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STRUCTURE & CLASSIFICATION

OF

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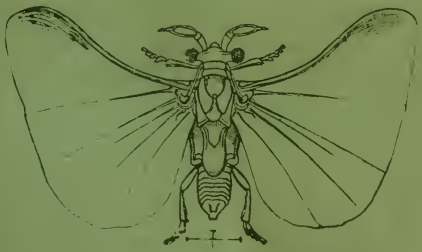

BY

ADRIAN J. EBELL, PH.B., M. D.

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STRUCTURE

AND

Classification of Insects,

BY

ADRIAN J. EBELL, Ph.B., M.D.

PART II,

OF THE TEXT-BOOK OF NATURAL HISTORY.

EBELL & CO.,
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DEDICATION.

The Author and Publisher would respectfully beg the liberty of dedicating this little work to

PETER COOPER,

OF NEW YORK.

as a slight token of regard for the great services he has rendered the cause of Science, by the facilities he has afforded for its diffusion among the people.

BERLIN, PRUSSIA,
July, 1872.

PREFACE.

The author of this little work has endeavored to attain in it two ends, *i. e.*, to prepare, in the first place, a guide to the observer of the life and structure of the insect, and, in the second place, an outline or groundwork for the class room or lecture room work in this department.

It is by no means intended to be complete in itself, and the interest to be awakened in this beautiful department of natural science must be attained by the study of the objects themselves, to which these pages are intended to serve merely as an index.

The illustrations of this work have been taken from E. F. Staveley's British Insects, and were kindly furnished the author by L. Reeve & Co., of London.

The author is well aware that many faults, especially of omission, may readily be found with this outline, but his plea for that is, that his aim in its preparation was to make an assistant to the teacher and learner, and not a complete work in itself.

ADRIAN J EBELL.

BERLIN, PRUSSIA,
July 24, 1872.

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STRUCTURE AND CLASSIFICATION

OF

INSECTS.

CHAPTER I.

The Order of Insects belongs to the Articulates—the fourth type of the animal kingdom (*Protozoa*, *Radiates*, *Mollusks*, *Articulates*, *Vertebrates*)—since they, as well as all the other members of this type, have their bodies formed of rings built around a central chain of nerve bunches.

Of the three classes of Articulates (*Worms*, *Crustacea and Insectians*) the insects belong to the third, that of Insectians, in most of which the rings of the body are gathered into three portions, called the head, the thorax, and the abdomen.

The class of Insectians comprises three orders:

1st. *The Myriapods*, having many legs, and the thorax and abdomen not distinctly separable, comprising such as

the *thousand-legged* worms, the centipede, the ear-wig, and the like.

2d. *The Arachnida*, having eight legs, and the head and thorax joined together, while the abdomen is usually distinct, comprising such as the spiders, ticks, mites and scorpions; and

3d. *The Insects*, which are distinguished in their perfect or adult condition, by having *three distinct parts* of the body—*head*, *thorax* and *abdomen*—and having always *six legs on the thorax.*

The study of Insects comprises three departments:

1st. The Transformations of Insects, and their structure in each of the stages through which they pass.

2d. The Classification of Insects into Sub-Orders, Families, Genera and Species, and

3d. The Natural History of these several groups, such as the appearances, habits, associations, geographical distribution, etc.

The first two of these departments alone will be outlined in this printed text, while the third, and by far the most interesting and important department, will be left for the Lecture Room.

1. *Transformations.*—Insects pass through four stages in their development, *i. e.:*

1st. The Egg,
2d. The Larva,
3d. The Pupa,
4th. The Imago, or Adult Insect.

CHAPTER II.

I. The Egg.

All insects are strictly Oviparous, and bring forth their young in the form of eggs, and, though a few seem to furnish an exception to this, and bear living young (as the Aphidæ, or Plant Lice), yet this is either during certain immature changes through which the insect passes before it reaches its adult state, when again it brings forth eggs; or, as is the case in a few instances, when the egg is carried through one or two of its subsequent changes within the body of the mother.

We might, therefore, according to their mode of birth, group insects as follows:

Ovo-Viviparous.

1. *Larviparous*—
   Brought forth in the form of a *larva*, as the (*aphis*) plant-louse. the (*sarcophaga*) flesh-fly, etc.
2. *Pupiparous*—
   Continuing in the mother during the larva state, and brought forth in that of a *pupa*—as the forest-fly (*hippobosca equinia*) the sheep-louse (*melaphagus ovinus*), the bat-louse (*nycteribia vespertilionis*), etc.

II. *Oviparous.*—Including all other Insects.

The eggs of insects may be studied in regard to their *methods of exclusion, situation, numbers, size, figure, color*

and period of hatching, and on each of these questions we will say a few words.

1. Methods of Exclusion.—By far the greater number of insects pass their eggs singly, at longer or shorter intervals. In those tribes which place their eggs in groups, as most butterflies and moths and many beetles, they usually are brought forth quite rapidly, while among those that deposit their eggs singly, as the *Ichneumonidæ* and *Œstri*, intervals of some minutes or hours may intervene between each.

Some insects, as the Crain Fly (*Tipula*) project their eggs several inches from their bodies.

A few two-winged insects extrude them as a chain or necklace, fastened together by glutinous matter. Some insects gum them together in an oblong mass, containing three or four hundred eggs.

EGGS OF THE HYDROUS PICEUS.

2. Situation.—Some insects deposit their eggs in bags, and others spread around them a liquid that hardens into an envelope. A few carry them about with them fastened to their bodies, under their abdomens. A family of Water Beetles (the *Hydrophilidæ*), spin an egg pouch like the spider. A moth, common to the willow, quite

conceals her eggs with a white, frothy substance that hardens and protects them from the weather. The female Saw Fly makes, with her double saw, a longitudinal incision in a leaf or a stem, and places in it her eggs, in a single row from end to end, and then closes up the opening with a green, frothy fluid, mixed with the small pieces of leaf detached by her saws. Some moths surround their eggs with hair, stripped from their own bodies. Many make the leaves and other parts of plants serve as covering for their eggs. A great many insects, however, satisfy themselves by covering the eggs with a water proof coat of varnish and leaving them near the food the larvæ are to live on when hatched. Some insects, as the Mosquitos and Gnats, deposit their eggs on the water, and let them float as little rafts. A great many lay them on the bodies of other animals, as on the hairs and feathers of Vertebrates, or on the bodies of other insects, or even indeed in the eggs of other species. Others bury them in the ground, either directly in the soil, or in the body of some other little animal they have buried for the purpose.

3. Substance.—The eggs of insects, as of birds, consist first of an exterior shell or membrane, and second, an internal vital fluid. This membrane is sometimes extremely delicate, and readily yields to evaporation if exposed to the weather; but among the *Lepidoptera*, and several other tribes, this integument is considerably stronger.

The fluid within the egg contains the material out of which the young larva is built; and the study in the microscope of the several changes through which it passes is an extremely interesting department of *Embryology*.

4. Number.—The number of eggs laid by an insect

varies from within a hundred up to several millions, *c. g.*, the wasp will lay as many as 30,000; the bee, from 40,000 to 50,000; and as many as 200,000 are laid by a little hemipterous insect (*aleyrodes-chelidonii*). But all these numbers are far exceeded by the white ant (*termes-fatalis*), the productive female, or queen, of which will lay as many as 60 eggs a minute—3,600 an hour, 86,400 a day, 2,419,200 a month, and the total sum of 211,449,600 a year—thus far exceeding the number of eggs laid by any other animal in creation.

5. Size.—The size of the eggs varies generally in proportion to that of the insect producing them, although the reverse of this is sometimes the case.

Commonly the eggs laid by one female are all of the same size, but in several tribes those containing the germ of the female are larger than those that are to produce a male, although the opposite is the case sometimes even of this.

The eggs of ants, water mites, and some others, grow larger after being laid.

6. Shape.—There is a great variety in the shape and markings of the eggs of insects, and they are by no means uniform, as are the eggs of birds; the commonest forms, however, are globular, oval or oblong, with various intermediate modifications; they are also flat and orbicular, elliptical, conical, cylindrical, hemispherical, lenticular, pyramidal, square, turban-shaped, pear-shaped, melon-shaped, boat-shaped, of the shape of an ale-stand, of a drum, and of many other strange shapes.

Some of them are delicately corrugated and marked over their surface, or raised upon little foot-stalks or stems.

7. Color.—The eggs of insects vary as widely in their coloring as in their shape and sculpture.

Often they are white, resembling minute pearls; some, as those of the silkworm, are of a beautiful golden yellow; others, as those of the bloody-nosed beetle (*timarcha tenebricosa*), of beautiful orange; others, again, are of a golden hue or a deep red, and of every intermediate shade; others are blue, green, speckled, striped, or banded with zones of different colors.

In general all these eggs are white when first laid, but change and assume these various colors in a few days.

8. Period of Hatching.—The kind of food the larva is to feed on, and the temperature of the air, determine the length of time required for the hatching of the eggs.

The carnivorous insects ordinarily require the least time, *e. g.*, the eggs of many flesh-flies are hatched in twenty-four hours, and they vary from that time up to nine months, as required by several of the plant-eating insects, as some of the butterflies; besides, many of those kinds that, in the heat of summer, require but a short period for hatching, will remain unchanged through the colder months of the year.

Most insects depend merely upon the heat of the sun for the hatching of their eggs, though many species make special provision for this by laying their eggs in heat-producing places, such as heaps of decaying vegetable mould, barnyard refuse, or even in the bodies of other living animals.

CHAPTER III.

II. The Larva.

The larva is the state of the insect immediately after it is hatched from the egg, in which it eats voraciously, changes its skin several times, and has the power of locomotion, but does not propagate.

a. Several families of the lower order of the class of Insectians pass through the larval state in forms closely resembling the mature condition, but without the full development of all the parts either in their numbers or proportions—of such are the common millepede or "thousand-legged worm," the centipedes, mites, the *lepisma* or "sugar-louse," *podura* or "spring-tails," the scorpions, the *phalangia* or "harvest-men," spiders, and a few others.

But such as the grasshoppers or locust, crickets, cock roaches, and many others, appear from the egg, closely resembling the parent in form, but destitute of wings; they change their skin or shell several times, till at last, after successive moultings, the wings are developed, and they assume the full form of the parent insect; but as the details of structure of these are much alike, we will omit their consideration till we reach the study of the Imago.

b. The second group of larvæ—*those that are wholly unlike the adult*—comprises the greater number of species of

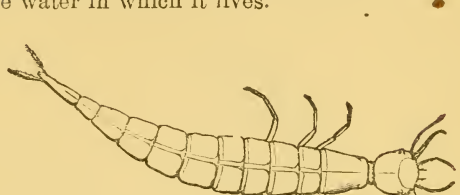
Larva of the Beetle Melolontha (*Cockchafer*).

insects. We might study these larvæ under the following heads:

1. The Substance of the Body; 2. Its Parts; 3. Shape or Figure; 4. Clothing; 5. Color; 6. Their Economy or Mode of Life; 7. Their Food, Moultings, Growth, Age, Sex; and 8. Their Preparations for assuming the Pupæ State.

1. *Substance of the Body.*—The body of the larva is, in most cases, much softer than in the perfect insect, and is covered with an elastic membranous skin, thus a general flexibility and ease of motion is attained which enables their long cylindrical forms to bend and twist along the surfaces of leaves and stems, or worm along through the narrow crevices they often occupy within the solid parts of plants and other animals, or even in the ground. The head and six fore-feet, however, are commonly corneous or horny, thus furnishing more effectual instruments for cutting and grasping. The bodies of larvæ are generally opaque, but some, as those of ants and a few *lepidoptera*, are diaphanous or semi-transparent, while that of a large mosquito (*corethra-crystallina*) is as beautifully transpa-

rent as a piece of crystal, and is scarcely distinguishable from the water in which it lives.



Larva of Water-Beetle (*Dytiscus*).

2. *Parts.*—The anatomy of the larva might be arranged as in this tabular view:

PARTS OF LARVÆ.

- Head.
  - Eyes. { *Simple Eyes.* / *Compound Eyes.* }
  - Antennæ. { Resembling those of the perfect insect. / *Not* resembling those of the perfect insect. }
  - Mouth.
    - Upper lip (Labrum).
    - Under lip (Labium).
    - Upper jaws (Mandibulæ).
    - Under jaws (Maxillæ).
    - Two, four or six palpi. { Maxillary palpi. / Labial palpi. }
- Trunk and Abdomen.
  - Segments or rings.
  - Legs.
    - Horny and composed of joints—or *true* legs. { Coxa, trochanter, femur, tibia, tarsus. }
    - Fleshy and without joints—or prolegs. { With terminal claws. / Without terminal claws. }
  - *No larvæ have wings.*
  - Spiracles.
  - Various extraneous appendages.

The *head* of the larva is rarely separated from the body by a distinct neck; yet it may be readily distinguished, as in most cases it is covered with a horny substance, or at least with a skin somewhat harder than that of the other portions.

The larvæ of many of the dipterous insects, however,

have their heads covered with the same flexible membranous skin that is spread over the rest of the body, but they make amends for this in the power they possess of changing the form of the head into different shapes, or extending and contracting it at will. The head is generally a little narrower than the rest of the body, though in some lepidopterous larvæ it bears no proportion whatever to the diameter of the other rings. At its first exclusion from the egg the head is the largest part of the larva, but it rarely continues so. It is either naked or uncovered as the rest of the body, unless, with small spines or prickles, its most common color is a reddish brown, or a darker shade than the other parts. Sometimes, as among the larvæ of some butterflies, beetles and two-winged insects, the head can be wholly or nearly withdrawn within the first segment of the body.

Eyes.—The larvæ of many insects have no eyes; of such are the lamellicorn and capricorn beetles, and all those among the two-winged insects that have a membranous or variable head.

Those that are said to have simple eyes have one, two, or, perhaps, three on each side of the head. While, when there are groups or bunches of five, six or more on either side, we may call them compound eyes. The structure of these does not differ materially from those of the perfect insect, in connection with the study of which they will be considered more at length.

The *antennæ* are feelers or projecting filaments from the heads of insects or larvæ. Many are without them altogether, as the larvæ of most of the two-winged insects some of the beetles, the bees, wasps, etc., but the larvæ of the greater number of insects are provided with antennæ,

which in some, resemble the forms of those in the adult insect, while in others they widely vary.

The *mouth* of the larva, situated in the head, has to answer the purposes, not merely of gathering and chewing the food, but often of instruments of cutting and grasping, boring, digging in the ground, of spinning silk, and sometimes also of walking or dragging the body along.

Upper Lip (*Labrum*).—The mouth of nearly all the larvæ is provided with a distinct upper lip for grasping and holding the food while it is being chewed. It is in general a moveable transverse plate fastened behind, or posteriorly, to a part of the head called the nasus, and situated just above the upper jaws; some of the two-winged insects or diptera, however, are without this appendage.

Under Lip (*Labium*).—Between the two under jaws in most insects is a projecting fleshy organ called the *under lip*. This varies in shape, being in some conical, in others quadrangular, etc. In those larvæ which are able to spin silk, on each side of the point of the under lip is a little feeler, and between these a slender bag-like organ called the *spinneret*, out of which the larva draws the silken thread with which it weaves its cocoon when it is about to assume the pupa state.

One of the most remarkable prehensile instruments in the entire insect world may be seen in the under lip of the various species of dragon-fly (*Libellulina*). In other larvæ this part is usually small and inconspicuous, and aids merely in gathering and swallowing the food, but among these it is the largest organ of the mouth, and it serves both for seizing and retaining the prey by means of a pair of saw-edged jaws, into which it is divided. With

these they are able to capture and devour, not only other insects, but even tadpoles and little fishes.

Upper Jaws (*or Mandibulæ*).—These are varied in form according to the kind of food the larvæ are intended to live on, but are always hard and horny, and serve such purposes as cutting or grinding the food. Their form in all the caterpillars is that of two slightly concave, oblong, or triangular plates; the lower extremity being often of irregular form and of considerable thickness, and filled with powerful muscles which move them transversely from the sides of the mouth. The other extremities are divided into two or more teeth, and are made to work against each other, like a pair of pincers.

In the larvæ of the capricorn beetles, and other wood-boring species, they are shaped like half a cone, the inner sides of which, applying close to each other, form a powerful pair of grindstones, capable of grinding the hardest timber. In many, their jaws form a kind of piercing instrument and sucking tube; in some even they are used for the purposes of walking or dragging the body along. Some, however, as the common house-fly, have but one mandible, while a few others have no perceptible mandibles of any kind.

Under-Jaws (*Maxillæ*).—These are placed immediately under the upper jaws, are of a softer structure, and do not have any action upon each other; they are rather intended to assist in placing and keeping the food between the upper jaws—somewhat as is done by the tongue among the vertebrated animals.

Feelers (*Palpi*).—The palpi are little conical spine-shaped or jointed feelers, placed either on the under jaws

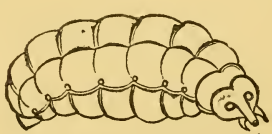
or *maxillæ*, hence called *maxillary palpi*, or situated on the *under-lip*, or *labium*, and called the *labial palpi*. In many families of the Dipterous and Hymenopterous insects, however, they are either entirely wanting or are quite rudimentary.

The Trunk and Abdomen are not distinguishable from each other, as they are among the perfect insects or Imago, or even indeed as they often are among the pupæ, but among the larvæ may be considered together. They are composed in general of twelve segments, excluding the head and the last or tail segment of the body.

The first three segments correspond to the trunk or thorax in the perfect insect, though they differ from the other rings of the body only in being shorter and in having the anterior six leg joined to them.

The Tail, or last segment, however, varies the most of any of the rings of the body. In many insects this tail ring is obtuse and rounded, while in many others again it is acute, truncate, or otherwise shaped. In some, also, it is simple and unarmed, while in others, again, it is beset with horns, spines, radii and tubercles of various forms.

Legs.—Of the larvæ that do not resemble the adult insect, we may say in general that those of the Coleoptera, Lepidaptera and Neuroptera have legs, and those of the Hymenoptera and Diptera have none.



Larva of Bee (without legs).

The legs of larvæ are of two kinds:

1. Horny and composed of joints; these we may consider as the legs proper, or the true legs. They are the chief instruments of locomotion, are always six in number, attached to the under side of the three first segments of the trunk, and consist usually of the same parts as those of the perfect insect.

2. Back of the true legs, along the body, many larvæ have little fleshy props, without joints; these may be called *proleys*; they serve chiefly as props and stays, by which the animal keeps its long body from trailing, or by which it takes hold of surfaces. They vary in form and number from one to as many as eighteen. They may be arranged in two principal groups:

1st. Those furnished with terminal claws; and

2d. Those without any terminal claws.

Spiracles.—The breathing organs of larvæ consist of tubes called spiracles that enter the body from the two sides of the rings or segments. As these are made on the same plan as those of the adult insect, we will omit them until we reach that part of our study.

Appendages.—While, on the average, larvæ have no other organs than those that have already been described, yet on several of them exist curious appendages, such as protuberances, horn-like processes, rays, retractile organs, and the like, which should be considered as extraneous appendages rather than as portions of the regular structure of the body, or of its clothing or covering, and so might demand a separate consideration.

We have thus given an outline of the entire anatomy or structure of larvæ, and, according to their structural features, we might group them on this plan:

GROUPING OF LARVÆ ACCORDING TO STRUCTURE.

- I. Larvæ without legs.
  - 1. With a corneous or horny head of determinate shape.
  - 2. With a membranaceous head of indeterminate shape.
- II. Larvæ with legs.
  - I. *With legs only*, with or without a terminal proleg:
    - 1. Joints short and conical.
    - 2. Joints long and subfiliform.
  - II. Prolegs only.
  - III. Both legs and prolegs.
    - Without claws.
    - With claws.

3. *Shape or Figure.*—From what has already been given in relation to the anatomical structure of larvæ, their general shape may be readily inferred to be cylindrical or vermiform, constructed into rings or segments, as if bound with a number of little bands or threads along the body. These rings are usually twelve in number (exclusive of head and terminal ring), and often, though not always, of a uniform length. The general outline or shape of the body, however, is extremely various, and a knowledge of these forms can be gotten only from the objects themselves, or from what is of next value, drawings of them.

4. *Clothing.*—Under this head might be considered the various kinds of covering with which the bodies of many of the larvæ are clad; some are quite smooth or naked, or furnished merely with little granular elevations regularly arranged along the body, but many are clothed with hairs or bristles of different kinds arranged in lines or clusters, or with spines or tubercles of various shapes. Sometimes these tubercles themselves are armed at their extremity with tufts of hairs or spines. These bristles, or hairs, furnish some of the most beautiful objects for the compound microscope. Some of them resemble wool or rows of little camel-hair pencils, others are feathered like the plumes of a bird, or resemble little rows of turquois beads surmounted with a black plume. Other hairs terminate in a club, or are flat and thickened at the apex. Some are rough, with little points or prickles, in circles or in spirals around them, while a few are composed of a series of little conical pieces placed end to end, and terminated with a point resembling the head of a pike, or with forked or star-shaped clusters. The outside skin or epidermis of the larva, through which these hairs or spines project, also furnish beautiful objects for the microscope. Some, however, clothe themselves with a viscid mucus covering, which they secrete in little glands between the rings, and thus fit themselves for the peculiarities of the life they are intended to lead.

5. *The Color of Larvæ* changes with the place they occupy and their age. Those that live in dark and gloomy places are of correspondingly sombre shades, while those that live in the bright sunlight are decorated with the greatest variety of tints and markings. These colors are sometimes of moment in distinguishing the

perfect insect. The shades of color also become more sombre just before the larva changes its skin, as again they become much brighter directly after, and in some even the markings of the skin are changed by the moultings.

6. *The Food of Larvæ* comprises almost the entire realm of organic matter. There is not a vegetable or animal product but some species of insect may be found to feed upon it. In fact, to *eat* is the great end and aim of the larva state. Some commence by eagerly devouring the egg shells from which they are hatched. Others, with great apparent relish, eat the skins they cast off from time to time. By far the greatest depredations committed by insects on the vegetable world and on manufactured fabrics is during their larval state. Every plant is inhabited by several species of larvæ, that consume its leaves and buds, stem, trunk, root and sap, and even the old timbers are devoured by several kinds. Others feed upon animal structures of every variety and in every state. Some larvæ, indeed, are hatched within the eggs or larvæ of other insects, and spend their lives preying on the various parts of their guest. Some live on the muscular tissues or skins of animals and others in the intestinal or other cavities of the body. Decaying flesh is eagerly devoured by many, and even such tough materials as hair, wool and feathers furnish food for many kinds.

The majority of larvæ derive all their moisture from the food they eat, no matter how dry it may be, and never drink any water. A few, however, have been seen to sip up drops of dew from the grasses and leaves on which they live.

Most larvæ gather their own food, but some, as those

of the hive and humble bee, wasp, ant, &c., are fed by the older members of the community, and for some the parent insect makes special provision by storing up a supply of food.

According to their times of feeding larvæ may be grouped into the Day-feeders, the Night-feeders, and those that feed at irregular intervals. The quantity of food consumed by the insect, while in the larval state, is immense, e. g., a caterpillar will devour daily, twice its own weight of leaves. This voracity is probably due to the circumstance that their stomachs are incapable of dissolving the food, but merely extract from it a juice. Carnivorous larvæ increase the most rapidly in proportion to the food consumed. Some of them have been known to increase their weight as much as two hundred fold in the course of twenty-four hours.

The methods of procuring the food among larvæ are various and interesting. Some browse upon the plants on which they were placed as eggs, while others have to seize their prey either by force or stratagem, as the larvæ of the ant-lion (Myrmeleon).

Larvæ shed their skins, or moult, several times, according to the species. For a day or more prior to each change the larva seems languid, refuses food, loses its beautiful colors, and seeks a retired place where it can undergo this important change in security. Here fastening itself by its legs or prolegs to the surface on which it stands, it twists and contorts the body until the skin splits along the back, and by continued contortions and motions it withdraws its whole body through this rent. The skin when cast, is often so entire, that it might be mistaken for the larva itself.

We are told that the grub of the beetle (*oryctes-nasicornis*) sheds not only its internal skin, but also the throat, and the inner lining of the large intestine, and the stomach, change their skins at the same time.

After each moult the larva appears weak and languid, and is covered with a liquid, while the entire body is extremely soft. A few hours' exposure to the air, however, gives tenseness to the membranes, and it soon begins devouring its food with a greater voracity than ever.

A few larvæ, however, such as those of the *musca* and *oustrus*, and also of the bees, wasps and ants, and probably many other *hymenoptera*, do not change their skin till they assume the pupa.

The size and growth of larvæ differ as widely as those of the perfect insect. The larvæ of some of the moths (*cossus-ligniperda*) attain a size at least 72,000 times heavier than when at first excluded from the egg. The stages of growth, however, except among those that do not shed their skin, is not by gradual and imperceptible degrees, as among other animals, but suddenly and at stated intervals. The body does not increase in size from day to day, but the parts become daily more tenso and compact, until the enveloping skin is no longer capable of containing them, when it is shed, and directly after the moult, the body rapidly increases, so that we are scarcely able to credit the possibility of its having been cased in so small an envelope, e. g., it has been estimated that the head of a silk worm that has recently cast its skin is about four times larger than before the change. This is partly due undoubtedly to the unfolding of the parts that before had been confined by the tenser covering.

The larvæ most remarkable for the rapidity of their

growth are those of the flesh flies, which become from one hundred and forty to two hundred times heavier in twenty-four hours, and hence their great efficiency in the removal of dead and decaying animal matter.

The age of the larvæ refers to the time that the insect spends in this state, which often includes the longest period of its life. We usually find that those larvæ that live on dead animals, on fungi, and on refuse material, spend the shortest time in this state, and those that live in the ground, on the roots of grasses and trees, and on wood, the longest. The former assume the pupa state in a few days or weeks, while the latter require many months, or even years, before they pass through the stages of the larva.

These differences evidently depend on their kinds of food and the purposes in the economy of nature they were intended to fill.

8. Preparation for assuming the pupa state.

Having attained their full size and laid up all the food for the construction of their parts, the larvæ prepare themselves for assuming the pupa state, by emptying the intestinal canal of not only its entire contents, but even of its lining membrane.

Their methods of disposal of themselves in preparation for this change might group them as follows:—

1. Those that remain in the substance they fed on.
2. Those that seek a hiding place or make a flocculent covering around themselves.
3. Those that suspend themselves by a silken cord. { Perpendicularly by the tail. / Horizontally by a silken girth around the middle.
4. Those that enclose themselves in cases or cocoons. { Formed chiefly or entirely of silk. / Formed chiefly of other substances.

CHAPTER IV.

THE PUPA.

The forms that the larvæ assume in preparing themselves for the pupa state have just been described. It merely remains for us now to arrange the pupæ according to their number and position of parts, and to consider their general structure.

The following arrangement might serve for their general consideration:

- 1. Pupa capable of eating and walking.
  - 1. Like the perfect insect except in the proportion and number of parts.
  - 2. With rudiments of the organs of flight.
    - With oral organs resembling those of the perfect insect.
    - With oral organs differing from those of the perfect insect.
- 2. Incapable of eating and walking.
  - 1. Incomplete pupa—body only partially incased, legs, tongue, &c., free.
  - 2. Obtected—body completely encased in a shell or skin, but *without* a cocoon.
  - 3 Coarctate—body incased, both in a shell or skin, *and in a cocoon* of silk, hair, &c.

We might study the general and structural features of larvæ under the following heads of *substance, figure* and *parts, color, age, sex, motions* and *extrication of the perfect insect.*

PUPA OF SPHINX MOTH.

Substance.—During the first stages of the pupa, it consists of a membraneous sack filled with a milky fluid, in which the forming membranes of the perfect insect float, and may be separated from each other by the point of a pin.

These parts, in time, fill up the larger portion of the case or puparium. In some pupæ this skin is smooth, in others it is covered with pimples and warts. While among some of the hawk-moths, it is covered with pits or depressions, or curiously shaped and even clothed with hair.

The figure and parts of incomplete pupæ, or those that resemble the perfect insect, are very various and nothing will be here said about them, but the complete pupæ or chrysalids are more uniform in their shape and parts, and the observance of them may be directed under the following plan :

Pupa of Papilio machaon.

1st. The Head Case, or *Cephalo-theca.*

2d. The Trunk Case, or *Cyto-theca.*

3d. The Abdomen Case, or *Gastro-theca.*

The Head Case is the armor or sheath of the head, and several portions of it may be recognized as the *antennæ* case, the tongue case, and eye case, etc.

The Trunk Case consists of two parts, the upper, or dorsal, and the lower, or pectoral. The dorsal portion comprises the thorax proper of the insect, and consists of three parts or segments, which take the names of the

similar parts in the perfect insect, *i. e.*, 1st, ring or segment, prothorax; 2d, ring mesothorax. and 3d, ring metathorax.

The lower or pectoral portion extends from the head to the middle segment of the abdomen, and to it are attached the wing cases and leg cases, which, with those of the antennæ and tongue, form what may be called the breast of the pupa.

The abdomen case, when viewed on the back, consists of *nine* segments, and of only six when viewed below, although these numbers are by no means invariable.

Pupa of Vanessa vertical.

The figure of pupa presents two great varieties: 1st, those that have no projections, or angular prominences, from the body, and 2d, those that have. These we might distinguish by the general term of *angular pupæ* and *conical pupæ*.

These differences in form of the pupæ are pretty sure criteria by which to determine the division to which the perfect insect will belong when disclosed.

The shape of most larvæ is cylindrical or conical, and the organs of the perfect insect, as they are formed, are arranged in a close and compact place. The tongue is, however, sometimes curved from the body and gives the appearance of a pitcher handle.

The colors of the pupae are either white or whitish-brown, though usually the various shades approach

black and red. But some are quite delicately tinted and marked, or shine as if gilded with burnished gold. It was from this gilded appearance that the terms Chrysalis and Aurelia were applied to the whole, since the alchemists mistook this for real gold. Some others have the lustre of real silver and are beautifully marked and spotted.

They are nearly all of a little different color when they first assume the pupa from what they soon after assume.

The duration of an insect's existence in the pupa state varies from two or three days to as many weeks, months or even years.

As a general rule the small pupæ continue their state a shorter time than the large pupæ.

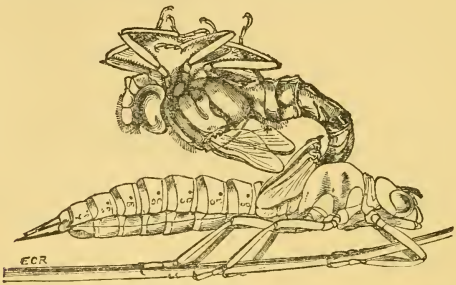
The temperature they are exposed to also has much influence, as those exposed to an uniform and higher degree of heat more rapidly pass into the perfect states and it can also be greatly retarded by being placed in a low temperature.

But some pupæ have a periodic time for passing into the perfect state, quite independent of the circumstances of temperature. Such, for example, are the Ephemeræ, which, in the proper season of the year, mature at between eight and ten in the evening, regardless of cold or rain, and certain species of silk worm and hawkmoths, which break forth from the pupa at sunrise.

The sex of the pupæ may be distinguished chiefly by the male being smaller than the female, and often by the evident organs of oviposition of the female doubled up on the abdomen, as the tongue sometimes is on the thorax.

Incomplete pupæ often continue their powers of motion

through the entire state, effected by the movement of the abdominal segments solely, but coarctate pupæ, or chrysalids, are incapable of even the slighest motion, and exhibit no symptoms whatever of animation.

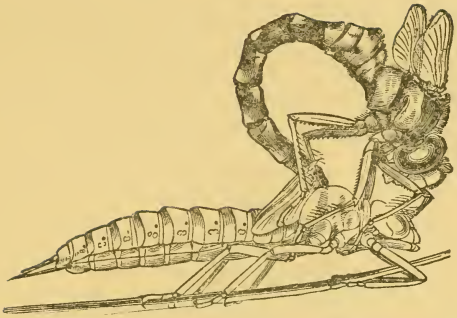


We would next consider the extrication of the perfect insect from the pupa case, or the puparium, and from the cocoon.

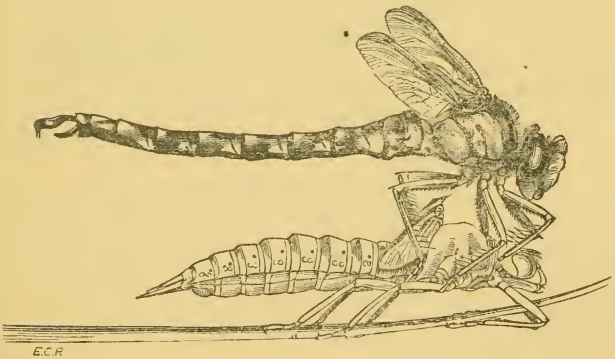
This may be considered under two heads, viz: 1st, The state or condition of the pupa when about to moult, and 2d, The means by which the insect frees itself from the pupa case and from the cocoon.

At the period of change the color of the pupa is apt to become more dull and transparent, often to such a degree that the motions of the insect within may be distinguished.

While the pupa case, however, loses its brilliancy, the beauties of the insect within become more apparent.



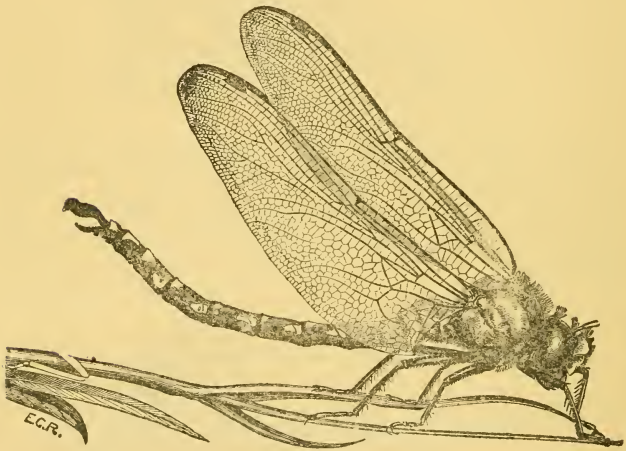
There are various methods in which the insect liberates itself from the pupa case, as graphic an example of which as any, however, is the liberation of the dragon fly (*Libellula*) from its case, as illustrated in the accompanying engravings.



When first liberated from the case the insect is moist and pale, and its organs weak and undeveloped. Its wings, in particular, are very small, and resemble little bits of leather, but exposure to the air for an hour or two, or even less, will entirely change its character: its wings

will rapidly expand and take their due proportions, its limbs become tense, and its body assumes the tints and shades of the adult insect, and it flies or hops away to lead a life entirely different in all points from its earlier stages of existence, as the perfect insect or

THE IMAGO.



Libellula quadrimaculata.

CHAPTER V.

STRUCTURE OF ADULT INSECTS.—THE IMAGO.

We have thus far traced the appearance and progress of the immature insect through its various stages of Egg, Larva and Pupa; but it is in the *Adult Insect* or *Imago*, to which we are now to turn our attention, that we find some of the most compact and beautiful mechanical structures of the entire animal kingdom. The earlier stages were each preparatory for this adult condition, and thus we find in the Imago the most definite as well as beautiful arrangement of parts.

For convenience, we will adopt the plan of considering first, the *External Anatomy;* and second, the *Internal Anatomy* of the Imago.

EXTERNAL STRUCTURE OF THE IMAGO.

The *External Anatomy* refers to the arrangement of the apparent parts of the body in relation to each other, and may be more readily used in the ordinary *observation* and *classification* of Insects; while the *Internal Anatomy* treats of the muscles, nerves, arteries, veins, spiracles, digestive organs, &c., and often requires much labor and microscopes of high power for its investigation.

In the external anatomy of the adult insect there are two general points of structure that may be considered as *primary.*

1st. *That the body is composed of rings;* and

2d. *That these rings are gathered into three portions or segments, called,* 1, *Head;* 2, *Thorax;* 3, *Abdomen,* and all the special parts of the body, as mouth, eyes, antennæ, legs, wings, ovipositors, &c., are arranged according to the work they have to do, on one or the other of these three parts.

STYLOPIZED ANDRENA.

The entire body is covered with a skin or crust, that in some resembles horn or shell, and in others leather, parchment, or even thin membrane.

This rind or covering is not the same in composition to the hair, skin, nails or shell of the higher animals, and it seems to concentrate within itself all the active principles of the plants the insect feeds upon.

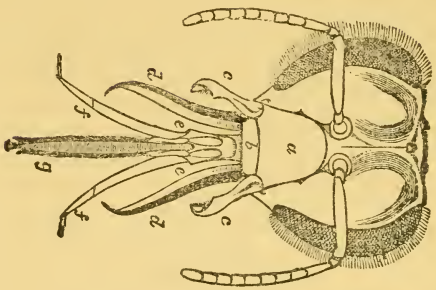
It is developed into a variety of forms on the same insect, e. g., into skin, hair, scales, shell, ring membranes, &c., according to the part of the body on which it is found.

In the abdomen, and sometimes in the thorax, the rings of the body are separated from each other by a thin skin or membrane, but in the head, and also at times in the thorax, they are merged together.

The arrangement of parts of the exterior of the body may be considered according to the accompanying table:

EXTERNAL ANATOMY OF THE IMAGO.

- **Head.**
  - Os or Mouth.
    - Labrum—upper lip.
    - Labium—lower lip.
    - Labial and other palpi or feelers.
    - Mandibles—upper jaws.
    - Maxillæ—under jaws.
    - Lingua—tongue.
    - Pharynx.
  - Facies or Face.
    - Nasus—nose.
    - Postnasus, or after nose.
    - Frons—forehead.
    - Occiput—hind head.
    - Genæ—cheeks.
    - Tempora—temples.
    - Oculi—eyes.
    - Antennæ—feelers.
  - Subfaces, or under Face
    - Collum—neck.
    - Jugulum—throat.
- **Thorax.**
  - Prothorax
    - Shield or upper part.
      - Apex.
      - Base.
      - Sides.
      - Limbs.
      - Disk.
    - 1st ring of thorax.
      - Ora, or under part.
  - Mesathorax—2d ring of thorax.
    - Legs.
      - Coxa.
      - Trochanter.
      - Femur.
      - Tibia
      - Tarsus.
    - Wings.
      - Articulation.
      - Nervures.
      - Membrane.
      - Margin.
      - Clothing.
  - Metathorax—3d ring of thorax.
- **Abdomen.**
  - Tergum or Back.
    - Articulation and Clothing.
  - Venter, or under part, and Sides.
    - Spiracles, or breathing organs.
  - Cauda, tail part—Ovipositors.



FACE OF NEUTER HIVE-BEE, MAGNIFIED.

a, clypeus ; *b*, labrum ; *c*, mandibles ; *d*, maxillae ; *e*, labium ; *f*, labial palpi ; *g*, lingula of the labium.

CHAPTER VI.

THE HEAD.

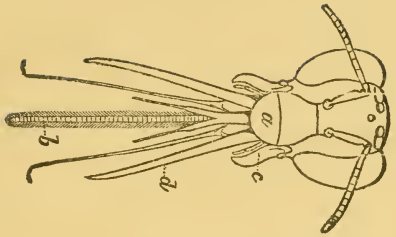
The Head is generally horny and round, and may be studied as a whole in relation to its *substance*, *figure*, *composition*, *articulation*, with the trunk *motions*, and *especially* as to its *parts* and *appendages*.

We would consider the external anatomy of the head under these three divisions, *i. e.:*

1. Os, or mouth.

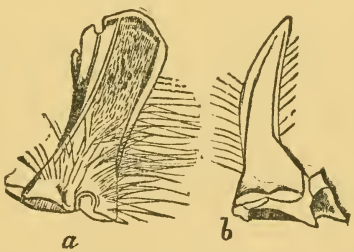
2. Facies, or face—all the frontal and upper part of the head; and

3. Sub-facies, including the under part of the head and the neck.



HEAD OF THE BEE.

THE OS, OR MOUTH, of the insect is provided with seven ordinary organs, differently modified in the two great divisions of *masticators*, or chewing insects, and *suckers*, or sucking insects. These are, 1st, the upper lip (labrum); 2d, the lower lip (labium); 3d, labial and other palpi, or feelers; 4th, the upper jaws (mandibles); 5th, under jaws (maxillae); 6th, the tongue (lingua); and, 7th, the pharynx.

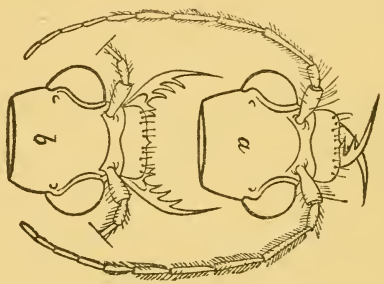


a, Jaw of Bombus—nest digging bee.
b, do. Nomada—parasite bee.

1st. The labrum, or upper lip, is a movable organ, fastened to the upper part of the mouth and placed between the two mandables, or upper jaws.

2d. The *labium, or under lip*, is fastened to the under part of the mouth and is placed between the two maxillæ, or *under jaws*.

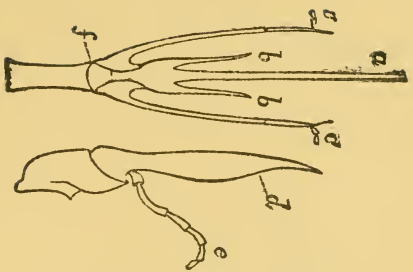
3d. The *labial palpi, or feelers*, are jointed filaments, placed one on each side of the labium.



HEAD AND JAWS OF THE TIGER-BEETLE.

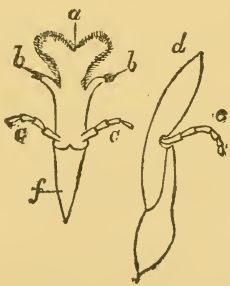
4th. The mandibulæ, or upper jaws, are a pair of horizontally moving organs placed under the labium, generally horny or corneous, and used for chewing; to these are often attached prominent points, which may be considered as teeth, since they discharge the functions of chewing and prehension.

5. The maxillæ or under jaws, are two organs moving underneath the upper jaws hinged on either side with the base of the labium and usually parallel with it; their chief use in the chewing insect appears to be the holding of the food, while being chewed, by the upper jaws; to them are attached the maxillary palpi, or feelers



TONGUE OF THE APIDÆ (A FAMILY OF THE BEES).

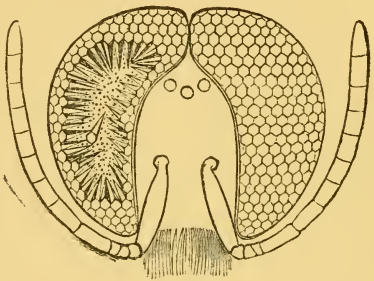
6. The lingua, or tongue, among insects, comprises quite a variety of forms, according to the way in which it is intended to serve as an instrument for gathering food. It is placed underneath the labium, and is sometimes an organ for sucking up liquid food; at others a lancet, or a set of tools, for gathering honey from flowers or the liquids of animals, as the case may be.



TONGUE OF THE SOLITARY BEE.

7. The pharynx, as among the higher animals, is the portion directly back of the mouth, the part where all the openings from the organs of sense combine.

FACIES or FACE, comprises the parts that are included between the prothorax and the labium or the upper surface of the head. It comprises what may be spoken of as the *nasus post-nasus, frons vertex occiput, genæ tempera oculi* and *antennæ.* Only two of these can claim attention in this outline, *i. e.*, the *oculi*, or eyes, and the *antennæ.*



EYES OF HIVE BEE (MALE).

The eyes of the adult insect are formed on the most interesting and wonderful plan. They are of three descriptions:

Simple, conglomerate, and compound.

1. *Simple eyes* may be observed in relation to their *number, structure, shape, color, magnitude, situation* and *arrangement.*

As to their number, they vary from two to sixteen. In the flea, the louse, the harvest-men (Phalangium,) there are only two, but in such as the bird-louse of the goose and some others, there are four; while such as the spiders and scorpions have eight, and some even as many as sixteen.

Their structure resembles that of a lens of a compound eye,and will be given in that connection.

Their color is usually black and shining, though many have the centre beautifully marked with red, sapphire, or crystal.

Where there are more than two they vary in magnitude and in shape.

The situation and arrangement of simple eyes may be readily studied with an ordinary magnifying glass, on the head of any insect, and it cannot be too strongly and repeatedly urged on the learner that these details be observed in the specimens themselves, and not merely taken and remembered from books.

Conglomerate eyes differ in nothing from simple eyes except that instead of being dispersed they are collected into a body, so as at first sight to resemble the appearance of a compound eye.

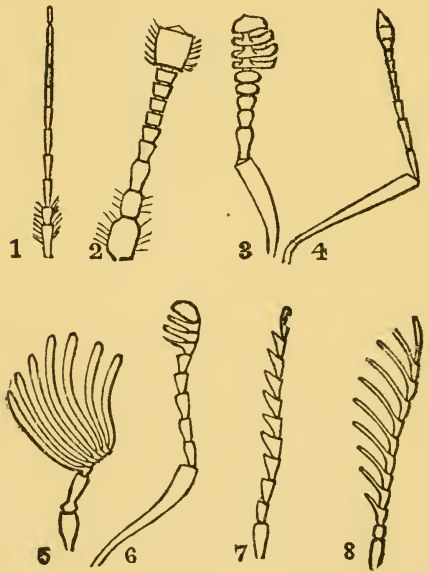
Compound eyes are the most usual form in the adult insect. They also may be observed in relation to their *structure*, *number*, *situation*, *figure*, *clothing*, *color* and *size*.

The compound eye, when seen under the miscroscope, displays a great number of convex, six-sided pieces; each of these is a distinct lens and has on the inner side of it a cone-shaped retina at the very point or apex of which alone is the optic nerve, or nerve of sight. These cones are often beautifully colored and placed side by side as the lobes of a section of an orange.

The number of these lenses varies from about 50 to over 30,000.

Hooke computed those in the eye of a horse-fly to amount to nearly 7,000; Leeuwencock found more than 12,000 in that of a dragon-fly; and 17,325 have been counted in that of a butterfly, and, according to

Geoffroy, in some butterflies there are no fewer than 34,650. And we are informed still further by other writers that in some beetles these lenses are smaller and even more numerous. The remaining points of study in relation to the eyes of insects will have to be left for the investigation of the student.



ANTENNÆ.

1. Filiform.
2. Capitate.
3. Perfoliate Club.
4. Geniculate.
5. Lamellate.
6. Fissate Club.
7. Serrate.
8. Pectinate.

The Antennæ appear to be among the most important of all the organs of the adult insect, and of a great variety of forms and uses.

They are filaments or feelers attached to the upper part of the head which not only aid and guide the insect in its motions, but which also probably serve as the organs of several of the special senses, as feeling, hearing, and smell.

They may be observed in relation to their *number*, insertion *substance*, *situation*, *proportion*, *general form and structure*, *clothing*, *expansion*, *motions*, *and state of repose*, *and uses or functions.*

Insects invariably have but two antennæ, while some of the lower articulates, as the Crustaceans, have four.

With the aid of an ordinary magnifying glass—or even indeed, in most insects, without any such assistance, the student may observe the details mentioned above, such as form, structure, clothing, or covering, &c., with a great degree of interest; and so this outline will be cumbered only with a few general hints.

As to structure, antennæ consist in general of a number of tubular joints, each being capable of an independant motion, and thus the insect is able to bend them in every direction that may be required.

Antennæ, as to form, may also be regarded as *tactile*, or those intended to explore the way of the insect by means of touch; and *non-tactile*—the short, thick antennæ, the last joint of which terminates in a bristle, or is furnished with a lateral one, and which do not guide the insect by the sense of touch.

The parts of an antenna may next be observed, as follows:

a. The *Torulus*—the orifice or depression in the head of the insect that receives the antenna.

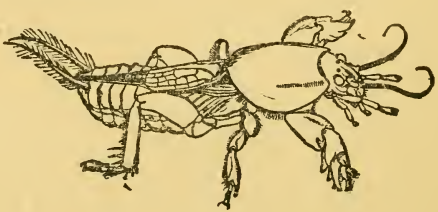
b. The *Scape*, or first joint; the base of this is called the *bulb*, and is inserted in the torulus.

c. The *Pedicellus* is the second joint, and is often the least conspicuous joint of the antenna; it is a hinge or pivot on which the upper members turn.

d. The *Clavola* are the remaining joints of the antenna taken together; they form the greatest part of it, and at the extremity of the last joint exercise the functions of touch, &c.

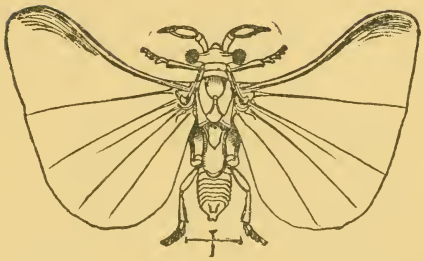
By the term clothing of antennæ, is indicated the down or hairs of various kinds with which they are generally covered.

The *Subfacies* demand but a moment's attention. Under this term may be included, 1st, the *collum* or neck, or at least the joint by which the head is joined to the thorax; and 2d, the *jugulum*, or throat, placed between the cheeks.



OUTLINE OF MOLE CRICKET.

CHAPTER VII.



STYLOPS ATERRIMA.

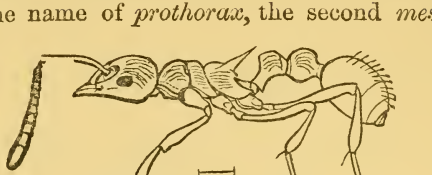
THE THORAX OR TRUNK.

The thorax of the insect is the centre of motion, and the main support and prop of the two other primary sections of the body, of which the *head* is the principal seat of the organs of sensation, and the *abdomen* of digestion, respiration and generation.

It may be observed in relation to its *substance, general form, proportions, composition or parts, internal anatomy and members*, and of these it will be spoken of here only in relation to its *composition* or *parts*, and *members*, *i.e.* wings and *legs*—its internal anatomy furnishing a subject for distinct consideration, and its substance, form and proportions are points that may be readily observed by the student without any assistance.

Composition or Parts.—The thorax is composed of

three primary rings, the first, or the one next the head having the name of *prothorax*, the second *mesothorax*,



MYRMICO, ONE OF THE SOCIAL ANTS.

and the third *metathorax;* in most insects, however, there are apparent but two segments, the *prothorax* constituting the first and the *mesothorax* and *metathorax* the second; to the former are attached the first pair of legs, often denominated the arms, and to the latter the remaining two pairs of legs, or legs proper, and the one or two pairs of wings.

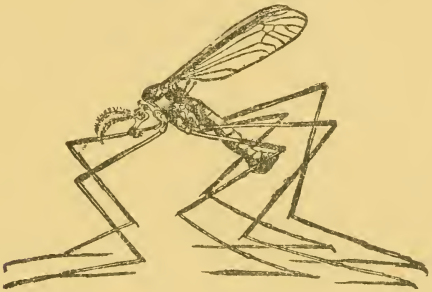
Each of these three sections might be considered in relation to a number of special parts, but we will designate only those of the prothorax, and then proceed to a consideration of their appendages, the *legs* and *wings.*

The *prothorax* consist commonly of two pieces; the *shield* or upper part, and the *ora* or under part, a continuation of the shield under the body. The shield has several plates or portions termed the *apex*, the part next the head, the base, that next the abdomen, the *border or limb*, and the *disk* or *central part.*

Omitting the details of the second and third rings of the thorax (mesothorax and metathorax), we are next to consider the special organs of motion attached to it, *i. e.*, the *legs and wings.*

The legs of insects are among the most conspicuous

and easily studied portions of the body. They may be observed in relation to their *number*, kind, substance, *articulation* with the *trunk*, *position*, *proportions*, *clothing or covering*, *composition or parts*, *and motions*.



TIPULA-OLERACEA—DADDY LONGLEGS.

The number of legs in insects is invariably six, though the first or anterior pair in several of the butterflies are merely folded over the breast as a tippet, and are not used for locomotion.

The different *kinds* of legs of insects may be observed with great interest, for thus we may determine much relative to their habits and homes, and methods of procuring food, when we cannot see them in the activity of real life. With reference to these requirements, they may be observed as *walking*, *running*, *climbing*, *leaping* and *swimming* legs.

CHALCIS-CLAVIPES.

The legs of insects are constructed on the opposite plan from that of vertebrates. Instead of consisting, as the arms or legs of the quadrupeds or the human system, of a central bone or hard substance for a lever, with the muscles as cords, and their attendant organs wrapped around it, each joint is a tube, and serves as the bone or skeleton of the limb, and includes within it the moving muscles, nerves and other special organs.

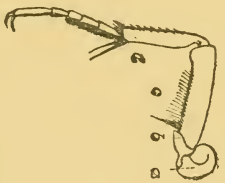
HIND LEG OF BEES.

a, coxa ; *b*, trochanter ; *c*, femur ; *d*, tibia ; *g*, tarsus.

The legs of insects generally consist of five pieces; the coxa or hip—the trochanter—the femur, or thigh—the tibia, or shank—the tarsus, or foot. These parts are not, however, the same in structure with those that bear

the same names among the vertebrates, but merely resemble them in position and functions; they may hence be said to be *analogous* with them, but not *homologous*.

Of these parts the tarsus alone is composed of several pieces or joints, which vary in number. The most universal number of joints is five, and such insects are termed *pentamerous*. In some the number of joints varies in the different pairs of legs, and such are termed heteromerous; others again have four joints—tetramerous; three joints, trimerous; two joints; dimerous; one joint, monomerous; or more than five joints, polymerous.



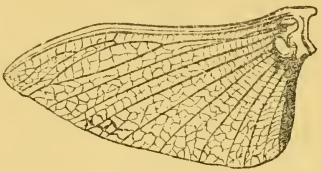
PENTAMEROUS, OR FIVE-JOINTED TARSUS.

The terminal or last joint of the tarsus is armed ithw claws, hooks, sponge or suction desk, according to the character of the surface the insect was designed to walk upon.

The remaining details in relation to the legs of insects which have here merely been hinted at, may be readily observed with the aid of a hand magnifying glass, an instrument that should always be the companion of every observer of Nature.

GNAT (CULIX PIPIENS).

We will next turn to a brief consideration of the second set of locomotive organs of insects, *i.e.*, *the wings.*



WINGS OF GRASSHOPPER (ACRIDA VIRIDISSIMA).

These organs are wholly different in their structure and derivation from the wings of birds, but merely resemble them in appearance and functions; hence we say that the wings of insects and birds are *not homologous*, but are merely *analogous.* The wings of insects, however, are derived from organs termed spiracles, with which the insect breathes, although they widely differ from them in functions and appearance; hence, also, we may say that the wings of insects are homologous with their spiracles, though not analogous with them.

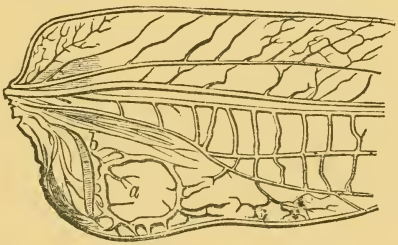
We may observe the wings of insects in relation to their *number*, *kinds*, and *composition.*

1 *Number.*—Most insects have four wings, but in almost every order, instances occur of insects that have solely a single pair, or even none at all. The latter kind, (those without wings), were formerly ranked in a distinct sub-order by themselves, termed "*aptera*," but this is merely an artificial sub-order, and its members belong to the several natural sub-orders we shall hereafter mention.

II *Kinds.*—Under this head we may consider the wings of insects in relation to their *situation* and their *substance.*

The first pair are usually attached to the *mesothorax*, and the second to the metathorax. According to their *substance*, they are termed *clytra*, *tegmina*, *hemelytra*, and *wings*.

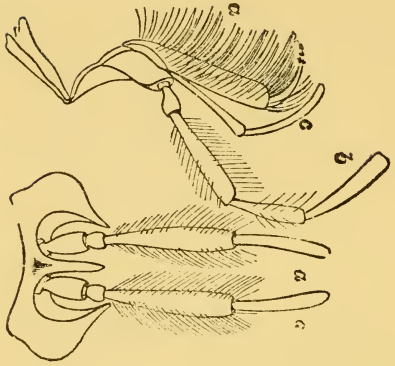
The first three of these words, *i. e.*, *clytra*, *tegmina* and *hemelytra*, are used to designate the first or forward pair of wings, when they are developed as *wing-covers*, as cases or organs of protection for the second pair which is such, are exclusively used as organs of flight.



BASE OF UNDER SIDE OF WING CASE OF GREEN GRASSHOPPER BY WHICH THE SOUND IS PRODUCED, (ACRIDA VIRIDISSIMA).

The clytra are such as the hard and often beautifully marked wing covers of the beetles or coleoptera.

By the term *tegmina* are designated the straight, shield-like wing covers of such insects as the grasshoppers, locusts, katy-dids, and the like.

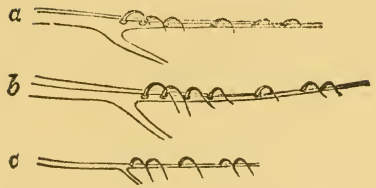


The hemelytra are the wing covers of such insects as we ordinarily denominate bugs; they are half horny and half membranous.

While these three are merely wing-covers, those delicate membranous organs that serve exclusively the purposes of flight, may alone properly be called wings. We will for a moment turn our attention to the composition or structure of these.

The wings of insects, as we have intimated before, consist of the breathing tubes, everted from the body, and covered over with a thin membrane, which in some kinds is plain, and in others decked with hairs, scales, hooks, &c.

The larger of these tubes are called the *veins*, and their branches the *veinlets*, or often they are termed the *lines* of *neuration*, or *nervures*.

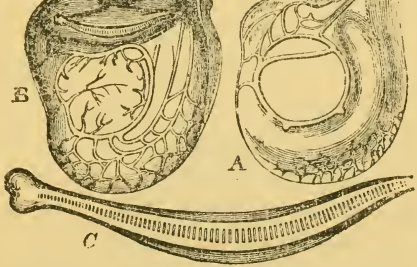


HOOKS ON THE BORDERS OF THE WINGS OF INSECTS (SPHECODES).

The spaces between the veins and veinlets are called *cells*.

The number and situation of these veins and their branches are of great importance in determining genera and species.

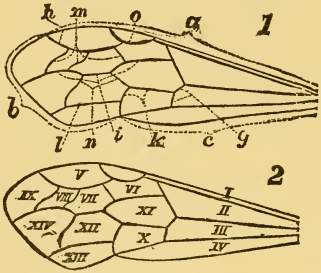
Many insects have their wings divided into three parts by the arrangement of these veins, *i. e.*, the costal, or upper edge of the wing; the *median*, the lower and central part of the wing— the largest of the three, and, in the grasshopper and cricket, sometimes modified to form a musical organ; and the internal area, which is placed between the other two, and is the smallest, and least distinctly marked of the three.



MUSICAL INSTRUMENT OF THE GRASSHOPPER (ACRIDA).

A, upper surface of right wing case; B, under surface of left wing case; C, file, more highly magnified.

To designate the manner in which these cells and nervures, or veins and veinlets, are often designated, we append the following diagram:



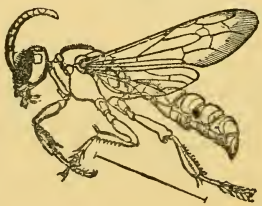
WINGS OF THE BEE.

1. NERVURES.—*a*, costal ; *d*, post-costal ; *c*, externo-medial ; *f*, anal ; *g*, *m*, transverso-medial ; *h*, radial ; *i*, cubital ; *k*, discoidal ; *l*, sub-discoidal ; *n*, recurrent ; *b*, apical ; *e*, postero margin ; *o*, *stigma*.

2. CELLS.—I, costal ; II, externo-medial ; III, interno-medial ; IV, anal ; V, marginal ; VI, 1st ; VII, 2d ; VIII, 3d ; IX, 4th sub-marginal ; X, 1st ; XI, 2d ; XII 3d discoidal ; X, 1st ; X, 2d, apical

CHAPTER VIII.

ABDOMEN.



CERCERIS ARENANA.

The abdomen of the insect, to which we next turn our attention, is the third great section of the body, and the seat of the organs of respiration and generation, and most of those of digestion. It consists of a series of rings usually without any appendages, though they exist in some species, as the external organs of generation, or as filiments, &c., attached to the extremity of the body. The typical number of these rings is eleven, and they are connected together with an elastic tissue, or membrane, which permits them to move one upon the other as joints; this number cannot, however, be counted in all insects for two or three of them are often joined together, or modified, as special organs, as stings, ovipositors, &c.

The abdomen may be observed in relation to its *substance*, *articulation*, with the trunk, *composition*, *shape*, *clothing*, and appendages, or *special organs*; of each of these points we will say a few words.

I. *Substance.*—In this connection the observer may notice the degree of hardness, firmness, or flexibility of the rings of the abdomen. When the body is covered by hard elytra, as among the beetles, the upper part is softer than the under or ventral portion; but in the open ringed insects the opposite is the case.

II. *Articulation with the Trunk.*—There are two ways in which this is effected: The first, where the entire width of the abdomen is attached directly to the trunk; and the second, where the abdomen and trunk are connected by a more constricted, and often a very slender and even thread-like waist; such is the case with many of the ichneumen flies.

III. *Composition, or Structure.*—Each ring of the abdomen is composed of several pieces, or segments, of which, though many are spoken of in technical works, it will suffice our purpose to mention but four, *i. e.*, the *dorsal*, *ventral*, and *right and left lateral.*

IV. *Shape.*—The abdomen is usually triangular with the point more or less obtuse, though there are many special forms varying from a simple spherical or ovoidal figure, to the most curious shapes, a description of which can scarcely be given in word, but which may be readily observed in the many specimens that in summer gratuitously offer themselves for our inspection. The Sub-Order of Hymenoptera furnish the greatest variety of these.

V. The *clothing*, or covering of the abdomen, is also especially adapted to the habitat and modes of life of the insect, whether in the form of horny plates, membrane. hair, etc.

VI. *Appendages, or Special Organs.*—There are two sets in particular that demand our attention, *i.e*, *Organs of Respiration* and *Organs of Oviposition*, including stings and a variety of instrument.

As the special organs of *respiration* will again be adverted to in connection with the *internal* anatomy of the insect we will here merely mention the pair of round eye-like disks that appear on the lateral segments of each abdominal ring—these are the *stomata*, or the exterior openings of the spiracles, or breathing tubes, through which the insect breathes.

The *Ovipositors*, or *Organs of Oviposition*, assume a great variety of forms and functions. They sometimes consist of a simple perforating tube, for the making

a place for the egg, but in others of a set of carpenter's tools, as it were, for boring and filing, and sawing and cutting; some of these boring tubes being, indeed, three or four times the entire length of the body, and with these they are able to drill into the most solid wood often to the depth of three or four inches, and there deposit the egg in the body of the larva of some other insect, or even within some other egg. Some of these organs are fashioned as shovels or spades for digging in the earth, others as scissors for cutting filaments of leaves, or as stings endowed often with a powerful, acrid poison, as many of us may have experienced from the bee, wasp, or hornet.

In this connection a great deal might be said in relation to the *architecture of the nests of insects*, as that of the honey comb, paper wasps' and mud wasps' nests, dwellings of the carpenter bee, ant hills that we may examine in almost any forest, the gigantic structures of the white ant or termites, and many other forms that would furnish of themselves a world of wonder and interest; but we will be obliged, with this bare outline, to close our remarks relative to the *external anatomy of the Imago*, and ay a few words in relation to its *internal anatomy.*

OVIPOSITOR OF CICADA.

CHAPTER IX.

INTERNAL ANATOMY OF THE IMAGO.

Our apology for not proposing to speak more at length in this connection, of the internal anatomy of the insect, is that this outline is especially intended as a guide to the *object study of the insect itself*, as we may observe it, without the aid of a dissecting knife, in Nature about us.

This department, however, arranges itself under the heads of the *generative*, *digestive*, *respiratory*, *circulatory*, *muscular or motive*, and *sensitive* and *nervous* systems.

Of the *generation* or *development* of the insect we have already spoken quite at length, under the heads of egg larvæ and pupæ, and the structure of the organs of oviposition.

The *digestive organs* consist of a long tube of different sizes, termed the alimentary canal; the several parts of it are the pharynx and mouth, the œsophagus, the craw, the gizzard, the stomach and the intestines; there are also biliary tubes, salivary glands and other special organs.

Respiration.—Insects breathe by means of two great tubes that extend along the sides of the body and give out to each abdominal ring two branches called spiracles, and these, through the stomata or breathing mouths at the sides of each ring, inhale and exhale the air.

From these tracheæ also pass out many little tubes that enter into all parts of the body, even between the muscles, and so aerate or rather oxygenate the blood.

The circulatory system is extremely simple. It consists chiefly of a long tube called the heart, with contracting valves that extend along the body directly under the back. This tube conveys the blood to the forward part of the body, and thence, as a cold, transparent and nearly colorless fluid, it circulates through the body and bathes the entire muscular and respiratory systems.

The only peculiarity in the *muscular* system to which we would here call attention is that instead of being attached, as is the case among the vertibates to an internal skeleton, the muscles are fastened to an external crust or skeleton.

The muscular power of insects is enormous and vastly superior to that of the higher animals in proportion to their bulk.

The *nervous system* of insects consists of two cords running the entire length of the body, each with a nerve bunch or ganglion for every ring of the body, thus making as many pairs of ganglia as there are elemental rings, and from these nerve threads pass out to the various parts of the muscular system, limbs, organs of sense, &c.

The ganglia of the head are joined together, giving the appearance of a brain, and so also, in a measure, are those of the thorax. We have already spoken in an earlier part of this outline of the *organs of sense.*

These few remarks barely mention the several systems of the internal structure of the insect, but they are all our plan will here permit of.

We have thus reviewed the two first departments of the study of the insect, *i. e.*, Life or history (as in the egg, larvæ and pupa), and the structure, external and internal of the perfect insect or the *Imago.* All that

we can here present in relation to the third department, or that of classification, is the character of each of the seven sub-orders, and a table of its subdivisions into families, and sometimes also, its genera.

Having progressed so far in the general observation of the life and appearance of an insect, the student is now prepared to study the relations and names that have been assigned to it by its first describers, on account of its resemblances to and differences from other insects in these details of structure.

This study is called the Classification of Insects, or *Systematic Entomology.*

CHAPTER X.

CLASSIFICATION.

We have found at the beginning of our study of this department, that the insects belong, from certain peculiarities of their structure, to the Type of Articulates, Class of Insectians, and Order of Hexapods or Insects.

They are still farther arranged in seven sub-orders or groups according to *three* peculiarities of their configuration, *i. e.*:

1st. The character of their transformations through the successive stages of egg, larva and pupa.

2d. The formation of the mouth parts in the imago, and

3d. The character and formation of the wings. This peculiarity has given the name to each sub-order.

Thus, the first of these three distinguishing peculiarities, that of its transformations, refers to the *incomplete* condition of the insect; and the second and third, those of the mouth part and wings, to the *complete* or imago condition.

The names of these seven sub-orders are as follows:

1. COLEOPTERA, from (κολεος-Koleos, a sheath; and πτερὸν-pteron, sheath-winged, a wing,) including beetles.

2d. ORTHOPTERA, (ορθὸς-orthos straight and pteron) straight-winged, grasshoppers, locusts, katydids, cockroaches, &c.

3d. NEUROPTERA, (*νευρον*-neuron, a nerve, &c., nerve or lace-winged,) such as dragon flies, lace-winged flies, and white ants, &c.

4. HYMENOPTERA (*ὑμην*-hymen, a membrane, membraneous-winged), such as bees, wasps, ants, ichennon flies, &c.

5. LEPIDOPTERA, (*Λεπὶς*-lepis, a scale, scaly-winged,) butterflies, moths and hawk moths.

6. HEMIPTERA—(*Ἡεμι*-hemi-half, half, half or irregular winged), bugs, aphidæ or plant lice, etc.

7. DIPTERA—(*Δὶς*-dis, two, two-winged), flies, gnats, mosquitoes, etc.

These sub-orders might be distinguished from their *wing structure alone*, as arranged in the following table:

- Wings
  - 4
    - The anterior as wing covers
      - Horny, with a straight suture and a little triangular piece near the thorax (cuttle) = *Coleoptera.*
      - Oblong, thickly veined without scuttle = *Orthoptera.*
      - Semicrustaceous incumbent = *Hemiptera.*
    - All
      - Covered with scales = *Lepidoptera*
      - Membranous, abdomen (unarmed = *Newroptera.*
      - With a ovipositor = *Hymenoptera.*
  - 2 With a pair of knobs or balancers in place of the posterior pair = *Diptera.*

The following is a synopsis of these seven sub-orders as distinguished by the three peculiarities of—1st, Wing structure; 2d, Mouth parts; and 3d, Transformation; and the names of the most important families of each.

The colored plates and their descriptions are for the purpose of giving to the eye the appearance of each of

the sub-orders, and not to illustrate the families or genera.

DESCRIPTION OF COLEOPTERA.

1. COLEOPTERA.

1st.—*Wing structure:* Have four wings, of which the anterior or first pair are hard like horn or leather, forming a pair of sheathes called *elytra*, which, when the insect is at rest, are joined in a line down the back.

The posterior, or second pair of wings, are the true organs of flight; they are membranous, and when unemployed are folded longitudinally and transversely, and protected by the elytra.

2d.—*Mouth parts:* Mouth made for chewing, with transversely moveable jaws.

3d.—*Transformations* or *Metamorphoses:* Larvæ active, resembling short thick worms, with three pairs of short legs attached to the first three segments.

Pupa incomplete.

FAMILIES OF COLEOPTERA.

Some of the families of the *Coleoptera* are the following:

Caribidæ or (ground beetles).

Cicendelidæ (tiger beetles).

Dytiscidæ (diving beetles).

Gyrinidæ (whirligigs)

Hydrophilidæ (water beetles).

Silphidæ (carrion or sexton beetles).

Staphylinidæ (the rove beetles).

Parnidæ (aquatic stone beetles).

Scaribidæ or Lamellicornia (horned beetle).

Elateridæ (spring back or snapping beetle).

Lampyridæ (fire flies).

Cleridæ (flower beetles).

Meloidæ—Stylopidæ

Curculionidæ (weevil family).

Scolytidæ (bark borers) crambycidae.

Longicornia (wood borers).

Chrysomelidae (leaf beetles) or "potato bugs."

Coccinelidae.

DESCRIPTION OF ORTHOPTERA.

ORTHOPTERA.

1st.— *Wing structure:* Anterior wings, as a pair of long and narrow sheaths (tegmina), thickly veined and overlapping at the tips.

Posterior or second pair of wings, large and thickly reticulated, and, when at rest, folded longitudinally like a fan, and protected by the anterior pair as sheaths.

2d.—*Mouth parts*, for chewing. The jaws always terminated with hard edges, resembling teeth, and moving transversely on each other.

3d.—*Transformations*, incomplete. Pupa active and resembling the imago, but with only rudimentary wings. No species aquatic in any stage of life.

FAMILIES OF ORTHOPTERA.

Grillidæ (cricket family).
Locustariæ (locust family).
Acrydii (grasshoppers).
Phasmida (walking sticks or spectres).
Mantidæ (praying mantes).
Blattariæ (cockroaches).
Forficulariæ (earwigs).

DESCRIPTION OF NEUROPTERA.

NEUROPTERA.

1st.—*Wings*—four, as active organs of flight, generally large and about equal sized, membraneceous, transparent, and covered with a delicate network of veins, like those of a leaf.

2d.—*Mouth parts*, for chewing; jaws transversely moveable, and never with the lips and chin lengthened into a trunk.

3d.—*Transformations*, quite various, complete and incomplete. Larvæ with six articulated legs; of some, aquatic—of others, terrestrial.

Pupa various; in some inactive with the limbs folded over the breast; in others active, and more or less resembling the imago.

FAMILIES OF NEUROPTERA.

Termitidæ (white ant family).

Ephemeridæ (May flies).

Libellulidæ (the Dragon fly family).

Hemerobidæ (Aphis Lions and lace-winged flies).

Phryganeidæ.

Psocidæ.

DESCRIPTION OF HYMENOPTERA.

HYMENOPTERA.

1st.—*Wings:* Four for active flight; first or anterior pair always larger than the second or posterior pair. Membranous and naked, reticulated with a smaller number of veins or nervures than the wings of neuroptera.

2d.—*Mouth parts*, for both chewing and sucking. The jaws horny, for biting and cutting, and the tongue, or lower lips and maxillae, prolonged into a sucking tube.

Abdomen, among the females, furnished with a great variety of ovipositors, as saws, borers, stings, &c.

3d.—*Transformations:* Complete, larva, worm-like, without legs. Pupa inactive.

FAMILIES OF HYMENOHTERA.

Apiariæ, or Apidæ (bee family).

Vespariæ (wasp family).

Crabonidæ (sand wasps, wood wasps).

Sphegidæ—Pompilidæ.

Formicariæ (ant family).

Chrysididæ (cuckoo flies).

Ichneumonidæ (ichneumon flies).

Poctotrypidæ (egg parasites).

Chalcididæ.

Cynipidæ (gall flies).

Tenthredenidæ (saw flies).

Urocerida (horntails).

DESCRIPTION OF LEPIDOPTERA.

LEPIDOPTERA.

1st.— *Wings:* Four for active flight, large and with branching veins like those of a fern leaf.

Covered on both sides with *great numbers of small scales*, arranged in rows like the tiles on a roof; these give the shadings and colors to the wings.

2d.—*Mouth parts*, for sucking. The most important part is a trunk, called the tongue, consisting of the jaws prolonged into a tube; this trunk or tongue, when at rest, is rolled up in a spiral between two hairy palpi in the front of the head.

3d.—*Transformations*, complete. Eggs more various in shape than in the other sub-orders. Larvæ as caterpillars, long and cylindrical, composed of thirteen segments, of which the anterior represents the head of the imago, and the next three, each usually with a pair of short legs, the thorax, and the remainder the abdomen of the imago.

The four intermediate and the anal segment have forelegs; the sides of the body have nine pairs of spiracles. The head has a strong pair of mandibles, a moderate sized upper lip or labrum, and the maxillæ and labium or under lip are small, fleshy and soldered together, and on the centre of this labium is placed the spinneret, or silk-spinning organ, in those that have one. Body of larvæ naked, or clothed with hairs, spines or warts.

Pupæ, obtected, conical in form, producing moths; or, angulated, producing butterflies.

Some chrysalids encased in a cocoon of silk, hair, etc.; others naked.

FAMILIES OF LEPIDOPTERA.

Papilionidæ (BUTTERFLIES or diurnal lepideptera).

Sphingidæ (HAWKMOTHS or humming bird moths).

(MOTHS) Aegeriadæ.

Zygænidæ, Bombycidæ (silk worm family).

Noctuælitæ (owlet moths).

Phalænidæ or Geometridæ (span worm or measure worm family).

Pyralidæ (snout moths).

Tortricidæ (leaf rollers).

Tineadæ (clothes moth family).

DESCRIPTION OF HEMIPTERA.

HEMIPTERA.

1st.—*Wing structure:* Presents quite a variety of modifications in this sub-order; among some members of it, the wings are altogether wanting—some have four membranous wings as organs of flight, while others have the first pair modified as wing-covers, either wholly horny or crustaceous, or partly thus and partly membranous.

These differences have led to two subdivisions of the Hemiptera; into *Hemiptera-homoptera*, in which the wings are *four* membranous organs of flight, and *Hemiptera-heteroptera*, in which are found the various other modifications of wing structure.

2d.—*Mouth parts:* For sucking and piercing, no jaws; instead, a beak or rostrum consisting of three lancets protected by a case which, when at rest, is bent under and along the body.

3d.—*Transformations—incomplete.* Larva and pupa like the imago, but without wings, and smaller in size.

FAMILIES OF HEMIPTERA.

Aphidæ (plant lice family).

Coccidæ (bark lice family).

Cicadellina (leaf-hoppers).

Fulgoridæ (lantern-fly family).

Cicadariæ (cicada, or 17 year locust family).

Notonectidæ (water boatman family).

Nepidæ—ploteres (water-bug).

Reduviidæ—corisiae (chinch bug family).
Thripidæ.
Membranacei (bed bug family).
Pediculina (lice family).
Mallophaga (bird lice family).

DESCRIPTION OF DIPTERA.

DIPTERA.

1st.— *Wings:* Two, as organs of flight, membranous, veins irregular; back of the wings are two little *knobs on stems*, answering as balancers; these represent the second pair of wings.

2d.—*Mouth parts*, for sucking and piercing, consisting of an absorbing organ, called the tongue, and the jaws developed as sheaths, answering the purposes of lancets.

3d.—*Transformations*, complete. The larvæ are fleshy, cylindrical, footless grubs, though among some species are representative legs; head of the larvæ in this sub-order alone is soft, fleshy and variable.

Breathing organs in most from the end of the body—aquatic and terrestrial. Pupa incomplete or coarctate.

FAMILIES OF DIPTERA.

Culicidæ mosquitoe and gnat family).
Cecidomyidæ (gall fly family).
Tipulidæ (crane fly family).
Mycetophilidæ, empidæ.
Pulicidæ (flea family).
Simulidæ, bibionidæ.
Stratiomyidæ (weapon flies).
Tabanidæ (horse fly family).
Asilidæ (robber fly family).
Therevidæ (dagger flies).
Syrphidæ (plant lice eaters).

Conopidæ (thick headed flies).
Oestridæ (bat fly or breeze fly family).
Muscidæ (house fly family).
Hippoboscidæ (forest flies and sheep tick family).
Nycteribidæ (bot tick family).
Braulina (bee lice family).

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