

catbird's nest. In appearance this nest closely resembles that of the willow thrush, though the different site in each case renders identification quite easy.

A type of nest radically different from any of the foregoing is presented by the American dipper, a bird which haunts the rapids of our mountain brooks, and plays in the splashing waters as they foam among the rocks or dash down the rock declivities. The nest of the dipper is a hollow ball of green moss, oftenest situated where it is kept soft and

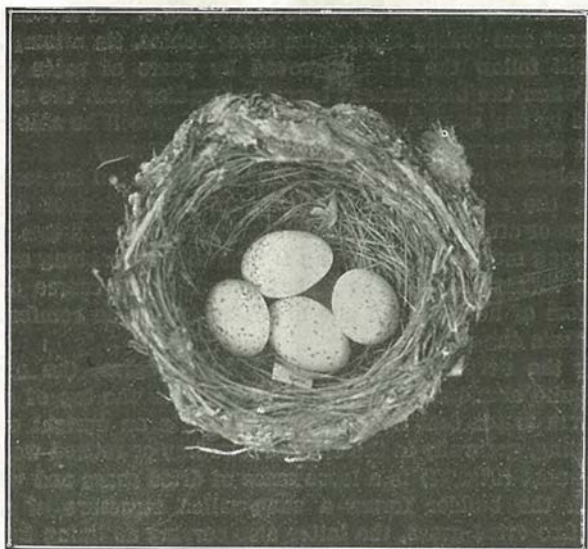


FIG. 18. Nest and Eggs of American Redstart *Setophaga ruticilla* L.

moist by the spray of rapids or falls, on a shelf of rock, or among the roots of trees washed by the brawling stream. On one side of this mossy, dome-shaped habitation is a circular entrance, and within it is an inner nest of leaves and grass. The site is nearly always among mossy surroundings, and the nest is easily overlooked by anyone not familiar with the nesting habits of the dipper.

Among the warblers of this region, the American redstart is a nest-builder of some note. It chooses dark gray-colored material (Fig. 18), such as fine strips of inner bark-fibers of weed-stems, bits of dark green lichen, flakes of gossamer, and fibrous grasses. These it shapes into a neat, well-rounded cup, fitted into some crotch formed by a small twig and a larger branch, generally upright, from six to twenty feet from the ground. In size the nest is probably the smallest among the warblers, and is difficult to detect in the gloomy light of the swamp-woods, as it resembles an enlargement at a joint of the branch.

The ground-dwelling warblers of this region manifest a great similarity of taste in their style of architecture. In this group are the western yellow-throat and Macgillivray's warbler, both of which make their

ests in grass tufts, about eight inches from the ground. The structure is made exteriorly of long pieces of grass stems, interiorly of fine dried grass, rootlets and horsehair. When made in a grass tuft among rank sprouts and small bushes, the nest of Macgillivray's warbler cannot be distinguished from that of the yellowthroat in similar situations. However, the yellowthroat chooses other sites, notably the rushes of ponds and swamps. In such situations the nest material is likely to be taken from that nearest at hand. A nest of the yellowthroat taken from *Daphnia*

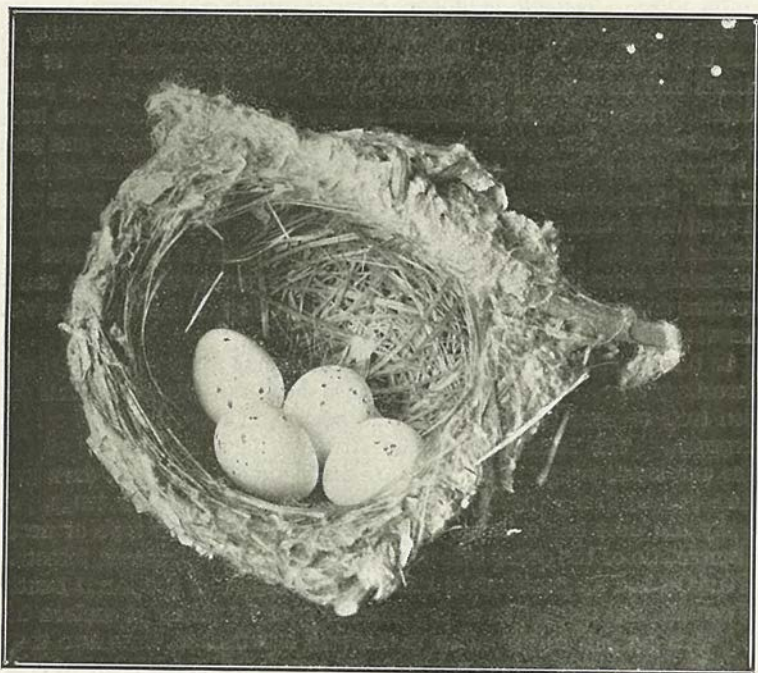


FIG. 19. Nest and Eggs of Warbling Vireo, *Vireo gilvus* Vieill. Photo by M. J. E

pond was made altogether of pieces of dried flag, with a lining of fine grass, thus resembling a cup-shaped basket of irregular weaving.

Though scarcely constituting a type, the nest of Audubon's warbler is somewhat different from other nests which it resembles. It is rather larger than that of the yellow warbler, and darker in appearance, assimilating more closely with its surroundings. Its outer appearance is much like that of the redstart, though it is so much larger that there is no likelihood of confounding the two. This nest is made of dark weed-stems, strips of weed-bark, gossamer, and fine dried grasses, with soft feathers and horsehair as lining material. The use of feathers in the inner wall serves to distinguish this nest from the work of the yellow warbler.

For neatness of structure and harmony of appearance, the nest of

the yellow warbler is a noteworthy example. It is usually made in an upright crotch of small branches, from five to fifteen feet from the ground. The materials chosen are of a grayish color. The predominating substance is fine dried grass, woven together with downy fibers, shreds of weed-bark, fragments of gossamer, and horsehair. The peculiar feature of this nest is the neatness of the interior finish. Frequently one is found that is lined throughout with white vegetable material as smoothly as if satin or morocco were used.

As a distinct type, the nest (Fig. 19), of the vireos is interesting in several ways. The site is unique, being invariably a horizontal or drooping fork of twigs near the extremity of a branch, from six to twenty feet from the ground. It is a swinging cradle firmly attached by its brim, without motion in itself yet swaying with every impulse of the passing breeze. The outer wall of the nest is very loosely arranged in an irregular covering of fibrous shavings, strippings of bark, gossamer, and pieces of hornet paper. The bedding of the nest is fine dried grass of a wiry texture. The foregoing description is alike applicable to the nests of the red-eyed and warbling vireo, the only representatives of the vireos in the Flathead region. The external materials of the nest of the red-eyed vireo is generally more loosely disposed, the cavity is somewhat larger, and the structure as a whole averages larger than the nest of the warbling vireo, otherwise no difference is observable.

In this locality the cedar wax-wing constructs a nest (Fig. 20), of an interesting type. It is generally placed near the top of a small evergreen tree, or near the extremity of a horizontal low branch of a larger evergreen. The foundation of the structure is a loose mass of dried grass and small twigs. The walls are made almost wholly of dark green lichen, pinned firmly together with pine needles and smaller twigs. Frequently the nest has a lining of fine wiry grass. This type of nest is characteristic of the cedar wax-wing in the northern evergreen forests.

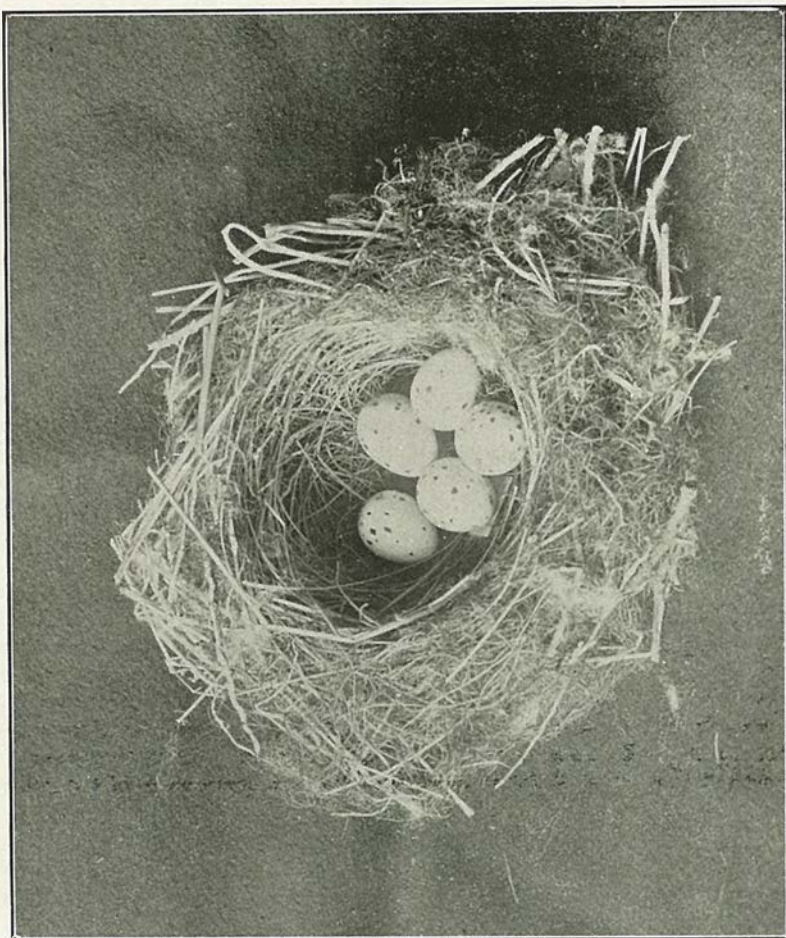
One of the most abundant birds of this region is the lazuli bunting, the western representative of the familiar indigo bunting of eastern habitat. The nest of this bunting is made in low bushes, from two to five feet from the ground. It is a type in its simplicity, being made of coarse dried grass and weed fibres, lined with fine grasses and horsehair, the main elements being of a grayish white color. The walls are loosely woven, and the nest is rather large for the size of the owner.

The nest of the black-headed grosbeak is a type because of its loose arrangement and frail structure. The ordinary site is the top of a large, loosely-spreading bush, a small evergreen tree, or the top of a low thorn tree. In such situations the eggs can generally be seen from below, as the nest materials are so loosely woven that the bottom is comparable to a net of several folds to retain the eggs. The affair is made of dark-colored twigs and rootlets, and is usually lined with finer rootlets of a darker color, or with fine grasses of similar hue. Last season a nest of grosbeak was found lined with fine moss-stems of a reddish brown color, the effect being a very handsome nest. The nest is so frail that the materials readily fall apart, or the twigs drop away one by one.

The familiar chipping sparrow constructs a nest of simple yet original

pattern. An outer wall of finer weed-stems, grasses, or lichens, and an inner layer of horsehair, are the essential features in the chippy's idea of building at all times and places. The outer layer is variable or may be lacking, but the horsehair is indispensable, and frequently the nest

FIG. 20. Nest and Eggs of Cedar Waxwing, *Ampelis cedrorum* Vieill. Photo by M. J. E.



contains only this material. The chipping sparrow's habit of using horsehair has suggested its nickname of hairbird in many localities. Generally dark or black hair is used, but this season I found a nest in which white or gray hair was used, the only nest of the chipping sparrow thus finished that I remember to have seen.

Another sparrow of this region, the western vesper, follows a plan of building similar to that of the chippy. The site is a depression in the ground, at the base of a tuft or small bush. There is generally an outer

wall of dried grass or weed-stems, and a lining of horsehair. In many nests, however, the horsehair is lacking, fine dried grass being substituted for it, hence we see that the type is not so constant as that of the chipping sparrow. Moreover, the nest of the vesper sparrow is a very flimsy affair, held in shape chiefly by the cavity it occupies, and not likely to retain its form when removed from the site.

The nest of the black-headed jay is seen frequently in this region, along the mountain streams and lake shores. This nest is oftenest made in small firs, on horizontal branches against the main stem, from six to eighteen feet from the ground. A typical nest consists of an outer framework of coarse dried twigs, interlaid rather loosely. Within these is a layer made of coarse weed-stems and muddy moss or lichen. Internally there is a layer of coarse brown rootlets. One of these nests is about eight inches across at its top, and five inches high.

The nest of the American magpie is a peculiar structure, though interiorly it is very similar to that of its relative just noticed, the black-headed jay. The base is a mass of large twigs, which supports a basin of dried clayey mud from seven to ten inches in diameter and about six inches deep. Within this earthen bowl is an inner nest of coarse brown rootlets, frequently with a scanty amount of horsehair. Over the nest, at a height of a foot or more, is a thick canopy of dried sticks, forming a snow-proof covering. Around the sides is a lattice-work of stout twigs, frequently so closely interwoven that a regular opening is necessary for the the entrance and egress of the owners. Commonly, however, the birds enter through openings due to the loose degree of interweaving of the materials.

Among the nest-builders of this region, Wright's flycatcher next demands consideration. A typical nest is very similar to one of the yellow warbler, both in situation and construction. It is made of grayish fibers of weed-stems, shreds of bark, and gossamer, within which are woven small downy feathers and cottony materials, besides which a few fine grasses are frequently used as lining. The tiny feathers used in this nest aid in distinguishing it from the yellow warbler's, though sometimes a nest is found which is felted as softly within as some nests of the yellow warbler. See Fig. 21.

The woodpeckers, of course, nest in cavities which they make in the trunks of trees, at varying heights from the ground, and deposit their crystal white eggs on the bare floor of the cavity, making no attempt to carry material to complete the interior.

Most of the hawks and owls of this region seldom go to the trouble to construct a new nest, but usually take possession of an old structure made by some more industrious builder in a former season. The spirited little sharp-shinned hawk, however, makes a new nest each year, its habitation being quite typical. The site is low, two that I have examined in this region being each within eight and nine feet from the ground. The nest is a mass of twigs, having a very slight depression and no lining material to receive the handsome eggs which this hawk produces.

Among the water-birds of this region, the most characteristic nests are those of the grebes. These nests are made in the swamps, among

dead and growing reeds, in water a foot or more in depth. The nest is a mass of black, decaying material, intermingled with which is some green material of the season. This mass of rubbish is anchored among the reeds, generally forming a low mound projecting about four inches above

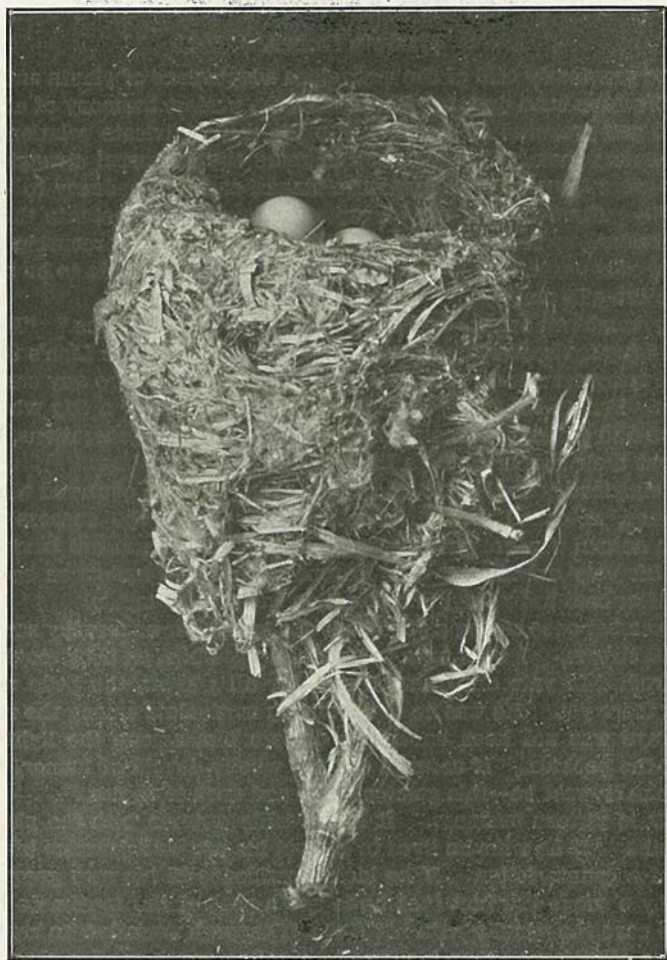


FIG. 21. Nest and Eggs of Wright's Flycatcher, *Empidonax wrighti*. Photo by M. J. E.

the water, and measuring from eighteen to twenty-four inches across at the surface of the water. The cavity is very slight, and generally contains a lot of loose stringy material like that in the nest, which can be hastily scratched over the eggs to conceal them when the owner leaves them.

Animal Counterfeits.

Maurice Ricker.

I have previously told of the marvelous adaptations of plants and animals. We have been duly impressed with the perfect harmony of adjustment and are prepared to examine into the more intricate relations existing between them. Let us keep in mind the universal struggle for food, the great loss of life in immature stages, and the tendency to variation. We believe that whatever variation tends to perpetuate the life of an individual, or to render it less liable to annoyance in procuring food, will prove of advantage to the race, since this variation tends to be transmitted to the offspring.

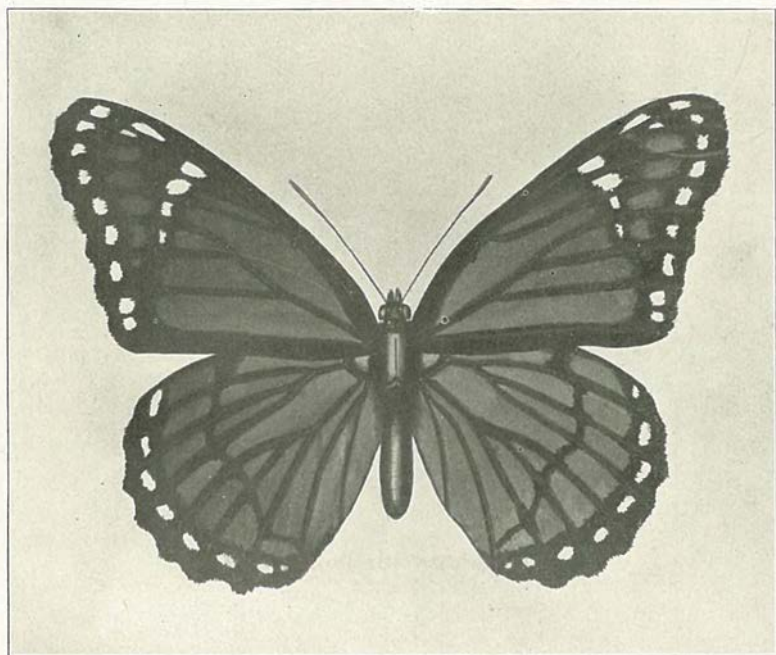
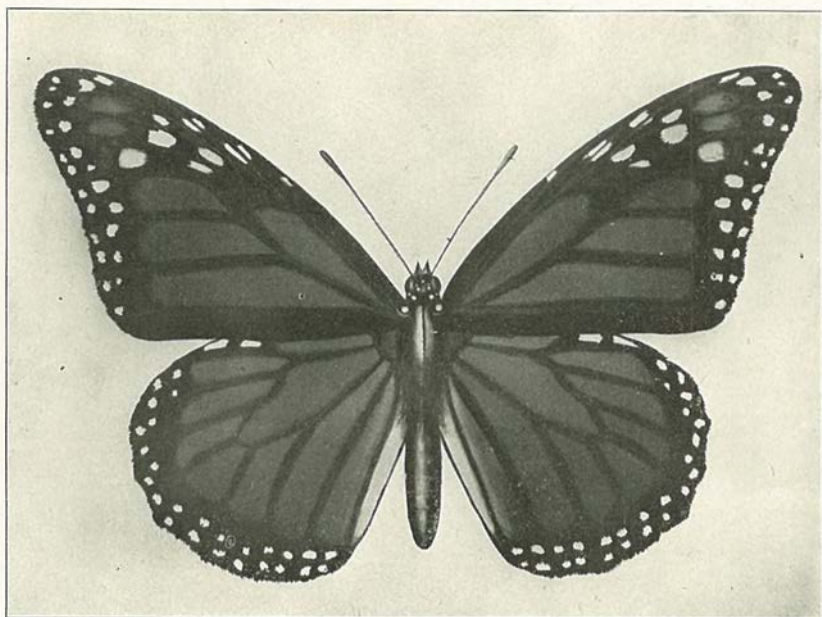
Truly, might an animal exclaim, "This is a world of shams." "Everyone is seeking to deceive." Aesop's fable of the "Ass in the Lion's Skin," is a tame story compared with the one we may see in nature any summer afternoon. For, in the fable, the ass masqueraded but for a day while in nature we find animals whose ancestors, for a thousand generations, have carried out their hypocrisy for a life time.

The simplest example, and one which every one has observed a great many times, is called protective coloration. Upon the success with which an animal can become apparently a part of the general landscape depends his very existence. The lessons we have all had when seeking some wild animal have fixed this principle well in our minds.

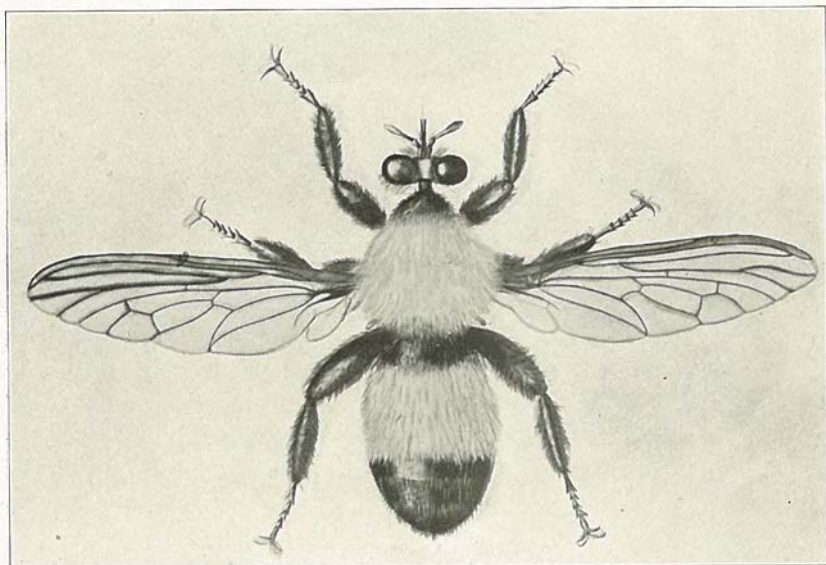
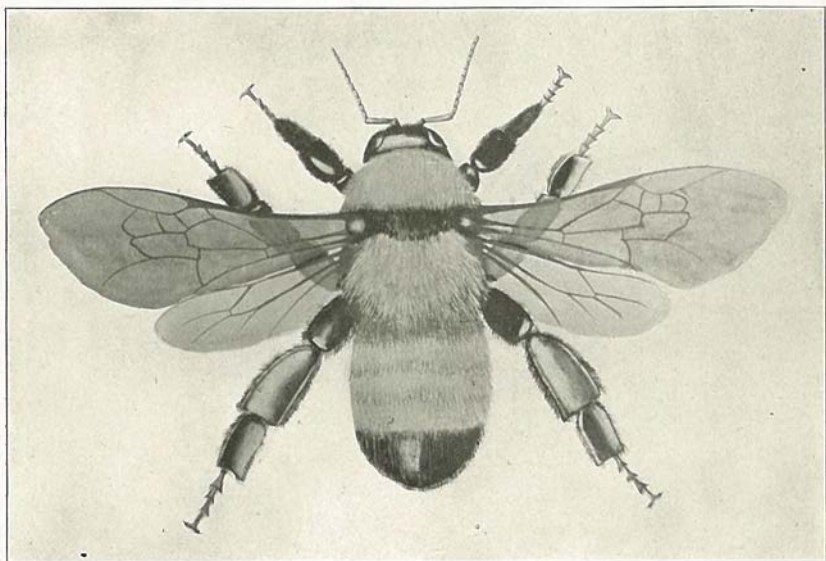
I remember once seeing a young spotted sandpiper on a rocky sandbar in a small stream. I went over to pick him up, when, as if by magic, he disappeared. In vain did I search and, for all I know, the little rascal is hiding there yet. He was no doubt sitting motionless among the rocks, and my eye was not keen enough to discern him among the light and shade of the pebbles. If animals are not wholly devoid of humor, what a good joke it must be—this game of hide and seek of theirs.

But it is serious business. It is in reality a game with the player's life at stake. If he wins he lives to perfect his art and practice his profession of a counterfeiter. If he lacks confidence in his own game and betrays by a move the fact that he is not a part of the inanimate landscape, he pays the penalty with his life. If through variation he happens to be more conspicuous than his type he stands a much greater chance of being picked up by his enemies. Thus nature would check a tendency to more conspicuous colors.

A few words on color in general may not be out of place. Scientists now find significance in nearly all coloration. At one time it would have been sacrilegious to have found other reasons for nature as it is, than as a creation solely and wholly for man's pleasure. I, for one, do not believe that man's reverence for nature or nature's God is any the less deep, for what may be called a more modern view. The true dignity of man and his exalted place in the universe is not lowered by this conception



Mimicry of *Anosia plexippus* (upper) by *Basilarchia disippus* (lower).
Photos from water color drawings by Mrs. Edith Ricker.



Bumble bee (above) mimicked by fly (below). Photos from water color drawings by Mrs. Edith Ricker.

of the organic world. A hundred years ago they said the hills are clothed in green and the valley bedecked with flowers solely to please man's eye for color. The poet says that "Full many a rose is born to blush unseen, and waste its sweetness on the desert air." I take it that the relations of plant and insect life thousands of years before man's appearance on the globe were much the same as to-day, and that an intelligent understanding of these facts will add largely to man's enjoyment of nature. Is not the pleasure of intellectual insight into nature of even higher order than the gratification of the sense of sight and smell." So color must be studied with the good of the race always in view.

In general animals wear colors that harmonize well with their surroundings. This arrangement may serve one of two important purposes and sometimes both. The most obvious use is that of the case just cited, where concealment is most desirable and necessary for protection of the animal sought by stronger animals for food. The other case is easily explained in the case of the polar bear. He has no enemy but hunger and his coloration enables him to steal upon his prey unobserved.

The advantages of protective coloration are still more clearly brought out by the examples of those animals which change their color with change of season. The Rocky Mountain goats live always on or near the snow. They remain white throughout the seasons but the ptarmigan changes to match the ground in summer and the snows in winter. The weasel and many other animals change their coat with the seasons.

We find in insects some of the most marvelous instances of coloration. It is well known that green larvae usually feed upon green leaves and brown larvae rest upon brown stems. The cocoons of moths are sometimes wrapped in leaves and the naked crystalids of various butterflies resemble dried leaves. The common walking stick, as it is well called, while a common insect of the field is seldom seen owing to its almost perfect resemblance to the twigs upon which it rests. The measuring worms, as they are called, more properly the larvae of grometrid moths, have not only the color of the plant upon which they rest, but when disturbed they hold to the stem with their abdominal feet, and, stiffening themselves at an appropriate angle to the stem, look precisely like the petiole of a leaf or a broken branch. It is a truly interesting experiment to tap a plant upon which they are feeding and note how rigid they become and how perfectly they assume the proper attitude. After a few minutes they will slowly unbend and become living larvae once more. Who has not walked through a forest and seen the brilliantly colored catocala moth flit an instant before his face and apparently disappear when he alights upon the tree trunk? As interesting a disappearance is that of the coralwing locust who flies with a gaudy flash of red or yellow and drops into the dust in the road to all appearances as lifeless as the clods around him. It is often necessary to scare him up many times before you are able to detect the dust colored form crouching in the dust, ready for a spring. So we might continue to name hundreds of familiar cases of protective coloration among animals. Besides, especially those birds which nest on the ground are protectively colored. We have all experienced the thrill of seeing a nighthawk get up from under our feet. You may

have searched the ground in vain for the speckled eggs laid so openly on some bare rock with the same lack of success that I have had.

I want here to mention some points not always understood. It is not supposed that the lower animals use cunning in their counterfeiting. We consider rather that they are unaware of the part they play. They certainly have no intent to deceive and are many times not conscious that they have any advantages in concealment. The chameleon changes color to suit the color of the substance it nests upon as nearly as possible, without conscious effort. By destroying his brain with a wire and then placing him on the colored backgrounds, this has been proven to be a reflex action.

The young robin instinctively remains in the posture I place him in, no matter how uncomfortable it may be. The nighthawk flops around and leads us away from her nest with no more thought than when she formed the blotched eggs which are so difficult to see on the ground. This leads up to a consideration of instinct and animal intelligence which must be deferred to another time.

Under the head of protective coloration are the many instances of warning coloration. Here the animal seems made for show and certainly intends to be seen. His colors stand out brilliantly; and as fitting actions accompany coloration we notice in this class of animals a disdain of concealment and often, in the case of flying insects, a loud buzzing noise. The bumble bee goes about its business and makes all the noise it pleases; in fact, seems to announce its coming.

As an example of warning coloration notice the orange or yellow banded bumble bees. If you are in doubt as to whether they need to conceal themselves catch one of them in your fingers and learn wisdom. If you need further experimentation next try the orange banded hornet. It may be difficult to teach one who has tried these experiments that these animals are well behaved, peace loving citizens of the insect world. If you stop to reason you will perceive that you were the aggressor in this instance and that you have hitherto carefully avoided thousands of these yellow or orange banded insects flying around with a buzzing noise. These insects are not armed with the intention that they are to use their weapons frequently. The occasional one who is imposed upon teaches the rest of the animal world to leave all similarly uniformed insects alone and as a rule they go on their way unmolested and to these colors owe their freedom from annoyance. Other insects like the brilliantly colored beetles and the Anosia butterflies are very distasteful to birds and their other enemies. Unless a bird inherits a suspicion against them he will soon get a bad taste in his mouth that will remind him for all time of its source. Certain caterpillars are likewise protected. Our common potato bug has few enemies after it hatches into the larva stage. If it were so fortunate with respect to its eggs it would no doubt exterminate the potato plant.

A very strangely marked blue frog of the tropics was placed before a number of cautious fowls. After a time an unsuspecting gosling took a number of cautious fowls. After a time an unsuspecting gosling took for some time shaking its head and evidently very sorry for its error.

Among mammals the skunk is a strikingly colored as well as a strongly scented animal. But why tell of warning coloration in a study of counterfeit? You say surely the bees are an honest self respecting folk. So they are, but we must understand what freedom from annoyance or extermination they enjoy and then we are fully prepared to comprehend the beautiful scheme by which nature protects her own from her own. Let us look for a moment at the *Anosia plexippus* (Plate L.) a butterfly of tropical origin, which migrates northward in the spring time, lays eggs for a spring brood which complete the cycle and migrate further northward. The fall brood migrate southward in September. There is no easier butterfly to raise from the egg which may be found on the common milkweeds. Why does this butterfly enjoy such a freedom of flight? It is found upon trial that birds forcibly fed upon the adult *Anosia* become very sick. It would seem that the birds have either tried the experiment or are warned in some way from doing so. They therefore never touch brown butterflies of this size with a black bordered wing bearing a row of white spots.

Let us now look at representative members of a widely separated genus, the *Basilarchias* (Plate L.) We find them to be generally purple in color with white or brownish markings. The common species of this genus in Montana has a broad white band on the forewings. In habit they are shy and flit from one bush to another.

One species of this genus differs radically from the others in coloring and habit. It is the species *disippus*. It is almost a perfect copy of the *Anosia* just described. It also has the habits of that insect. The early entomologists, who made the classification a matter largely of external appearance, very naturally classified the two together. In fact they are so nearly alike that they deceive everyone but the trained entomologist who looks beneath outward appearances. They differ in that the *Basilarchias* are edible when birds can be induced to try to eat them. This is doubtless a very rare occurrence in nature owing to the perfect resemblance to the undesirable species.

Wallace states the conditions necessary in order to effect mimicry are follows:

1. The two species, the imitating and imitated, must occur in the same locality.
2. The imitating species must be the more defenseless.
3. The imitating species must be the less numerous.
4. The imitating species must differ from its allies.
5. The imitation is external only, affecting only external appearances.

As to the origin of such a species some think that it must have come from *Basilarchia astyanax*, the common species of the middle states, which is sprinkled with brown spots. It may be that certain individuals differed from the current stock in being nearly or entirely brown. A sudden variation to a widely different type is called a sport and occurs in all species. If the sport came near enough the *Anosia* in color to be mistaken by its enemies for an edible species, it would be likely to live to reproduce. From the eggs of such an insect perhaps only a few would resemble the parent but these few would stand the better chance of

living and eventually would become distinct, owing their very existence to an accidental similarity of sports. Each generation tends to make the resemblance greater as the unprotected ones would be more likely to be eaten by hungry birds. We therefore call this a case of insect protective mimicry. It is probably the best case known. The manner in which the species arose teaches Darwin's great doctrine of the survival of the fittest and explains what he means by natural selection. Without this great key to the secrets of nature before the time of Darwin man was unable to explain many great biological problems, as for example the existence of related species and the enormous waste of life in arriving at maturity. The law of survival of the fittest solves to the satisfaction of many these great problems. The animal takes no conscious part in the great scheme of nature. It takes no thought as to how it is clothed or fed. The unalterable laws of the universe are at work upon it, but it need not know or care.

Another line of counterfeits of very great interest are the numerous unarmed insects who wear the uniforms of the wasps or bees. We need not go into the subject very deeply since it is almost a parallel case to the one given at length above. It is of obvious benefit to a defenseless fly to wear the yellow sash of a bee and thereby escape attacks of enemies which fear the sting of the bee. Many such can be found on the flowers almost any sunshiny day in summer. There is a family of flies that especially enjoys this disguise and feeds on the nectar of flowers, sucking through their long slender probosces. Since they aid in cross-fertilization as much as would a true bee I do not know that we should condemn their deception too severely. We may look upon them as harmless masqueraders.

While we admire the cunning in nature which protects so many helpless and innocent ones from injury, what shall we say of those rascals who wear the uniform of the bee, not for protection to themselves, but for the purpose of being better able to steal upon their victims. Many a tragedy in insect life occurs in about this way. A strong two-winged fly looking very much like a bumble bee in size and color and differing slightly in the buzz of his wings alights on a clover blossom and settles down to await a victim. Soon a heavily laden bumble bee alights upon a neighboring clover head wholly unsuspecting the counterfeit bee on the other blossom. Like most honest people he has little time to harbor suspicion of evil from one of his own kind. The villain squares himself for a jump through the air. A second later he alights upon the back of his victim. He holds the dangerous abdomen with its deadly sting securely in his bristling legs, and punctures with his strong beak the shiny armor on the bees thorax. In a minute it is all over, and, dropping the lifeless victim, he begins to clean himself after the manner of the fly family. I have his picture for the rogue's gallery. (Plate LI.) See how much like a bee he is even with wings and legs spread to show the differences. Gibson has told the *Syrphus* fly story especially well in his "Sharp Eyes." There is a large number of the robber flies who mimic for aggressive purposes.

Why are all small boys afraid of a dragonfly? The boy believes the

real mission of the dragonfly in life is to feed snakes and sew up the eyes, ears or mouths of small boys? Catch a dragonfly or a crane fly or any other insect with a long abdomen and how does he act? It turns the abdomen around wasp like and pretends it will sting. The boy believes the dragonfly will sting. Later in life he learns that the insect is perfectly harmless.

Among caterpillars there are many amusing instances of larvae being provided with means of putting on a horrid face or swelling up in such a way as to strike terror to the heart of all but those who know his ways. Snakes coil as if to strike, dart out their little forked tongues and look very vicious. Butterflies have big eyes on their wings giving them the appearance of larger and more ferocious animals. There are thousand of instances in which the animal, while perfectly harmless, deceives the uninitiated into believing him a very ferocious beast.

I sometimes think of the swagger and bluff of the biped coward who assumes the role of "a bad man." He may be pretending to be just spoiling for a fight. The fact is wild animals put up what we call a bluff. Some will fight a wicked battle when opportunity offers, but in general they want to be let alone. The rattlesnake sounds his warning. His rattle serves to protect him by frightening away more enemies than he fights. The armed bees carry warning colors and wish to be let alone. The mosquito seems an exception to this rule, but only the female, seeking nourishment for her brood that is to be, bothers man. Another series of counterfeiters that I must expose are those who by some display simulate the food of animals and the victim discovers his mistake just in time to be himself eaten. The kinglets and fly-catchers among birds as well as certain fish display traps of this kind. The term alluring coloration is appropriately applied to this class.

The fish bury themselves in the mud and by moving certain appendages lure smaller fish to believe that there are edible worms to be had in that vicinity. Upon attempting to obtain them they are themselves eaten.

The crowned kinglets and the tyrant fly-catcher spread a crest of orange or ruby feathers in a way that attracts flying insects to the supposed flowers. I have observed the ruby crowned kinglet engaged in attracting insects by this device. It seems to work well in early spring when both flowers and insects are scarce.

I have purposely reserved to the last an illustration in protective coloration that excells them all in the wonderful detail with which it is worked out.

Sir Alfred Russell Wallace, the naturalist who shares with Darwin the honor of discovering the theory of natural selection, on a visit to Borneo was told of two strange butterflies. One grew on trees and could be occasionally found apparently attached to the limb. The other was a brilliant blue and orange insect that totally disappeared when it flew into the shade of a tree. As you have already discerned, Wallace soon found them to be the same form and he gave to the world the example of the Kalima butterfly.

Words can not adequately describe this marvel which must be seen in its natural size and color to be appreciated. The wings fold in such

a way that the tips of the hind wings touch the twig, giving it the appearance of an attached petiole. The outer border resembles that of a torn leaf. Running up the middle of the folded wings is a dark line which represents perfectly a midrib. It has a raised appearance given by an artistic rendering of light and shade effects. One can scarcely believe that it is an effect produced by flat scales.

Still more wonderful is the way in which the venation of the leaf is brought out. The natural color of the veins is heightened in the two quarters where wing veins would harmonize with leaf veins. Still more wonderful is the almost total suppression of the wing veins in the other two quarters where wing veins would run across leaf veins; but in their place, to carry out the deception, it would seem, to the minutest detail, a series of shadowy scales take the direction of leaf veins. Thus the pattern of leaf venation is completely represented. The leaf insects, leaf carrying ants, and all the long list of nature's deceivers, must yield the palm to the magnificent Kalima butterfly, the prince of counterfeiters of the animal world.

Thus nature strives to protect her own. The key that unlocks many a mystery in animal adaptation is not always easily found. Working upon the hypothesis that animals have come to their present forms and colors through adaptation to their environment we believe that there is sufficient reason for all phenomena. We have the privilege here of working in nature's own laboratory where as yet the hand of man has hardly disturbed the balance which has been brought about by years unnumbered. A few years more and where can we find a spot on this hemisphere where man has not turned the plant and animal world topsy-turvy by destruction of native species and the introduction of foreign ones. Let us then improve our opportunity.

The Forest and the Prairie.

Harry Nichols Whitford.

Plants may be divided into two groups, herbaceous and woody. In the former the part above ground dies in the unfavorable season; in the latter the part above ground does not die annually. These two general forms may be subdivided. For example, the herbs may be divided into annuals and perennials, and the woody type may have the form of the shrub, vine, or tree. The climate of the greater part of the state of Montana is more favorable to herbaceous than to arboreous plants. The portion of the state east of the Rocky mountains is primarily a region where the moisture conditions will not permit trees to grow. However, there are certain parts in which the rainfall is sufficient in quantity to favor the growth of trees. The northwestern portion of the state, embracing the Flathead valley and the mountains on each side, is an extremely favorable place for the production of forests, but parts even of the Flathead valley are incapable of supporting trees. On one side of the valley, the prairie side, the rainfall is less than sixteen inches. The forest side has a rainfall of about twenty-one inches.

In order to understand why trees are confined to certain regions, it is of extreme importance to know what functions they perform and how the conditions in which they grow affect the work they do.

The tree absorbs water. It does this through its root system, and the greater the root system, the greater the power of absorbing water. The tree with an extensive and deep root system can live in drier situations, other things being equal, than the tree with a shallow root system, for its roots come into contact with more water in the soil, and in some cases may reach to the underground water level. In the latter case it is not so dependent on the amount of rainfall. Where the underground water level is near the surface, trees with shallow roots have as good a chance to get water as trees with deep roots. To illustrate these two points, compare the **bull pine** and the **silver pine**. The former has a deep and wide spreading root system. It can grow in much drier soils than the latter, which, on the other hand, has a shallow root system. It is, as a rule, confined to those situations where there is a great deal of water in the soil. Again, the root system of a tree serves to hold it in place. Those trees with deep root systems cannot be blown over so easily as those trees with shallow root systems. In the Flathead valley it is not an uncommon thing to find silver pines lying prostrate with almost their entire root system exposed, while other trees in the same situation are able to resist the wind because they have deeper root systems.

The tree is using water continually for three purposes:

1. Small quantities are used to supply the new growth that is added to the tree annually.

2. Small quantities are used in the manufacture of foods, such as starch, sugar, and other carbohydrates.

3. Large quantities are used to supply the loss by evaporation that is continually going on.

Analysis of the last process will show what role it plays in the distribution of trees.

The evaporation of water from plants is known as transpiration. The water taken in through the roots is carried through the stem to the leaves and other superficial parts of the plant, whence it passes into the atmosphere as vapor just as water in any moist object may. Other things being equal, the greater the surface a plant exposes to the atmosphere, the greater the amount of water given off. The tree, because it has a greater surface exposed than other forms of vegetation will give off more water. A birch tree with about 200,000 leaves has been estimated to give off from 350 to 470 pints of water on a single hot day. The amount of transpiration is regulated in a great measure by the conditions of the atmosphere. If the atmosphere is damp there is less transpiration than when the atmosphere is dry. Again, on a windy day the tree will give off more water than on a still day. Other things being equal, more water will be transpired on a warm day than on a cold day. Indeed, any condition that will affect the evaporation from wet objects, like clothes on a line, will affect the transpiration of a tree. In the growing season a tree like the birch will give off more water than a pine or fir tree of equal size, for the birch exposes to the air more leaf surface than the pine or fir; also its leaves are more delicate in structure than their hard needle-like leaves. Therefore the pine, other things being equal, can live in situations, which are drier during the summer months than can the birch. However, during the winter season the birch having shed its leaves exposes nothing but bare limbs to the atmosphere, so transpiration is much reduced. On the other hand the pine holds its leaves and has as much surface exposed during the winter as during the summer, and it is therefore in more danger then of losing water than a tree without any leaves. For even though the loss be checked by cold weather, absorption is checked also, because the colder the ground, the less the absorption; and if the ground be frozen around the roots, little or no water can pass into the tree.

It will be seen from the above that there is a relation between the intake and the outgo of water from the tree. If the tree is to survive, absorption must be greater than transpiration. As soon as it is equal to or less than the transpiration, the tree is in danger of drying out. In those climates where the rainfall is not sufficient to keep the soil wet enough to maintain this inequality between absorption and transpiration, trees cannot exist. But even in prairie regions there are places where there is sufficient water in the soil, as is the case near bodies of water where the underground water level is near the surface. This, no doubt, accounts for the presence of trees along streams in climates where the rainfall alone is insufficient to maintain trees.

Trees, being green plants, manufacture starch, sugar, and other carbohydrates. They do this in all green parts and therefore mostly in

the leaves. Water taken in through the roots is united with carbon dioxid absorbed from the air through the leaves. In the presence of light, by an unknown chemical process, the carbon dioxid and water are changed to a carbohydrate and oxygen is given off. Of course, light reaches the trees only in the day time. This process needs a certain amount of heat, but small quantities of starch can be produced by trees with evergreen leaves even at temperatures slightly below freezing. There are probably many warm days during the non-growing season when considerable quantities of carbohydrates like starch and sguar can be made. Especially would this be true in the early spring and late fall. The trees with broad leaves can manufacture more food during the summer months than trees with needle leaves, for they have more surface exposed to light, and the greater the green surface, other things being equal, the greater the amount of food that can be formed. But the time for the making of food by these broad leaved plants is practically limited to the time of the year during which they have their leaves. As soon as the leaves are shed little or no food can be produced. Thus, while they have an advantage over the evergreen trees during the summer, the latter, because they can work more or less during the whole year, may manufacture more food in a year than the former. This is more likely to be the case in high latitudes where the temperature of the summer months is comparatively low, than in more southerly climates. Especially is it the case in climates with a more equable distribution of the heat throughout the year, the summer months having a comparatively low mean and the winter months a comparatively high mean. Such is the climate in the Puget Sound region, where conifers are developed best in America. In the Flathead valley the distribution of the temperature throughout the year is not so equable as it is in the Puget Sound region, but it is more so than in a similar latitude in the eastern part of the United States. The evergreen trees reach a more luxuriant development in this valley than anywhere in the east, but of course are not so luxuriant as in the Puget Sound region.

The greatest danger that trees have to meet is an excessive loss of water. They are excluded from those climates that have little rain fall. A prairie vegetation can exist in these places because the plants growing here have met the danger of drought better than trees. There may be climates where the rainfall is so little that even prairie plants cannot thrive; then a desert is the result. There is, however, no true desert region in Montana, although in places it approaches the desert condition. These regions are known as the **great plains**. In such regions the sage brush is a characteristic plant, although it is not so conspicuous an element there as in the more desert like regions.

When the climate of a country makes conditions favorable for a certain form of plant life, then that form gives character to the landscape. If the grass and its associates give character to the region, then there is a **prairie formation**. If trees give a tone to the landscape, then there is a **forest formation**.

It may not be out of place to compare the relative capacity of these two forms of plants (the grass form and the tree form), to meet this

danger of too great a loss of moisture. The danger to plants becomes greatest during the dry summer months and during the winter. As already shown, during the winter months the cold soil is not favorable to absorption, and if the plant be subjected to evaporation then, it is likely to transpire more than it can absorb. A cold soil then acts in a measure like a dry one, and the plant is in danger of excessive loss of water during the winter as well as during the dry summer months.

The herbaceous plants meet the danger of transpiration and freezing by dying down to the ground during the unfavorable season. The annuals of course are tided over this season in the form of seeds, and the perennials, beside seeds, have also underground stems. The latter, because they are protected by the soil, are in little danger of drying out. The woody plants, on the other hand, are exposed to all the extremes of winter. All trees are protected by their bark. In the young twigs this is not so thick, and hence these parts are more exposed than the older parts with heavy bark. So it is with the seedlings; for, although not so exposed as the older trees, the seedling stage of a tree is the most delicate one in its existence. If the dry season comes on before its root system is well developed, the seedling is very likely to perish. The seedling is subject to other dangers that will be mentioned in another connection. Those trees that shed their leaves are not so exposed during the unfavorable season as those that have their leaves the year round. Even the trees without leaves may be winter-killed. On the whole, then, herbaceous plants are less exposed during the dry and non-growing season than the trees.

Fires are detrimental to all vegetation, so it will not be out of place to compare the two forms with regard to their powers in resisting fires. A fire sweeping across the prairie may burn the surface clean of vegetation, but seldom if ever injures the underground parts. As soon as the season permits, the grass will spring up from these underground stems. Trees that have the power of developing suckers from roots will be protected in the same way. But few conifers have this power. However, the bark of old trees is often a protection against fires. The bull pine, Douglas spruce and western larch have thick bark and are protected in this way from fires that are not too intense. Young trees, however, succumb even to light surface fires, so acres of young trees may often be destroyed by fires that will not injure the older trees. The perennial herbaceous plant, then, has greater powers of surviving fires than trees.

Again, grazing animals are injurious to vegetation. The perennial grass is protected, because, when the top is eaten off, the under ground part is usually uninjured. Of course, if the above-ground green parts are eaten off so frequently that they have no opportunity to manufacture new food, the plant will be killed, and when the food stored in the underground stems is used up, then the plant will starve. Hence close pasturage is dangerous to the grass form. However, other forms of herbaceous plants that have an objectionable taste or are covered by spines or prickles will be avoided altogether by the grazing animals, or eaten only when nothing else is available. Sheep are the most destructive ani-

mals to pastures. The grass type has an advantage over some other forms of herbaceous plants in another respect. The growing region of a grass leaf is at the base, often below the surface of the ground. This part is less likely to be injured by fires or by grazing animals. As soon as the danger is passed, growth is resumed if the other conditions are favorable.

Young trees are subject to destruction by grazing animals. Especially is this true early in the spring, in the late fall, and in winter, for then there is often little to eat. Trees with needle-like leaves are protected more or less in that the needles, acting as prickles, are disagreeable. Yet even the shoots of conifers are often eaten. Young trees of bull pine and Douglas spruce have been found thus injured by cattle. Herds of cattle and sheep kill many trees in the young stages by trampling them. The older trees are less likely to be injured by grazing animals than the younger. The most important growing parts of trees, unlike that of the grass leaf is at the tip of the young shoot, and as this is the most tender as well as the most exposed portion it is likely to be eaten, by which the tree may be damaged or killed.

From the above it will be seen that the young tree is more subject to drought and is more likely to be destroyed by fire and by grazing animals than the perennial grasses and other herbaceous forms that grow in the prairie. In the drier regions, then, the prairie forms can exist where trees cannot, and even in regions where the moisture is sufficient to make tree growth possible, the occurrence of fires and the presence of grazing animals may favor the prairie rather than the forest. Of course, the forests that border on the prairie are open and prairie plants can exist there, but where the forest forms a heavy canopy, nearly all grasses are excluded, for as a rule, they require more light than they can get in the deep shade of the trees.

It should be emphasized that the seedling stage is the most critical period of a tree's life. Probably many trees could exist in drier regions than those in which they are found, if they could survive the juvenile stage. Especially would this be true of those trees that have deep and widespreading root systems, for they might later be able to get a sufficient supply of water from the soil to supply the excessive loss by transpiration. A number of successive favorable seasons no doubt permits some trees to be established in places where otherwise it would be impossible for them to get a start.

Another factor that is against tree growth is the prevalence of wind. Of course, occasional violent storms may destroy forests. But since on a windy day there is more water given off than on a still day, even moderate winds may be prohibitive of tree growth whereas the occasional storm only partially destroys it. Because this factor is not so obvious, it is often overlooked. Even if the rainfall is sufficient to support tree life, in regions of excessive wind trees are often absent. A good sample of this is found in contrasting the two sides of the Rocky mountains. At the east base of the mountains where the Great Northern Railroad crosses, there is a rainfall of twenty inches or more, with little or no tree growth. The west base in the Flathead valley with a rainfall of ap-

proximately twenty inches bears a luxuriant forest growth. In the former situations, the winds are excessive. In the latter, they are neither so frequent nor so strong.

From the above it will be seen that the main cause for the absence of trees in a greater part of the state of Montana is the lack of sufficient moisture. In some places, however, where there is sufficient moisture, winds, fires, and grazing animals may prevent the growth of trees and thus favor the prairie.

Montana Shells.

NATURE STUDY LESSON.

Morton John Elrod.

The state of Montana is not very productive of conchological specimens. The conditions are all against shell growth. The rivers are rapid, the water quite soft, and food in the rivers scarce. The large lakes, as Flathead lake, contain clear, cold water. They are usually deep, with rock bottoms, and surrounded by mountains with steep slopes. The marshy, stagnant parts of the lakes are usually small. The mountain sides in summer become dry and parched, except in protected portions and along streams. Great stretches of plain are without moisture for a portion of the summer, drying up almost every living thing that cannot move to the water-courses. The days are hot, the nights cool. In this mountainous state, where very little soil is lower than 3,000 feet above the sea, the air is dry and evaporation rapid. A passing rain cloud may leave considerable moisture, but it is soon taken up by the parched earth or evaporated if left on the surface. Stagnant ponds with decaying vegetation are few and confined to the vicinity of a few rivers. Even such ponds usually become dry each summer.

Most of the valleys were former lake beds of greater or less extent. As these lakes have been drained, they left swamps in which rhinoceroses, camels, three-toed horses, elephants, titanotheriums and other beasts became mired, their remains being buried for long ages. These swamps have dried up, and the waters have become more widely separated, now occurring as deep mountain lakes, or larger lakes, which are mere expansions of rivers. Such isolation must have caused the separation of shells of a species which naturally would take different lines of development. Accompanying this gradual separation of waters we might expect a region of moisture on the land adjacent to the lakes, giving suitable environment to the land snails.

As a result of the above conditions, we may expect great variations in adjacent regions, where the barriers may be sufficient to cut off all communication. There is very little doubt but that the isolated lakes in Montana and the northwest will produce interesting variations. But the sparsely settled country and the small number of collectors make the work of collecting and studying very slow.

The lack of lime in the waters of the state in considerable quantity is another element contributing to the paucity of shell life. Specimens taken from water invariably have thin or frail shells. Some are exceedingly delicate. The land forms, although not numerous in species, have thicker and heavier shells, affording much better protection. One species of slug, without a shell has been taken, but in small numbers.

In considering the above conditons it is apparent that collecting living shells is confined largely to the rainy season, i. e., the spring and early

summer. While this is particularly true of the land species, it applies also to water forms. The pond inhabiting animals in spring are given more extensive territory, thus increasing the food supply and furnishing better opportunity for the development of the young. The rushing waters of the rivers, except in shallow and swampy areas along shore, are almost destitute of shells. In the western part but one bivalve is found in the

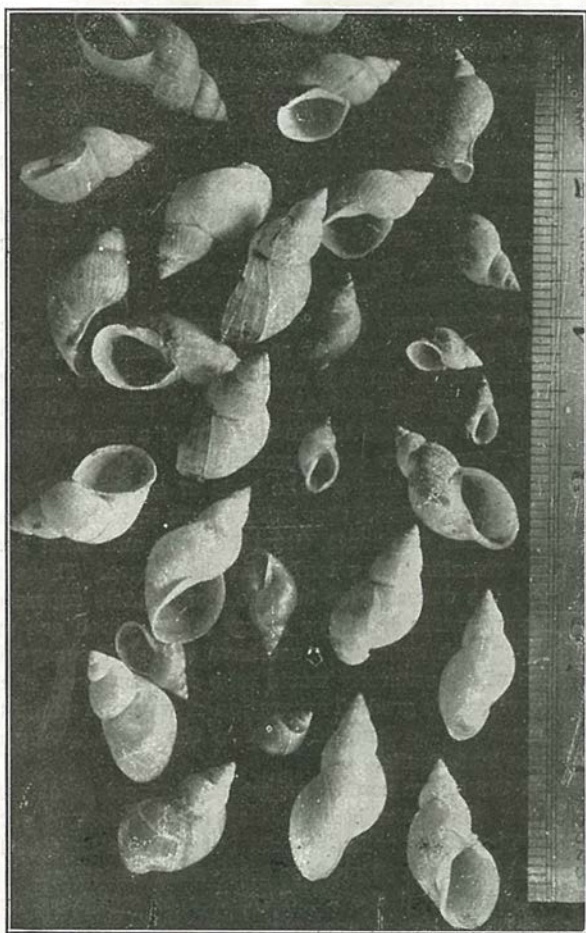


FIG. 22. *Linnæa palustris*, the commonest fresh water shell.

sand bars of the rivers, the common black clam, *Margaritana margaritifera* L. In the eastern part, tributary to the Atlantic, two Unionidae are recorded, *Anodonta plana* L., and *Anodonta ovata* L. In each case only the young were taken. Three other small bivalves, to be found among the vegetation of ponds, have been collected, one from the western and two from the eastern part of the state. It is thus seen that the total list

of bivalves inhabiting the waters of the state at present numbers but five species.

In most sections of the state rains are more or less constant in the state from early spring until the last of June. In May, June and sometimes early July, land forms may be hunted successfully. After this it is rare to find living animals except in very limited areas around lakes, ponds, or water courses. It is not uncommon to find bleached shells lying out in open and exposed places, but they are usually of one species, *Pyramidula strigosa* Gld., or some of its numerous subspecies or varieties.

To secure shells for the sanilery for class use is not exceedingly difficult, although they are not to be picked up at random. The water inhabiting species may be sought in shallow ponds, among the decaying or living vegetation. To secure them requires a pair of rubber boots, if one does not wish to have wet feet, and some form of a net for dipping them out of the water. The species in greatest abundance which is most likely to be taken is a small gastropod, with tapering spire, *Limnaea palustris* Muell. (Fig. 22). It is found throughout the state, may usually be had in abundance, and is not difficult to keep in the school room or laboratory. With it is likely to be had the smaller and more delicate *Physa*, with left handed turns in the shell. With these specimens in a vessel of water with suitable food a fund of information relative to their habits, movements and life may be secured. They will prove easy subjects for genuine work in nature study, and a large number of persons may carry on original observations. Other smaller species may be had possibly by sifting fine sand and separating the few shells to be had. I have kept many of these minute animals in vessels for months, and they have multiplied and done well. Those I have had were the diminutive *Pyramidula striatella* Anth., *Physa ampullacea* Gld., and *Limnaea palustris* Muell.

The land species must be sought in damp places. My most successful hunts have been in June on rainy days, although they may be had earlier than this. It is usually necessary to search among the weeds and underbrush of the timber along the water courses or ponds, or in the damp canyons and gulches on the mountain sides. I distinctly remember several days in the Mission mountains where specimens were gathered. It necessitated crawling around on hands and knees among rank and dense vegetation, while rain was falling in torrents. While this was very disagreeable, it was the time when snails were active. Even when abundant they are difficult to find, owing to their color. They very much resemble the leaves and dead wood over which they crawl in search of food.

The snailery must be kept neat and clean, for snails are dainty creatures, and will not thrive in dirty cages. The water species will need occasional fresh water. The water of Montana's lakes and streams is so free from mud and silt, as a general rule, and so full of oxygen, that changes need not be made often. Once in two or three weeks will probably suffice if the vessel be large enough to hold a gallon or more. Water vegetation should be supplied, which will not only furnish food for the

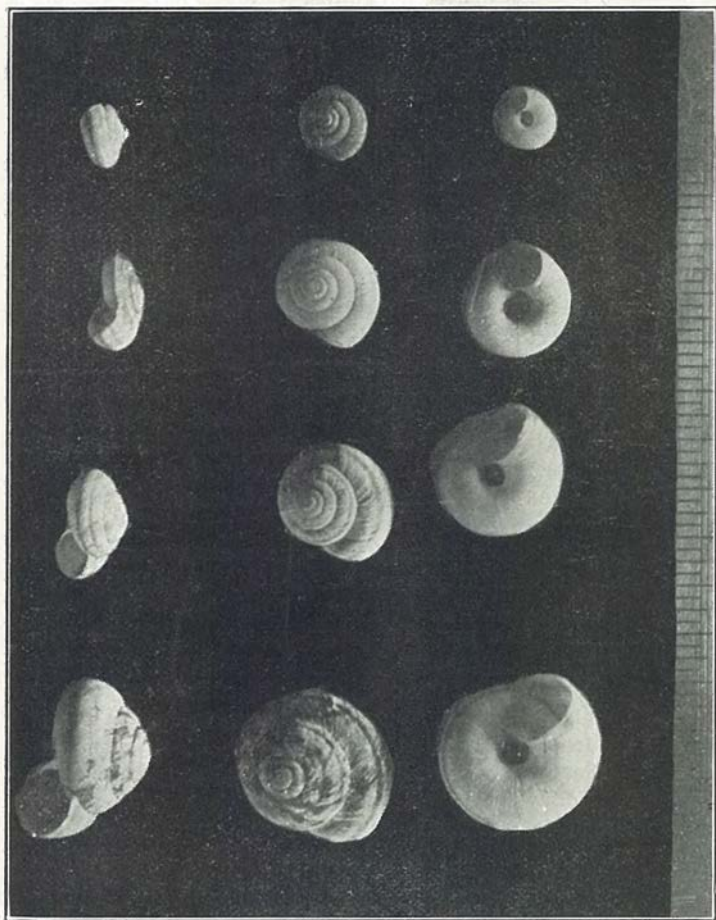


FIG. 23. A series of shells showing the varieties of *Pyramidula strigosa* due to high altitude. The largest, to the left, from McDonald Lake, altitude 3,300 feet. The next size, from Tobacco Root Mountains, east of the main range. The third, from the Bitter Root Mountains, altitude 5,000 feet. The smallest, from McDonald Peak, altitude 8,000 feet. Photo by M. J. E.

animals, but will also by its growth supply oxygen for their needs. I discover that pond scum may be kept growing all winter if placed in a south or west window for sunlight. Of course, water species may be kept in winter, when it will probably be found impossible to keep land species. In spring and summer the land snails may be kept in a suitable cage, and with a small amount of care and trouble in supplying food and in keeping the cage clean they will amply repay for the trouble. Pupils will find them interesting, and with a few suggestions will be able to make many valuable observations, and thus get true nature study lessons, a study of the living specimen whose habits and natural peculiarities may be known first hand.

The land snail most abundant in the state is *Pyramidula strigosa* Gld. It is found abundantly west of the Rocky mountains at all altitudes from the lowest elevations to 9,000 feet. The shells found may easily be referred to several varieties. Figure 23 shows their general appearance. The shell is rather thick and heavy, recognized by two dark bands, one of which extends into the spire for several whorls. Closely related to it, and often associated with it, is *Pyramidula solitaria* Say, but the latter is more earthy, with darker color, a trifle flatter, and with broader bands, not extending into the spire. *Solitaria* is less common, and is not yet reported from east of the range.

Pyramidula strigosa has been taken by us abundantly in the western part of the state. It has been found on the slopes of many mountain ranges in the state. It has been taken as far east as Lewistown. It is a Rocky mountain species, and is so variable that conchologists despair of bringing the numerous subspecies and varieties into systematic relations which will be satisfactory. At two places in the Mission range, Sinyaleamin and McDonald mountains, it has been found at high altitudes, as explained in "A Biological Reconnaissance in the Vicinity of Flathead Lake." The lower snails are large and fine looking. The higher ones are very small, greatly reduced in size, and have very hard conditions to fight against in the struggle for a living. While the species is apparently of western origin, its presence at Lewistown shows that it has crossed the range, and is slowly making its way eastward. This is the second species, according to our studies, that has crossed the main Rockies, the other being a dragonfly. As there are seven species found in the state on both sides of the main range it is apparent that they have crossed the range in some way. As *P. strigosa* has been found at elevations up to 9,000 feet it seems reasonable to suppose that it was not carried over by some larger bird or animal, but crossed over by its own wanderings.

Several hundred duplicates have been collected, and two or three will be sent to any teacher of nature study, so long as they last, if postage accompanies the request for them.

It is needless, in this lecture, to attempt giving a list of the sixty species found in the state, twenty-five of which have been found west of the range, with forty-two from the east side. A list may be found in Bulletin University of Montana, Biological Series No. 3, pp. 170-174. Teachers who wish shells identified may send them to the writer, who will

name them without charge. For much work in nature study a name is unnecessary, but it is very desirable. There are no keys available for identification of western species.

It will be seen from the above that the molluscan fauna of the west end of the state is entirely different from that of the east end, but seven being found on both sides of the mountains. As very few collections have been made it is very desirable that material be secured from various sections, and correspondence is invited on the subject and specimens very much desired. If teachers will suggest to pupils the desirability of gathering a few specimens the boys will probably bring them if they are in the neighborhood.

If the animals die, or if it is desired that they be killed so the shells may be used, the process of cleaning the shells and removing the dead animals is very simple. The shells containing the animals are dropped in hot water, and left for a few minutes. This quickly kills the animals and loosens them from the shell. The soft parts may then be removed by a bent pin or a piece of small wire bent at an angle at the end. Perfect specimen may then be made by washing out the inside with a pipette or small syringe. By gently rubbing the outside with a tooth or nail brush and water the outside may be shown off to best advantage. Such shells will ornament any school room or cabinet of collections.

Some of the suggestive points to which attention should be called may now be given.

Habitat. This includes the natural home, whether in water or on land, in the open or among dense vegetation. If among rocks the nature of the rocks should be determined. Shells found in water will suggest running water, sand banks, rocky bottom, shallow ponds, lake swamps, cold springs, or some other varying condition. Every phase of the environment should be noted, and suggestions thrown out for the purpose of having the pupils secure the information individually.

Movements. These may easily be watched, if specimens are kept in the snailery. It is very essential that the conditions in which the snail is placed should be as lifelike as possible, so as to be able to study movements that are natural and not forced. The animal may be watched while crawling around over the vegetation or along the sides of the aquarium. The use of the tenacles, the protrusion of the body from the shell, the withdrawal into the shell in times of danger, the action of the creeping foot during progression, and the movements of the mouth in feeding, all should be noted if possible.

Color and markings. Dead and bleached shells are not of much value, but are better than none. From them few conclusions may be drawn except as to size and shape. Teachers who understand the theory of protective resemblance will find shells suggestive of many things to which reference may be made. Those who do not understand it should make haste to consult some good zoology and discover its meaning. Shells generally resemble the surroundings so closely that they must be sought closely. I have frequently tried the experiment of searching a given spot carefully, to be followed by a second person who will see how many I have missed. A new spot is chosen and the order is reversed. Rarely

will the second person fail to find some overlooked specimens, so closely do they harmonize with their surroundings. This blending of colors applies with almost equal force to the species living in water. Markings may refer to spots or bands on the shell, or to the indentations on the surface. This latter may be coarse or fine, deep or shallow, numerous or few. It may be possible to count the number per inch or millimeter, and thus determine points of variation.

The Spiral. This may be right or left handed, dextrose or levulose. Most shells are dextrose. If shells are in quantity each should be examined carefully to see if perchance an accidental specimen may be found the reverse of the ordinary. Such cases occur. Some species have the shells left handed, turning opposite to the hands of a watch. Each should be examined. The number of turns in the spiral should be counted. A means should be devised for determining the fractional turn at the last, as it is very likely to result in a fraction. By making count of a series variations will be found and a mean established.

Diameter and Depth. Adult specimens should be used. Three straight edges are necessary, one of which should be a finely graduated ruler. Place the shell against the ruler, and put the two remaining straight edges on either side, also against the ruler. The reading may be taken from the ruler directly. With a ruler and two square blocks any number of shells may be quickly measured. By turning the specimen measurements may be made in different ways, and variations noted. It is understood that the value of such work to the pupil depends largely on whether it is done for him or by him.

Variations. In a mountainous region shells of a given species from different localities or altitudes will show many variations. In fact, not two shells from any place are exactly alike. By noting the above points many lines of variation may be noted. It is possible to determine the direction toward which the species is tending; i. e., it is becoming thicker shelled, with deeper markings, broader bands, fewer turns to the spire, less width and depth, smaller in body, or the reverse. All such observations afford food for reflection, and are excellent mental stimuli. As this is the main thing sought in nature study work the observations should be encouraged by each individual, and not by the class as a whole.

Food. Few suggestions need be given on this. In the snailery different things must be tried. Daily observations may show whether land forms eat living or dead leaves, decaying wood, wet or dry leaves; whether water snails eat living plants or decaying material in the water, or living animals. All observations should be carefully recorded, and at stated times notes may be compared.

Enemies and Unfavorable Conditions. Drouth kills most land snails. Those living in water have no doubt many enemies about which little can be determined. Permit some shells to become quite dry and watch their actions. Notice the film across the shell to prevent evaporation. Other enemies to land snails are rodents, including mice and squirrels. If broken shells are found, examine carefully to see if the break is by accident after death, as by washing among rocks, or by an enemy before death. This must be determined by the position and character of the

opening, as also by its recurring in a given manner. Observe whether the break is haphazard or shows evidence of careful selection as to place.

Geographical Distribution. Having found the name of the specimen in the snailery, it may be possible to find how extensively it is distributed over the state, over the United States, or over the world. This information may be had by consulting a library with conchological literature, or by inquiry of friends versed in knowledge of shells. In any event, whether the information is found or not, suggestions may be thrown out as to ways by which the species may be scattered, reasons for dispersal, and barriers which may prevent it.

Some Devices Tending to Insure Cross-Fertilization of Plants.

Maurice Ricker.

The oak has a wind-pollinated flower. In some plants the pollen is carried by water. A large number of the conspicuous flowering plants are pollinated by insects, bees taking the leading part, though moths, butterflies, flies, beetles and bugs do much of the work. Some of the deep throated flowers, as the honey-suckle, are pollinated by the humming bird. Other especially adapted plants are said to be pollinated by snails.

Christian Konrad Sprengel was a pastor in a German parish until he neglected his duties, to the extent that he lost his position. This neglect came about through his love of the study of plants. He then made a precarious living by teaching the languages and mathematics, and continued his investigations, the results of which appeared in 1793 in a volume entitled "Das Endeckte Geheimnis der Natur." He shows in this

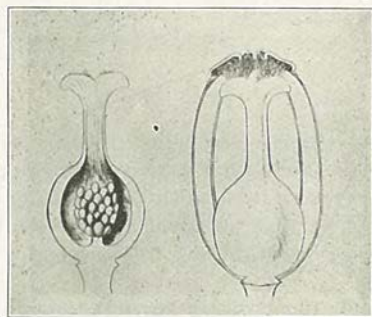


FIG. 24.

book a perfect understanding of the nature of fertilization and believes that insects play a part in putting pollen upon the stigma. Waetcher in a memoir in 1801, taught the structure of the orchid pollen-mass, or pollinia, as it is now called, and showed that it must be removed by an insect.

It remained for Darwin to discover the real secret of nature. He approached the subject through experimentation upon flowers fertilized by their own pollen as contrasted with those which are fertilized by the pollen of other flowers. His book on the "Fertilization of Orchids by Insects" appeared in 1862, nearly 70 years after Sprengel's work was first published in Berlin. We have illustrated the difficulties in the way of accepting Sprengel's work and Darwin's final solution of the problem by four charts, after Gibson.

The first (Fig. 24) shows how Sprengel taught the method of fertilization by showing how the pollen is shed upon the stigma by being borne above it.

The second chart (Fig. 25) shows how Sprengel overcame objections to his theory when his attention was called to flowers which bear the anthers below the stigma. It shows bees crawling over the nectaries, incidentally smearing themselves with pollen, and then climbing over the stigma, carrying the pollen with them.

The third chart (Fig. 26) shows the next problem with which Sprengel was confronted. Flowers were found where the pollen is all shed before

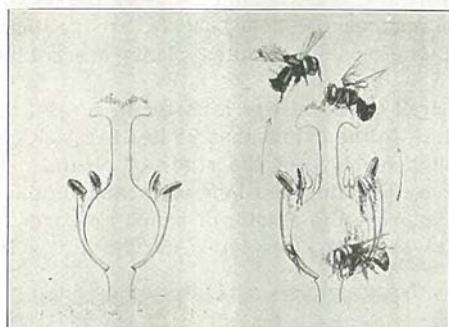


FIG. 25.

the stigma is open or receptive to pollen. These are what we now call *proterandrous* flowers. Somewhat similar in nature is the problem of the *proterandrous* flowers where the stigma ripens before the anther. Sprengel is said to have admitted that he could not solve all these enigmas but that, nevertheless, he thought there were reasons for these various structures.

Darwin, coming at the problem from the standpoint of cross-fertilization, saw it as in chart four (Fig. 27), which represents bees going from the ripe anthers of one flower to the receptive stigmas of older flowers; and it was made clear.

In his twelve years of experimentation on the subject of "Self and Cross Fertilization in the Vegetable Kingdom," Darwin showed that not only was it advantageous for flowers to be fertilized by pollen of other flowers of the same species, but that they produced more seeds if fertilized by pollen from distant fields. These two books by Darwin are of great interest to the botanist and may be read with profit by any one. As examples of the experimental method of to-day they are worthy of consideration. I suppose no other man has spent such years of painstaking labor and accompanied his theories with such an enormous amount of data.

Some plants, like the common violet, have two kinds of flowers. We only note the ones that open to insects with their beautifully colored corollas, but there are others, which may be found later in the summer

on the same plant. These do not open but shed the pollen upon the stigma, in the mud, as we might say. These are called cleistogamous flowers and I believe are borne only upon those plants which also produce the ordinary showy flowers, thus insuring cross pollination at some period in their history.

Many flowers provide against self-pollination by some such common

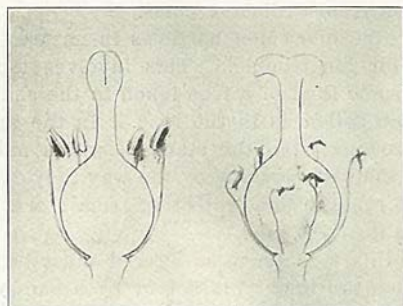


FIG. 26.

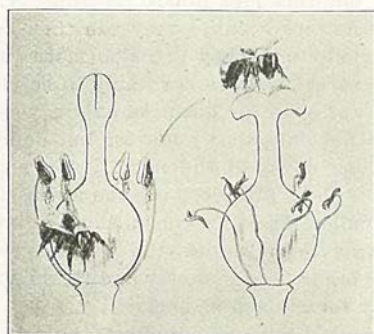


FIG. 27.

device as in the bluet (*Houstonia*), where some flowers bear the anthers in the lower part of the cup and the stigma near the top, while in other plants adjoining and perhaps raised from seed from the same plant, the opposite arrangement of anthers and stigmas is found. One can readily see how this will result in preventing self-pollination and furthering cross-pollination.

A still more effective method is found in many flowers where the parts mature at different times, as has been already mentioned. The most effective method, however, is shown in those plants like the willow where only pistillate flowers grow on the one plant and only staminate ones appear on another. These are called dioecious plants. The oak represents the type where the two kinds of flowers are borne separately on the same plant. These are called monoecious plants.

as might be supposed, those flowers which depend upon wind pollination must produce a great abundance of pollen, even though every device such as light feathered pollen be brought into use. The monoecious rag weed and the pines are good examples of plants which shed their pollen freely. We can readily see how great would be the benefit to a plant if an insect could be induced to carry its pollen. The saving in quantity would be considerable, as well as the advantage before mentioned of pollination from a distant plant.

Since there are no one sided bargains in nature the insect must be enticed and paid for his trouble. This involves the necessity of the plant's putting up some kind of a free lunch in the shape of nectar, as in the clover, or edible pollen as in the rose. In the Spiderwort we have some fine hairs growing from the stamens which must make delicious fodder for some of the bees, judging by the way they eat it. Some plants offer lodging for the night and protection from storm and cold. What more could a vagrant insect ask?

The fact that this free lunch is offered must be advertised, either by an odor to entice the hungry insect or by a showy blossom. Some plants with small inconspicuous blossoms, as in the clover, unite into heads so the busy bee can readily go from one to another without loss of his valuable time, for the summer is short.

One can follow out this idea almost indefinitely. Plants blooming at night have white flowers because they can thus be more clearly seen by their nocturnal visitors. They are also more likely to be fragrant. Flowers desiring nocturnal visitors are likely to be closed the rest of the day. Flowers that are open for business only a very short time, as the morning glory, have not only showy flowers but delicate stripes of color running from all sides down to the nectaries, seemingly to direct the insect to the sweets with as little loss of time as possible. These nectary guides, as they are called, are very conspicuous in many insect fertilized flowers. By following these guides, the welcome host will always rub against the essential organs of the flower and thereby assist in pollination, or in other ways pay for his sup of nectar.

It may be interesting here to note that the early botanists thought nectar was a waste product that must be removed, and an early suggested reason for insect visits was to assist the flower in its removal.

While most insect-fertilized flowers are beautifully colored and many of them pleasantly scented there are also some that are flesh-colored. They have a bad odor, as the smell of decaying meat. The visits of carrion flies suggest the purpose of the bad odor.

Sir John Lubbock made an interesting series of experiments from which he deduced the facts that dull yellow, brownish or purple flowers seem to attract flies more especially. Also that bees and butterflies are more likely to go to violet, red or blue flowers. Packard believes that no insect can distinguish clearly color or objects at a greater distance than six feet. What extremely short sighted animals they are! We know that odors will attract flies from much greater distance.

The insects, as well as the flowers, are modified to meet the conditions that arise from this inter-dependence. When Darwin's book was under

discussion soon after its first appearance, some one brought a flower from Madagascar which had a nectary measuring seventeen inches. Some were inclined to ridicule Darwin's theory and ask him to produce the insect having a tongue long enough to reach the sweets at the bottom. Though no such an insect was known, Darwin readily accepted the challenge and declared that he would stake his theory on the proposition that somewhere there was an animal capable of reaching it, else there would have been no such development. His critics were much disconcerted soon afterwards by the finding of just such a moth as Darwin had said there must be.

Let us consider some of the devices for preventing waste of pollen in insect fertilized flowers. We can readily see that after a plant has specialized to such an extent as to secure transfer of its pollen by certain flying insects only, that it may be necessary to arrange some means to keep out a large class of crawling insects, like the ants, which might seek to take advantage of the food and at the same time be of no use to the flower. They would not be adapted to transfer pollen to another plant in good order. The nasturtium for instance has numerous bristling hairs that bar the way to the nectary. The snow-berry has a perfect ball of cotton over its sweets. Some plants as the sunflower have such spiny, hairy stems as to discourage creeping visitors. Other plants secrete sticky gums which act very much in the same way as hairs, in that they are a serious impediment to insect travel. Some plants, like the milkweed, have smooth, waxy stems which are easily punctured by the sharp claws of a climbing insect. When the plant is injured the sticky milk will flow out and one can readily understand how disgusted an ant would soon become with such a plant. The rubber plant has sticky sap for the similar purpose of self protection.

Numerous schemes for prevention of visits by any other than the favored guest might be cited. The nectary is often located in long spurs where only long tongued insects can reach it. The columbine has five such spurs. The common flies and bees cannot disturb this flower. It reserves its nectar for certain long tongued insects. The bumble bee sometimes thwarts nature's scheme by alighting on the outside of the flower, and cutting a hole for a back door, as it were, drains the nectaries dry without having touched the essential parts of the flower. If this ingenious device of the bumble bee should become universal among bees it might have a serious effect upon the plant's survival. It would then have to depend upon allies of the butterfly order, who carry no knives, to make the first call.

One of the most astonishing tricks in the plant world is played by the blue flag or iris. One must examine a flower and find the parts to fully appreciate the situation (Fig. 29.) At last you will find the false honey guides running down the interior of the flower and Needham reports that many insects seem to make the very natural mistake of probing down the center of the flower as indicated by the guides, for the nectar. They find nothing and go away no doubt with a poor opinion of the flag.

A bumble bee, for whom the flower seems especially designed, alights

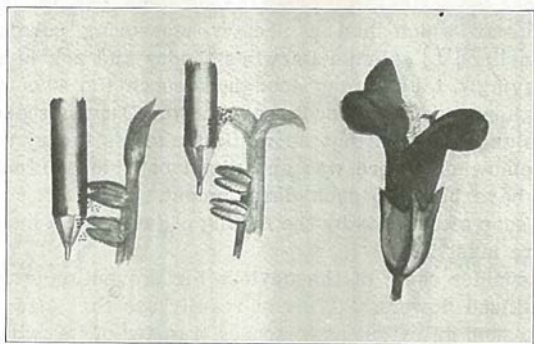
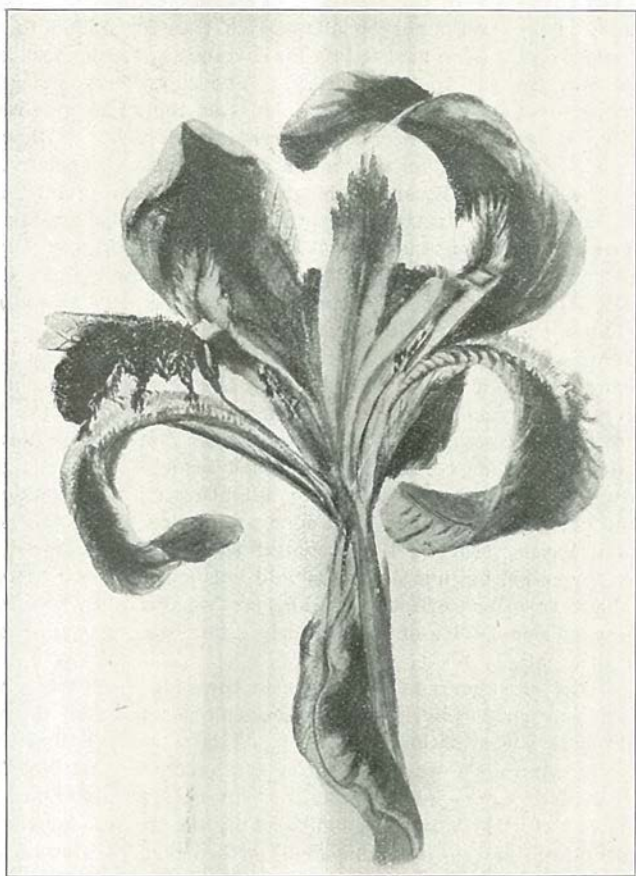


FIG. 28.



4 FIG. 29. The blue flag. From water color drawing by Mrs. Edith Ricker.

upon one of the graceful sepals and his weight is just sufficient to separate it from the closely covering carpel. The bumble bee then wedges himself in between the slowly opening part and, by stretching his long tongue to its full length draws the nectar from its deep well. The true honey guides are on the upper surface of the petal. The cover is a style and bears the stigma on a shelf like projection just where the bee will rub his head and thorax in wedging himself in. The stamen rises and bears an anther at the point where it will rub the pollen into the thoracic hairs of the bee. Why is not this same pollen left on the stigma when the bee backs out? If the stigma shelf is rubbed with the finger it opens

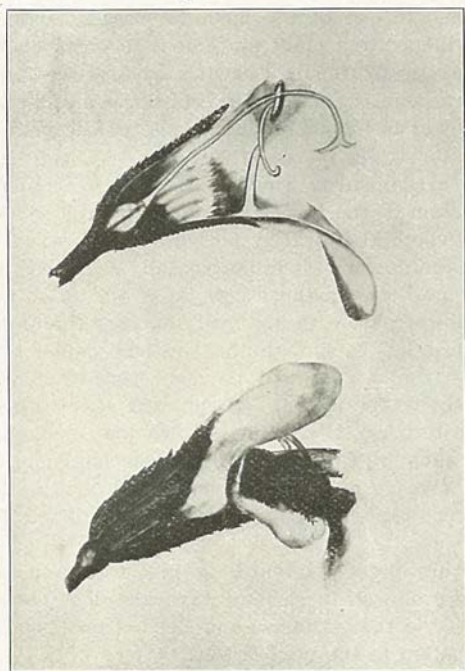


FIG. 30.

outward as by a bee in entering, and closes when rubbed the opposite way. Thus the pollen gathered from this flower will be transferred to some other flower. The blue flag teaches us several lessons in adaptation. All of the irregular flowers are peculiarly shaped with reference to their insect visitors. They are a source of never ending speculation.

Protective closure to keep out rain and unwelcome insects has been mentioned earlier. The hanging position of many flowers serves the same purpose. Many flowers have a movement of parts in addition to this closing, some of which are of great interest. My attention was first called to a closing of the lips of the stigma in the catalpa. Near the station, at Big Fork, is a swampy place where many interesting plants

abound. On inspecting a number of blossoms of *Mimulus* (Sp—) (Fig. 28) I found the styles different in various plants of all ages and proceeded to tickle them with a straw. The style divides into two flat surfaces at the end which spread widely apart, as is so often the case. Selecting one that was well open. I found on touching it that it closed slowly and in perhaps thirty seconds was shut up as tightly as if it had never been opened. After a few minutes I visited the plant again and found it was slowly opening. The plants taken to the laboratory for experiment did not stand the trip very well, and reacted somewhat more slowly than in the field. When fertilized with fresh pollen from another flower the style will remain permanently closed.

We now come to one of the most interesting arrangements in the botanical world illustrating plant movement to bring about cross pollination. The sage was figured in Darwin's earliest work of this kind and given to the world as a wonderful piece of floral mechanism.

The sage flower is irregular, having one of the petals produced into a landing place for flying insects (Fig. 30.) The anthers are modified with a peculiar arrangement which can be better understood from the figure or the section of the flower. Two standards carry each a sort of C shaped piece, which is delicately poised so as to stand in a nearly vertical position, if the flower is held horizontally. A bee in order to enter the flower must go between these standards and in so doing will necessarily push the lower part with his head and rock the anther bearing part over so as to dust his back with the powdery pollen. Since the sage is proterandrous, the stigma will be non-receptive even if it were far enough out to receive the pollen. If the next sage visited has a ripened stigma the style bearing it will have grown long enough and will curve down so that it must rub the back which was lately dusted with pollen. The bee will receive no pollen from such a blossom as its pollen has all been scattered. The sage has indeed a wonderful story to tell to those who will stop to consider it.

Certain flowers greet the entering insect with a bombardment of pollen. This is produced in various ways and does not seem to be anything of a surprise to the visitor who proceeds to collect his fee for carrying his load of pollen to the next flower.

Our common Milkweeds have a waxy pollen mass and will need investigation. They have been charged with the murder of hundreds of innocent guests and any summer day one may find them holding their dead victims fast by the legs. The insect finds himself caught and is perhaps, unable to pull his legs out of the trap or pull the trap with him. This trap, which consists of two bags of pollen, he is supposed to take with him. An insect's foot, coming into contact with the V shaped slit in the trap formed by the union of the two pollen bags, is quite likely to be caught. If the pollen be ripe, and normal in every way, any ordinarily strong insect is able to pull the pollen sacks free from the flower if he does not get too many feet caught at the same time. If he has a foot firmly fastened in one flower and in trying to pull out tangles another foot or two, he may tire himself out and die after a hard struggle. Insects usually succeed in pulling out the pollen sacks. These they carry to another flower, and drag over the stigma with the desired effect.

The orchid represents the most highly specialized flower and a consideration of these wonderful forms must be left until another time.

The Plant Associations.

Harry Nichols Whitford.

From what has been said in the preceding pages it can readily be seen that the climate affects the distribution of plants. The so-called **plant formations** are the direct result of certain climates. However, the landscape of a **forest formation** (Fig. 5) does not show an equal distribution of the kinds of trees in it; nor does it show an unbroken mass of trees. On the other hand there is a tendency for trees of certain kinds to be growing together, and there are gaps in the forest, island-like openings, as it were, in the sea of trees. The gaps may contain a meadow, a heath, or even a prairie. A **prairie formation** may also contain trees in certain favorable situations (Fig. 5) where there is a sufficient water supply. In distinction from the **formation** these groups have been called **plant associations** or **plant societies**. It is now in order to inquire what causes have brought about the division of **formation** into **associations**. This can be done best by selecting a limited region in the forest formation, for example, and by noting what associations are found and in what conditions they are growing. The region around the Montana Biological Station at Big Fork is a good one to illustrate the point. Any region in the state can be studied in the same way, whether it be in the prairie or forest.

In the **forest formation** near Big Fork there are five more or less distinct **plant associations**. In the low places in the Swan river valley along streams and around ponds are moist areas that are usually submerged during the spring and early summer months. These are known as **meadow associations** (Plate LII.) The grass type prevails in these places, grasses and sedges of various sorts being here associated. Oftentimes peat moss is abundant, and with it may be found the interesting carnivorous plant called sundew. Around the borders of the meadows, and sometimes in them, are willows, alders and birches. Shallow ponds containing water lilies and pond weeds are often found in the meadows. It is very evident that the reason why trees do not grow in these meadows is because there is too much water, which, like too little water, is injurious to them.

Bordering on the meadows are localities, not quite so damp, where the Engelmann spruce and other plants growing with it are found, forming what may be called the **Engelmann spruce association**. On the edge of the meadow the trees of this association are small and scattered. Depending on the amount of water in the soil, there may be peninsulas and islands of spruce in the meadow. Sometimes there are almost pure stands of spruce forests; again the spruce element is scattered along streams. Very often lodgepole pine, narrow-leaved cottonwood, aspen, and birch are associated with the spruce. These particular combinations of trees are always found in soil that is quite damp, but not so damp as

the soils in which the meadows occur. It must not be supposed from what has been said that the trees mentioned above never grow in other situations, for they do, as will be seen later. In the spruce associations they are the predominant trees. In some of the other situations, they are subordinate.

Around the drier borders of the spruce association, and sometimes on peninsulas or islands in it, are stands of trees other than those mentioned. These trees are clearly associated with soil in which the water level is still further beneath the surface. Because the western larch and the Douglas spruce are the most common trees in this stand, it will be given the name of **western larch—Douglas spruce association**. Far the greater part of Swan valley is occupied by this association. Other trees in it are the lodgepole pine, lowland fir, silver pine, and occasionally an arbor-vitae. The Engelmann spruce and the birch are sometimes present also, though they seldom form a conspicuous element. The lodgepole pine (Plate LII) occupies vast tracts of this area. Its presence here is clearly due to fires. Often the older trees of western larch and Douglas spruce, their charred trunks telling the story of former fires, are seen standing above young forests of lodgepole pine. Sometimes almost consumed trunks show that the fires have been more destructive. The western larch and the Douglas spruce are the last to be killed by fires, because they can resist them best. Where fires have not been so destructive, the lodgepole pine is less conspicuous. Indeed, in places it is almost entirely wanting. The lowland fir, silver pine, and Engelmann spruce are more abundant in the moister parts of the western larch-Douglas spruce association. In isolated patches the bull pine is also found.

Just as the meadows form treeless places in the forest formation so occasionally the soil may be too dry to form forests. It is a well known fact that clay soil holds water better than sandy soil. The rainfall may be sufficient to support trees in the former, where it would not do so in the latter. This fact may account for the prairie "islands" in the forest formation, to be seen in Fig. 5.

Surrounding these prairie islands and bordering on the prairie formation is another type of forests which is due primarily to the fact that there is more water in the soil than in the prairie, and less than in the western larch-Douglas spruce association. This type of forest may be called the **bull pine-Douglas spruce association**, because these two trees are the predominating ones. Sometimes the western larch is found with these, but it never occupies the drier soils. In other places the Rocky mountain juniper is present. The bull pine-Douglas spruce forest usually is an open one, with grass patches between the trees. It grades imperceptibly into the prairie formation.

In the foregoing it is shown that the type of plant associations in the forest formation depends on the amount of water in the soil. Warming, a Danish botanist, who was the first to fully perceive this relation between the grouping of plants and the amount of water in the soil, classified plants into **hydrophytes**, **mesophytes**, and **xerophytes**. Those plants that grow in soils with a great amount of water in it are known as hydro-

phytes. This word comes from *hydor*, meaning water, and *phyton*, meaning plant. Those plants growing in soils with an intermediate amount of water are known as **mesophytes**, that is, literally intermediate plants. Those plants growing in soils that have little water, are known as **xerophytes**, that is, dry plants. Now it is convenient to use the terms **xeromesophytes** and **hydromesophytes**. So under this classification the associations discussed above are as follows:

A wet meadow is a hydrophytic association.

An Engelmann spruce forest is a hydromesophytic association.

A Western larch-Douglas spruce forest is a mesophytic association.

A Bull pine-Douglas spruce forest is a xeromesophytic association.

A prairie is a xerophytic association.

In the **prairie formation** there are two places where trees may grow, namely, along streams and on protected hill sides. It is obvious that in the former situations the roots of the trees penetrate to or near to the underground water level, which is not far from the surface. In the latter situation (Plate LII) the fact that trees are protected from drying winds and the soil from the heat of the sun, prevents both trees and soil from drying out rapidly. The plants that grow there can get more water and give off less than they would absorb and transpire if the hill were not present. Thus the protected slope of a hill may have forests in a **prairie formation**.

Again, if a hill be high enough to cool sufficiently the moisture-bearing winds so as to cause precipitation of moisture, it may get more rainfall than the lower lying land. This is very probably the reason why the tops of mountains or of high hills in prairie regions have trees and sometimes dense forests. This leads to the discussion of the forest conditions in high mountains.

The climate towards the top of a mountain is different from that at its base. It is always colder and usually more moist. The moisture conditions are favorable to trees, the low temperature conditions are against tree growth. The slopes exposed to dry winds have less moisture for trees than those not so exposed. At the same time the exposed slopes receive more heat, rapidly melting the snow, which would otherwise lie longer, and thus shorten the season. As a consequence tree growth is more prevalent on these slopes than on the protected slopes where the snow lies the year round. As one ascends a mountain like MacDougal's peak or Hall's peak, which are in the Swan range bordering the Flathead valley on the east, the species that require the most heat will disappear first. Those that are adapted to a shorter season will be found higher up. The bull pine is one of the first to disappear. Higher up the western larch and silver pine are absent, and on the ridges the Douglas spruce and lodgepole pine are the last of the lowland forms to disappear. In the valleys the Engelmann spruce will be found as high as these or higher. Before the conditions are too severe for the last three named species, the alpine trees come in. In the region under discussion these are the white-bark pine and the alpine fir. (Plate XLVII.) It has already been shown that the latter species is found occasionally in the valley. In the cold canyons it and the Engelmann spruce may

form almost pure forests. Near the top of the two mountains under discussion, the exposed places have only the two alpine trees, the white-bark pine and the alpine fir. In basins on the east side, however, the conditions are different. Here the snow lies longer. The white-bark pine is infrequent here, but the alpine fir does better than on the exposed ridges. In the basins there are three distinct plant associations. On the steep slopes where the weathering processes are frequently adding new rock material, (Plate XLVII) the conditions are too strenuous for the existence of any plants. As soon as one of these talus slopes becomes stable enough, then plants begin to get a foothold, and finally trees may

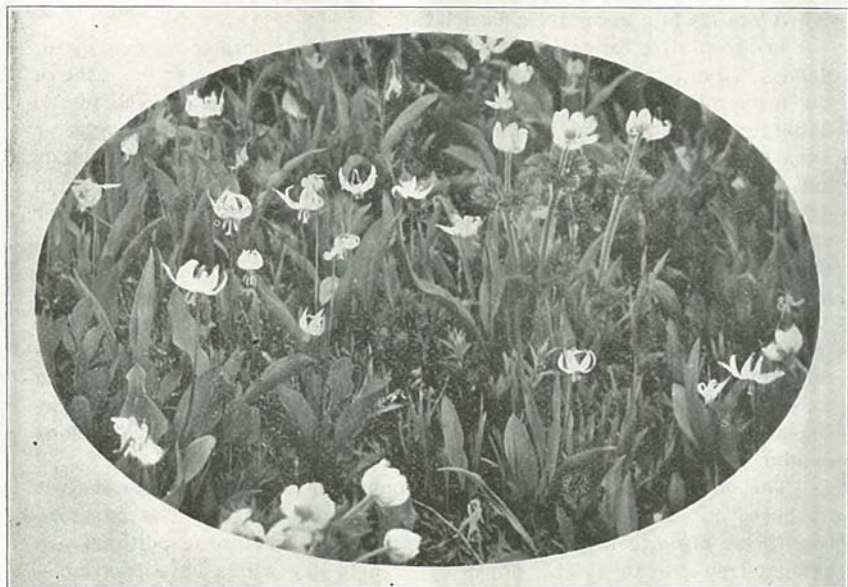


Fig 31. Portion of an alpine meadow, 7000 ft. altitude, Swan range, August, 1903. Photo. by M. J. E.

appear. In places where the snow lies the year around, there is no vegetable life except the simple one-celled plant known as the "red snow." Bordering on these snow banks are the so-called alpine meadows. (Fig. 31.) They usually follow up the retreating snow and sometimes dog tooth violets, spring beauties, and anemones come up through the snow itself. Thus one can see these forms just appearing on the border of the snow field. At a little distance they are in full bloom, further away where the snow has disappeared earlier they have produced seeds, and still further from the snow they have finished their growth and have died down to the ground. It is usually in the latter places that one finds groups of trees, (Plate XLVII) nearly all alpine fir, for they appear where the snow first melts. Thus there is a relation between the plant societies found in these regions, and the time snow lies on the ground.



General view of Rost Lake from the outlet. The Swan Range of the Kootenais is in the distance. Around the lake are tree or forest plant association. Bordering these are meadow societies. In the water are hydrophytic forms.

Bird Music in the Flathead Region.

Perley Milton Silloway.

Bird music is the blossom or flower of bird life. The plant is with us throughout the summer and perhaps throughout the year, but its fragrant flower attracts our attention during only a limited period of its summer life. So it is with the bird song; it reveals a life that may have been neglected until that time, and for a brief period we wait and listen for the bird. A little later the song dies away, and the author is likely to be overlooked during its further existence among us.

The bird song is an index of a changing phase of the bird's activities. Its humdrum habits of the workday world are to be laid aside for a time, and it is to enter upon a brighter and more joyous period of its yearly round. New impulses actuate its little breast, and its kindling spirit leaps forth in song. For weeks and months it has been silent, except in such calls and cries as have been impelled by its usual emotions, but as it sees its little world enlarging to renewed companionship and more enjoyable relationships, it gives unusual utterance to impulses newly aroused, and the song becomes a part of its daily experience.

As is well-known, the gift of song is generally confined to the male bird. Though the rule is not invariable, the exceptions are few enough to prove the rule. The fact that the male bird alone produces the real song has led to the conclusion that the song is a means by which the male announces his presence to his lady-love, and by which he seeks to attract her attention to his graces and accomplishments. Bird music is the forerunner and accompaniment of the mating season, and continues through what may correspond to the "honeymoon" of more rational beings. The song is prompted by the sexual instinct, and in the mating season is doubtless designed to please some listening female. Once her attention is attracted and her ear captivated, the song becomes one of the ways in which she is wooed and won. After she has been won, the song becomes an index of the domestic bliss of the songster. With many birds, the season of song ends quite abruptly with the beginning of the female's household duties; with a few, the period of song is prolonged even until the younglings have left the nest and are able to forage for themselves. In some instances, there is what appears to be a fall period of song, though the fall singing of any bird seldom equals its vernal performances in power and volume.

Some of the birds come to us on their way northward in the spring, caroling in the renewal of their domestic felicity. During the weeks of winter we have missed the presence of the songsters, but on some auspicious morning we hear the old familiar carol, and we note that one of our avian friends of last summer has returned to us. So our bluebird comes to us, and sitting in the top of a convenient tree or on the ridge of some low building, it warbles its tender message of the returning spring. For several weeks after the advent of the bluebird, the low-

voiced utterances of this species charm our ears. Then the songs cease in frequency and spirit, even before the sitting bird has seen her younglings break the delicate blue-tinged shells. When we arrive at the Biological Station for our annual summer outing, the voice of the bluebird has been hushed, so far as its song is concerned; its tender calls, however, can be heard as we chance on the birds flitting from the deadened boles of the adjacent ridges. To some of us, at least, these calls are a plaintive reminder of the earlier song season, and are worthy of a place in our thoughts regarding the bird music of the region.

Of our familiar western robin, what shall we say that has not often been said? In his usual business-like way, he comes from his southern sojourn, squeaks about the neighborhood for a day or two until he gets his bearings and ascertains that everything is as it was when he departed late in the preceding autumn. Then he begins his recitals, generally from the topmost branch of the tallest tree in view, giving his lyric as a fitting ending to a day that has begotten in us a genuine case of "spring fever." There are but few feet in a verse of robin music, and that verse is oft repeated. Florence Merriam has quite accurately described the song in syllables "trill-er-ee, trill-er-ah." Generally the song is enunciated in a loud, hurried manner, so nervously that it appears as if the songster were losing breath; at times, however, the song is uttered in a high, squeaky falsetto tone, the same performer sometimes changing from one tone to another at will. Again, the singing is done in a low, subdued tone, for our friend robin frequently drops into a poetic mood, especially if his fair charmer is sitting near, and often whispers his flat-teries into the ears of his promised bride. The song season of the robin is longer than that of the bluebird, and in this region is prolonged by some individuals well into July, the late songs, however, being heard chiefly early in the morning and less frequently late in the day.

As we skirt the shores of Daphnia Pond (See Plate XLIX) in quest of biological specimens, the singing of the catbird greets us like the strains of familiar music. Nowhere in this region is this gifted songster more numerous than on the enchanted shores of Daphnia Pond. In the bushes there the catbird nests until late in August, and as it thus prolongs its domestic duties, it carries the spirit of song far beyond the season common to most of our bird musicians. Sitting in some secluded nook of the bushes, this songster gives expression to its impulses in voice low and sweet, in most fitting accord to the fast ebbing tide of summer bird music. The opening hours of the day are generally used by the catbird in its recitals of the later season. At such times we must rise early in the morning if we want to hear the birds begin to sing. In the cool morning hour the catbird is at its best, and if a nest is anywhere in the neighborhood, the listener is certain to be regaled by a prodigality of wild-wood music by the gifted owner of the household.

The warblers, notwithstanding their name as a group, do not excel generally in musical powers. Many of them, though, are songsters of no mean ability. The vocal power of the warblers that occur in the Flat-head region serve about the same function in the woodland chorus as the side-horns in the instrumentation of a large band. They are not soloists

nor leaders, but they furnish the harmony in accord and accompaniment, and thus aid in bringing about an effect which is quite satisfying to the listener. So it is with the efforts of that gem of the swamp-woods, the American redstart. Its song is short, ringing verse, very similar to that of the yellow warbler, and is repeated from time to time with great energy and earnestness. Like the catbird, the redstart nests comparatively late, and hence its singing is an incident of our life at the Station during these summer sessions, in the early part of July.

Any of us who has been so fortunate (or unfortunate) as to have been delayed at Selish, may have heard the peculiar notes of the long-tailed chat in the bushy tract near the depot. The chat itself is one of our beauties, a yellow songster somewhat smaller than the catbird. No other bird, unless it is one of the smaller sparrows, understands so well and practices so much the art of skulking. When you are looking for the chat it is certain to be behind a convenient tangle of branches or foliage. Its music, though, will continually come to your ears, not in song, but in a series of strange whistles, suggestive of schoolboy signals, and uttered in varying intonation. It is to be hoped that the chat will work its way northward and establish itself among the bushes of our classic Daphnia.

(In 1903 the chat appeared in the bushes of Daphnia and its song was heard daily.)

Another warbler whose song can not be overlooked is the western yellow-throat. This handsome songster skulks in the reedy tangles of Daphnia Pond, and there its energetic singing regales us who have an ear open to the voices of the birds. The song of the yellow-throat is an accompaniment of the July afternoons, for this warbler has a note till the end of the nesting season. The usual production may be represented by the syllables "wich-i-ty, wich-i-ty, wich-i-ty," generally in series of three, with the emphasis on the leading syllable. It is a loud, ringing song, uttered with persistence throughout all hours of the day, and always from some low situation. The songster is a handsome little yellow creature, easily identified by the band of black which marks his upper face and forehead. His less musical spouse lacks the black markings, and is not so readily distinguished from other small yellow birds, but she may be known by the rich yellow of her throat on the under side.

The two representatives of the vireos fill no mean place in the avian chorus of this region. Both are persistent songsters, and through all the summer their voices can be heard mingling with other wildwood performers. The warbling vireo utters a series of hurried, subdued measures, characterized by a plaintive intonation, forming a most pleasing song in gentle accord with its surroundings. The song of the red-eyed vireo is a loud, monitorial repetition of three or four syllables, easily identified by its peculiar delivery. This songster has been called the "preacher" because of its monitorial style of execution in its singing. Wilson Flagg has aptly translated the song of the "preacher" in these words: "You see it—you know it—do you hear me,—do you believe it?"

The vireos are unlike most of the birds in the manner of their singing, as they prefer the shade of the foliage of the deciduous trees they

be one year's continuous work, daily if possible, to discover seasonal changes.

Let us now go to the laboratory and examine the collection. We usually tow the net over the surface, and have taken very many bottles of this material. We will examine an average sample from a representative bottle, under the compound microscope. You will be delighted with the beautiful forms, the delicate desmids and diatoms, and those wonderful creatures classed broadly as microscopic crustaceans, and more properly as *entomostraca*. Note the beauty and variety of this life, and then I doubt not you will be seized with a desire to know their names and uncover their secrets. We would soon have you dissecting out the fifth feet and noting other characters, for we must classify whether we like it or not. Then we are ready to count forms, study movements, or go more deeply into their reason for being. You could not long question the motives of the enthusiastic student, and you would probably soon find yourself as deeply into the problem. "You have but to look at life and you will find it interesting, in whatever form, or from whatever standpoint you view it."

For the second reason I gave a hint as to the economic interest. We may be charged with magnifying this side of the question, since it is from the economic point that we solicit aid in carrying on the work. But the United States Fish Commission would not have been organized in the interests of pure science. It is supposed to deal with problems that affect the food and labor of millions. There were two reasons given for its creation. (1) "An investigation into the cause of the decrease of the seacoast fishes and those of rivers and lakes, with suggestions as to the best methods of restoring the same; and (2) active measures looking toward the propagation and multiplication of the useful food fishes, either by restocking the depleted waters, or by introducing desirable species into new localities."

Allow me to quote from Prof. Reighard on the subject. "In this country the fisherman continues to fish in any locality until it becomes unprofitable. He then moves his base of operations to new waters, until these in turn have been exhausted. He is apt to look upon each new body of water as inexhaustible, and rarely has occasion to ask himself whether it is possible to determine in advance, the number of fish that he may annually take from the water without depleting it.

"On the other hand the fish culturist is likely to plant the fry in waters that are quite unsuited to them; or to plant them in water far to the excess of what the water can support. The fisherman proceeds as a farmer might who imagined that he could continually reap without either sowing or fertilizing; while the fish culturist proceeds often as if convinced that seeds might grow on barren soil, or that two seeds might be made to grow in place of one."

Now, since the whole structure of animal life rests ultimately upon vegetable life, large or small, and since most fish feed upon food produced in the water, we must readily see the interdependence between the larger and the smaller animals and plants. The food of our game fishes, as you know is live animals. The food of these animals is no doubt smaller

living creatures; and so you may follow the series down to the smallest animal, one who can find no smaller victim. Among this lower class are the copepoda. Their food is largely vegetable, and they are no doubt an important element in the survival of the game fish during that critical period of youth. Together with aquatic insects they make up the food of the small fry of the game fishes. In the ocean they form the food of the whale. They are a connecting link in animal life. No man can foresee what would result, and few would believe if told,—if these insignificant animals should cease to be.

INDEX.

	Page		Page
Abies	216	Cyclops pulchellus	232
Abies grandis	228	Daphnia pond	230
—— lasiocarpa	229	Daphnia pulex	230, 232
American dipper	236	Darwin	246, 247, 263, 264, 266, 281
American redstart	236	Diaptomus lintoni	232
Animal counterfeits	242	Douglas spruce	217, 225, 227, 272, 273
Alluring coloration	246	Douglas spruce association	272
Alpine fir	225, 229	Dragonfly	246
Alpine meadow	274	Echo lake	201, 203
Anodonta plana	256	Englemann spruce	225, 226, 227, 272
—— ovata	256	Engelman spruce association	271, 273
Anosia	244, 245	Entomostraca, study of	283
Anosia plexippus	245	Environment	248, 231
Arbor-vitae	216, 222, 223	Fertilization of plants	210, 263
Aristotle	210	Fir	216
Arlee	202	Fir, lowland	225, 229
Bailey, Florence Merriam	205	—— alpine ..	225, 229
Basilarchia	245	Flathead lake	
—— disippus	245	197, 198, 199, 202, 203, 280
—— astyanax	245	Flathead Valley	243, 250
Birch	250	Flathead river	197, 203
Bird, how to recognize	204	Fly-catchers	247
Birds, value of	206	Forest formation	215, 251, 272
Bird food	206	Forest fires	252
Bird companions	208	Frog	244
Bird courtship	208	Geometrid Moths	243
Birds at Daphnia pond	232	Giant arbor-vitae	222
Birds' nests	234	Gibson ..	263
Bird Music	275	Glacial epoch	200
Black oak	212	Great plains	250
Blackwelder, Eliot	202	Grosbeak, blackheaded	238, 272
Blaine lake	203	Hemlock	216
Blue flag	268	Heredity	230
Bumble bee	244, 246	Houstonia	264
Burroughs, John	205, 272	Ice age	200
Cabinet Range	202	Jay, blackheaded	240
Catalpa	269	Junco	272
Catbird	270	Juniper	216, 224
Catbird, nest of	235	Juniperus	216, 224
Cedar waxwing	238, 239, 278	—— scopulorum ..	224
Chamelon	244	—— virginiana ..	224
Chat	277	Kalima butterfly	247
Chapman, Frank M.	206	Kinglets	247
Chipping sparrow	238, 239	Larch	215
Climate of Montana	249	Larix ..	215
Colors in animals	242, 243	—— occidentalis ..	216, 217
—— alluring	246	—— laricina	216
—— warning	244	—— lyallii	218
Columbia Falls	202	Lazuli bunting	238, 272
Cuvier	210	Lewistown ..	259

	Page		Page
<i>Limnaea palustris</i>	257	Protection to trees	252
—— <i>striatella</i>	257	<i>Pseudotsuga</i>	216
Locust	243	<i>Pseudotsuga taxifolia</i>	217, 227
Louisiana tanager	272	Ptarmigan	243
Lowland fir	225, 228	Puget Sound	250
Lubbock, Sir J.	265	<i>Pyramidula strigosa</i>	232, 256, 258, 259
McDonald peak	198	<i>Pyramidula solitaria</i>	259
MacDougal peak	200, 202	Robin	276
—— view from	201	Robin, young	244
Margaritana <i>margaritifera</i>	256	Rocky Mountain goat	243
Macgillivray's warbler	236	Rost Lake	201
Magpie	240	St. Ignatius Mission	202
Meadow association	271	Shells, where found	253
Milkweed	270	Sinyaleamin mountain	220
Mimicry	245	—— lake	223
—— protective	246	Skunk	244
Mimulus	270	Spiderwort	265
Mission Range	197, 202, 203	Snails, how to kill	260
Mission Valley	197, 202	—— habitat	260
Mountain building	198	—— movements	260
Mountain disintegration	198	—— color and markings	260
Mountain larch	218	—— distribution of	261
Nature Study, object of	204	<i>Sphaerium partumeium</i>	232
Needham, J. G.	267	Sprengel, C. K.	263, 264
Nighthawk	243, 244	Spruce	216
Oak, study of	210	St. Hilaire	210
Olive-backed thrush	234, 280	Swan lake	203
Orchid	270	Swan Range	197, 202, 203
Pasteur	282	Swan River	200, 202, 203
Pend d'Oreille lake	220	Tamarack	216
<i>Picea engelmanni</i>	226	Thompson, Ernest Seton	205
—— <i>canadensis</i>	226	<i>Thuya</i>	216
<i>Physa ampullacea</i>	257, 232	<i>Thuya plicata</i>	222
<i>Picea</i>	216	<i>Thuya occidentalis</i>	222
<i>Pinus</i>	215, 218	Torrey, Bradford	205
Pine, bull	221, 249, 222	Towhee	277
—— lodgepole	221, 222	Transpiration in plants	250
—— silver	218, 249	<i>Tsuga</i>	216
—— jack	222	<i>Tsuga heterophylla</i>	225
—— yellow	217, 222	—— <i>canadensis</i>	225
—— white	218	Variation	245, 242
—— white bark	218, 219, 220, 274	Variation in shells	258
<i>Pinus divaricata</i>	222	Vesper sparrow	239, 279
<i>Pinus monticola</i>	219	Violet	264
—— <i>albicaulis</i>	220	Wallace	247, 281
—— <i>ponderosa</i>	229	Warbling vireo	236, 277
—— <i>murrayana</i>	222	Warning coloration	244
Pollen, quantity of	218	Western hemlock	225
<i>Planorbis trivolvis</i>	222	Western yellowthroat	277
Plankton study	281	Wild-horse bay	202
Potato bug	244	Willow thrush	235
Plant associations	271	Wright's flycatcher	240
Prairie formation	250, 271, 272	Yellow warbler	238
Protective coloration	243		

PUBLICATIONS IN THE BULLETINS OF THE UNIVERSITY
OF MONTANA BIOLOGICAL SERIES.

- No. 1. Summer Birds of Flathead Lake, by P. M. Silloway, pp..... 1—84
Pl. I—XVI.
- No. 2. Announcement of the Fourth Annual Session, University of
Montana Biological Station at Flathead Lake, pp..... 85—88
- No. 3. A Biological Reconnaissance in the Vicinity of Flathead
Lake, by Morton John Elrod, pp..... 89—182
Pl. XVII—XLVI, fig. 1—4.
- No. 4. Announcement of the Fifth Annual Session, University of
Montana Biological Station, pp..... 183—190
- No. 5. Lectures at Flathead Lake, by the Staff of Instructors, pp..... 191—288
Pl. XLVII—LII, fig. 4—31.

