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10. Insects as Mimics.

MAN, especially in his savage state, is as a rule obliged to resort to various subterfuges to provide himself with animal food. The hunter tracks his quarry through the woods, his dress of hides, or his naked skin harmonizing with the dusky hues of the forest; his step is wary and light, his weapons are noiseless, the deer falling dead from his arrow, the bird from his blow gun without startling their fellows; or he hunts them by traps, from behind screens or while hidden by the foliage of trees. At times he disguises himself, and stalks the deer dressed in the head and skin of one of their own kind. He mimics their voices, calling the moose by means of a birch bark horn, and whistling to the woodcock or snipe.

The civilized sportsman, if he would be successful in the chase, adapts his hunting suit to the colors of the field or woodland, wearing gray or green, some color harmonizing with the landscape through which he ranges. Even his pointers or setters are protected by their tan-brown hue. He makes decoy ducks, and tolls in a flock of ducks or geese flying overhead or feeding off-shore beyond the reach of his gun. The fact that birds and quadrupeds are so easily deceived is a good proof that the use of disguises among animals in a state of nature is an actual fact. If some birds can be deceived by clumsy, painted, wooden decoys, others may mistake a caterpillar for a twig, a weevil for a bud, or an edible butterfly mimicking one which they generally discard as too nauseous to their taste.

All this mimicry on the part of man is conscious. What is often necessary with man is still more essential with animals. In the animal world there is an unconscious mimicry. The manifold disguises are worn unwittingly by the brute, the bird, or insect or mollusk, but there is no less an underlying design in nature, and some useful end subserved. That everything which exists has some use in the world may be regarded as an axiom. The savage knows that himself and his offspring will starve unless he by strategem and through some disguise can kill his game. Unless the insect protects itself from harm by imitating some natural object, or other insect which enjoys immunity from the enemies peculiar to the mimic, it and its species will die out. All the disguises in nature are, then, for a manifest utilitarian purpose, and we shall see that each species is by some peculiarity in its form, or color, or movements, at one or another critical period in its life, protected and preserved in the struggle for existence. It often happens that the weaker species are overlooked by their enemies, while on the other hand the predaceous species are as often enabled to approach their prey through the disguise they have assumed.

But it will be seen that the ultimate fact in this matter of mimicry is, as insisted on by Messrs. Darwin and Wallace, the advantage to the species. It will not unlikely occur to the unbiassed reader that the result of this law of mimicry is rather *the preservation of forms already established*, than the origin of new ones.

I shall assume as true that quadrupeds, birds, and insects, and the lower animals as well, are deceived and protected in turn by the disguises they assume, and that the end is a utilitarian one; while I disagree with the conclusions of those who believe that species originate from mimicry, assuming that if some species owe their preservation to this cause, they may have originated from the same natural causes as their unsuccessful fellows whom mimicry, or rather the want of it, failed to preserve. The fossiliferous strata of our globe are filled with the remains of organisms which have perished in unsuccessful attempts to survive in the struggle for life in a world existing in a state of constant inequilibrium. It is the changes in the conditions of life, the revolutions in the physical surroundings of organisms, which have induced the transformation of one species into another, while protective mimicry has often acted as a conservative agency in preserving the species. Both sets of causes have, then, been factors in the origination of animals and plants as we see them, and Darwinism is perhaps as essential as Lamarckianism in explaining the present conditions of life on the globe.

But to come at once to the subject of protective mimicry, we will study in the first place :—

Insects mimicking other natural objects.—The examples under this head illustrate some of those harmonies in nature which the distinguished Bernard de Saint Pierre saw so clearly. The adaptive coloration of animals, the harmony in tint and form with the trees on which they live, or the rocks among or under which they hide, the sand over which they run, are a part of the general harmony in nature. A desert animal is of a sandy complexion, a silk-worm moth is brown, a grasshopper is dusky for much the same reason that the grass is green, the sky seems blue, or the rocks are gray. These harmonies in form, in color, are as striking in the world as a whole, as in isolated portions of it, or isolated species of the animals or plants growing on its surface. These harmonies extend to other worlds and systems of worlds, and are cosmical in their nature. So the causes that lead to the origination of life, of a new species, are perhaps of a piece with those resulting in the origin of a planet. We must remember that life at first resulted in all probability through the action of cosmical laws. Before animals and plants had multiplied to any extent, where was the material for the laws of natural selection to act upon? There was once a time when some of the mills of the gods failed to run for the reason that there was nothing to grind.

Among the insects adapted by their peculiar style of coloration to live on the sand or soil are the tiger beetles. They are most commonly seen running over sands by the river or on the warm, light colored soil of wood or forest paths. The *Cicindela generosa* (Fig. 196) is ornamented more conspicuously than usual with broad light bands and spots. It is found on the white sands of Cape Cod and the beaches southward. But a more decided case of protective mimicry is the white-backed tiger beetle (*Cicindela dorsalis*). Here the wing-covers and front of the head (clypeus) are white, while the back part of the head and the prothorax are dark, so that as the beetle lies on the white sand in wait for its prey, it would be easily mistaken for a hole or dark spot or pebble. On the other hand the bright green six-spotted Cicindela (*C. sex-guttata*) is adapted for its life in the grass in which it runs and flies, and in its flight would be mistaken by its enemies or victims for a large green fly (*Musca vomitoria*).

FIG. 196.

Tiger Beetle.

"The beautiful *Cicindela gloriosa*, of a very deep velvety green color, was only taken upon wet mossy stones in the bed of a mountain stream, where it was with the greatest difficulty detected. A large brown species (*C. heros*) was found chiefly on dead leaves on forest paths; and one which was never seen except on the wet mud of salt marshes was of a glossy olive so exactly the color of the mud as only to be distinguished when the sun shone, by its shadow! Where the sandy beach was coralline and nearly white, I found a very pale Cicindela; wherever it was volcanic and black, a dark species of the same genus was sure to be met with." (Wallace.)

The black or reddish ants are protected from observation by their dark colors in climbing the trunks of trees, while the smaller, lighter species frequent the sandy light paths about our dwellings. Within doors the Reduvius (Figs. 56, 57) covers itself with dust, a good disguise in approaching its prey and escaping its enemies. Ground spiders by their hues simulate the inequalities of the dark soil over which they run. The trap door spiders (Mygale, Fig. 62) are colored like the soil in which they excavate their nests. The desert Mantis (Eremophila) is of a sandy hue, and is easily confounded with the sands of the Sahara. An example of protective coloration is probably afforded by a moth of the silk worm family (*Euleucophœus tricolor*, Fig. 197), which inhabits New Mexico. Instead of the dark brown hues of its allies, it has a faded appearance, adapting it for conceal-

FIG. 197.

Euleucophæus.

ment while resting on the dry parched ground. It will be interesting to learn whether its exceptional style of coloration adapts it for a life in the deserts of New Mexico. Here the change is evidently induced by the dry climate.

The grasshoppers nearly always harmonize in color with the general hue of the fields in which they abound. They are most abundant towards the last of summer, when the fields have lost their freshness and the grass has turned brown; at this time the russet garb of the Carolinian locust, and the red-legged grasshopper admirably conceal them when at rest. I have noticed the sulphur-winged grasshopper (*Arphia sulphurea*) flying about dry hillsides, and in northern Maine, the crackling grasshopper (*Trimerotropis* *verruculata*) is especially abundant on burnt lands and elevated hill tops or in mountain valleys, where it harmonizes well with the soil. The maritime grasshopper (*Trimerotropis maritima*) is, like the maritime tiger beetle, specially adapted for concealment on the sea shore, as observed by Mr. Scudder, who says "it so closely resembles the color of the sand on a sea beach that it is difficult to see it when alighted." It differs remarkably from its inland allies by the white or pale bands and spots.

How protective mimicry may affect the different species of a genus is shown in the common red-legged grasshoppers. The *spretus* of the west, and the *femur-rubrum* of the east, harmonize in color with the brown hues of the grass lands in August and September, but the large two-banded one (*Caloptenus bivittatus*), so abundant during the same months in our gardens, in its green coat with yellow stripes, agrees with the green and yellow tints of our garden vegetables, among the leaves of which it lives. From its comparatively sedentary habits it grows larger and much more clumsy than its lean and agile congeners.

There are numberless little froth or spittle insects, such as the green *Helochara communis* and the russet *Ptyelus lineatus*, our commonest spittle insect, which pass their youth in concealment in masses of froth on the stems of grass in June. These masses of bubbles would be easily mistaken for drops of dew, or at least not suspected of containing any living beings. The bright pea-green leaf hopper abounds late in summer with others of its ilk in the highly colored grasses of damp places, which retain their freshness late in the autumn. On the other hand, the Ptyelus in its brown dress harmonizes with the hues of the upland fields which have turned brown by the summer droughts. Many other hemipterous insects, however gayly colored after they fly about, in their early wingless stages are green, like the herbage in which they hide. The common squash bug (Fig.

198) is of the exact color of the garden soil; it is only seen about the roots of the plant near the ground, while the little yellow beetle (Fig. 199) is a frequent visitor of the yellow flowers.

Among the moths which hide on the surface of the ground or in the grass are the numerous species of owlet moths (Noctuidæ). The Agrotis and Mamestra, and many others of this family, as caterpillars, show many peculiar adaptations in color to the soil on which they live. The dusky, livid cut worms would be easily overlooked as they crawl over the soil, when disturbed from their retreats under sticks and stones. They move about at night, and nocturnal insects are usually dull colored. On the other hand the pretty, green, cinnamon spotted Leptosia (*L. concinnimacula*) flies by day in the short grass. When the larger, dull brown moths, such as that of the army worm of the north, are disturbed, they quickly dart into the dry rusty stubble, and it is almost impossible to detect them if they remain quiet, as they often have the instinct to do when an enemy is close at hand.

FIG. 198.

Squash Bug.

Lichen-covered rocks are frequented by certain moths and butterflies which afford some of the most remarkable examples of protective coloring I have ever observed. This is particularly noticeable in Arctic and Alpine Lepidoptera. The cranberry fields and barren moors of Labrador abound in little gray and dun colored leaf-rolling moths, which are impossible to detect until they are startled. Some geometrid moths are called carpet moths in England from the large number observed carpeting the lichen and moss-grown rocks of the hills of Scotland. I have captured within an hour's time as many as seventy-five of the Polar Glaucopteryx on Table Rock at the mouth of the Straits of Belle Isle. As they rested on the lichened rocks it was

FIG. 199.

Squash Beetle.

extremely difficult to detect them, so well did their pepper-and-salt and greenish hues agree with the gray and green rocks. On another occasion, while entomologizing on some peculiar, light gneiss rocks overgrown with gray lichens, a couple of hundred miles farther north on the Labrador coast, I found it impossible to detect the Anartas, though resting almost under my feet, so closely did these owlet moths resemble the rocks over which I clambered. Again, on the hills above the Moravian settlement of Hopedale, thousands of the beautiful dun-tinted Chionobas of different species fluttered feebly over the lichen-clad rocks, the underside of their wings corresponding exactly in color with the ground

FIG. 200.

Chionobas semidia.

FIG. 201.

Grapta progne.

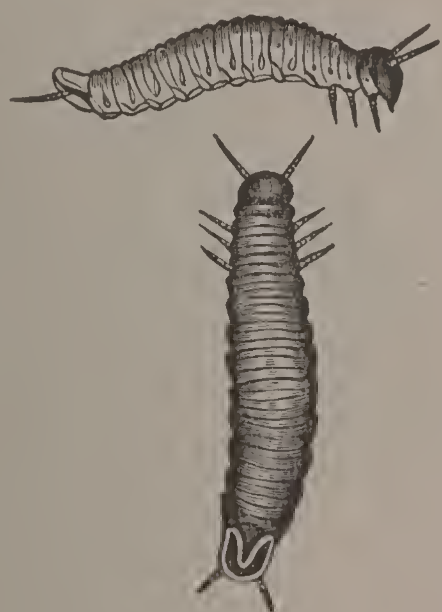
on which they rested. This scene is repeated on that bit of Arctic landscape, the extreme summit of Mt. Washington, where the *Chionobas semidia* (Fig. 200, from Tenney's Zoology) occurs; as well as in other Alpine peaks of Europe and the Rocky Mountains. A geometrid moth (*Marmopteryx strigularia*), which inhabits the mountainous regions of the eastern states from Vermont to West Virginia, has the same peculiar marbled under surface of the hind wings, and also an allied species found in the Sierra Nevada.

The under side of the Grapta butterflies (Fig. 201, *Grapta progne*, right side) have the color of dead leaves, and as they sit in paths with their wings folded over their backs would

be readily mistaken for a dead leaf. All these Graptas, with *Vanessa Antiopa*, are among the most abundant of our butterflies. The most perfect resemblance to a leaf with its stalk is afforded by the well known case of the Kallima, figured and described by Mr. Wallace in his interesting book entitled "The Malay Archipelago."

The caterpillars which feed on herbage or the leaves of trees are almost universally protected from the attacks of birds by their adaptive coloration. Those caterpillars which feed on the pines have a family look, though belonging to

FIG. 202.



Pine Lyda.

FIG. 203.

Honeysuckle Abia.

different natural families. For example, the larva of the European pine Fidonia, our native Cleora of the pine, the pine Trachea, the pine hawk moth (Ellema) and other caterpillars have markings very much in common, having as a ground color the peculiar green of fresh pine needles, with red stripes and bars corresponding in tone to the red sheaths of the needles. The leaves of the Austrian pine are devoured by a saw fly larva (Lyda, Fig. 202) which is reddish olive green with reddish and purple patches and lines. The Abia of the Tartarean honeysuckle (Fig. 203) is of a peculiar pale bluish green color, somewhat resembling the peculiar glaucous green hue of the leaf on which it feeds. It is generally overlooked until the bushes are stripped. This worm does not seem to be eaten by birds, probably on account of the fluid which is suddenly poured out through the pores in the sides of the body when it is disturbed. The false caterpillar of the currant saw fly is rarely eaten by birds and enjoys an unusual immunity; so also the pear slug (Fig. 204) perhaps if not on account of its resemblance to a slug (for slugs are greedily devoured by birds), possibly on

FIG. 204.

Pear Slug.

FIG. 205.

Cimbex Larva.

account of some disagreeable taste. The larva of the Cimbex (Fig. 205) when coiled upon a leaf has a tolerable likeness to the common *Helix albolabris*.

Returning again to the grasshoppers, the species of the family of Locustarians, to which the Katydid belongs, are modified for a life hidden among the leaves of trees. Nearly all the species are green. In their youth they hop about in the grass, and are better protected from harm than the young Acrydians, which are usually dark, though some are green.

Some species remain in the grass throughout their lives, but most of the Katydids and others which produce a loud cry reside in the trees. Here it is difficult to detect them, their green hues matching so well the hues of the leaves forming their covert. Moreover the fore wings are inclined to be broad and oval, as seen in those of the Katydid (Fig. 206). It will be noticed in this insect how closely the veins resemble those of the leaves. There are, in the Museum of the Peabody Academy of Science, a number of Brazilian species

FIG. 206.

Katydid.

allied to the Katydid which have very broad, thick fore wings, some oval in shape like orange or lemon leaves, others with jagged outlines, somewhat as in the holly leaf. Others are of the color of a dead leaf. Such is the *Cyrtophyllus perspicillatus*, which bears a close resemblance to a withered leaf. There is in Brazil a grasshopper of this family, which represents the East Indian Megalodon figured by Wallace on page 580 of "The Malay Archipelago."

There are some insects which resemble anything but themselves. This paradox may be explained by a glance at a Selandria larva (Fig. 207) which sometimes occurs on the chestnut. Its body is entirely concealed by a cottony secretion which rises half an inch above the body. A group of these sluggish caterpillars could feed exposed on a leaf with impunity. The bark lice, such as Eriosoma, cover themselves with a cottony exudation which serves as a disguise. Many bright colored flower beetles are protected by their resemblance to the tints of the flowers in which they hide. The Galeruca and Clytus, almost invariably found on the golden rod in September, are thus protected.

Why butterflies are so much more commonly seen than their caterpillars is not known. It is probably due to the fact that the latter are often of the color of the leaves on which they feed. The caterpillar of the *Colias Philodice*, our common sulphur yellow butterfly, which lives on clover, is rarely found, owing to its pea-green tint so much like that of the clover leaf on which it feeds. It is possible that the caterpillar is so well protected that the butterflies can afford to have their numbers thinned out by predaceous insects and birds. So with the caterpillars of the white cabbage butterflies, whose dark green velvety coats so thoroughly assimilate them with cabbage or turnip leaves or stalks. The caterpillar of *Vanessa Antiopa* is one of the most conspicuous objects in nature, large clusters of these black spiny creatures feeding exposed on the leaves of the willow and other plants. It is probable, however, that bristling as they are with spines, birds do not fancy them; but the butterflies as well as the chrysalides assume the tints of dead leaves and old wood, and the butterfly may be easily confounded with the trunks of the trees on which it rests, as it does not settle on the ground as in

FIG. 207.

Selandria Larva.

the Graptas. Many geometrid moths rest on the bark of trees, where they escape the observation of the entomologist whose eye is trained at looking for them, and perhaps also of the birds. The white pine trees often shelter the *Tephrosia Canadaria*, which I have found in no other position. The Red Under wings, or Catocalas, spend their days on the bark of deciduous trees, and only expose themselves to the attack of birds when they show their gorgeous red and yellow hues in flight.

The Arctian moths, so brightly painted with strong contrasts of black and vermilion or red, can afford to be snapped up by the birds, which allow their spiny, hairy larvæ to go scotfree. It is possible that the bright colors of the Arctians and other Bombycidæ, as well as the butterflies, are needed to ensure the meeting of the sexes, as by their bright colors they can detect each other afar off; though the acute sense of smell possessed by these moths, whose antennæ are broadly pectinated, may be sufficient for ensuring the prompt recognition of each other's presence. That the white colors of the *Spilosoma Virginica* and the moth of the fall web worm (*Hyphantria textor*) serve the same purpose of mutual recognition as the conspicuous white Pieris, seems probable. Mr. Darwin (Descent of Man, i, 387; Appleton's edition, 1871) states that "the common white butterfly, as I hear from Mr. Doubleday, often flies down to a bit of paper on the ground, no doubt mistaking it for one of its own species." The owlet and geometrid moths fly in such large numbers that there is a greater chance of their encountering one another in the night, particularly as they feed on common objects of attraction, *i. e.*, the honey of flowers.

But all these points need to be thoroughly investigated. Many statements and assertions on the subject of mimicry need reëxamination and confirmation, and some of the facts I give here are simply hints for future observation and experiment.

The most wonderful cases of protective mimicry among caterpillars are afforded by the geometrids or span-worms. I have never seen a better example than that afforded by the larva of *Drepanodes varus* (Fig. 208), which feeds on the

FIG. 208.

Drepanodes and Larva and Pupa.

FIG. 209.

Stick Insect.

juniper. It would be difficult in the accompanying figure, as well as in life, to tell where the caterpillar begins or the juniper twig ends. The body of the larva holds itself out stiff and rigid, after the manner of its tribe, with warts over its back exactly like the leaf scars of the juniper, and the entire worm concolorous throughout with the bark is a perfect imitation of the twig.

Nearly every bush has its distinct kind of inch worm or geometer, which resembles a broken branch or twig when it is at rest and holds itself out stiff by its muscular hind legs. Most caterpillars remain quiet by day, when they need protection, and feed at night. The stick insect (Fig. 209, from Tenney's Zoology) is so obviously a mimetic form that we need only speculate how it came to differ from its allied forms, unless the intermediate forms have become extinct through the want of similar adaptation. This and the celebrated leaf-insect are the two insects which first come to mind when the subject of mimicry is mentioned. The Phyllium is broad and flat, with leaf-like dilatations on the legs, while the broad wings are provided with a midrib and vein exactly like a dried leaf.

Other remarkable stick insects of the group of Phasmids are figured by Professor Westwood in his "Thesaurus Entomologicus Oxoniensis." Such as the *Extatosoma bufonium* from Australia, *Heteropteryx Castelnandii* from Tringany, Malacca and *Ceroys laciniatus* from Nicaragua. They are much alike in form, though inhabiting different quarters of the globe, and are slender, with long legs, with flattened tubercles and spiny expansions, resembling the young and spiny twigs on which they possibly rest.

The caterpillars of the leaf-rolling and Tineid moths often live in rolled-up leaves, where they are protected in a great measure from their enemies; though the insectivorous birds, attracted perhaps by the deformation they cause in the foliage, feed upon them; and their insect parasites, particularly the minute chalcid flies, have the requisite instinct to find them out and oviposit in their bodies. No insects, however protected by these disguises, are ever thoroughly safe from the attacks of enemies especially created to gain their livelihood by preying upon them.

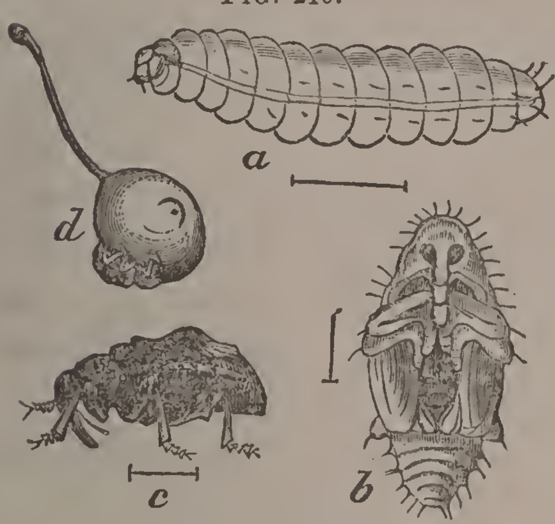
One of the most striking cases of mimicry is afforded by the caterpillar of the *Tolype Velleda*, as well as that of its ally, the lappet moth, which is found on apple trees, and would easily, when at rest, be mistaken for a swelling or cankered spot on the bark (Harris' Treatise on the Injurious Insects of Mass., 1862, p. 379). Miss Dix, as quoted by Harris on the same page, states that "when at rest the resemblance of its upper surface was so exact with the young bark of the branch on which it was fixed, that its presence might have escaped the most accurate investigation; and this deception was the more complete from the unusual shape of the caterpillar, which might be likened to the external third of a cylinder. The sides of the body were cloaked and fringed with hairs. It was of a pale sea-green color above, marked with ash, blended into white; and beneath of a brilliant orange, spotted with vivid black. When in motion its whole appearance was changed; it extended to the length of two inches, and two-thirds of an inch in breadth, its colors brightened, and a transverse opening was disclosed on the back, two-thirds of an inch from the head, of a most rich velvet-black color. It was sluggish and motionless during the day, and active only at night."

The gray color and roughened surface of many longicorn and Buprestid beetles which rest in the daytime on the bark of trees are undoubtedly protective, though why multitudes of these two groups of insects are, on the other hand, among the most highly colored and brilliant of any in existence, needs further investigation. Mr. Wallace observes that these brilliant beetles would not be eaten by birds on account of their very hard, dense tegument, but this will equally apply to the gray and dull colored species, which are evidently protected by these adaptive colors. The bright colored species are the exception in the temperate regions, and more the rule in the hot and moist forests of the tropics. Here the physical environment of the animal is undoubtedly the primary cause of its high colors.

The buds of plants and trees are imitated by many kinds of weevils, whose oval, often rough, bodies and sluggish natures protect them. Such is the plum weevil (Fig. 210), which looks like a dried plum bud. The small cones of the pine are simulated by the *Chalcophora liberta*, a Buprestid beetle. Early in June when the brown Elaters are coming out of the ground and are found resting on the low maple bushes, I have observed some to resemble closely the long leaf buds of that tree.

Certain small weevils resemble the seeds of plants. Wal-

FIG. 210.



Plum Weevil and Larva.

FIG. 211.

Young Chlamy and case.

lace quotes Kirby and Spence's statement that the small weevil named *Onthophilus sulcatus* looks like the seed of an umbelliferous plant. Wallace also quotes Bates as saying that some tropical spiders "are exactly like flower buds, and take their station in the axils of leaves, where they remain motionless waiting for their prey."

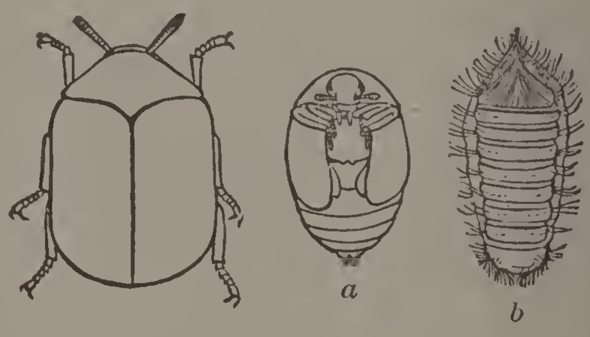
Some beetles, like the little, thick, rounded, oblong Chlamys, have been noticed by Bates, and also by Wallace, to resemble the castings of large caterpillars, and the case of the larva of this beetle (Fig. 211), which is not uncommon in the United States, is black and oval in shape, and would be readily mistaken for a pellet of bird's dung. Wallace quotes the statement of an observer, who had more than once mistaken an English moth, *Cilix compressa*, a little white and gray moth, "for a piece of bird's dung dropped upon a leaf, and *vice versa*, the dung for a moth." Wallace also tells us that "there are in the east small beetles of the family Buprestidæ, which generally rest on the midrib of a leaf, and the naturalist often hesitates before picking them off, so closely do they resemble pieces of bird's dung." The same might be said of the little dark brownish, bronzed Brachys often seen in midsummer resting motionless on the leaves of the oak.

Some carrion beetles are dark, like the decaying bodies under which they live, and so are their larvæ, but why other

FIG. 212.

Attagenus Larva.

FIG. 213.



Anthrenus and young.

forms, like the Necrophori and Necrophili, are banded so conspicuously with red or yellow, does not seem clear to us. Many of the small Catops, the Nitidulæ, the Staphylini, are dark red or brown or black, these colors harmonizing with the sombre tints of the decaying substances on which they live. I have noticed that the *Antherophagus ochraceus*, a dull ochreous reddish beetle, is of the same hue as the cells of the humble bee, in which they are often exceedingly common. The Dermestes, Attagenus (Fig. 212, larva) and

Anthrenus (Fig. 213; *b*, larva and *a*, pupa, all enlarged) assimilate in color the dried skins and decaying matter in which they luxuriate. The larvæ especially are so densely clothed with gray or reddish brown hairs, that it is difficult to detect them when at work in dried insects and bird skins. Their stealthy ways also favor their protection, and these beetles, like the weevils and many others, when disturbed feign death.

How this mimicry of death so common among insects came to be such a universal habit would form a curious subject of inquiry. It can scarcely, perhaps, be regarded as anything more than instinctive in the insects of the present day, but in the earlier ages of the world, when the insects were schooling themselves in the arts of life, such acts as these must have been in a degree conscious, and only became habitual after many mistakes and trials, resulting in the extinction of many individuals and incipient species. When one looks at the beds of fossil beings of the earlier geologic periods, he peers into the tombs of millions which could not adapt themselves to their constantly changing surroundings. No fossil being is known to us which could not have been as well adapted to its mode of life as the animals now living; but the conditions of life changed, and the species as such could not withstand the possible influx of new forms due to some geological change which induced emigration from adjoining territories, or to changes of the contour of the surface, with corresponding climatic alterations. Let one look at the geological map of North America before the Cretaceous period, ere the Rocky Mountains appeared above the sea, and reflect on the remarkable changes that took place to the northward; the disappearance of an Arctic continent, the replacement of a tropical climate in Greenland and Spitzbergen by Arctic cold. Are there not here changes enough in the physical aspects of our country to warrant such hypotheses of migrations with corresponding extinctions and creations of new faunas out of preceding ones, as are indulged in by naturalists of the present day, in the light of the knowledge pouring in upon them from Arctic explorers and western geologists? Granted these extraordinary changes in the physical surroundings of the animals whose descendants people our land, do not a host of questions arise as to the result in the beings of our day of these changes in the modes of life, the modes of thought, so to speak, the formation of peculiar instincts arising from new exigencies of life, which have remodelled the whole psychology, as it were, of the animals of our country? Instincts vary with the varying structure and form of the animals. Change the surroundings, and at once the mode of life and psychology of the organism begin to undergo a revolution. These changes may result in the gradual extinction of whole assemblages of animals, which are as gradually replaced by new faunas.

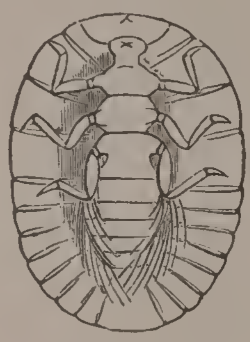
Many, indeed most, insects are in our northern hemisphere represented in the colder months of the year by the chrysalis or eggs. These are eagerly sought after by the smaller birds, and are in most cases protected by their colors, or by their resemblance to the bark of the trees on which they may be laid. The eggs of the canker worm are gray, like the bark of the tree or paling on which they are deposited. The eggs of the tent caterpillar are covered over with a coating of gum, so that the bunch looks like an excrescence on the tree. The chrysalis of *Vanessa Antiopa* is exactly of the color of old wood, and it is often found hanging from fences and out-houses, while, before houses were built, for this butterfly belongs to an ancient family, it assimilated in hue the bark of trees. The cocoons of many of the silk moths, like those of the Promethea moth, are covered with leaves drawn around them in the process of weaving, and hang all winter on the wild cherry, having the semblance of a dead leaf. Those of the Polyphemus (Fig. 214) which fall to the ground among the leaves of the oak are covered with dead leaves, and the color of the cocoon when bare harmonizes with that of the soil or leaves.

Aquatic insects are often nearly colorless, like the water they inhabit. Many water larvæ are pale green, like the plants in which they hide. What excellent mimics the caddis worms and Ranatra and Belostoma are, we have previously adverted to in the chapter on Insects of the Pond and Stream. To the cases there given might be added certain sluggish larvæ like Psephenus (Fig. 215) and others, which

FIG. 214.

Cocoon of the American Silk Worm.

FIG. 215.



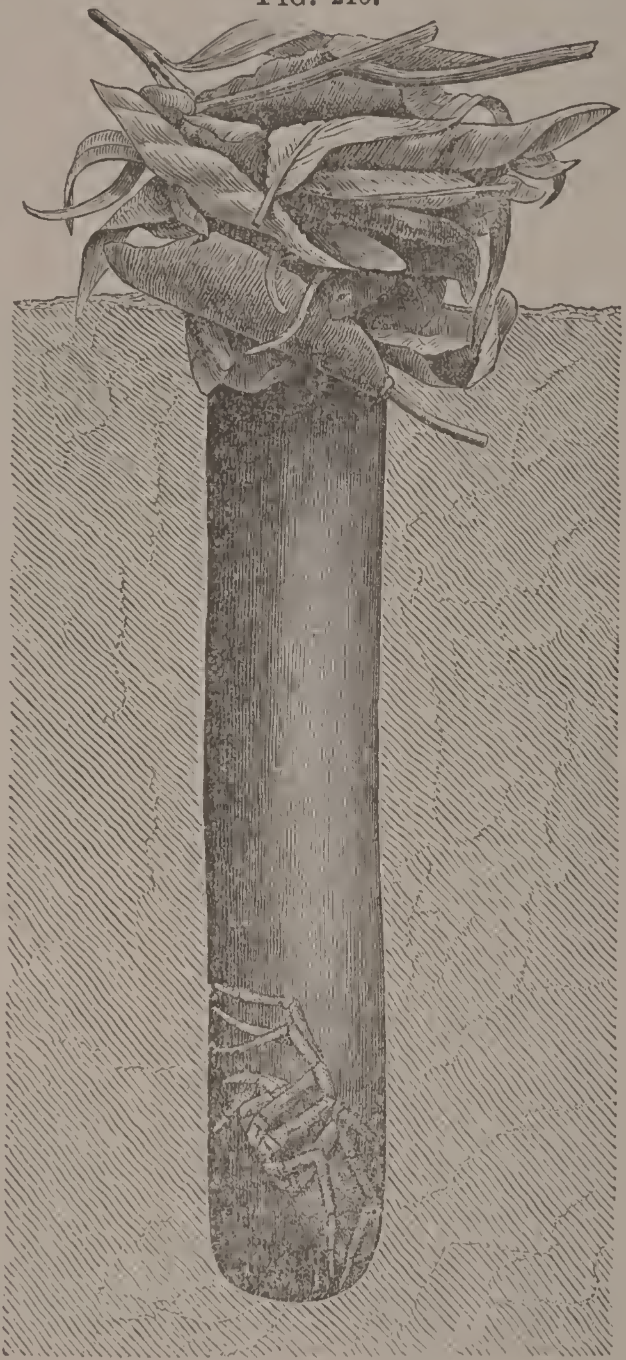
Psephenus.

adhere to the under side of pebbles, and are thoroughly assimilated in color to the mud of streams and the shores of the sea.

Much light may be thrown upon this subject by a study of cave animals. Here the harmony in color and often in form to surrounding objects is most striking and the causes are quite apparent. The cave insects becoming blind from the darkness of their subterranean abode, lose their colors and are assimilated to the colors of the stalactites on which they walk or the walls of the cave to which they cling. The ground beetles, instead of being dark like their out-of-door relations, here fade out to the color of the limestone sands over which they run. The harmony in form and color with the environments of their subterranean abode is as apparent as the cause.

All the cases hitherto given are examples of unconscious mimicry, and in many, if not most, cases the effect of climatic and other physical causes, resulting in a general harmony of hue and form which adapts all animals to the world in which they live. But there are a few cases known in which it is difficult not to believe that at some time in the life of the species there was a conscious intention to deceive. I refer to the trap door spiders and other forms which curiously conceal the entrance to their holes with the manifest design of hiding it from their enemies or of using it as an ambuscade. I would refer the reader to Moggridge's capital work on "Harvesting Ants and Trap Door Spiders," for much curious and reliable information regarding the habits of these spiders. Like our trap door spider, Mygale (Fig. 62), its allies in southern Europe excavate deep tunnels in the earth; they seem to take unusual pains to conceal the entrance from their enemies. The hole is usually situated in moss and small ferns, etc. After the door is made the top is actually planted with bits of moss and small plants, so that it is often impossible for the practised eye to detect the trap door. Moggridge remarks that the moss thus transplanted by the spiders "grew as vigorously, and had in every way the same appearance, as that which was rooted in the surrounding earth, and so perfect was the deception that I found it impossible to detect the position of the closed trap even when holding it in my hand. There can be no doubt that many nests escape observation in this way, and the artifice is the more surprising because there is strong reason to believe that this beautiful door-garden is deliberately planted with moss by the spider, and not the effect of a mere chance growth." The evidence he adduces is strongly confirmatory of this view. In the nests of other spiders he tells us that "it is rare to find any of the larger mosses or lichens growing upon them; but, as if to compensate for this deficiency, a variety of foreign materials are employed which are scarcely ever found in cork doors, such as dead leaves, bits of stick, roots, straw of grasses, etc., and I have seen freshly cut green leaves, apparently gathered for the purpose, spun into a door which had recently been constructed."

FIG. 216.



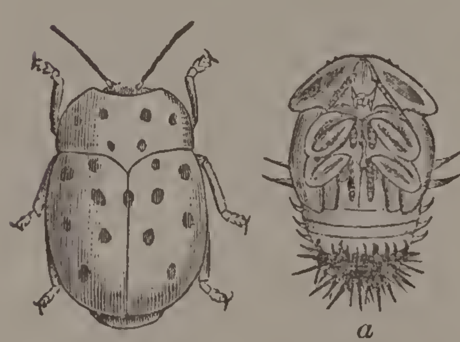
Lycosa in its nest.

We have in this country a species of Tarantula (Lycosa) which as if by design covers its hole with a mass of dead and dry leaves, as indicated in Fig. 216 (after Emerton). In an article in the "American Naturalist," vol. iv, Mr. Emerton tells us that his attention was drawn to these nests by Mr. J. A. Lintner, who noticed on the sandy hills west of Albany, N. Y., a number of holes about half an inch in diameter, each surrounded by a ring of sticks and bits of leaves loosely fastened together by fine threads.

The larvæ of Cassida, the helmet beetle, and Lema, which live exposed to the sight of their enemies on the upper side of leaves, afford examples of what, at some period in the life of the species, may have been a conscious attempt at deception. The larva of Cassida is broad, flat and oval, edged with long, sharp spines. By means of the two long terminal spines terminating its upturned extremity it holds the old cast skin over its body like an umbrella. The beetle itself in its resplendent golden hues has been compared, by Wallace, to "glittering dew-drops upon the leaves." In another form, *Chelymorpha cribraria* (Fig. 217; *a*, pupa), which is considerably larger than Cassida, and feeds very much exposed on the silk weed, and sometimes on the raspberry, is also protected by its cast skin, though in a less degree.

The larva of the common potato beetle of the eastern states (Fig. 218; *a*, larva; *b*, *c*, pupa; *d*, eggs) covers its dull gray soft body with a black mass of its excrement,

FIG. 217.



Helmet Beetle and Pupa.

FIG. 218.

Young Potato Beetle.

which is at once a protection from the heat of the sun and the attacks of birds, which probably regard them as anything but living and edible insects.

It would seem, then, that while in the generality of cases insects harmonize in color and often in form with surrounding objects, or even distinctly mimic natural objects, this is owing in all probability mainly to the physical environment of the animal; in a few cases, however, there is an appearance of design, and natural selection has been the means by which the mimicry has been effected and the species preserved.

Mimicry of other Insects.—We now come to instances where insects resemble others of different genera, families and orders. They are exceedingly numerous, and entomologists have been familiar with some of them for at least a century. Struck with the fact that as a rule the insects which were mimicked were higher in the scale than the mimickers, the writer attempted in an essay published in 1863* to classify some of the known facts, adding some supposed to be new, and to give a partial explanation of them. In the light of the facts published a year previous to this by Mr. Bates,† and afterwards by Mr. Wallace‡ and Mr. Darwin,§ I am inclined to the belief that the resemblance in pattern and color between insects belonging to different groups is probably due to causes more fundamental than natural and sexual selection, and reaching possibly farther back in geological time. I will quote the following passage from my essay:

"If we consider the Hymenoptera, Lepidoptera and Diptera by themselves, in the order in which Latreille has placed them, we shall find these three groups full of reciprocal analogies. Certain forms in the one suborder leap over their neighboring suborder to find their analogues in one a third removed; or again, we see analogous forms between the two higher groups, leaving the lowest for a while isolated; or on the other hand the two lower groups are thus united, leaving the highest one standing by itself. For example, the clear-winged Sesia imitates the humble-bee in its form and flight; the different species of Ægerians (Fig. 219, *Ægeria tipuli-*

*On Synthetic Types in Insects. Journal of the Boston Society of Natural History. 1863.

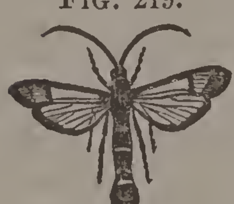
†H. W. Bates. Contributions to the Insect Fauna of the Amazon Valley. Lepidoptera: Heliconidæ. Transactions of the Linnæan Society, vol. 23, 1862.

‡A. R. Wallace. Mimicry, and other Protective Resemblances among Animals. Westminster Review, July, 1867. Reprinted in "Contributions to the Theory of Natural Selection." 1870.

§Charles Darwin. The Descent of Man, and Selection in Relation to Sex, 1871.

formis) simulate members of nearly every hymenopterous family, as we can see when recalling such names as *apiformis*, *vespiformis*, *philanthiformis*, *tiphiæformis*, *scoliæformis*, *spheciformis*, *chrysidiformis*, *cynipidiformis*, *formiciformis*, *ichneumoniformis*, *uroceriformis*, and *tenthrediniformis.* So also other Ægerians resemble different family forms of Diptera, as seen in the names *culiciformis*, *tipuliformis*, *bibioformis*, *anthraciformis*, *muscæformis*, etc. In the Diptera we find Bombylius, resembling, as its name implies, Bombus; and also Laphria, which so closely apes the humble-bee in its form, coloration, size and flight, even to the buzz, which is, if anything, still louder. Also, there is the strongest resemblance in some Syrphi to Vespa, and especially to different species of Crabro. But while the Lepidoptera and Diptera resemble the Hymenoptera, we cannot say that Hymenoptera ever *assume* the form of any flies and moths. They seem isolated, and resemble only themselves. In the case of the Laphria, the plump, bee-like form, and the dense yellow and black hirsuties, which cause them to be mistaken for humble-bees by persons unacquainted with their structural differences, are just those features that are exceptional in the Diptera, and are normal in the Hymenoptera. The fly to get them has to pass over one suborder to obtain a bizarre form which is a prevalent and common attribute of the Apidæ.

FIG. 219.



Ægeria.

"There is a similar parallelism of analogous forms between the Coleoptera, Hemiptera, Orthoptera, and Neuroptera, which seem bound together by affinities such as those that unite by themselves the bees, moths, and flies. Thus there are certain Hemiptera (Corixa) that resemble the coleopterous genus Brachys; Forficula is analogous to the Staphylinidæ and Blatta may be said to resemble some Lampyridæ. The close affinities between the Orthoptera and Neuroptera hardly admit of these analogous forms, though we find them still. Here again we see the isolation of the Coleoptera from the other suborders with which it is connected. The suborders below it, by an exact parallel with the case above mentioned, reach up and connect themselves by these remarkable analogies with the Coleoptera, which do not in turn assume any of their forms. Some Orthoptera are very coleopterous-like, and some Hemiptera are very coleopterous-like. The reverse cannot be said. So the Diptera and Lepidoptera, as they advance in their family forms, are constantly throwing out hints and suggestions of forms that seem very strange to them, but become generalized in the group that tops them. Thus in the broad, irregular, net-veined, neuropterous fore wing, which becomes smaller and thicker in the orthopterous Blatta, and still more coleopterous in the hemipterous Corixa, we arrive at the perfected elytron, with its regular, obsolete veins and new protective function.

"Most of the examples above mentioned are familiar to entomologists, and others will occur no doubt to illustrate the subject more fully.

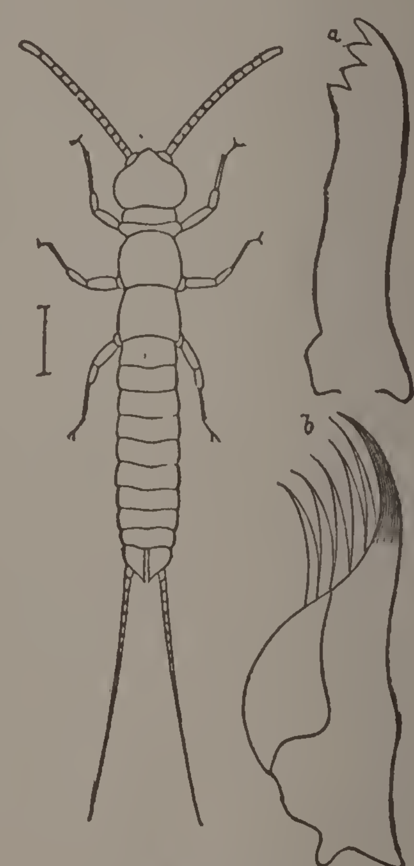
"Many authors have agreed that the suborders of insects can be arranged into two series or groups, often called Mandibulata and Haustellata, though disagreeing as to the relative rank of these two divisions, and the true places the suborders should occupy within them. It is enough for my purpose to assume that there are two such series, though believing that the two culminate in the Hymenoptera and Coleoptera respectively, in the succession that I have indicated above.

"What have we now in common with both, and which shall reunite this seeming polarity in the two series of suborders? There is needed a group which, while retaining its own strong fundamental features, and maintaining an equal footing with its equivalent groups, shall have besides the strongest analogies to those groups farthest removed by affinity, in order that these two series may be virtually brought together; while the successive forms in the several families shall afford us some conception of the larger categories these minor groups foreshadow. Such a group Professor Agassiz* has pointed out in the class of Selachians, which combine the characters of all the other classes of fishes existing during the same period, and also, by their being the earliest in time, afford what he calls *prophetic types*

FIG. 220.

Lepisma.

FIG. 221.



Campodea.

of all the coming classes of vertebrates. The former case affords what he calls *synthetic types*."

In endeavoring to show that a similar synthesis as marked as in the fishes or reptiles, or other groups of animals, occurs in the different neuropterous families of insects, the case of the *Lepisma* (Fig. 220, *L. quadriseriata*) or bristle tail, may be cited, which is closely allied to the Campodea (Fig. 221),

* Essay on Classification.

supposed to be a stem form of all the insects, and which is a remarkable synthetic type, combining the characters of the six-footed insects and the Myriopods.

The two families of May flies and dragon flies do not have any species with marked analogies to other insects. In an-

FIG. 222.

Adult of the Ant Lion.

other family, however, of which the adult of the ant lion (Fig. 222) is an example, we have the Ascalaphus, which was regarded by Scopoli as a Papilio, the wings being large and broad, and the antennæ knobbed. The neuropterous Mantispa (Fig. 223), in its fore legs adapted for seizing its prey, mimics the orthopterous Mantis. The Panorpa (Fig. 224), the type of another family of net-veined insects, assumes the shape of the crane flies (Tipula). Bittacus has its analogue in the fly named Bittacomorpha. The large lace-winged fly called Polystœchotes has some features reminding us of the Hepialus (Fig. 225). The Caddis flies imitate the Tineid moths so closely that excellent entomologists have confounded them. The species of Psocus mimic the Aphides so closely that they are often

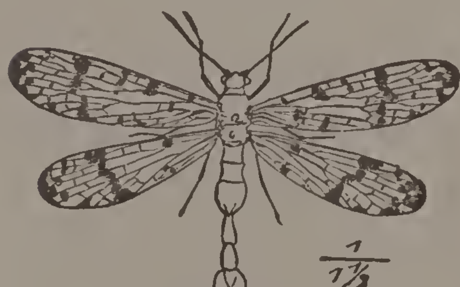
FIG. 223.

Mantispa.

mistaken for each other, and the wingless Atropos, or death tick, reminds us of the louse. The ants have among the Neuroptera their well known analogues, the Termites or white ants. Like the true ants they live in large colonies, and have wingless workers of two sorts. Now these and certain peculiarities in structure, which place the white ants at the head of the Neuroptera, are just those which make them so much like the true ants, which are among the most highly developed insects, ranking near the honey bee.

From the facts here and elsewhere given it may be regarded as quite well proved, that some, if not the majority of mimics among insects belong to groups, lower in the organic scale than the insects they mimic. Moreover, the paleontological record shows that the Neuroptera were the

FIG. 224.



Panorpa.

FIG. 225.

Hepialus.

first to appear. The fossil forms discovered were also synthetic types, combining the characters of other neuropterous and some orthopterous families. These fossil insects, it should be observed, were remarkable "mimics," but we have no proof that the living insects they resemble were then in existence. We can only explain the matter by regarding them as prophetic types, anticipating in nature the coming of whole families and even orders of insects. They represent ancestral or stem forms, from which arose lines of descent resulting in the present insect creation. The original Devonian May fly-like insect, and the Xenoneura and Homothetus, as well as the Carboniferous Miamia and Hemeristia and Eugereon, possessed features which they have, perhaps, transmitted through different sources resulting in families whose distinguishing marks are based on the primordial traits united in the same insect, but now scattered in different families. For example, the raptorial fore leg and form of the head of the singular neuropterous insect, Miama, the peculiar veining of the wings, form characters now existing in two very different families.

Just as the embryo dog passes through a fish and a reptile stage before attaining its canine physiognomy, have the Neuroptera of the present day, in the process of building up new groups based on a modification of a single character, thrown aside the characters united in the more embryonic and primitive types. We would thus expect to find among the fossil insects the most startling anticipations of types not yet called into existence. The scanty paleontological record we have shows that the grasshoppers and their allies appeared after the Neuroptera; that the bugs (Hemiptera) appeared still later; that the moths and butterflies were very late in their arrival; that the flies probably preceded the Hymenoptera, and that the bees and wasps, the most highly developed structurally and intellectually of all insects, were the latest to be developed. It is a startling fact that the white ants which foreshadow so wonderfully the true ants, appear in great force in the coal formation, while the ants do not occur fossil before the Tertiary period. Now as an example of mimicry, any one ignorant of the geological record would regard the case of the white ants as one of the best, but the fact is the white ants were nearly as perfect, and doubtless as wonderful in their colonizing instincts in the Carboniferous period as in the age of man. Clearly, then, "mimicry" in the sense of being a factor in the origin of species does not as a rule exist, though there may be exceptions, and it is not improbable that a large proportion of so-called mimics are so by virtue of their similar physical surroundings. There have been cycles of creation, as if the same thought were taken up in successive geological periods, and worked out in different ways, but with the same fundamental plan. The plan is the result of an unbroken line of forms transmitted by genetic descent; the variations in the typical forms have been induced by changes in the soil and air. These lines of development, from so-called archetypal forms suddenly stop, and we have to follow them back before we can again take up the thread of development of other lines. There is not a continuous chain of being, but lines of development sometimes parallel, but more often diverging and connected by cross ties and branches linking the animal creation into a whole, all converging to a primordial ancestor, perhaps no more highly organized than the structureless Moner, a drop of living, moving, self-reproducing protoplasm.

Turning now to the cases of mimicry in the butterflies described by Messrs. Bates and Wallace and Trimen, from South America, the East Indies and South Africa, respectively, all agree that the Heliconidæ are mimicked by other butterflies which are very unlike the members of their own families, and copy in form and color the Heliconidæ which, probably owing to a bad odor, are not eaten by birds, and thus multiply in great abundance. The object of the mimic is claimed to be a utilitarian one. It flies about in the disguise of a Heliconia, and were it not for this protection it and its offspring would become extinct. This resemblance, moreover, has probably, these authors claim, been brought about by natural and sexual selection. In the beginning some butterfly, through the tendency to variation assumed by Mr. Darwin, had a remote resemblance to a Heliconia; this favored it above its fellows, and the character growing more strongly marked became perpetuated, until after a great number of generations the similarity of form became perfected. Mr. Darwin adopts the view, and regards the mimicry as brought about by natural and sexual selection.