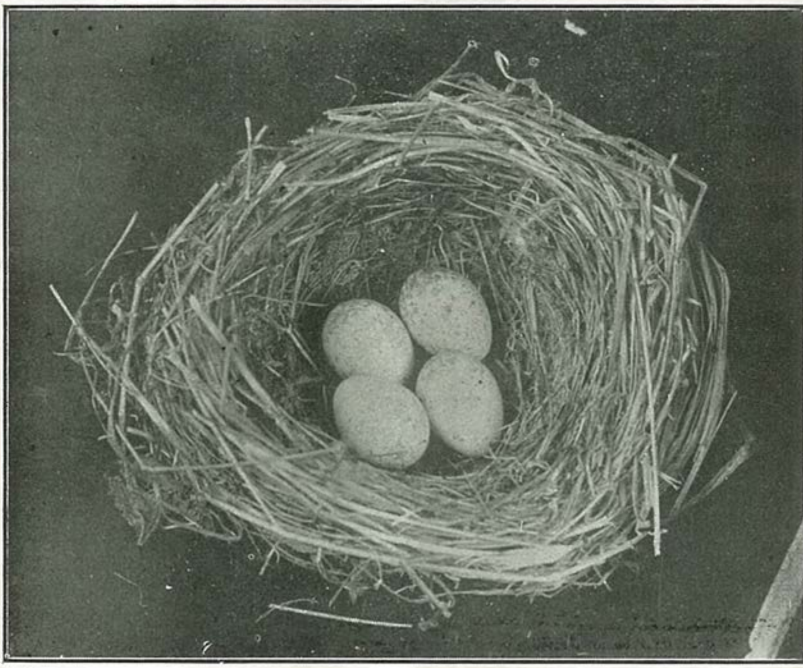


Fig. 17. Nest and Eggs of Olive-backed Thrush.

part of the year, should settle upon a particular site, and construct a habitation that often withstands the climatic vicissitudes of many seasons? We regard the cowbird as peculiar because of its habit of stealing among the bushes and depositing its eggs in the nests of other birds; but are not the other birds even more peculiar in their instinct of suspending their Bohemian habits for a short period, and settling down to the humdrum occupation of house-building and home-keeping? When we remember that for eleven-twelfths of the year the birds have no place of shelter

or retreat known as home, we may well wonder at the power of the impulse or instinct that leads them to build a strong dwelling for use but several weeks at most, and confine their activities to a limited range.

The knowledge of nest-building manifested by the birds is doubtless inherited. This theory is strengthened when we learn that birds of the same species construct nests of the same general type, following a common pattern of architecture and using materials of similar texture. A robin's nest in Montana differs in no essential feature of structure or material from one in Illinois or New York, and generation after generation of robins construct nests of the same typical style. If a robin be taken from the nest and reared apart from other robins, its attempts at nest-building will follow the plan approved by years of robin experience. Therefore when the bird-student becomes familiar with the type of nest constructed by any species of his avian friend, he will be able to identify the nest of that species thereafter with little difficulty.

After selecting a convenient crotch of some tree not far removed from civilization, the robin makes a substantial foundation of dried grass, strings, rags, or other similar material. Upon and within this Mrs. Robin erects a strong mud wall, smoothing it interiorly by rubbing and molding it with her breast. Then she places a bedding of coarse dried grass in the bottom of her cot, and she has a habitation as comfortable as a prairie settler's dug-out.

Among the nest-builders of the Flathead region, the olive-backed thrush is quite abundant. It selects a site near the top of a small fir tree, from six to ten feet from the ground, or in an upright crotch of a slender sapling, generally in the edge of a swamp or retired woods. The base of the nest (Fig. 17) is a loose mass of dried grass and weed-stems, upon which the builder forms a snug-walled structure of dark-green lichen and fine dried grass, the latter also serving as lining for the nest. It is said that in more northern localities a larger proportion of moss and lichen is used by this thrush, but the type of architecture is characteristic wherever the thrush is found nesting.

Belonging to the same genus as tne olive-backed is the willow thrush. It is the rule that birds of the same genus have similar habits of nidification, but the willow thrush differs very materially from its congener in its plan of architecture. It uses very coarse weed-stems and strips of bark, pine needles, and dried leaves, all dark material, making a thick-walled cup generally deeper than the work of the olive-backed, lining it with dark root-fibers. This nest is generally placed on or near the ground, frequently on a heap of decaying leaves or similar rubbish. In 1902, however, a nest of this thrush was found six feet from the ground, in an upright crotch of an oblique sapling, a very unusual situation for the nest of the willow thrush.

The catbird is one of the common birds of this portion of the Flathead region. Its nest is made in a low bush, usually among upright stems. It is a bulky structure, also made of dark material. Like the willow thrush, the catbird uses strips of coarse bark, weaving them into a strong basket, which it lines with coarse rootlets. Pieces of dried leaves, and fragments of twigs are also used in the framework of the