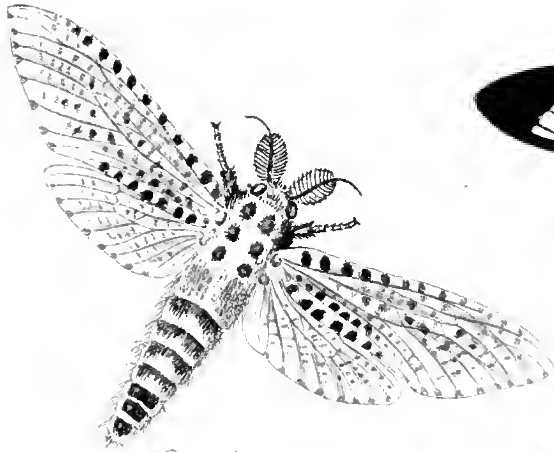

Zeuzera Æsculi

Sesia Fuciformis

Deilephila Euphorbiæ

Chariclea Delphinii

Abraxas Grossulariata

Adela De Geerella

Argyrosetia Brockella

J. O. W. del.

THE ENTOMOLOGIST'S Text Book.

BY

J. O. WESTWOOD, F.L.S.

Secretary to the Entomological Society of London.

Cynthia Orythia. Var.
(China)

LONDON,
PUBLISHED BY WM S. ORR & CO AMEN CORNER,
PATERNOSTER ROW,
1838.

THE ENTOMOLOGIST'S TEXT BOOK;

AN INTRODUCTION

TO

THE NATURAL HISTORY, STRUCTURE, PHYSIOLOGY, AND CLASSIFICATION

OF

Insects,

INCLUDING THE CRUSTACEA AND ARACHNIDA.

BY J. O. WESTWOOD, F.L.S.,

SECRETARY TO THE ENTOMOLOGICAL SOCIETY OF LONDON, HON. MEM. SOC. NAT. HIST. QUEBEC, MOSCOW, LUND, LILLE, MAURITIUS, ENT. SOC. PARIS, ETC.

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PREFACE.

The present Volume owes its existence to a desire on the part of the Publisher of the British Cyclopædia of Natural History, that the leading Entomological articles which appeared in that work from my pen should be collected, so as to form a general sketch of the outlines of the science to which they relate. The object of that work was essentially popular, and it was written more especially for the general reader. It was necessary, therefore, not only that the various articles should be divested, as much as possible, of technicality, but also that the attention of the reader should be constantly directed to the uses of organs of which the descriptions were laid before him; thus not only imparting to the subject a greater degree of interest, than though bare descriptions and technicalities had been given; but, which was of far higher importance, proving that in all the various formations exhibited by these tribes of animals, an All-wise Creator had bestowed those various structures for the performance, in the most satisfactory manner, of their different functions.

In re-publishing these various articles, I have met with one difficulty, for which I hope due allowance will be made by the reader. In an Encyclopædia, the most ample, and generally the most interesting details, are confined to those articles treating of genera and species, to which constant reference is made for the illustration of the more general articles. I have endeavoured, in some degree, to make up for this deficiency, by the introduction of the various orders of insects.

These two circumstances will, I trust, be considered a sufficient reason for the omission of much valuable matter relative to the anatomy, not only of the Crustacea and Arachnida, but also of the true Insects, of which such ample details have, in these few late years, been given to the world by Strauss-Durckheim, Léon Dufour, Kirby, Audouin, Burmeister, Newport, and others. All that I dare affirm of this volume is, that it will be found to contain a concise introduction to the Elements of Entomology, brought down to the present state of the science; in which, indeed, many interesting details are necessarily omitted, which the student who is disposed to enter more deeply into the subject must seek for in the works of Kirby and Spence, Burmeister, and others.

It has ever been my wish to instil into the minds of those who feel an interest in the science, the idea that the mere collecting of specimens, or of attempting their classification, could not be compared, in an intellectual point of view, or with reference to the amount of pleasure derivable from the subject, with the investigation of habits of the animals, and the variations in their structures dependent thereon. To those conversant with Entomological Literature, it was evident that there existed the want of a work like the present, which should convey the modern elements of the science in as popular a form as possible; and it appeared to me, that this work might be so written, as to be the means of extending this leading principle of philosophical zoology.

To make the present volume more acceptable to the general reader, several plates of insects have been added, not contained in the British Cyclopædia, and which, together with the very numerous wood illustrations, will render the subject more generally intelligible than though double the space had been devoted to mere descriptions. These figures, together with those in the body of the book, are from my own pencil, being in almost every instance original.

I have added, for facility of reference, an alphabetical index of the anatomical parts, and an arranged list of the figures of insects scattered through the body of the work.

J. O. W.

Hammersmith, October, 1838.

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Plate I.—Page 80.

Class CRUSTACEA.—*Order* DECAPODA.
Gonoplax angulata, young, var.

Order ISOPODA.
Limnoria terebrans, magnified.
Arcturus longicornis, female, rather magnified.

Class ARACHNIDA.—*Order* DIMEROSOMATA.
Dysdera erythrina.

Order PODOSOMATA.
Pycnogonum Balænarum.

Class AMETABOLA.—*Order* CHILOGNATHA.
Iulus terrestris.

Order THYSANURA.
Petrobius maritimus.

Order ANOPLURA.
Hæmatopinus Suis.

Plate II.—Page 335.

Class PTILOTA.—*Order* COLEOPTERA.

Cicindela hybrida,	natural length	one-half	of an inch.
Miscodera Arctica,	,,	one-fourth	,,
Orectochilus villosus,	,,	one-fourth	,,
Agabus serricornis,	,,	one-half	,,
Spercheus emarginatus,	,,	one-fourth	,,
Abdera, four-fasciata,	,,	one-sixth	,,
Clythra Hordei ?	,,	one-sixth	,,
Saperda Carcharias	. .	natural size.	

Plate III.—Page 349.

Order ORTHOPTERA.

Acheta campestris, natural size.

Order HEMIPTERA.

Chorosoma miriformis,	natural length	one-third of an inch.
Centrotus Genistæ,	,,	one-sixth ,,

Order NEUROPTERA.

Chrysopa perla, natural size.

Order HYMENOPTERA.

Eumesius (Euceros) crassicornis,	natural length	one-third of an inch.
Tengyra Sanvitali,	,,	one-third ,,

Order DIPTERA.

Ochthera mantis, natural length one-sixth of an inch.

Plate IV.—Page 389.

Order LEPIDOPTERA.

Butterflies.

Papilio Machaon and larva.
Papilio Podalirius.
Lycæna Chryseis.
Polyommatus Arion.
———— Artaxerxes.
Cynthia Orythia, var.—*Title-page.*

Plate V.—*Frontispiece.*

Moths.

Deilephila Euphorbiæ.
Sesia Fuciformis.
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Chariclea Delphinii.
Abraxa grossulariata.
Adela De Geerella.
Argyrosetia Brockella.

ERRATA.

P. 155, fig. *a*, Lithob*i*us forcipatus.
— 288, fig.—The insect here figured is the *Chrysina macropa* (*Scarabæus macropus*, Francillon). The male of *Chrysophora chrysochlora* (Latr.) is similarly organized.
— 292, fig. G*o*erius olens.
— 312, fig.—The figure in this page, reduced from Lyonnet, shows the *circulatory* system of the caterpillar of the goat-moth,—the large dorsal vessel, with angulated sides, extending along the back.
— 389, fig. Andrena n*i*gro-*æ*nea.

PROŒMIUM.

" Full Nature swarms with life; one wond'rous mass
Of animals, or *atoms organized,*
Waiting the vital breath, when Parent Heaven
Shall bid his spirit flow. * *
* * Through subterranean cells,
Where searching sunbeams scarce can find a way,
Earth animated heaves. The flowery leaf
Wants not its soft inhabitants. Secure
Within its winding citadel, the stone
Holds multitudes. But chief the forest boughs,
That dance unnumber'd to the playful breeze,
The downy orchard, and the melting pulp
Of mellow fruit, the nameless nations feed
Of evanescent insects. Where the pool
Stands mantled o'er with green, invisible,
Amid the floating verdure, millions stray:
* * * Nor is the stream
Of purest crystal, nor the lucid air,
Though one transparent vacancy it seems,
Void of their unseen people. * *
* * * These, conceal'd
By the kind art of forming Heaven, escape
The grosser eye of man. * *
Let no presuming impious railer tax
Creative wisdom, as if aught was form'd
In vain, or not for admirable ends.
Shall little haughty Ignorance pronounce
His works unwise, of which the smallest part
Exceeds the narrow vision of her mind?

As if upon a full proportion'd dome,
On swelling columns heaved, the pride of art,
A critic fly, whose feeble ray scarce spreads
An inch around, with blind presumption bold
Should dare to tax the structure of the whole.
And lives the man whose universal eye
Has swept at once the unbounded scheme of things,
Mark'd their dependence so, and firm accord,
As with unfaltering accent to conclude
That this availeth nought? Has any seen
The mighty chain of beings, lessening down
From Infinite Perfection to the brink
Of dreary nothing, desolate abyss!
From which astonish'd thought, recoiling, turns?
Till then alone let zealous praise ascend,
And hymns of holy wonder, to that Power
Whose wisdom shines as lovely on our minds
As on our smiling eyes his servant Sun."

THOMSON.

THE

ENTOMOLOGIST'S TEXT-BOOK.

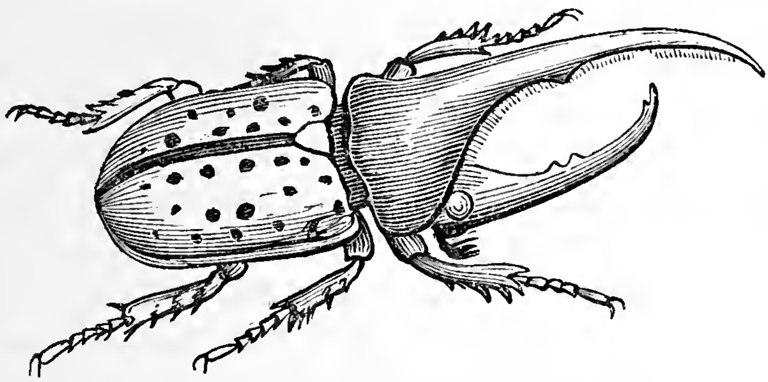
INTRODUCTION.

ENTOMOLOGY is that branch of zoology which treats of the insect tribes, as restricted by the knowledge obtained by the elaborate researches of modern comparative anatomists. The term is derived from two Greek words, *entomon,* an insect, and *logos,* a discourse; the former word, as well as the synonymous Latin word, *insectum,* which we have anglicised into insect, being themselves compounded of other words, signifying a cutting or dividing into sections or articulations, whence, in fact, we arrive at one of the great characteristics of these tribes, namely, the articulated structure of the external parts of the body, which, being of a corneous texture, serve as supports for the muscles and other internal organs, just as the internal vertebræ of the higher animals support the same parts; so that in this class of the invertebrated animals the external covering may properly be regarded as the skeleton. Now, this character, joined to those derived from the respiratory, nervous, and locomotive systems, tends to separate the true articulated animals from a great number of other small creatures, with which, under the common name of insects, they are classed even in some of the latest popular compendiums of natural history which have issued from the press, in which the leech and snail, together with many of the still lower animals, are introduced, without even a sectional note of distinction, amongst insects.

If we look around, on every side, in every place, and in every season, we behold the immense profusion with which nature has scattered the objects of our present meditation. The earth, the water, and the air, teem with insect inhabitants; every vegetable supports numerous colonies; the diminutive fungus and the gigantic oak are alike subject to their attacks; and as a proof of the vast extent of the series it may be added, that Saint Pierre tells us, that several hundred different species of insects visited a small rose-tree placed in the window of his study, whilst a single forest tree is the abode of numerous tribes and families. In like manner they cease not in their attacks upon animal matter, both in a dead and living state; and man himself, the lord of all, is not exempt from annoyances from them. How necessary, then, from the insurmountable difficulty resulting from the almost infinite number of these creatures, is it to bespeak the indulgence of the reader in attempting to lay before him, in as concise a manner as possible, a sketch of the insect world. It is not difficult to imagine the painful nature of the researches necessary for obtaining a knowledge of the internal anatomy and other peculiarities of creatures, of which by far the greater portion do not exceed an inch in length. And here it is that we, in the most especial manner, discover the invaluable worth of the microscope, that surprising instrument, by which the minute wonders of the creation are brought as vividly before the eye of the observer, as are the wonders of the celestial sphere by that other philosophical wonder, the telescope. These instruments are now, it is true, no novelties; but we know no more striking instances in which the powers of the mind have worked a victory over nature. Speak of the powers of the steam-engine, and the many hundred times by which the manual forces of the human frame are increased by its operations—and what is this in comparison with the tens of thousands of times to which the ordinary size of the meanest insect is increased by the assistance of the microscope? Still, the continued employment of this instrument is a painful operation, increased a thousand fold by the minuteness of the objects, and the extent to which it is necessary to carry the investigation of them. Look at the unwearied labours of Lyonnet, which were for years devoted to the anatomical examination of a single insect; or at those of Strauss-Durckheim, whose memoir upon the cockchafer exhibits almost an equal endurance of observation. If, moreover, we consider that not only does an insect combine within itself the systems of respiration, circulation, digestion, secretion, and sensation analogous to those of the higher animals, but also that, owing to the remarkable circumstance that the majority of these animals undergo a series of transformations, whereby these systems are completely altered several times in their progress to the perfect state, it is essential to extend our observations to every period of the life of the animal, before we can arrive at a perfect knowledge of its structure, so as to enable us to form a proper estimate of its comparative anatomy; we cannot, therefore, but admit that the difficulties attending the labours of the entomologist are not fewer than those in any other department of zoology; difficulties which, from their very nature, cannot cease to arouse the attention of the devoted admirer of the Creation. And hence arises the necessity of our having recourse to the labours of our predecessors in the vast field opened to us, and in the works of Swammerdam and Lyonnet, De Geer and Reaumur, Latreille and Kirby, we find the materials, not for a short essay, as this must be at its greatest extent, but for volumes upon volumes.

Of all the classes of zoology, then, that of insects is the most numerous, the most beautiful, and the most varied; and yet it cannot be denied that no portion of the science presents, to those who are ignorant of its merits, so many apparent points of repugnance; but which, nevertheless, so much captivates the attention the more its merits are examined. It is, indeed, for those who undertake its investigation, an unceasing source of instruction and of pleasure, open to all, requiring not, like the study of quadrupeds or birds, great pecuniary sacrifices in the collection of materials, but yet possessing for every observer a still unopened mine of knowledge, even in the very commonest species. Volumes have been written upon the bee; but still how many wonders of the hive remain unexplained? The domestic fly swarms in every apartment, and yet how many points in its economy are uninvestigated? And, which is not less peculiar and interesting to the student of the insect world, he may pursue his observations without pain to the objects of his research; he may watch them at their occupations, observe their manœuvres, and contemplate the beautiful harmony which exists between their organization and their economy, and leave the contemplation "a wiser and a better man." Here he will find life in its widest extent; sensation and motion are here bestowed to a degree even far exceeding that of the higher animals; and it is this which constitutes one of the greatest charms of the pursuits of the entomologist. The botanist may boast of the splendour of his flowers, the conchologist may glory in the beauty of his shells, and the ornithologist in the interesting economy of his birds; but the entomologist can do more. The objects of his pursuit are not less splendid than flowers; indeed, what flower can vie with the brilliant butterflies of South America?

Neither are they less beautiful than the most beautiful shells—for what shells can equal the splendid coatings of the *Chrysididæ,* or with the extraordinary forms of the *Dynastidæ?*—Neither are they inferior to the feathered tribes in



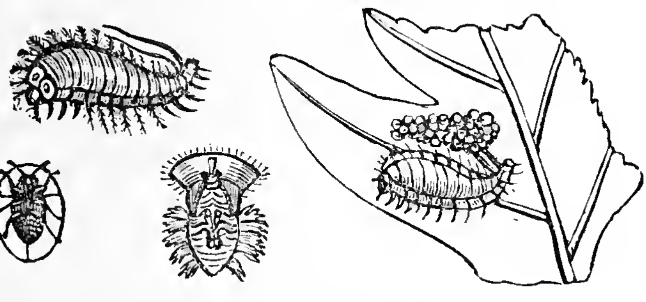
Dynastes Hercules (Brazil), one-third of the natural length.

their varied economy, whilst the very circumstance of their infinite numbers and ubiquity renders their observation a matter of comparative facility. If we notice them with reference to the latter peculiarity (that of their varied economy), we find them occupied in works as varied as those of the most consummate mechanic and artist. Here we find one suspending itself by a series of mechanical motions, by one extremity of the body, whilst others keep themselves from falling during their state of inactivity, by passing a cord round the middle of the body; here some construct, for the like purpose, a bed of the finest silk, whilst others, with the greatest ingenuity, form their domicile of other and very different materials, varying in the several species, whose economy is consequently different. Some unite to form a common lodging, whilst others separately incase themselves in a coat of wool as soon as they are born. In many instances the patient care of the female in the construction of her nest, and in the preservation of her offspring, is not surpassed by the highest amongst animals. In all these things, and in the infinite diversity of means exhibited by insects tending to one common end—the preservation of each—the supremacy and wisdom of a Divine Intelligence,—creating all things, preserving all things, directing all things,—are so pre-eminently conspicuous, that it is impossible, even whilst paying but the slightest degree of attention to such things, to overlook the sublimity of the science, or not to be filled with the most profound respect for the all-powerful wisdom and goodness of the Creator, and, even in the midst of the most profound grief, it is impossible to contemplate these wonders of the creation without an assuagement of our pain.

If, moreover, we would institute a comparison between the objects of our present contemplation, and those of the higher ranks of nature, we shall find here assembled all those striking peculiarities which abound in the latter; the piercing eye of the lynx and the falcon, the hard shield of the armadillo, the splendid tail of the peacock, the imposing horns of the stag, the swiftness of the antelope, the fecundity of the hare, the architectural powers of the beaver, the climbing powers of the squirrel, the gambols of the monkey, the swimming of the frog, the burrowing of the mole, and the leaping of the kangaroo; all these things are found amongst insects, and often, indeed, in a redoubled degree. The eye of the fly, with its thousands of lenses, the horns of the stag beetle and dynastes, the splendour of the scales upon the diamond beetle, the hard covering of the beetles (whence even their ordinal name, *Coleoptera*, wings in a case), the admirably constructed works of the hive, the maternal cares of the spider, which guards its bundle of eggs with incessant care, carrying them about with it beneath its body; the ingenuity of the cocoon * of the emperor moth, which

* The cocoon of this moth is of a brown colour, and shaped somewhat like a flask. It is composed of a solid tissue of layers of silk, almost the texture of parchment; but at the narrow end it is composed of a series

is constructed with an elastic aperture, preventing the entrance of enemies, but allowing exit to the inhabitant; the numberless progeny of the aphis, the powerful flight of the locust, the leap of the elater and grasshopper, the brilliant light of the glow-worm, the instinct of the sexton-beetles (*Necrophorus*), the mottled jacket of the larva of the clothes-moth, formed of different coloured wool, or the excrementitious covering of the larva of the *Cassida*, the frothy abode of the *Cercopis*, the abandoned



Cassida viridis in its different states.

shell inhabited by the hermit crab, and the extraordinary *gall* residences of the *Cynipidæ;* all these, and a thousand other not less interesting circumstances exhibited, and to

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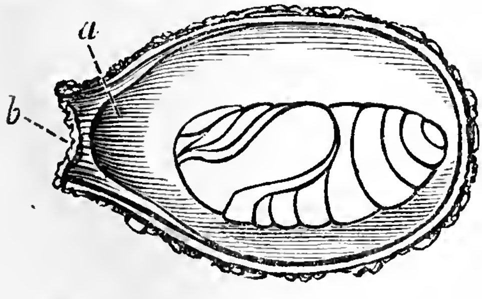
of loosely attached longitudinal threads, converging like so many bristles to a blunt point, in the middle of which is a circular opening, through



Chrysalis and section of the cocoon of the Emperor Moth, showing, *a*, The internal dome—*b*, The external aperture.

which the moth makes its escape, the threads readily yielding to pressure from within, and acting somewhat upon the principle of the wires of the opening to a rat-trap, or the willow cricks of an eel-trunk. In order, however, to guard against the danger which might arise from the opening permitting the ingress of ichneumons or other enemies, the caterpillar constructs within the funnel-shaped mouth a second funnel formed of a similar series of threads converging to a point, without the smallest opening being left, and its arched structure rendering it im-be exhibited more at detail in our pages, cannot fail to convince the reader that the class of insects does not possess fewer claims to his attention than any other of the classes of nature.

The continued action which insects exercise upon the other productions of nature (and I may mention, in passing, as a most conclusive evidence of such action, that the island of Grenada is now reduced to a ruinous state owing to the attacks of the diminutive cane-fly upon the canes, having extended nearly throughout the island), the insurmountable power of these enemies, owing to their minuteness, the injuries which they inflict upon our possessions, animal and vegetable; the benefits arising from many of them, their extraordinary forms and transformations, rivalling the most striking creations of fable, the complexity of their organization, external and internal, their inconceivable industry in the construction of their nests, and the foresight which they manifest in their self-defence, all teach us that Entomology is well worthy of the attention of the observer of nature.

But it will be said, why devote our attention to objects so minute? We reply, if the colossal alone be worthy of notice, search elsewhere for the objects of your notice, for here the objects are so small, that the full stop at the termination of this sentence is much larger than many of the species. But, to the eye of philosophy, what matters colossal

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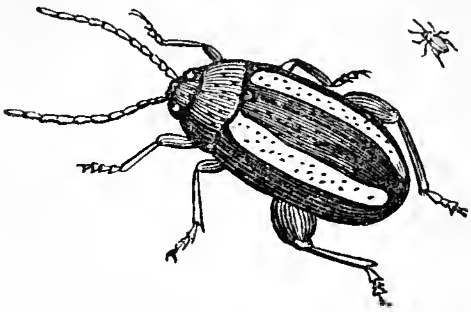
penetrable to the most violent efforts of any external enemy, whilst it yields to the slightest pressure from within, and allows the egress of the moth with the utmost facility, immediately resuming its former appearance, so that it is impossible at first to conceive how it is that the moth can have made its escape from an entire cocoon. Meinecken has also suggested that the pressure of these converging threads upon the abdomen of the moth as it emerges from the cocoon, has the effect of forcing the fluids to enter the nervures of the wings, and give them the proper expansion, having noticed that the moths from chrysalides taken out of these cocoons were crippled in their wings.

size and gigantie expanse? The wisdom of the Creator is coneentrated in these minims of creation, in order the better to develope His power; sinee in these creatures, whose exeessive minuteness renders it difficult, and even impossible, to observe some of them with the unassisted eye, how can we conceive it possible to arrange all the machinery which exists in the bodies of these "atoms organized," as perfect and as eomplex as in those of the largest? The little beetle (*Atomaria atomos*), and the minute parasitie fly (*Mymar monas*), although not one-hundredth part of an inch in length, possess precisely the same number of organs, and even of joints of those organs, as their larger brethren of the tribes to whieh they respectively belong. To neglect this portion of the ereation is to say, that these living machines, in which the rules of the most perfect mechanical knowledge have been implieitly followed, and of which the various parts are arranged with the utmost art, but which are nevertheless so fine and delicate as to escape our view, are less worthy of regard than the larger machines made precisely upon the same model. Absurd reasoning! Who does not regard the skill of the artificer capable of forming a minute pocket-wateh, with its delicate maehinery, as more worthy of notice than that of the workman who ean but construct a town-elock.

The benefits and injuries resulting to mankind from these creatures (insignifieant though they may be regarded) are, moreover, amply sufficient to prove that they are, on the eontrary, well deserving of his attention, either with a view of extending the former or diminishing the latter. Of their obnoxious powers all are more or less directly or indireetly cognizant, their minute size insuring them success in their assaults, and searcely permitting the possibility of extirpation. On the other hand, the benefits we experienee from inseets are searcely less extensive, serving as an ample counterbalance against their attacks upon our properties or persons. If we would therefore endeavour successfully to combat the latter, it can only be done by the acquisition of a knowledge of their habits, in every state of their existence; and, in this point of view, the study of Entomology becomes of the highest importance. Let us take, for instance, the case of the turnip-flea beetle (or turnip fly, as it is often called—*Haltica nemorum*), and we find that all the numerous investigations of the Doncaster Agricultural Association have proved next to useless, because the natural history of the insect itself was not ascertained. In like manner it must be equally evident, that the diffusion of correct knowledge, and more especially inquiries into the chemical properties of many insects, hitherto considered useless, might be the means of adding considerably to the list of benefits conferred by insects on man.



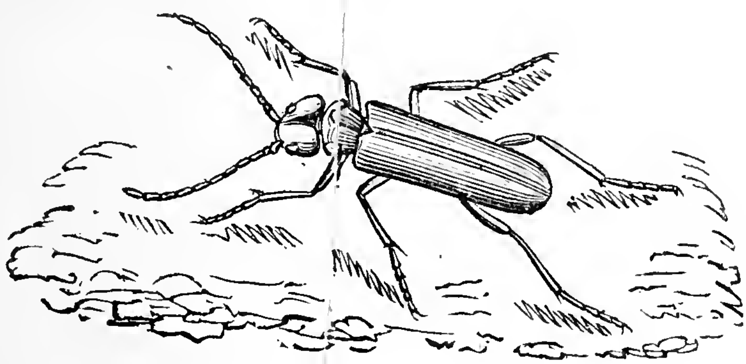
Turnip-flea Beetle.

Amongst the *Crustaceous Annulosa* many species of crabs, lobsters, prawns, and shrimps are employed to a very great extent as articles of food; and even amongst the winged or true insects various species are found similarly serviceable.

In the deserts of Africa and Asia, where the locusts acquire a large size, those insects are employed, when dried and preserved, as food. I have tasted locusts thus prepared, and found them not unpalatable; but they are said to possess very little nutritious quality, and to produce disease when too much is eaten. The larvæ or grubs of many large beetles are also devoured by the negroes of India and America: and even the luxurious Romans were exceedingly fond of a large fleshy grub which they called Cossus, and which is supposed to have been either the larva of the Goat-moth

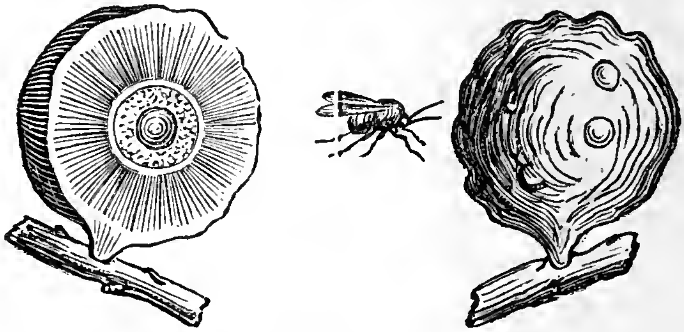
(*Cossus ligniperda*), or that of the Stag-beetle (*Lucanus cervus*). In like manner the white ants (*Termites*) are devoured by the savages of Africa and America; whilst the great quantity of honey annually consumed in every quarter of the world is sufficient to prove, that in this point of view insects are highly beneficial.

It has also been recently discovered, that the manna which, it will be remembered, served the Israelites for food during their passage through the Wilderness, is but the concreted juice of an Arabian tree (*Tamarix mannifera*), which is caused to flow by the puncture of a small species of *Coccus*, which the celebrated Prussian entomologist, Dr. Klug, has recently described and figured under the name of *Coccus manniparus*, in his splendid work upon the inseets of Arabia, and to whom I am personally indebted for specimens of this interesting insect. In medicine insects are also of great service. Of these the *Cantharis vesicatoria* or blister beetle



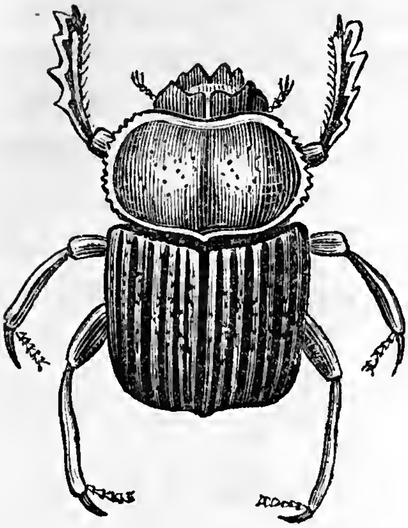
Blister Beetle.

is the most important. Numerous other species were formerly introduced into the Pharmacopœia, but they have gradually been disused. In a commercial point of view, silk, chermes, and cochineal are some of the most important products. There are many other insects which construct silken cocoons, and emit various coloured dyes, and which it might be very serviceable to endeavour to introduce, as well as the true silkworm and the *Coccus cacti*. Gumlac also, wax and ink-galls are insect productions of too great importance to be passed over without notice. But there are other classes



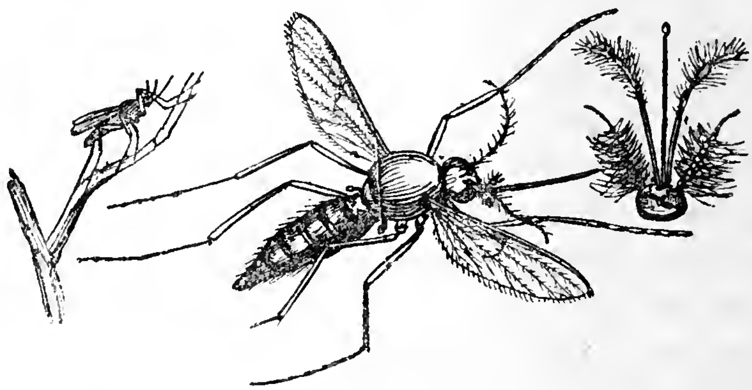
The Ink-gall entire, and cut open, with the insect by which it is produced (*Cynips tinctoria.*)

of benefits resulting from the relations of insects with other organized beings. These, although less directly affecting man, ought not to be overlooked in a general survey of the economy of nature. Suppose the race of insects to be entirely annihilated, and then observe the thousands of ills which would inevitably result from the putrefying masses of animal and vegetable productions, and which are now, as it were, reduced to their native elements solely by the interference of the insect tribes. The entire tribes of *Silpha, Necrophagi, Dermestes, Nitidulæ*, immediately fall upon the dead carcases of animals, devouring the flesh, and accelerating the dissipation of the putrid mass; and these, assisted by myriads of flies, which deposit their eggs in the decomposing body in such immense numbers, succeed, in a very few days, in reducing the carcass to a mere skeleton. In like manner, the *Scarabiædæ* (whose extraordinary habits of rolling their eggs in globules of dung caused them to be regarded as sacred by the Egyptians), the *Geotrupidæ, Histeridæ,* and many other insects, are equally serviceable in burrowing into the earth underneath the fallen excrements of animals, and thus disseminating them, rendering them serviceable to


Scarabæus Ægyptiorum.

the agriculturist; whilst the tribes of insects which feed upon decaying vegetable matter are even still more numerous. As serving for food to some of the higher animals, as fish, birds, some of the smaller mammalia, &c., insects are eminently serviceable in the scale of the creation. Amongst birds, the shrikes, and the genera *Sylvia, Motacilla, Anthus, Certhia, Muscicapa,* and *Hirundo,* as well as the cuckoos and pies; and amongst quadrupeds, the genera *Stenops* and *Otolicnus,* which feed upon grasshoppers, the bats, shrew, hedgehog, mole, and especially the genus *Myrmecophaga,* derive their sole nutriment from insects. Many species of insects are equally serviceable in destroying other noxious insects. Of these the tribes of predaceous beetles, sandwasps, ants, dragon-flies, spiders, &c., are to be noticed, but more especially the larvæ of the lady-birds, *Syrphidæ,* and golden-eyed flies, which destroy myriads of plant lice. All these, however, yield to the *Ichneumonidæ,* which annually destroy more caterpillars than the whole tribes of insectivorous birds, having almost universal dominion over the other insect tribes. In the last place, we have to notice the great services rendered by insects in effecting the impregnation of plants, in many of which the position of the sexual organs is such, that the intervention of insects, especially bees, butterflies, &c., is required, which, whilst seeking food for their own nourishment, unconsciously perform this most important office; whilst some of the *Cynipidæ* effect the more rapid ripening of the fig, by the process termed caprification by the inhabitants of the Levant.

It is, however, necessary for us now to reverse the picture, and to observe, that if insects are capable of being serviceable to mankind, other species are not less injurious to him and his property. We will first notice such species as possess a direct influence against mankind. Of these the various species of lice, the flea, jigger, and the bed-bug, are pre-eminently obnoxious. Besides these, we are condemned to suffer from the occasional attacks of multitudes of other species, which at all hours of the day cease not their tor-



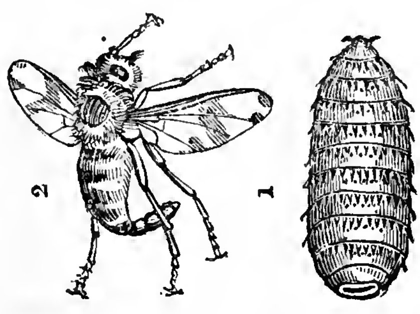
Gnat (*Culex pipiens*) female, natural size and magnified, with the head of the male.

menting powers. Moreover, the hotter the clime, and the period when the body requires the greatest portion of rest, the more numerous are the hordes of our insect enemies. The *Tabani*, *Stomoxes*, and *Asili*, are all highly irritating; but all these yield to the gnat and the musquito, which are sometimes so annoying and so numerous, that their victims have sunk under their attacks. They both belong to the same natural group, *Culicidæ;* and as they breed in stagnant water and damp situations, it does not seem improbable that the last-named insects were the species of flies which were employed as one of the ten plagues of Egypt to punish the rebellious Egyptians. In the article BAT, in the British Cyclopædia, there is the following passage, which especially bears upon the subject:—"The banks of the Nile, in Egypt, where they (the bats) dwell in the palaces and sepulchres of forgotten kings, and the temples of forgotten gods, are particularly replenished with them, because *the swelling and subsiding of the Nile cause a vast production of insect life.*" Mr. Kirby, indeed, adopts another opinion, suggested to him by an eminent and learned prelate, that the Egyptian plague of flies, which is usually supposed to have been either a mixture of different species, or a fly then called the dog-fly (*κυνομυια*), but which is not now known, was a cockroach, the Hebrew name of the latter, which is the same by which the raven is also distinguished, furnishing no slight argument in favour of it, the same word also signifying the evening. Hence, as the cockroach of Egypt is black, and appears only in the evening, Mr. Kirby considers the reason sufficient for the name given to it. I am afraid of being charged with presumption in venturing to differ from these learned divines on a point of biblical natural history, but I cannot avoid adopting the opinion, that the plague of flies was caused by the musquito. Mr. Kirby evidently appears to have previously adopted the view of the subject given by Bishop Patrick, who says of these flies, that they were "flesh-flies or dog-flies, very bold, troublesome, and venomous. Some think the Hebrew word means a mixture of different insects, all manner of flies;" and Bruce regards it as being probably identical with the insect which he describes under the name of the zimb. We read, on the denunciation of this plague, that Moses was directed to say to Pharaoh, "If thou wilt not let my people go, behold I will send *swarms* of flies upon thee and upon thy servants, and upon thy people, and into thy houses; and the houses of the Egyptians shall be full of swarms of flies, and also the ground whereon they are; and I will sever in that day the land of Goshen, in which my people dwell, that no swarms of flies shall be there," &c. Now in this passage we are first struck with the expression "*swarms of flies;*" and we are sure that every one who has seen "a swarm of gnats at even-tide" will perceive the aptness of the expression, supposing the Egyptian fly to be a species of gnat, or, in other words, the musquito. We next read of their making their way into the houses, which shall be full of flies. This is also precisely the habit of the *Culicidæ*. The next passage, that they should also swarm upon the ground, is certainly not in favour of my interpretation, and would apparently apply to some other species; but it is in the last passage quoted that we perceive the fullest corroboration of my view of the subject. Bryant says, "The land of Goshen was a tongue-like piece of land, where the Nile first divided at a place called Cercasora; Said, or Upper Egypt, lying above, and Mesre, or Lower Egypt, was in a line downward;" and Bruce states, that "the land of Goshen was a land of pasture, not tilled or sown, *because it was not overflowed by the Nile.* But the land overflowed by the Nile was the black earth of the valley of Egypt, and it was here that God confined the flies, for He says it shall be a sign of this separation of the people which He then made, that not one fly should be seen in the sand or pasture-ground of the land of Goshen; and this kind of soil has ever since been the refuge of all cattle emigrating from the black earth to the lower part of Atbara." These observations appear to me almost conclusive upon the question: the sandy pasture soil of the land of Goshen would have been the spot where the cockroach would have resorted to naturally, and it is the spot where the musquito would not have been found. Far be it from us to deny the miraculous power of the Almighty in producing this surprising flight of flies, but we know, in our own days, that in certain seasons certain species of insects are multiplied to such an extent as to become a positive evil. We know not, of course, for what end such multiplication is permitted by the Creator: but in the one case, as well as in the other, we must certainly acknowledge the working of an all-wise Providence, which sees and understands what man cannot comprehend.

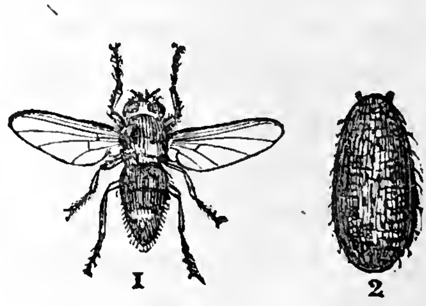
I am aware that Dr. Hale and Bryant have given calculations, whereby it would appear that this succession of plagues took place between the month of January and the beginning of April, and consequently the plague of flies, &c. must have been miraculous, occurring at a season when the Nile was at its lowest, and when flies, &c. were not naturally abundant; but there seems nothing fully to warrant the adoption of a fixed period of time between the early plagues.

I have said that the musquito is a species of gnat (*Culicidæ*), nearly allied to our common English species, *C. pipiens*. In making this statement I have followed the best authorities. Mr. Kirby says, that the musquito from Batavia, whose bite is exceedingly venomous, occasioning a most intolerable itching, which lasts several days, is distinct from the common gnat, and approaches *C. annulata*, but the wings are black, and not spotted. Robineau Desvoidy and M. Percheron have described and figured the insect under the name of *Culex musquito;* and Pohl and Kollar have described the Brazilian musquito, as it is termed by the Portuguese, under the name of *Culex molestus*.

There is also another little insect, which in the autumn is very annoying to persons who walk about the fields, and which is so minute that it escapes observation. It is called the harvest-bug, but is in reality one of the *Acaridæ*, of a red colour, its mode of attack being to insinuate itself into the flesh of the legs, where it causes an intolerable itching, and raises the most irritating sores. An analogous species inhabits the West Indies, where surgical operations are required to dislodge it, causing, if neglected, abscesses, gangrene, and even death. The name of *Scholechiasis* has been applied to a disease in which the larvæ of various species of insects are found in the human body, but these appear to be entirely accidental cases, wherein these larvæ have been injected. A species of *Œstrus*, in like manner, has been found to be parasitic within the bodies of persons residing in the tropics, but this (although it has received the name of *Œstrus hominis*) I should be rather induced to regard also as an accidental locality selected by the insect, instead of its real habitat. There is another tribe of insect enemies whose attacks are not less annoying, although not resulting, like the former, from a desire to feed upon our bodies. Here are to be ranked the bees, wasps, and other insects provided with poisonous stings, which, however, they seldom employ except in their own defence, or to resent injuries offered to them. Here also may be added the spiders, whose powerful jaws are equally provided with a poisonous fluid, as well as the scorpion, whose long and jointed tail is defended at the tip with a powerful sting. Other insects are to be ranked amongst our minor miseries, namely, those which by the emission of a caustic or disgusting fluid, operate strongly upon our olfactory nerves. But the tribes of insects which prey upon our cattle are equally numerous, including



Gasterophilus equi.

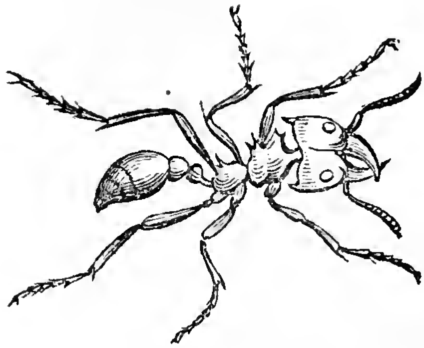


Gasterophilus hæmorrhoidalis.

fleas of different species, ticks, gadflies, forest flies, and especially the remarkable family of *Œstrideous* flies, the larvæ of some of which are ordinarily termed bots. In like manner our poultry and our bees are subject to the attacks of various insects, of which the *Death's-head moth* and the *Galleria* are examples.

Death's-head Moth.

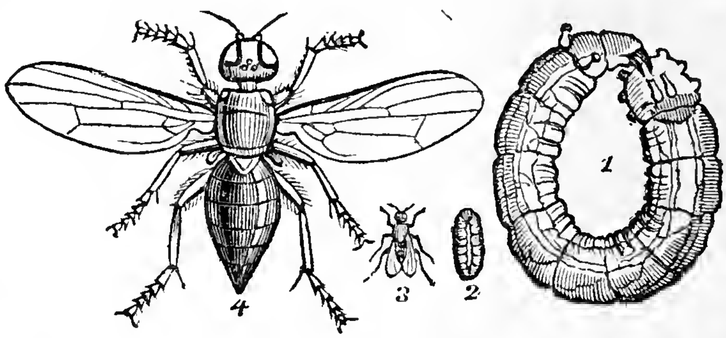
It is not, however, to ourselves and living animals that the ravages of insects are confined, almost every species of property being in some measure or other liable to be injured by them. Our clothes, and other woollen productions, are devoured by the larvæ of various species of clothes-moths, which not only feed thereon, but also form for themselves coverings of the same materials; and the richest furs are subject to the attacks of a similar insect; whilst our museums are equally ravaged by the *Dermestes* and *Anthreni*. Our furniture is often completely destroyed by the timber-boring beetles and death-watches (*Anobium*); and some species of white ants, in warm climates, are so destructive in this respect, that if a chair or table be suffered to remain for a time in the same situation, the interior substance will be completely consumed, nothing remaining but the outside shell, which the insect has the instinct to leave entire. The last-named insects may indeed be regarded as amongst the most destructive of our insect enemies, since they scarcely leave any article untouched. Ants also are, in warm cli-



Atta cephalotes, the visiting ant of the West Indies.

mates, almost as destructive; and, even in our own country, one of the smallest species of ants (*Myrmica unifasciata*) has increased to such an extent in certain parts of London, and some other towns, devouring all kinds of articles, that the inhabitants have been compelled to quit their abodes.

Our provisions are also not less liable to the attacks of insects; bread and flour are devoured by the blattæ and meal-worms, and we have seen ship-biscuit swarming to such a degree with the grubs of a species of *Anobium* as to be worse than useless. The *Dermestes* feed upon our dried meats. Cheese is attacked by mites, and the cheese-fly, the grubs of which are termed cheese-hoppers, from their singular motions. Our granaries are ravaged by the corn weevil and by the larvæ of a species of tinea; but if we turn our attention to the species of insects which attack such living vegetable productions as are most gratifying to the taste of mankind, we find the catalogue wofully augmented.

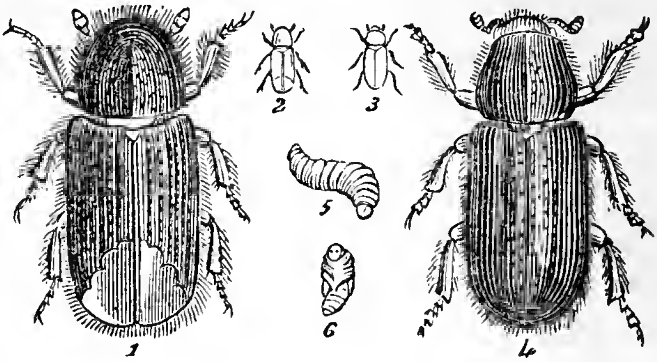


Cheese-fly (*Piophila casei*).

I need scarcely mention the locust as being the most redoubtable of our insect enemies in this respect, although, fortunately for our country, their ravages are here unknown, except by description. Our wheat whilst in blossom suffers from the attacks of the Hessian fly *Cecidomyia tritici* and *C. destructor*, the larvæ of which devour the pollen,

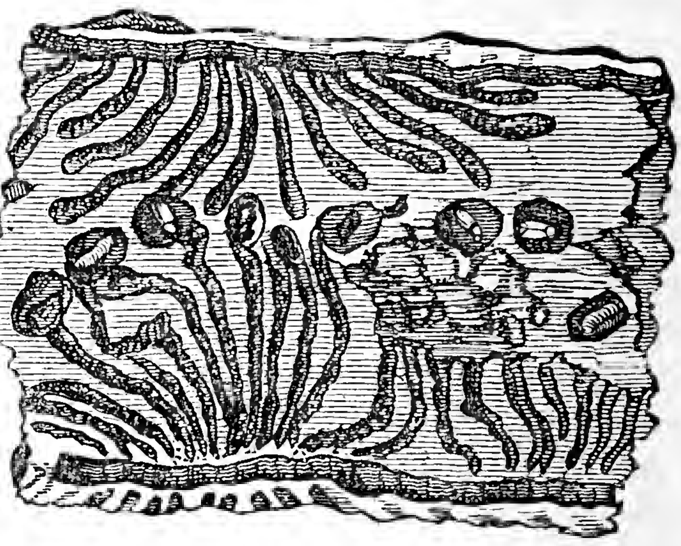
Cecidomyia tritici and destructor.

whilst its roots are devoured by the larvæ of the *Zabrus gibbus*, which sometimes, as in the year 1812, near Halle, in Germany, is produced in such numbers, that whole corn fields are entirely destroyed. The larvæ of some of the *Elateridæ*, known by the ordinary name of wire-worms, also attack its roots, as well as the roots of various other garden plants and culinary vegetables. The grubs of the cock-chafer in like manner often do much injury, by devouring the roots of grass, as do also those of the *Tipulæ*. Of the former, an instance is recorded by Kirby and Spence, in which all the fields of a farmer near Norwich were entirely destroyed, and as many as eighty bushels of the insects were collected by him and his men. Various other esculent roots are also devoured by the larvæ of other insects; amongst which the damage occasioned by the onion-fly (*Anthomyia ceparum*), the grub of which destroys the plant when still very young, is perhaps the most obnoxious. In like manner the stems and the pith of trees and plants are equally subject to the ravages of insects, amongst which may especially be noticed the various species of *Scolytidæ*, of whose appearance and proceedings some idea may be obtained from the accompa-



1, 2, Tomicus typographus—3, 4, 5, 6, Hylurgus piniperda (natural size and magnified).

nying figures. The gigantic larvæ of the longicorn beetles, goat-moths, *Siricidæ*, &c., are not less destructive, by



Track of Typographer Beetle under bark.

boring through the solid wood of various trees; whilst an ant (*Formica saccharivora*), which takes up its abode in the stem of the sugar-cane, has proved at certain periods in the highest degree injurious. But it is upon the leaves and young buds, and stems of plants, that insects are the most detrimental in their attacks. Of these the turnip-fly (*Haltica nemorum*), and some other species, hold the foremost rank. Several species of *Apion* devour the seed of growing clover. Entire and extensive families of beetles (*Crioceridæ, Chrysomelidæ,* &c.) are similarly employed in devouring the leaves of various plants, as well as the numerous species of saw-flies; but it is among the *Lepidoptera* that this species of injury occurs in the highest degree, whole forests being sometimes entirely defoliated by various species. In like manner the flowers and fruits of various plants are subject to similar devastation by insects. It would, however, require an entire enumeration of vegetables and their attendant species of insects, in order to lay before the reader a complete account of the ravages of insects upon our vegetable productions; since it is to be observed that, for the most part, the latter are destined by an all-wise Creator for the support of the former. Their ravages, therefore, which man regards as injuries towards himself, are but the natural result of the ordinary workings of the economy of nature. A few observations upon this branch of the subject, and with reference to the employment of remedies against the attacks of these noxious insects, will not be considered out of place. One of the most common, and at the same time most weighty charges brought against the entomologist is, that whilst he bestows endless labour and trouble in collecting and preserving the various species of insects, his attention is never, or but very rarely, directed to inquiries into the most effectual remedies against those insect scourges which nature has inflicted upon our vegetable productions. He is told over and over again, that to make the science which he cultivates more beneficial to society, and thereby more generally known, a share, at least,

Apion.

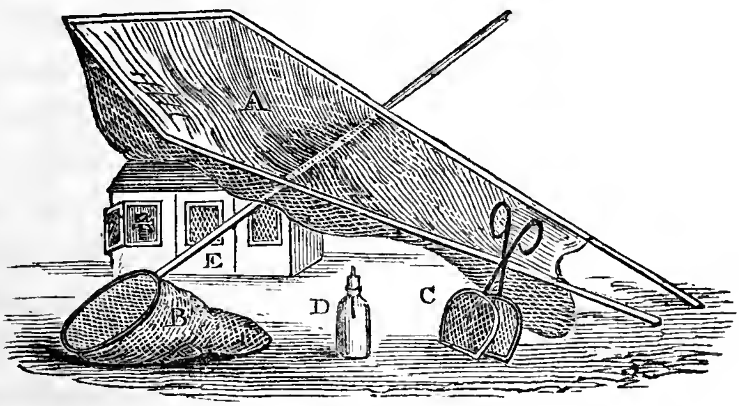
of his attention must be occupied in prosecuting experiments for the purpose of discovering how this or that insect enemy may be combated in the most successful manner. And, indeed, it must be admitted, that this is a charge too well founded, although, perhaps, a few observations may convince those who are the most ready to bring it forward upon every opportunity, that it may be greatly palliated. In the first place, therefore, it may be urged, that these destructive insects, appearing as they do in occasional seasons in vast profusion, are produced in such myriads for some wise purpose, which we may not be permitted to understand. They, like the locusts, of which so splendid a poetical description is recorded in the second chapter of the prophet Joel, form a portion of the army of the Almighty wherewith He scourges the nations; and, although the scientific researches of mankind might discover means of destroying, in some degree, these hosts, it may perhaps not unreasonably be supposed either that he would not be allowed to frustrate the designs of Providence, or that, if this evil were removed, others perhaps more weighty might arise in their stead. In the second place, the minuteness of the size of these creatures presents an almost insurmountable barrier against those delicate inquiries and examinations of them, during every state of their existence, by which alone we can arrive at a knowledge of the real nature and cause of the mischief, and be thereby, and thereby alone, enabled to judge of a suitable remedy. In the third place, the want of a sufficient opportunity for such researches is not the least objection which may be brought against the charge. It must be admitted, that no effectual check can be given to the ravages of any species of noxious insect, until its entire habits and economy have been ascertained. Thus far in the inquiry is the strict province of the entomologist, whose attention ought to be directed from day to day, and from year to year, not to isolated spots of ground, but to whole acres, more especially with reference to the peculiarities of seasons, and to atmospheric changes; but here we have only gone half-way. It now becomes the province of the agriculturist to discover a remedy, since it seems equally clear that this ulterior branch of the inquiry can only be prosecuted effectually by persons perfectly conversant with the chemical nature of soils, the action of various ingredients which may be employed as remedies, not only upon insects themselves, but also upon the plants which may be attacked. Such persons too are alone able to judge of the practicability of the application of the proposed remedies, since it would be useless for an indoor entomologist to endeavour by experiment to discover remedies which, when discovered, cannot be adopted from the great expense of the article itself, or the impossibility of applying it, or the liability of the destruction, not only of the insect, but also of the plant itself; and even instances of the latter description have been recorded.

Hence we must evidently look for the discovery of the most efficient remedies to persons who, residing in the country, are the best enabled to obtain a knowledge of the economy of these destructive insects, founded upon the most general and practical modes of examination, and who unite the entomological knowledge requisite to trace most effectually their habits, with a perfect and scientific knowledge of the true principles of agriculture. Thus it seems undoubted, that this want of sufficient opportunity for investigation has hitherto proved one of the greatest barriers to our proposing satisfactory remedies against these ravages; and knowing, as we too well know, that the study and investigation of this branch of zoology have hitherto been almost uncultivated amongst us, it is not, perhaps, surprising that so little has been done. The observer of insects has, indeed, proposed remedies which the agriculturist cannot adopt; and the agriculturist, on the other hand, ignorant of the nature of insects, has pursued the very plan which has been the most congenial to the habits of the insects which he wished to destroy; as in the case of the French gardener, mentioned by Reaumur, who, thinking to destroy the caterpillars of the cabbage-moth, buried them just at the time when they were themselves on the point of going into the earth to change to chrysalides.

Such being the claims which the objects of the entomologist's study possess upon his attention, I next proceed to state the most efficient modes of research, whereby, also, the most satisfactory and pleasing return may be obtained for the toils of investigation, premising, that all animals destitute of internal vertebræ, having articulated bodies and articulated legs in the perfect state, are here regarded as insects.

Entomologists, like the objects of their research, may be classified. First, there is the amateur, whose sole object is the procuring, either by capture or by purchase, of a collection of handsome insects, either to be placed in drawers, without any other arrangement than that of beauty of colour or size, or in glazed picture-frames, to be hung up in his room. This, it is true, is the lowest class of entomologists; but the labours of such amateurs are not without pleasure to themselves, and are sometimes serviceable to the science of Entomology. The delightful sensations with which the pent-up entomologist inhales the breeze upon Shooter's Hill or Wimbledon Common, when on the way to those well-known entomological spots, Darenth and Coombe Woods, are real enjoyments. The best practical collector whom I have ever heard of is Daniel Bydder, a Spitalfields labourer, by whom some of the most interesting of our English insects were first discovered. And, in like manner, Joseph Standish, a Brixton cobbler, from a pure love of entomology, taught himself to draw and paint insects; and having followed up this pursuit, during his leisure of many years, at length acquired the art of giving to his figures of moths a beautiful downy appearance, so like nature, that we have known a volume of his drawings sold for many pounds. Can it be denied that if, amongst the lower classes, the collecting of objects of nature, and such-like pursuits, were more general, the vice of drunkenness and the reign of gin-palaces would be over?

It is not of course my intention, in this work, to lay down an account of the instruments required, or the modes of collecting insects, for the information of the mere collector. These will be found in Kirby and Spence's Introduction, in the "Insect Miscellanies," or in Mr. Ingpen's little manual devoted to this subject. Suffice it to say, in this place, that when captured and killed, either by immersion in scalding water (as is usually done with beetles), or by being placed in a close small box, with bruised laurel leaves (as is very serviceable with flies, moths, &c.) the insect is stuck through one of the wing cases (if a beetle), or between the wings (if a fly or moth), with a pin proportioned to its size; the entire collection being preserved in chip-boxes, or in a cabinet of



Instruments for collecting Insects.

A, The large gauze flap-net; B, The sweeping or water net; C, The gauze forceps; D, The collecting bottle for holding small beetles, &c.; E, The breeding cage.

shallow glazed drawers, having the bottom lined with cork and covered with paper.

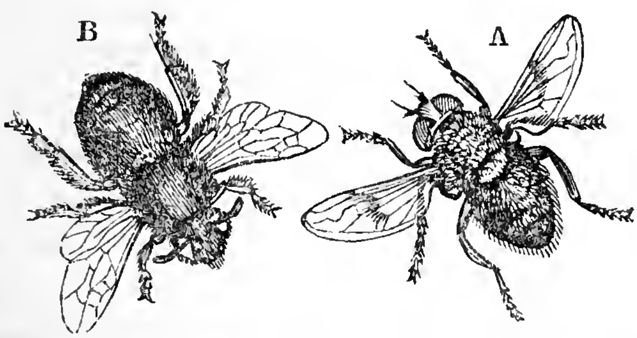
Various kinds of nets are employed in collecting insects, such as the flap-net, for catching insects on the wing, made of fine gauze, resembling a bat-fowling net, and the sweeping net, for catching insects on grass and low herbage, made of strong canvas, and resembling a landing net. When secured, the insects are either immediately pinned, or carried home loose in quills or glass bottles. After they are killed and pinned, their limbs are arranged in a natural position by means of pins and bits of card, by which they are retained in their places until they are dry enough to be placed in the cabinet. Caterpillars are kept in boxes with gauze sides, and fed with leaves of the peculiar plants upon which they are found, until they assume the chrysalis state; and in this manner moths and butterflies are procured with their plumage much more beautiful than when captured at large. Insects which may have become stiff before they have been displayed, are readily relaxed by placing them upon damp sand for a few hours. It is necessary that the store-boxes, or cabinets, containing insects, should be kept in a dry situation, otherwise the specimens soon become mouldy. It is not advisable to place them against an outside wall of an apartment; moreover, it is necessary that camphor should be kept in little cells in the drawers, to prevent the attacks of mites or other insects, especially the species of the Coleopterous genus *Anthrenus*.

The insects of this genus are deserving of attention, both from the ravages which their larvæ commit upon preserved animal substances, objects of natural history, &c., and from the curious formation of the larvæ themselves. Perhaps there is nothing more curious amongst insects than that, during the preparatory states of an animal, its habits should be totally distinct from those of its adult state. The perfect Anthreni are generally found on flowers, preferring, as we have often observed, those of umbelliferous plants. They employ their wings, seeking, after impregnation, to penetrate every spot where dried and preserved animal remains are to be found, in order to deposit their eggs in such situations. They counterfeit death, also, like the *Byrrhi;* and, from their small size and banded colouring, look like small seeds. In the larvæ state they are exceedingly destructive, especially in museums, whence they have obtained the name of museum beetles, devouring the internal parts of bird skins, preserved insects, &c., and attacking feathers and hairs, reducing all to powder. They must not, however, be confounded with the *Tineæ,* or small fleshy grubs found in similar situations, which form for themselves cases of hair, woollen, &c. The larvæ of the Anthreni, on the contrary, are uncovered, except by their own coating of hairs, which are disposed in bundles, the posterior part of the body being furnished with two large patches, which are longer than the rest, and each of which is thickened in a singular manner at the tip. These crests, as they may be termed, are so arranged that the insect has the power of spreading them out, in which position it affords a very beautiful object when magnified.

The perfect insects are of a rounded and depressed form, the surface of the body being adorned with undulated bands of coloured scales, which are easily rubbed off. The antennæ are terminated by a three-jointed club, and are capable of being retracted and concealed in grooves on the under side of the thorax, which is produced behind, on its upper side, into three lobes. There are five or six British species, of which the *Anthrenus* (Byrrh.) *Musæorum* of Linnæus is the type, and which seldom exceeds one-eighth of an inch in length.

These hints will suffice for the practical collector and the professed amateur; for the more systematic entomologist, who is not content with merely collecting insects, but who is intent in classing his collections, arranging each in its proper place and under its proper name, and describing such as are nondescript, another plan of study is requisite. Of the nature of the pursuits of this class of entomologists, Messrs. Kirby and Spence, (having previously spoken of them as possessing an agreeable and unfailing provision of that "grand panacea for the tedium vitæ,"—employment,) make the following observations:—" With what view is the study of the mathematics so generally recommended? Not certainly for any practical purpose—not to make the bulk of those who attend to them astronomers or engineers, but simply to exercise and strengthen their intellect—to give the mind a habit of attention and investigation. Now, for all these purposes, if I do not go so far as to assert that the mere ascertaining of the names of insects is equal to the study of mathematics, I have no hesitation in affirming that it is nearly as effectual, and, with respect to giving a habit of minute attention, superior." Examples are then given of the necessity for minute discrimination in the examination of insects, for the purpose of discovering the proper name of each and the descriptions to be given of it, if it should happen to be undescribed: but there is still another advantage to be gained from this kind of investigation. It may be asserted that no one who has studied the classification of insects, commencing with the class, and going regularly through the orders, sections, families, genera, down to individual species, and neatly arranged his insects in his cases, can leave the subject without having gained certain principles of regularity and order, which will communicate themselves to his every-day employment, inducing a methodical correctness and precision in the details of life, which are so superior to the careless proceedings of the thoughtless and irregular.

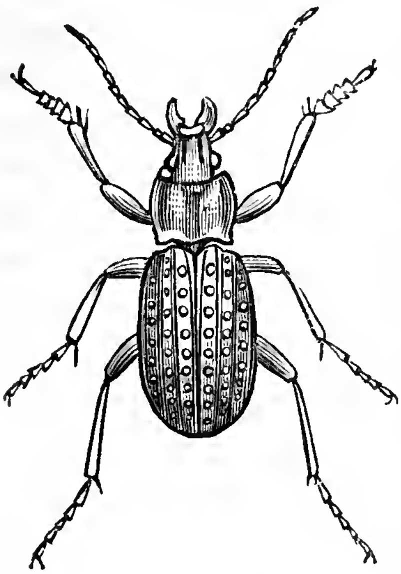
By the student, therefore, who would attempt the classification of his collection, it is requisite that a progressive series of inquiries should be made. It is not advisable that he should commence by the investigation of isolated species: his collection must be in the first instance generalized, since it is only by studying groups of insects in the mass that we can ever acquire any general views of the science. If this be not done, we shall be constantly falling into the error of separating intimately allied groups, because their external appearance is different, and of uniting insects which, from the difference of their organization, are widely apart, because their appearance is similar. Let us take any every-day example of the want of this generalized view of insects. There is an extensive group of two-winged flies which are called drones: they are the very personifications of luxuriant idleness—they do nothing but sip the nectar from the brightest flowers, and enjoy the sunshine basking upon the leaves of plants; and there is an extensive group of bees, having the same general appearance, but being in habits the very reverse of the drones—toiling all day long, either in the construction of the nest, or in provisioning it with pollen paste. Now, by ignorant persons, the same name is given to both groups of insects, and not the slightest idea is entertained of the totally opposite nature of their habits.



A, Drone-fly (*Eristalis*). B, Spring wild-bee (*Anthophora retusa*).

I am the more anxious to impress upon the reader the necessity for obtaining a generalized view of insects, and indeed of the entire productions of nature, because it is well known that many of our fellow-labourers fritter away their talents and time in the sole elucidation of the characters of obscure species of insects, without a thought of the higher views which lay open before them. "English naturalists," says Mr. Bicheno, "appear to me, from various causes, to have pursued the nomenclature and examination of species in such a way as very much to exclude from their attention the higher ends of science, in which alone the bulk of mankind is interested. Ever since the subject has been pursued in the spirit of true philosophy, it has almost solely been confined to the analytic form, which, however important, is apt to degenerate into unprofitable detail, as the synthetic mode leads oftentimes to the other extreme of loose and impracticable generalization." "The necessity of knowing particulars has made our researches into species very minute, and has given to our operations in the eyes of the multitude rather a puerile cast. The method by which the name of an unknown species, and all that has been written about it, can be discovered, necessarily involves such minute discrimination, that it cannot escape this superficial objection. It is, however, an inconvenience not incident to our subject alone, but to all the sciences, more or less, which require a minute examination of particulars." And he concludes by observing, "I am anxious not to be misunderstood; I do not want to disengage naturalists from attention to the analysis of species, or to absolve them from the labour of minute investigation, which, after all, is our chief business; but I do wish to see them following nature through all her varieties, with a view to generalize as well as to particularize; to relieve the memory from the overwhelming multitude of names which the discovery of new species has imposed; and to compress the result into a size adapted to the human capacity. This may safely be pronounced to be among the highest efforts of a created intelligence."

Hence will be seen the necessity for studying collections of animals, and particularly of insects, in the mass; for though the knowledge of species, as Mr. Kirby has well observed, is indispensable for the registry of facts and other practical purposes, yet the knowledge of groups leads to a higher wisdom; and indeed it is through these that we best descend to the study of species. The first thing, therefore, requisite is, to ascertain to what order of insects any individual specimen may belong. For this purpose an inspection of the mouth (for the purpose of ascertaining whether it is furnished with jaws or with a sucker), and of the structure of the wings, will generally suffice. The next step is the separation of your collection into the primary sections and families of which the orders are composed; and here, of course, the characters will vary in the different orders; for instance, in the order of beetles (*Coleoptera*), the primary sections are founded upon the variations in the number of joints in the tarsi (or last articulated part of the leg); whereas in the two-winged flies (*Diptera*) this character is constant, and the number of joints in the antennæ constitute the leading characters of the primary divisions. For the families, no better rule could be laid down than to study the characters of the Linnæan genera, which in fact correspond generally with the modern families of insects; but, as will be more fully detailed in a subsequent page, the contents of these groups have so immensely increased since the days of Linnæus, that it has become necessary to subdivide them into minor divisions, to which the names of genera and sub-genera have been given; and here it will be necessary to have recourse to such authors as Fabricius and Latreille, Stephens or Curtis, for obtaining an idea of the extent to which these subdivisions have been carried, as well as for obtaining a knowledge of the various subdivisions themselves. The practised eye, indeed, can readily reduce an extensive family of insects into its sectional groups, without any other assistance than that derived from long experience, because the most nearly allied species possess such a general resemblance to each other, that it is almost impossible to overlook their relationship: for instance, the restricted genus *Carabus* comprises a very extensive series of ground-beetles,



Carabus clathratus.

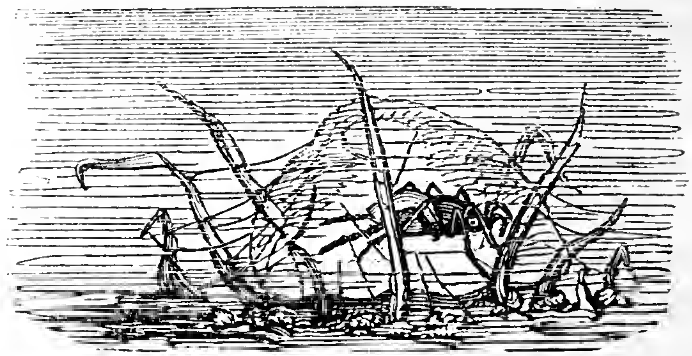
varying but little in size (compared with the variations in size which occur in the family), being moderately large, and ornamented more or less with metallic tints; so also among butterflies, the genus *Colias* comprises species being generally of a brimstone colour. We now arrive at the investigation of the specific name of the insect under examination; and here lies a great difficulty, owing in general to the number of species; great relief, however, is afforded by the introduction of subdivisions in the longer genera, by which we arrive almost immediately at the name of the species itself. In general the descriptions of insects are written in Latin, or at least, if an author chooses to give a specific description in his native tongue, it seems by common consent and usage to be required that he should commence his descriptions by a short Latin character, which, from the almost universal employment of that language in works of natural history, is intelligible to naturalists throughout the world. Moreover, the indication of the natural length and expansion of an insect, the addition of the country which it inhabits, and the references to the works of other authors by whom the species may have been described, and especially where it has been figured, all tend to render this branch of the science less intricate than it at first appears. If, however, after all research into the works of those authors who have especially devoted their attention to the family or genus of insects, to which the one under examination belongs, it should be evident that it is a nondescript, its description, embodying the points of distinction which it presents with reference to the already described species, and whether resulting from structural variation, or from differences of colour, or of striation or puncturation (as in the beetles), may be attempted, taking as models the specific descriptions contained in such admirable monographs as those of Mr. Kirby upon the English bees or the genus *Apion*, or that of Latreille upon the ants.

But the investigation of species, although valuable for the sake of precision in the identity of the object which is the subject of observation, is by no means essential for enabling us to study the structure or economy of an insect; and this brings to our notice several other classes of entomologists, who more especially merit the title of philosophical observers of nature. Of these the out-door naturalist first claims our attention. Instead of running from one end of the country to the other, climbing mountains and descending valleys, stopping only so long as may be necessary to transfix the luckless objects of his chase, and deeming himself happy only when his collecting box is filled with specimens, the real observer of nature finds materials for study even at his own door. The former, it is true, meets with many rarities, and even perhaps nondescript species; but notwithstanding all his toil, has he observed a single fact relative to the history and economy of a single insect? Swammerdam and Reaumur toiled not thus, and yet their labours are read even now by all the world, whereas the labours of the collector are but at best selfish, and the descriptions of his new species read only by a few amateur collectors like himself.

Seek then a spot favourable for the habitations of insects—

a sunny nook in a wood, a hot sandbank, or the margin of a stream, and watch the proceedings of the numberless insects which frequent these spots.

Examine, for instance, the clear water, and watch the movements of the various aquatic insects with which it abounds; and especially observe the silvery silky globe which the diving water-spider bears about with it, and in which, in an enlarged form, it passes the winter. Observe the mode



Diving water-spider, in its diving bell, fixed to plants at the bottom of the water.

in which the butterfly, resting upon a flower, extracts the honey from its cup: trace the flight of the sandwasp, and notice the peculiarities of its manœuvres in the construction of its burrow: examine with careful eye the movements of the sawfly in the act of forming a channel in the sprig for the reception of its eggs; or listen to the chirping of the field-cricket, and trace it to the burrow, at the mouth of which it sits ready to dart upon its prey.

Notice these things, and then say whether these and a thousand other observations of a similar nature are not infinitely more interesting than the mere pursuit and capture of specimens, or the dry technical detail necessary for their specific determination.

"Those who have studied nature only in books," observes St. Pierre, "can see only their books in nature: they look upon the natural world only to find therein the names and the characters of their systems. If they are botanists, they are satisfied to have discovered a plant of which some author has spoken, and having assigned it to the class and the order which he has pointed out, they gather it, and spreading it between two bits of grey paper, they sit down content with their knowledge and their researches. They do not form a herbal to study nature, but they study nature to form a herbal. It is in the same way that they make collections of animals, that they may learn their genera and species, and treasure up their names. But can he be a lover of nature who thus studies her wonderful works? How great a difference is there between a dead vegetable, dry, faded, discoloured, whose stems and leaves and flowers are crumbling to powder, and a living vegetable, full of sap, which buds, flowers, gives forth perfume, fructifies, and sows itself again—maintains an universal harmony with the elements, with insects, with birds, with quadrupeds, and, combining with a thousand other vegetables, crowns our hills and adorns our banks. The animal loses by death even more of its characteristics than the vegetable, for the animal has received a more vigorous portion of life. Its principal qualities vanish, its eyes are shut, its pupils are dim, its limbs are stiff, it is without warmth, without motion, without feeling, without voice, without instinct. What a difference between the animal which enjoys the light, distinguishes objects, moves towards them, calls the female, couples, makes its nest or lair, brings up its young, defends them from their enemies, congregates with its kind, and gives music to our woods, and animation to our meadows."

But the out-door observation of these and such-like subjects by the real lover of nature—and no one merits this name who does not bestow attention of this kind upon the objects of his research, leads to far higher considerations and views. Peculiarities of economy (and herein almost every species of animal differs from its neighbour,) necessarily involve corresponding peculiarities of organization, at times, indeed, minute, and to be sought after with great care and labour, and often with the assistance of the microscope. The philosophically minded student will therefore combine with the observation of habits, investigation of structure, and in this latter particular lies the merit of such laborious naturalists as Lyonnet, Swammerdam, or Strauss-Durckheim, who lay open to our view the minute intricacies of the internal anatomy of various species of insects. The following observations upon the connexion between these two branches of our subject, from the "Introduction to the Menageries," will be read with pleasure, from the soundness of the views which they inculcate:—"It is amazing how much quickness the habit of observation will impart to the whole intellect, and give it an aptitude for understanding and enjoying the thing observed. There is nothing, for instance, so common as to find men wanting in a perception of picturesque beauty, of that feeling which enables some to take great delight in a landscape, not only for its extent, or the grandeur of its parts, but for the harmonious arrangement which is necessary to the effect of a picture, or for some accidental circumstances of light and shadow, or of colour, which render the prospect more than usually attractive. Now this is strictly an acquired faculty, and one which is produced by the practice of looking at nature, or at the monuments of art, with the previous adaptation of the vision to picturesque objects; and a person who enjoys the faculty (we say enjoy, for it is a source of real pleasure) is said to possess a painter's eye. It is precisely in the same way that a naturalist, by constantly observing the peculiarities of animal life, acquires the readiest perception of the differences in the structure and habits of the great variety of living beings, and he perceives in each of them qualities which a less practised observer would entirely overlook. Through these habits of observation, the science of zoology, which comprehends all that relates to the description or classification of animals, has been gradually established. By diligent observations, the *peculiar structure* of vast numbers of *individual* animals has been ascertained; their habits have been accurately described, and many ancient errors, which arose from hasty examination, have been exploded. Thus, in the more recent scientific works on zoology, the accidental circumstances of size or colour, or locality, or any identity in unimportant habits, have ceased to be guides in the classification of animals, but the *essential peculiarities of their formation, which chiefly determine their habits*, have alone been regarded. We mention this, to point out that the actual observations of successive naturalists, leading to the accumulation of a great body of facts, have principally contributed to the advance of zoology as a science in modern times; for the science being wholly founded upon observation, and not upon previous calculations, or any series of experiments, the greater our collection of facts the nearer have we approached to systematic perfection."

These views so fully coincide with my own opinions of the necessity for continual observation of facts, that I have not hesitated to introduce them into this place, as they are equally valuable with reference to every department of zoology. The observation of facts has been too much neglected amongst us; there is, however, one passage contained in the above extract, which appears to call for further notice. We are there told that "the *essential peculiarities of formation chiefly determine the habits*" of animals, and a little further we meet with the remark, that the systems of Cuvier, Blumenbach, and others, are founded upon a consideration both of the teeth and of the organ of touch, and therefore, "being formed with especial reference to *the two great distinctions which de-*

termine the most important habits of the animal, are called natural systems."

Now this passage, and numerous others which I might quote from the works of other modern writers, both popular and scientific, to the like effect, appear to me to result either from very incorrect ideas of the system of nature, or from a carelessness of expression which leads us to imply the existence of such incorrect ideas. Let me not be misunderstood. These passages seem to imply that, in the opinion of the writers, a certain formation being bestowed upon an animal, certain peculiarities of habit dependent thereupon are acquired. Observe the result:—If we adopt this mode of looking at the operations of nature, do we not immediately fall into one of the worst errors of some of the worst of the French philosophers? Do we not at once virtually deny the existence of design in the creation? It was upon this very point that our great philosopher, John Ray, contended with such eloquence in his "Wisdom of God in the Works of the Creation." Against the doctrine, that the bodies of men and all other animals were the effects of the wisdom and power of an intelligent and Almighty agent, and the several parts and members of them *designed to the uses* to which now they serve, the atheist, he observes, has one subterfuge in which he most confides, viz., that all these uses of parts are no more than what is necessary to the very existence of the things to which they belong, and that *things made uses, and not uses things;* and in this spirit Lucretius says,

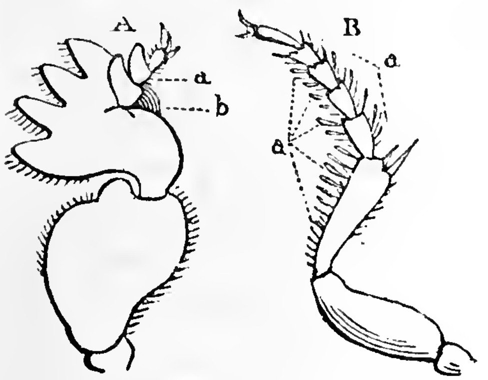
—— Nil ideo natum est in corpore ut uti
Possumus, sed quod natum est, id procreat usum:

And again—

—— Omnia denique membra
Ante fuere, ut opinor, eorum quam fuit usus.

So that, in the opinion of the atheist, all this admired and applauded usefulness of their several fabrics is but a necessary condition and consequence of their existence and propagation.

If it could be proved that the doctrine contained in such passages as those I have quoted, ought not to be identified with the atheistical doctrines above alluded to, and refuted so ably by Ray, I would not have noticed the subject in this manner; but when it cannot be denied that the only interpretation to be put upon the former coincides so exactly with the latter, I think it my duty to guard my readers, and especially my younger readers, from unheedingly falling into a train of thought in which the fore-knowledge and harmonious contrivances of an all-wise Creator, with reference to preconceived and intended uses, are virtually denied; attributes which it is expressly within the duty of the zoologist to hold up to contemplation and admiration, and which the objects of his study so continually present to his view. I have purposely abstained from entering into the arguments adduced by Ray in refutation of these atheistical opinions, the opposite view being fortunately too clear to need much argument in its support. He would be but a sorry architect who, having completed the building of a splendid palace, had not, previously to its erection, planned the uses of its various apartments, and adapted the size and situation of each to its intended uses.



A, fore leg of the mole cricket, formed for digging under ground, the articulated tarsus, *a*, being lodged in the groove, *b*, when in action. B, fore leg of a sand-wasp, formed for burrowing in loose sand; the ciliæ, *a a*, being employed in brushing away the loose particles.

We have thus seen that it is by the continual accumulation of facts, and by noticing the adaptation of structure to habits, or, as Ray more quaintly styled it, the making of things to uses, that we obtain more decided chances of attaining to perfection in our systematic classifications. But we are enabled to do more than this. Natural History is not a mere science of system and names; we have living objects for our study. The student must, however, guard against both extremes. It is as erroneous to consider that person a true naturalist who contents himself with giving a series of hard names to a collection of dried insects or other objects, as it is to assert "that any person, with a little care, may become a tolerably good naturalist the first walk he takes in the fields, without much knowledge of books."

To observe well the habits and economy of animals, to notice, by the assistance of anatomical examination, the adaptation of structure dependent upon such habits, to study the writings of our predecessors who have pursued a similar mode of research, and to apply the information thus obtained to the discovery, not only of the systematic name, and the relationships, more or less remote, existing between the various species of animals, with reference to their arrangement in a natural system*, but also of their relationship with nature in general, the weight of each in the great scale of the universe, and the mutual dependence of animals or plants upon each other, which constitutes that mighty whole which St. Pierre has so well termed the harmony of nature: this it is which constitutes a knowledge of nature, and he,

* Some writers have either wilfully or ignorantly confounded the mere methodical classification of animals, i. e., their system of names, with the natural system, than which no two things can be wider apart. Thus, in the former, that classification must be the best by which we are enabled with the least labour to arrive at the name of an animal; whereas perfection in the latter can only result from a knowledge and adoption of the numerous and intricate relationships existing amongst animals, whether of affinity (that close relation existing, for instance, between a hive bee and a humble bee), or that more remote relationship termed analogy, of which an instance may be mentioned in the hornet, the hornet sphinx, and hornet asilus.

and he only, who will look at an insect or a plant in this manner,—he who will not rest contented with the possession of a specimen, or the observation of a fact in its economy, or the knowledge of its name and place in the system, but will give to his views this extent, he only is the good naturalist.

Before, however, entering upon the peculiar characteristics and modern distribution of insects in the most extended sense of the word, it will be serviceable, in the first place, to enter into an inquiry into the nature of the various relations existing amongst insects; and secondly, the mode of application of the principles to be derived from the study of such relations, either in the construction of an arrangement most fitly adapted for the artificial bringing together of objects, so as to enable the memory with least difficulty to retain an idea of their various characters, distinctions, and names, or, with a higher view, of endeavouring to trace out, by the strict application of their relationships, the general plan by which the wondrous whole has been so beautifully arranged. The latter branch of this inquiry will be best attained by offering a concise sketch of the rise of Entomological science, brought down to its present state.

I have heard it maintained, by men whose views of natural history have been based upon a too partial examination of a few isolated species of some limited groups of animals, that, except in the relations existing between the sexes of a species, or the sexes of distinct species which might accidentally couple together, or between a predaceous insect and the insects upon which it preys, there can be no such thing as a relationship amongst insects. And this view of the subject is endeavoured to be supported by the argument, that the various species of the group which we term a family or genus are totally independent of each other in all their relations of life, and that the annihilation of one species would in nowise influence the remaining species.

Now, all this may be, and much is, certainly true; but it is most assuredly a most partial mode of looking at the relations of animals, even in a natural history and economical point of view. We ordinarily employ the term relationship to designate that bond of community existing amongst the members of a family; but there are numerous other species of alliances to which we may also give the general term of relations. And it is upon these undeniable relations, affinities, analogies, resemblances—call them as you will—that the classification of all animals is founded. And the more perfect our knowledge of any animal, in all its states, and in its relations to all other animals, the more correctly are we enabled to give due weight to every peculiarity, whether structural or functional, which it exhibits; and thus to trace its more or less contiguous relations with other animals. Again, if we look at the habits of insects, we find some exhibiting a similar predaceous economy; others are vegetable feeders; some attack particular species of animals; others particular species of plants. Now each of these groups of species will, both from economy and from structure dependent upon economy, exhibit more close relations amongst their respective members, than the species belonging to groups possessing opposite habits. Hence we may be induced to affirm, as has been done by a celebrated writer, Dr. Fleming, that we shall have as many systems of animals as there are variations of function. And thus, animals differing from each other, except in one isolated particular, are thought to be more nearly related together than they are to other species, to which, in all their other particulars, they are more intimately allied; but this also appears to us to be an equally incorrect and partial view of looking at nature. We have given too great a weight to such an isolated peculiarity. I will endeavour to illustrate this view of the subject by a reference to the recently published volume of the Count de

Saint Fargeau, upon hymenopterous insects, in which we find the social character of these insects regarded as outweighing all other characters. The result of this is, that we have the ants, wasps, hive bees, and humble-bees, united together, whilst the solitary wasps, and the *Psithyri* (parasitic bees, closely resembling the humble-bees), and all other solitary or parasitic bees, are separated; although their structure is in every respect almost identical, except in the organs which are necessarily modified in the former, so as to be fitted for the duties of their social character. Now, this mode of distribution appears erroneous, because too limited in respect to the great workings of the creature. These social habits are but the results of a modification of the instinct for securing the developement of the progeny of these particular species, whilst the great object of these insects in nature is overlooked. The solitary bee, which burrows in rotten wood, and then forms its cell, exhibits as much instinct as the humble-bee, which is the foundress of a community. The wonders of the hive are but the exhibition of a more highly developed instinct in building and provisioning a nest. "In rejecting from the family of the humble bees," observes Saint Fargeau, "the *Euglossæ* of Latreille (which that author had always inserted in the same group with the former), I may remark, that in a system (*dans un systeme*) the very long tongue may indicate a relationship between *Bombus* and *Euglossa;* but in a natural method (*une methode naturelle*), this length *only* indicates that both are destined to gather honey from flowers having long and narrow tubes, although their habits are in other respects entirely different, as indicated by the structure of their hind legs."* Here, however, the difference in habit between these two tribes of bees is only such as is immediately connected with their social or solitary nature, their entire

* Hist. Nat. des Insectes Hymenoptères, Paris, 1836, p. 438.

structure being in other respects similar; thus indicating that, except in this single circumstance, the entire system of the two groups must be as nearly as possible identical. Thus, too much weight appears to have been given to the social conditions of the *Bombi*, and the characters of structure resulting therefrom; and, in like manner, the same remark may be applied to all classifications founded on the presumed superiority of an isolated character, independent of the question of its real value, as proved by the functions for which it is bestowed; and herein lies one of the great obstacles in the way of our tracing the real relationships of animals. Thus one author will maintain that the metamorphoses of insects are entitled to the first consideration; and will hence insist that the all-devouring locust and the suctorial bug are closely allied together. Another will give the same weight to the organs of the mouth; and, denying the relationship between these two insects, will assert that the one is more nearly allied to the mandibulated *Neuroptera*, and the other to the suctorial *Lepidoptera;* whilst a third will maintain the superiority of the wings, and thus bring the mandibulated *Hymenoptera* and the suctorial *Diptera* into contact. Now all these variations of classification do not prove that there are no such things as relationships existing amongst these tribes of insects; but simply that the correct mode of applying the various characters, so as to correspond with their natural relationships, has not been discovered.

These relations, whether of structure or of habit, must have presented themselves to every one who has paid the least attention to natural objects. Let us take an example or two. Among the most powerful means of defence possessed by insects, the sting, furnished with its attendant bag of poison, occupies the foremost place, the pain arising from which must probably, at one time or other, have been experienced by all? Now every one knows that wasps, as well as hive bees, are stinging insects. This circumstance, then, insures the existence of one species of relationship — that resulting from functions; but if we take the trouble to notice these two insects more particularly, we shall find that they possess numerous other characters in common. Both are provided with membranous wings of unequal size; both are social in their habits; both are similarly organized in the structure of their antennæ, and in the number of their abdominal rings. Here, then, we find so many points of resemblance, that we at once admit the existence of a relationship, or similarity, so close that it cannot have escaped the most indifferent observer. This intimate kind of relationship is termed an affinity; but there is another kind of relationship which must have been equally observed by every observer of nature. We have already taken the wasp and the bee as our guides, and here again they will serve our purpose. Whoever has walked, during the heat of the day, in any woody situation, must have observed various bee and wasp-looking insects hovering about in the sunbeams, and darting away, on being approached, with astonishing rapidity. These are not, however, bees nor wasps, neither do they belong to the same order as these insects, although they are sometimes called drones, when seen settling upon flowers, which name is also given to the male honey bee. Figures of these insects, exhibiting their resemblance, have been already given in page 33. Here there is no real affinity,—no resemblance extending through a series of particulars. Habits, structure, wings, legs, antennæ, are all different, when examined with precision; and yet, on a casual glance, the general appearance of the two insects is so similar. This distant kind of relationship is termed an analogy. Further; as there are instances in which a similarity of appearance may thus exist without any real affinity, as regards the structure of essential organization; so, on the other hand, are there numerous instances in which a direct affinity, resulting from similarity of the essential organs, exists between two insects, although their general appearance be quite unlike each other. Of this masked kind of affinity, numberless instances might be produced. Thus an heteromerous insect, related by affinity to *Tenebrio* and *Helops*, so closely resembles some of the predaceous beetles, that Fabricius called it a *Carabus;* and Mr. Kirby has described several allied species under the names of *Adelium Caraboides, Calosomoides,* and *Licinoides.* We have further to notice, that as there are more than one species of hive bees dispersed over the globe, so there are other social species of wild honey bees; in like manner there are as many species of wasps and hornets. Each of these groups of species constitutes a certain series; and thus we discover some of the links of a chain extending throughout nature. Now, it is impossible to adopt these views without, at the same time, admitting that all these beautiful and harmonious affinities and analogies must have been bestowed upon animals with regard to some fixed system.

"Order is heaven's first law,"

and the naturalist must be blind indeed, who cannot trace, in the beautiful gradations of form, and the various relationships of animals, the marks, slight enough in too many cases, of a universal system, wherein just regard is paid to every peculiarity, and every structure shown in juxtaposition with allied structures, none being excluded. This is termed the *natural system;* but in what manner the knowledge of this system is to be attained,—whether, as appears generally to be supposed, by a review of mere structural peculiarities, or by selecting the general functions of each species, or by taking into consideration its geographical range — whether the system be a linear series or a circular one—whether it be supposed to resemble the intricacies of a map* or a sphere—whether it be resolvable throughout its divisions in a binary (Dr. Fleming and Haworth), trinary (Swainson), quaternary (Fries), quinary (MacLeay), or septenary manner (Newman)—whether we confine ourselves to the now existent species, or have regard to the countless multitudes of extinct species—whether by means of any of these proposed modes or any other,—it must be evident that natural history, and especially philosophical natural history, is too new a subject to allow any one to assert that his system, and his only, is superior to all the rest. Great progress has been made of late years in this field, but how great is the yet untrodden portion we have to labour at unceasingly; and he who, by a minute analysis of any animal, enables us to solve any dubious point connected therewith, does more for the elucidation of this much abused natural system than the greatest and most ingenious theorist who has yet taken the subject in hand.

The celebrated Cuvier, whose laborious researches and acute reasoning made such vast strides in the philosophy of natural history, and effected as great a revolution in received opinions as was ever brought about by one man in any science, was fully sensible of the correctness of these opinions. He laboured not to support system, but to discover the truth; and the further he advanced, seemed the more convinced that he did not know enough to enable him to form a system. And if this were the case with the greatest comparative anatomist who ever lived, how truly must the same remark be made of those who, without ever having touched the dis-

* Linnæus, in his Philosophia Botanica, thus speaks of the natural system as exhibited by plants:—" Plantæ omnes utrinque affinitatem monstrant uti territorium in *mappa geographica*."

secting knife, sit down to construct, out of the workings of their own fanciful and ingenious brains, the natural system. Speaking of such theories, Cuvier, a little before his death, said, "I have sought, I have set up some myself, but I have not made them known, because I have ascertained that they were false, as are all those which have been published up to this day. I affirm still more: for I say, that in the present state of science it is not possible to discover one, and it is for this reason that I persevere in my observations, and that I continue to publish them. This perseverance only can lead to the truth. We ought to labour, not with the object of supporting a theory, because then the mind, being pre-occupied, will perceive only that which favours its own views: our labours should be for the object of discovering the truth."

Taking into consideration the immense number of species of insects, which, as already observed, so far exceed all the other animal sub-kingdoms, it must be evident, as Mr. MacLeay observes, that it is here, owing to their myriads of species, that the mode in which Nature's chain is linked—a mode, the knowledge of which comprises all knowledge in natural history—will be most evident, and therefore most easily detected. This same circumstance, also, is attended with another consequence. If the species of insects (and, indeed, of any tribe of animals) be so numerous, and their natural distribution so difficult of attainment; and yet, if we would nevertheless retain and extend the knowledge which we already possess, either of their structure or habits, it must be evident that this can only be done by distributing their groups in the most convenient mode for reference. This may, and, indeed, must be done in an *artificial method:* that is, we select certain constant characters, which may indeed possess but very little influence upon the habits of the animal, and whieh, indeed, in many cases, eompel us to separate groups which we know to be naturally allied by affinity to each other. Thus we separate the wasps from the bees, beeause the former fold their upper wings longitudinally when not flying; and thus we divide the beetles aecording to the joints of the tarsi, although, in some instanees, direet affinities are thereby separated.

Nevertheless, the great advantages resulting from an artificial method are so obvious, that we find them admitted by persons who do not hesitate to reject, as an absurd fancy, the existenee of a natural system. These advantages will appear the more evident when we investigate the actual number of inseet species. Our great and pious naturalist, John Ray ("le premier véritable naturaliste pour le règne animal," as the equally great Cuvier has styled him), in his "Wisdom of God," published at the close of the seventeenth century, tells us respecting the number of British insects:—"The butterflies and beetles are such numerous tribes, that I believe, in our native country alone, the species of each kind may amount to 150 or more. The fly kind (if under that name we eomprehend all the flying insects, as well such as have four, as such as have but two wings, of both whieh kinds there are many subordinate genera), will be found in multitudes of species to equal, if not exceed, both the forementioned kinds. The creeping inseets that never come to be winged, though for numbers they may fall short of the flying or winged, yet they are also very numerous. Supposing then there be a thousand several sorts of insects in this island and the sea near it; if the same proportion holds between the insects natives of England and those of the rest of the world, as doth between plants domestic and exotie—that is, as I guess, near decuple—the species of insects on the whole earth (land and water) will amount to

10,000, and I do believe they rather exceed than fall short of this sum." Subsequently, however, in consequence of having discovered a greater number of English moths and butterflies, he was induced to consider that the total number of British insects might be about 2000, and those of the whole earth 20,000. Mr. Stephens, however, in the most perfect catalogue of insects ever yet published, devoted to the British species, has introduced not fewer than 10,000 native species, and perhaps 2000 or 3000 remain unnoticed.

Linnæus, in the edition of the Fauna of Sweden, of 1761, described 1700 species; and in the twelfth edition of the Systema Naturæ, the entire number of these animals (Swedish and exotic), with which he had become acquainted, amounted to about 3000; but during the last half century the investigation of insects has so much progressed, that Mr. MacLeay, in his Horæ Entomologicæ, published in 1821, stated that there were certainly more than 100,000 of the annulose animals (nearly synonymous with the Linnæan insects) preserved in the various collections. The latest insect census is, however, that of Dr. Burmeister, who states that there are in Germany about 6000 plants (including *Cryptogamia*), and more than 12,000 insects; so that, if this proportion be constant, the number of known insects, according to the 60—70,000 known plants, will amount to 120—140,000 species; and if the opinion of the latest botanists be adopted, that about one-third of the collective species of plants are known, the number of species inhabiting the earth would amount to 360—420,000 species. Kirby and Spence, indeed, averaged six species of insects to one phanerogamous plant, and considering there may be 100,000 species of phanerogamous plants in the world, they obtain the number of 600,000, or more probably 400,000 species of insects. There are computed to be 28,000 species of beetles in the royal collection at Berlin; and from the supposed superiority of the extent of the coleopterous order, Dr. Burmeister considers that the actually known species of insects may be thus distributed:—

Coleoptera	36,000
Lepidoptera	12,000
Hymenoptera	12,000
Diptera	10,000
Hemiptera	4,000
Other insects	4,000

Mr. Stephens's British catalogue shows the following proportions; but it must be observed, that the attention lately bestowed upon the minute *Hymenoptera* and *Diptera* have raised their numbers very considerably:—

Coleoptera	3300
Lepidoptera	1838
Hymenoptera	2054
Diptera	1671
Hemiptera	605
Other insects	544

Now it must be evident, that unless some convenient and easily applicable mode of classifying these vast masses be adopted, the mind will be compelled to remain in a state of the most profound darkness as to their general character and relations.

The annulose or insect sub-kingdom has, therefore, been divided, in the first place, into several primary classes, each of which comprises a number of secondary groups, to which Linnæus applied the name of Orders.

These secondary groups are exceedingly varied in their extent, and are, therefore, respectively divisible into a greater or less number of groups, and gradually decreasing in value until our arrival at the families, genera, and species.

The modern nomenclature of natural history is a subject respecting which we constantly hear great objections raised.

It is true that natural history is not a science of names alone — we have living objects for the subjects of our contemplation; and blind indeed must he be to the beauties of the visible world, who could look at a plant or an insect with no other interest than that of ascertaining its scientific name. The astronomer would be worse than mad who should regard the great luminaries of the universe with no other feelings for the benefits which they bestow than that of a desire to prove their place in the "heavens above." But whilst we thus uphold the superiority of the observations of the economy and natural history, in its legitimate sense, of the animated world, let us not disregard one of its important, although subservient, adjuncts—that of names. No one will indeed deny their utility, the supposed abuse, not the use, of the system being objectionable. Should, however, any one object to the latter, and affirm that nature may be studied in all its details without the technical machinery of names, we shall feel no disinclination even to agree with him in this latter observation, so far as his own experience is concerned; but how greatly is the case altered should he wish to impart his knowledge. I have, indeed, only to refer to the highly valued memoirs of Reaumur for a confirmation of these observations upon the utility of names, since it has unfortunately happened that many of his most interesting histories, for want of a precise determination of the animals whose habits are thus recorded, have been lost to science.

Admitting then the necessity of names, it is advisable to prove the necessity of that extended system of nomenclature which, from having been so much paraded, to the exclusion of natural history, has caused great clamour to be raised by those who were led to believe, first, that our science was but a science of names, and secondly, that the system of Linnæan nomenclature was amply sufficient for every purpose,—hence that the great multiplication of the minor divisions of the Linnæan genera was but an unnecessary frittering of science, having not the least utility, and tending only to disgust the student. Let us, however, look more narrowly at the subject, and endeavour to ascertain what are the grounds for these opinions. It cannot be denied that the machinery of nomenclature, like that of every other apparatus, must have had both a commencement and a founder. Take, for instance, the machinery of a timepiece, which, in the early stages of clock-making, was most cumbrous, notwithstanding its simplicity. Still, to a certain extent, it fully answered the purposes of its construction—that of dividing the day into a certain number of portions. By degrees, as the additions of the minute hand and the striking apparatus, and that of the divisions of a minute, of the repeater, and that of the chimes, were made, the machinery became more complex; and instead of simply turning round once in a certain period, we find wheel revolving within wheel to an extent which, to a savage, has the appearance even of life itself.

Such is precisely the case with the nomenclature of natural history. Linnæus, the great inventor of the system, was indeed so well acquainted with the general relations of the great divisions of nature, that, although it is certain that his botanical far surpassed his zoological knowledge, it is a tribute which is willingly bestowed upon him by all, that in the construction of his general groups the modern naturalist must be compelled to tread, for a great extent, in his steps. Look, however, at the progress of zoology since the days of this great master. Take a single genus of insects—for instance, *Carabus*, of which he described fifty-three species, and we find not fewer than two thousand five hundred contained in the single collection of the Baron Dejean, whilst the more minute peculiarities of organization, both internal and external, have been studied with the greatest zeal by numerous authors. The discoveries of later days have likewise presented numerous groups, equal to those of the genera of which he was ignorant. Now, this torrent, both of novelties and of science, has rendered the old Linnæan genera of such amazing extent, and so unwieldy, that entomologists, in their own defence, have been compelled to institute subdivisions of various ranks. For instance, if a person wish to record some fact concerning one of the Linnæan *Carabi*, he is enabled, instead of wading through the descriptions of two thousand five hundred species, to reduce the objects of his inquiry to one of the great sub-families of the Linnæan genus; and thus, by the assistance of three or four other still more inferior sections, to bring his inquiry into the lowest possible compass. In doing this, however, a sufficient regard has been paid to the authority of Linnæus by converting his genera into families, terminating uniformly, according to the admirable plan of Mr. Kirby, in *idæ*. Subfamilies have been introduced, which are again subdivided into genera and sub-genera, which present varieties in structure of their different organs, while they agree in possessing the characters of the great family to which they belong. Now the advantages of this plan of names are evidently these:—1st, The peculiar construction of an animal is instantly called to mind by the naming of its modern generic or sub-generic names, whereas if the old Linnæan (but now family) title were employed, a very indefinite idea would alone be obtained: for instance, if we were merely told that a friend had observed the habits of one of the two thousand five hundred *Carabidæ*, we should be almost as completely in the dark, as to its precise structure, as though we had been told that it was a beetle. 2nd, The beautiful perplexity arising from the employment of stars, and daggers, and other marks, for sections of the Linnæan genera, is entirely removed. Those who have studied, for example, the invaluable *Monographia Apum Angliæ* of Mr. Kirby, will readily agree with us, that the benefit arising from the use of names, which in general carry some structural idea with them, is alone sufficient to overbalance the difficulty of bearing in mind either the sectional marks of distinction noticed above, or the names which were at times employed in their stead. And, 3rdly, An immense saving of time is obtained by the student in investigating the species of his collection; since, if two thousand five hundred species of *Carabi* composed but one genus, as they do according to Linnæus, what person can be found with either time or inclination to identify the species of even a local collection. For general purposes, indeed, the employment of the old Linnæan names would, in many cases, be sufficient; but for the ends of science, not only the modern generic, but also sub-generic names must be employed; and a plan has been suggested by Mr. Robert Brown, which has the advantage not only of not materially disturbing the names already existing, but also of insuring the co-operation of two classes of naturalists at present opposed to each other—namely, by introducing the modern sub-generic name in brackets between the old generic and specific name: thus we should call the devil's coach-horse, *Staphylinus* (*Goerius*) *olens*. "This," as Mr. Brown observes, in the Appendix to the Narrative of Travels and Discoveries in Northern and Central Africa, "is analogous to the method followed by the Romans in the construction of the names of persons, by which not only the original family, but the particular branch of that family to which the individual belonged, was expressed. Thus the generic name corresponds with the *nomen* (Cornelius), the name of the section with the *cognomen* (Scipio), and that of the species with the *prænomen* (Publius)."

Naturalists are further agreed in retaining for the old generic name those species which were more striking instances of the Linnæan groups. In extensive modern genera it has still even been found serviceable to introduce minor divisions, which in like manner facilitate the acquisition of knowledge. It is, however, the opinion of some authors (as, for instance, Mr. Vigors, in the Zoological Journal), that their existence ought not to be admitted; or if they present sufficiently distinctive characters, they ought to be regarded as genera, and the next higher group of which they form a part, as sub-families. That the gradual approximation of form in the most extensive groups, (where, for instance, it must be admitted that the series, from the number of species, is evidently least unbroken), prevents us from assigning such distinctive limits to our groups, whether of genera (that is, speaking theoretically) or sub-genera, as shall comprise those particular species, in which the characters of distinct genera are blended together, cannot be denied; and the great genus of *Carabidæ* (*Feronia*) has frequently been cited. But still, even in these kind of groups, we find various types of form, which, in the typical species of each minor group, are so well marked, that if the genus were less numerous in species, entomologists would not hesitate to consider them as so many distinct sub-genera. But by many naturalists the great chain of nature is regarded as formed upon this very mode of confluent characteristics; and were we to admit, in those most extensive, and consequently, as we may well suppose, most perfect series of species, the non-existence of genera or sub-genera, we should be compelled to admit still further, that there is no such thing in nature as any other distinct division than that of species. "It appears to be the opinion of most modern physiologists," observes Messrs. Kirby and Spence, "that the series of affinities in nature is a concatenation or continuous series; and that though an hiatus is here and there observable, this has been caused either by the annihilation of some original group or species, in consequence of some great convulsion of nature, or that the objects required to fill it up are still in existence, but have not yet been discovered; and this opinion is founded upon a dictum of Linnæus's, '*Natura saltus non facit.*' If this dictum be literally interpreted, according to the evident meaning of the word *saltus*, few will be disposed to object to it, since both observation and analogy combine to prove that there must be a regular approximation of things to each other in the works of God; and that, could we see the whole according to His original plan, we should find no violent interval to break up that approximation: but if it be contended that in this plan there is no difference in the juxtaposition of the lowest groups or individuals, and never any interval between them, I think we are going further than either observation or analogy will warrant. Were this really and strictly the case, it seems to follow that every group or individual species must, on one side, borrow half its characters from the preceding group or species; and on the other, impart half to the succeeding. (Query, whether every real species or group has not some one or more peculiar characters, which it neither derives from its predecessor nor imparts to its successor in a series?) But one of the most evident laws of creation is variety, and if we survey all the works of the Most High, we shall nowhere discover that kind of order and symmetry that this strict interpretation implies. The general march of nature, therefore, seems to say, that there must be varying though not violent intervals in the series of beings, or, in other words, some conterminous species or groups have more characters in common than others."

Very few words will suffice upon the nature of species, a term employed to designate those groups of animals which (save as respects sexual distinctions) possess a perfect conformity in their characters, which indeed they have uninterruptedly possessed since the first establishment of species. The oldest records of natural history, where sufficiently clear to be relied upon, show us that in the species which are therein described or figured, not the least variation has taken place in them. Were not this the case, indeed, there would be grounds for the belief that there are new species of animals produced, which, as Ray says, would certainly now and then, nay very often, happen were there any such thing. But, as in the higher animals, the species of insects are liable to variation, as every collector is well aware; thus, some moths, which have the ground of their wings of a pale colour with dark markings, will be found to have dark wings with light marks. Variations in size are equally common, and entomologists deem it expedient to retain in their collections suites of individuals of each variable species, from the smallest to the largest: sometimes, indeed, the latter are many times larger than the former, a circumstance often occurring in wood-feeding insects. In general, also, male insects are much smaller than the females. The reader will also bear in mind that this variation in size is not the result of increased growth after arrival at the winged state, and that the small individuals will by and bye attain the size of their partners. This is quite contrary to every principle of insect physiology. It is in the larva state that the eating and growing of these animals chiefly takes place. And it would be as requisite for the imago to cast its horny envelope, in order to increase its size, as it is for the larva to do the same thing: again, it must be self-evident that without the sloughing, the external envelope could never, from its consistence, undergo the slightest change after once attaining maturity. Moreover, the change which the digestive organs undergo in the passage from the larva to the imago states, sufficiently proves the same fact. But species often vary even in structure, not indeed in any of the more important organs, but in the various arms with which they are furnished. This is especially the case with the cornuted species, and those which have the mandibles very greatly developed. Here in many instances there appear to be a series of individuals intermediate between the fully developed species and the females, which are generally destitute of these appendages. This is to be noticed in many species of lamellicorn beetles, and in some of the Staphylinidæ (*Siagonium quadricorne*). The Rev. Mr. Burrell also observed it in another species of the same group (*Bledius armatus*), of which he describes a variety with horns shorter than the head, although usually longer, and which he was even disposed to regard as a neuter, an opinion also entertained by Mr. Haworth, who considered that such neuters are far more frequent, even in the Hymenoptera, than hitherto imagined. Besides these, which appear to be casual occurrences, there likewise exist what have been termed *permanent varieties* in many species, the individuals of which are found in situations different from the ordinary type of the species, and it has been considered that these variations have originated somewhat in a similar manner to the varieties of domestic animals: but this may certainly be doubted, because, in most domesticated insects, the common house-fly for example, disseminated as it is over the whole surface of the globe, and the hive bee, we find not the least liability to vary; and if this be not the case with these species, we can hardly attribute the production of varieties in species, which are in nowise subject to the agency of man, to a similar cause.

The characters by which species are distinguished are very variable, partaking indeed, in this respect, of the peculiarities which we have noticed in our observations upon generic and sub-generic groups. In very extensive genera the distinctions of species are so minute, that it requires the most practised eye to separate them; and indeed there are some groups, the species of which are so intricately blended together, that no two entomologists are agreed as to their distinctness. The genus *Nothiophilus* (a genus of small *Carabidæ*) affords an instance of this. Until very lately it was supposed to consist of only two British species. Mr. Curtis, however, added another; Mr. Waterhouse increased the number to eighteen, in a monograph published in the Entomological Magazine; whilst Mr. Stephens has subsequently reduced this number to six. The characters which supply specific distinctions are also very variable; size, sculpture, colour, markings, locality, general forms, are all employed, and it often happens that a character, which in one group of insects would be deemed of sufficient value to characterize a genus, is in others only serviceable as a specific mark of distinction: thus in the genus *Rhipicera* (a group of exotic beetles, with beautiful pectinated antennæ), these organs vary in the number of their joints; whereas in the entire section of the aculeated Hymenoptera the same number of joints runs throughout the whole.

In describing species of insects it is usual to give a short character, embracing the most striking characteristics of the species. This is ordinarily in Latin, that language being generally regarded as peculiarly adapted to science, being universally understood wherever science exists; indeed the neglect of this plan, which we often notice in French and German, and sometimes in English authors, shows a disregard to a settled and most convenient custom, enabling persons unacquainted with those particular languages to identify, in some degree, a species, although the more extended description may be written in either of these or any other tongue. It is usual also to add the length of the body and expansion of the wings, these admeasurements being taken in inches and lines, which are the twelfth parts of an inch in English, and the tenth parts of an inch in French measure.

To each species of insect two names are given, namely, a generic and a specific one: as, for instance, *Smerinthus ocellatus* (the eyed hawk-moth). This admirably concise plan superseded the old verbose mode of speaking of species, which ordinarily required many words to distinguish them; as for example, the name of the eyed hawk-moth in Ray's time was "Phalæna magna, cinereo, dilute rubente et nigro coloribus varia, cum maculis oculos referentibus in interioribus alis." The names of species are ordinarily derived from, or are, Latin words, expressive of some specific peculiarity. Thus we have *Phalæna mori*, the silk-worm moth, or moth of the mulberry-tree; *Melolontha solstitialis*, the summer cockchafer; *Mutilla europæa*, the European mutilla; *Carabus violaceus*, the violet-coloured carabus, &c.&c. &c. Often a poetical licence was introduced, the death's head moth, for instance, being named *Acherontia Atropos*, after one of the Fates. From the great advantages resulting from the specific names, it is highly essential that they should be unchangeable. The Linnæan names have consequently and constantly a pre-eminence, the great Swede having first introduced them into natural history. In like manner, the name imposed upon any new species by the original describer thereof, is retained in preference to all subsequent ones; unless, indeed, some signal error should have occurred in the imposition of the original name. Here, however, it is necessary that we do not permit our love of change to overcome what is really useful. It has been said, for instance, that if a specific name be derived from a character which is afterwards discovered to be a generic one—as, for instance, *Leistus spinibarbis*, *Loricera pilicornis*; or if such name be derived from a sexual character—as, for instance, *Eucera longicornis*, *Eulophus ramicornis*, *Eulophus damicornis*, *Eulo-*

phus pectinicornis, &c.; or, again, if a name has been employed indicative of the habitation or place of capture of an insect, and it is afterwards discovered that the supposed habitation was merely accidental—as, for instance, *Curculio lapathi;* or it be discovered that the insect is not confined to the supposed locality—as, for instance, *Agonum Austriacum, Raphidia Londinensis*—that in all, or any of these cases, it is necessary that new specific names should be given to these insects. We, however, see no necessity for any such step: *Loricera pilicornis* is known throughout the entomological world under that name. The object for which a specific name is given to the animal is therefore completely obtained; and if we would change this name, and give it another strictly referable to some specific peculiarity, we cannot see what there is to prevent a would-be reformer of names from throwing down the hundreds of names, derived from the heathen mythology, given to insects, and substituting others of his own in their stead. I would not, however, be understood to advocate error, even though long perpetuated.

The name of the author by whom an insect was first described and named, is generally placed in an abbreviated manner after the specific name. Thus the insect described by Linnæus under the name of *Carabus intricatus* is spoken of as *Carab. intricatus* Linn. Sometimes, however, when an insect has been removed from the genus in which it was originally placed, the new generic name is written, and the name of the person by whom the removal was made is added after that of the species. Thus the *Cychrus rostatus* Fabr. was originally the *Tenebrio rostratus* Linn.; but Fabricius removed it to the genus *Cychrus*. Here, however, an evident injustice takes place, as the name of the original describer of a species ought always certainly to follow his own name. This difficulty might be obviated in two ways: either by writing the names of the last-mentioned insect, for example, thus, *Cychrus* Fabr., *rostratus* Linn.; or, more correctly, thus—*Cychrus rostratus* Fabr. (*Tenebrio, p.* Linn.)—the letter *p* standing for the word part.

Generic names are, for the most part, derived from the Greek, and are generally indicative of some peculiarity of the genus. Thus the genus of bees, *Macrocera,* derives its name from two Greek words, *macros* long, and *keras* a horn; the antennæ being very long in the males. In like manner we have *Platycerus,* broad-horned, &c. &c. Many of the Linnæan generic names are, however, destitute of any direct application to the insects which such genera contain, this author having employed the old natural history names, which he met with in the early authors, in the most senseless manner. Indeed, this could not be avoided in many instances, from the vague manner in which the names had been employed; and hence Linnæus, anxious to enlist them all again into the service of natural history, hesitated not to employ them for objects which probably had not the least connexion with those to which they had been applied by the ancients. The universal adoption of the Linnæan nomenclature throughout the zoological world has rendered these blemishes too trifling to cause any confusion to originate in consequence of their adoption. For the like reason, and in order to prevent the equally great confusion which would arise by employing several names for the same animal, naturalists have adopted the plan of retaining that first proposed, unless it should happen to be evidently incorrect, the subsequently proposed names sinking into synonyms.

In concisely tracing, in the next place, the rise of Entomological science, including a sketch of its present state, the names of various celebrated men who have given, from time to time, an impulse to the study of insects, or who have rendered it the most signal services, mark the eras of the more remarkable periods in its history. This order, founded upon the growth of knowledge, is certainly preferable to that established upon the lapse of years from century to century.

Without dwelling upon the Book of Holy Writ, from whence it is evident that the Hebrews had a certain knowledge of the habits of various insects, and had distinguished a certain number of them, the first memorable era is that of Aristotle, since it is in the writings of that father of zoology that the first traces of Entomology, as a distinct science, are to be found. This era dates from three centuries and a half before the Christian era; and, as Latreille observes, it is not less memorable in the history of the world, as being that in which one of his pupils, Alexander the Great, flourished; and, by a remarkable coincidence, the modern Aristotle (as Cuvier has been called) flourished during the reign of a man scarcely less celebrated than Alexander. Aristotle noticed the difference between masticating and sucking insects, and many of the divisions which he established amongst insects are adopted by the latest entomologists; but the distinctive character of the science of Entomology of this period was the admission of a greater number of insects as distinct species, which were the preparatory states of others, which were also observed. In like manner, many species which had not been traced to the egg-state, were regarded as the offspring of a spontaneous generation. With insects were arranged the *Annelidæ* and many other animals of a widely different structure. Entomology was, however, at this period, but a summary of popular traditions, often fabulous or in part erroneous, and more under the domain of medicine than of zoology, mixed up, nevertheless, with some facts which were too apparent to escape the simplest investigation. As to the other ancient naturalists, they have scarcely added any thing to the knowledge transmitted to them by Aristotle. This knowledge passed from the Greeks to the Romans, and from them to the inhabitants of the northern parts of Europe, by whom the Roman power was broken down. Pass we, therefore, over a period of nineteen centuries, and arrive at the second great entomological era, when the revival of letters led to a corresponding revival of the so long dormant sciences. Albert the Great devoted one out of the twenty-two folio volumes, of which he was the author, to Natural History, and in which he treated upon insects, which he separated from the Crustacea. Half a century afterwards (about 1550) the simultaneous appearance of Gesner, Belon, and Rondelet, three of the fathers of zoology, gave a great impulse to this branch of science. Still, however, Entomology was much infected with the radical vice of spontaneous generation; but the spirit of observation was abroad; facts were collected, and both by the assistance of figures engraved upon wood and of microscopic glasses, much increase was made to the stock of knowledge. Some naturalists even confined their researches to Entomology; and in 1602, Aldrovandus published a treatise upon this science. In like manner, in the "Treatise of Insects," (an extensive folio volume, being the joint labours of Wotton, Gesner, Penny, and Mouffet, published in 1624, and being remarkable as the earliest work which appeared in England, expressly devoted to Entomology), a great variety of figures of insects were given, which from their rarity have been overlooked, or regarded by modern writers as entirely novel. The work was divided into chapters, in each of which some genus of insects was treated upon; the first seven being devoted to the honey-bee. Still, however, there were incongruously blended along with insects, all sorts of larvæ of other species belonging to the winged orders, and likewise many of the Linnæan class of genuine *Vermes*, and even the *Hippocampæ*. Moreover, in the works of this period, we find the same continual reference to the supposed medical virtues of almost every species of insect, an instance of which, showing the ridiculous extent to which these ideas were carried, is given below.* But better days were now at hand. Redi, and Malpighi, and Swammerdam, towards the close of the seventeenth century, laid the foundations of a true system of Entomology by the excellence of their respective observations. The first of these celebrated men, by experiment, threw down the doctrine of equivocal or spontaneous generation, and also corrected numerous other errors into which naturalists in general had fallen. The second published a variety of researches of great importance upon the anatomy of these animals; whilst the third, by stripping from the transformations of insects all of the marvellous with which they had been invested, and more especially by the clearness of the details by which he illustrated the extraordinary and startling fact which he quaintly designated as "an animal within an animal," contributed more to the true knowledge and systematic distribution of insects than any of his predecessors. His work, as well as those of Mouffet, Redi, and Malpighi, are still sought after with avidity by the student; and his pages, although containing much verbosity, are filled with the most valuable materials—the result of the most patient attention, devoted both to the habits and structure of the animals investigated. If, indeed,

* The *Curculio antiodontalgicus*, which feeds upon the thistle, *Carduus spinosissimus*, was highly praised in past times as a specific against the tooth-ache (whence its specific name); and it was said, that if fifteen larvæ of this species, or fifteen of the weevils, immediately after their arrival at the perfect state, were rubbed between the fingers till all the moisture was gone, these fingers would acquire the power of causing a cessation of pain, on touching the affected teeth, for a period of twelve months, notwithstanding all the washing which they might undergo. Truly our forefathers were not a whit less gullible than their posterity of the present day.

in our days, the distribution which he proposed, founded upon the nature of the transformations of insects, has been abandoned, it is not less true that the considerations upon which it was established, constitute one of the most valuable elements for a classification of insects, according to their natural relations with each other.

About the same period Lister, Leeuwenhoek, Madame Merian, Vallisnieri, and Ray, rendered great service to Entomology by making known, in considerable detail, a great number of insects, whilst the Memoirs of Reaumur, which appeared about the middle of the eighteenth century, form a storehouse of facts to which every entomologist cannot but turn with new delight. De Geer also, the prince of entomologists, as he has been termed by MacLeay, flourished about the same period, and either as regards classification, anatomy, physiology, or the economy and habits of insects, his "Mémoires pour servir à l'Histoire des Insectes," written in French, although printed at Stockholm, cannot be cited without praise. There are other authors who have trod in the steps of these illustrious men, but, up to the present time, their labours have not been surpassed.

We now arrive at the era of Linnæus—a name to be revered by every naturalist. To him, every branch of Natural History, Entomology in particular, are under the greatest obligations for the strong impulse given to them. This is not the place to detail his classification of insects, valuable as it is, and purified from the errors with which the ancients had darkened the subject; but we must here pay the debt of justice and of gratitude for the admirable system of names which he invented, and which has now become general; for the clearness and precision of the definitions which he gave of the different orders of insects, for the establishment of genera, and for the promulgation of a code of philosophical precepts relative to natural history and botany.

The same era gave birth to other entomologists, whose works must be cited with praise—Rosel, Schaffer, Frisch, all of whom have figured and described many insects. Bonnet, whose researches upon the habits and generation of *Aphides* are of the greatest interest, not only with respect to the natural history of these animals, but also to physiology in general; Lyonnet, to whose incomparable anatomical details upon the *Cossus*, I shall have occasion repeatedly to refer; Fabricius, also the pupil of Linnæus, by the vast number of new species of insects which he described, and the pains which he took in bringing to perfection a novel system of classification founded upon the structure of the organs of the mouth (that of Linnæus being built upon the structure of the wings), has merited the thanks of the entomologist.

Hitherto we have seen that in the distributions which had been proposed by entomologists, a single organ, or series of organs, had been selected as a key-stone of the system; the natural consequence of which, as might have been expected, was the constant artificial results to which such distributions were exposed.

We now arrive, however, at the era of the eclectic system, or that of Latreille, one of the most indefatigable and philosophical entomologists that has yet appeared, who, perceiving this difficulty, successfully accomplished the task of remedying it. He did for Entomology, what his compatriot, Barnard de Jussieu, had succeeded in doing for botany. By making use of the various characters which are exhibited by various organs, in various degrees of developement, in various groups of insects, and by neglecting neither the metamorphotic characteristics (which were the key of Swammerdam's arrangement), nor the variations in the structure of the wings (upon which the Linnæan system was founded), nor the structure of the mouth (which Fabricius had employed as above stated), he has established amongst insects natural groups, arranged according to the affinities which they respectively possess with each other. His first work appeared in 1796; and since this period up to the present time, the works of entomologists in general have been directed towards the same end. Latreille himself, until his lamented decease in 1833, ceased not to strive to render his views more accordant with nature. Cuvier, by his admirable comparative anatomical researches; Dumeril, Lamarck, Savigny, MacLeay, Kirby, Meigen, Schonherr, and a great number of other distinguished authors, have followed in the same steps, and have endeavoured to render the distribution of insects more perfect, and more easily applicable; or to complete our knowledge of groups by the publication of descriptions of new species, or of anatomical details of those already known.

In respect, therefore, to precision of observation, to the distribution of insects into natural groups, and the classification of such groups, it is evident, that in our own times the greatest progress has been made in Entomology. Earlier classifications were founded upon individual and isolated characters, so that the groups which exist in nature were but vaguely exhibited; but at the present day, by the examination of the general characters of insects, all such as are allied together in nature are brought into contact, the effect whereof is, that it is sufficient only to obtain a complete knowledge of a single individual, in order to gain a clue to the general structure of the whole of the species which are arranged with it.

In like manner, the investigation of the internal anatomy of these animals has been equally progressive; for, instead of simply examining the structure of such or such an isolated animal, entomologists, following in the steps of the comparative anatomists, have traced the modifications which each organ exhibits in the whole of the animals of which the class is composed. Cuvier led the way in this branch of the science, and has been followed by Marcel de Serres, Herold, Treviranus, Léon Dufour, Gaede, &c.; whilst the the minute researches of Strauss-Durckheim upon the *Melolontha vulgaris*, and of Mr. Newport upon the Privet Hawk-moth, published in recent volumes of the "Philosophical Transactions," may be cited as models of patience. Besides the last-named author, the English entomologist may boast of the works of several other labourers, whose researches are not inferior to those of any of the continental authors.* The "Illustrations of the Genera of British Insects," published by Mr. Curtis, is a work of the highest service to the science, displaying not only the most minute care in the dissection and delineation of the typical species of the genera illustrated, but also the highest style of elegance in its pictorial representations; whilst the work of Mr. Stephens, which may be regarded as a a companion to the former, presents to us a far more complete series and description of the species of insects found in our own island, than any other country can boast of. The "Systematic Catalogue" of the latter author, is a work exhibiting the most astonishing exertion; whilst the completion of Mr. Haworth's Lepidoptera Britannica, the Australian Monograph of Mr. George Gray, with beautiful illustrations from the pencil of Mr. Charles Curtis, the English translation of the "Règne Animal," by Mr. Griffith and others, the work upon the Lepidoptera of Java, by Dr. Horsfield, together with numerous valuable memoirs published in the "Magazine of Natural History," the "Annals of Philosophy," Dr. Jameson's Edinburgh Journal, the Linnæan and Zoological Society's Transactions, the Entomolo-

* The "Introduction to Entomology" of Kirby and Spence has given a great impulse to the science, and completely answers its title.

gical Magazine, and the Transactions of the Entomological Society of London, all prove that the spirit of Entomology is rising strongly amongst us.

It may also be mentioned, as affording a most gratifying fact in the history of the science of Entomology, that societies expressly devoted to the cultivation of this branch of zoological knowledge, both in Paris and London, have recently been established. England, it is true, led the way by the establishment of such a society nearly forty years ago, for the support of which the best energies of the late Mr. Haworth were in an especial manner, and for a great length of time, directed; but for the last twenty years nothing had been done by it. It must, however, be admitted, that it is to the establishment of the French Entomological Society that we may, in a great degree, attribute the rousing of the energies of many entomologists amongst us: the result of which has been the formation of a society established upon liberal principles, and likely to prove of the greatest service to the science, for the cultivation of which it has been called into existence.

At the end of the present volume I have given a concise list of the writers of Entomology, and their chief productions, which, in conjunction with the preceding pages, will give the reader an introductory knowledge of the rise and progress of Entomological science.

CHAPTER I.

ON THE EXTENT AND APPLICATION OF THE TERM INSECT.

The ordinary English name Insect is given to the individuals composing the most extensive class of animals, to which Linnæus and the older authors gave the name *Insecta,* a word derived from the Latin, and signifying an animal cut or divided into numerous parts or segments, and equally applicable to various species which have the chief divisions of the body connected together by slender points of attachment; the legs in like manner are insected or composed of various articulations. It is not surprising that these characters should have attracted the notice of the earliest naturalists, and we accordingly find the group of insects established by the first writers upon zoology; not, indeed, with that precision of definition which the anatomical researches of modern authors have enabled us to apply to the group; but, on the contrary, united with many other small invertebrated animals, which, even in the present day, are considered as insects by ignorant persons. On examining the body of an insect, we find it externally covered with a strong scaly coating, which, when internally examined, is found to give support to the muscles and other organs, thus becoming as it were an external vertebra; but the observation will immediately occur that the horny nature of this external covering must necessarily prevent the growth of the animal; and this would certainly be the case were not the difficulty obviated in a manner as remarkable as it is perfect, namely, by the periodical shedding of the external envelope, forced open as it were, from time to time, by the internal organs, which have increased in volume since the preceding moulting, owing to the quantity of food taken by the creature. This shedding of the covering of the body is very variable in its effects upon the various groups of insects, in some consisting of a mere throwing off of the outer envelope, without any other change being effected, save that of an increase of size; in others, however, an increase of limbs is obtained; and in some, an entire change in the form of the body is effected, and organs of flight acquired. These latter changes are termed metamorphoses or transformations, and are more especially applicable to the winged groups of insects. Another important character distinguishing this tribe of animals is to be found in the highly organized structure of the eyes in the majority, although in some the organs of sight consist only of a number of small tubercular lenses, which are moreover found in some species which also possess the compound or facetted eyes. The head is also furnished, in the majority of the tribe, with a pair of articulated organs, varying infinitely in their construction, termed antennæ, of which the precise uses have not hitherto been decidedly ascertained. Such are the leading characters of the great mass of animals, to which Linnæus gave the name of *Insecta*, but which Latreille has changed into *Condylopa*, from the articulated structure of the legs. The anatomical investigations of foreign naturalists, about the commencement of the present century, threw a great light upon the real nature of the various groups of Linnæan insects, and upon the respective value of the characters by which the orders into which they had been divided were separated from each other. It was thence at once discovered, that, although the winged orders of insects established by Linnæus were nearly allied amongst themselves, the wingless order (*Aptera*) contained a mass of objects having the most discordant organizations, and which, when properly examined, were proved to be characteristic of groups of higher rank even than the winged orders themselves. In this manner, the apterous Linnæan genera, *Cancer, Monoculus,* and *Oniscus,* were formed into the class *Crustacea; Aranea, Scorpio, Phalangium,* and *Acarus,* into that of *Arachnida;* whilst *Scolopendra* and *Iulus,* as a group named *Myriapoda; Lepisma,* and *Podura,* under the name of *Thysanura,* and *Pediculus* under that of *Anoplura,* have been alternately raised to the rank of classes, or regarded as orders in the classes *Arachnida* and winged insects, to which last it been proposed to restrict the name of insects. But this is a step to which I would strenuously object. I would not willingly be charged with veneration for the works of our predecessors in science merely because they happen to be old; but I do object to the spirit of innovation which cannot distinguish between what is old and what is good; and if the Linnæan group of insects is to be retained, as I submit that it ought to be, as one of the chief divisions of animals, I would certainly retain for it the name of *Insecta,* which so peculiarly refers to the great character of the group, in preference to that of *Condylopa,* proposed by Latreille. It may, indeed, be said, that it is not proper to apply the name of insect to a crab or a lobster, but they are as strictly insected animals as a bee or a beetle; and it may be said, that if we apply the name in this general manner, we shall need some other name to distinguish the true winged insects from the *Crustacea* and *Arachnida;* and this it must be admitted is the fact: and the question then arises, shall we, in order to obviate this difficulty, throw ourselves into the other dilemma, and take away the name of *Insecta* from insected animals? I, however, see no occasion for this step. Systematically, the winged insects may be named *Ptilota,* as proposed by Aristotle, and the Linnæan insects will retain their name of *Insecta,* divisible into four classes, namely,

1. Crustacea,
2. Arachnida,
3. Ametabola,
4. Ptilota.

The limits of the first two of these are acknowledged with scarcely any variation by most modern writers, but the third is a class, the limits of which have been by no means so decided, Dr. Leach placing in it only the hexapod lice (*Pediculi*), and the spring-tailed insects (*Lepismæ* and *Poduræ*); whilst MacLeay has added thereto the *Myriapoda,* consisting of the two orders *Chilopoda* (*Scolopendræ*) and *Chilognatha* (*Iuli*), as well as certain vermes.

For the purpose of making this work an introduction to the knowledge of the whole of the Linnæan insects, I shall in the first place give the characters, &c., of the first three classes as concisely as possible, and subsequently detail more at length the structural, physiological, and systematic characters of the true or winged class of insects.

CHAPTER II.

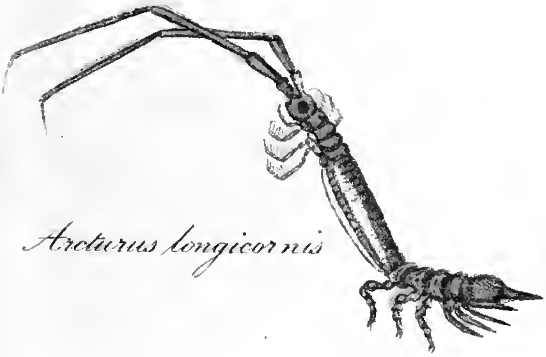
Class I.—Crustacea.

The animals composing this class are distinguished by having the head generally confounded with the thorax, and respiring by branchiæ or gills placed at the sides of the body, beneath the hard covering or shell in which they are incased. The large and better known species are those marine animals known under the ordinary name of shell-fish, and in the Linnæan system they composed two genera alone in the apterous order of insects, namely, *Cancer* and *Monoculus*. Brisson, perceiving the impropriety of allowing these animals to remain amongst the true insects, first separated them—forming them, together with the *Myriapoda* and *Arachnida*—into a class intermediate between fishes and insects, thus taking the first step towards a natural distribution of the articulated animals. Fabricius and Latreille, by accumulating many valuable materials relative to them, assisted greatly towards the same end, but it is to the immortal Cuvier that we are indebted for the first separation of the *Crustacea* as a class within its strict limits.

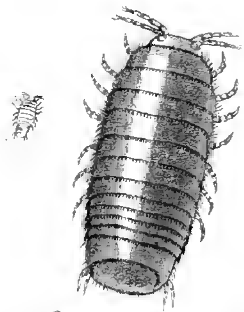
Since this period Lamarck and Leach, as well as Latreille, have occupied themselves in an especial manner in endeavouring to elucidate this class, distributing its contents into various natural groups. Jurine, Strauss, Shaw, Savigny, Audouin, and Milne Edwards, have studied with great success the oral and internal anatomy of the *Crustacea*. In our

PLATE I

Gonoplax angulata, Var?

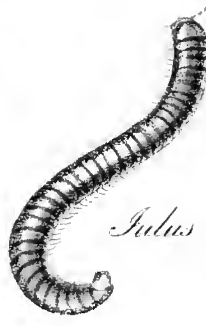


Arcturus longicornis



Limnoria terebrans.

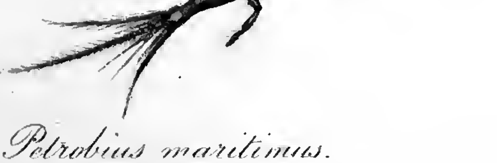
Pycnogonum Balænarum



Julus terrestris

Dysdera erythrina

Hæmatopinus Suis



Petrobius maritimus.

J. O W. del.

own country the recent observations of Johnstone, Hailstone, and Fleming, and the beautiful work of Mr. J. V. Thompson, have shown that the subject is not neglected amongst us.

The *Crustacea,* regarded under the different relations exhibited by their organization, ought unquestionably to occupy an elevated range in the annulose sub-kingdom. They ought not, indeed, to be far removed from the *Arachnida* and insects, which, like themselves, have a symmetrical body incased in a hard corneous covering, performing the offices of an external skeleton, and with articulated legs, eyes always apparent, sexes distinct, &c. They are, however, evidently much farther removed from the *Annelida,* in which the body is destitute of true articulated limbs, the eyes wanting, and the generation often hermaphrodite. These last, indeed, in many respects inferior both to the *Crustacea* and *Insecta,* seem to be more nearly allied to the intestinal worms and *Epizoaria.* With respect again to the fishes, with which they are vulgarly associated, their relations are very trifling indeed*; but with the mollusca, especially such as the *Cephalopoda,* there is much greater affinity, so that they might naturally be placed after them in the series of animals; but as we find other mollusca, such as the *Gasteropoda* and *Acephala,* still less perfectly organized, we should either be compelled to introduce the *Crustacea* in the midst of them, or to place the mollusca either after the entire group of annulosed animals, as the ancients did, or before the *Crustacea,* as the more recent zoologists have done; and this latter step is confirmed by the observations of Latreille, who has proved

* A celebrated zoologist recently requested a friend who was going a long sea-voyage, to bring him home all the fishes he could procure. "Yes," was the reply, "I will catch you all kinds, from a whale to a shrimp;" neither of which, as every person acquainted with the slightest outlines of zoology well knows, are fishes. This anecdote shows that a little knowledge would not have been a dangerous thing, in this instance at least.

the existenee of the great affinity between eertain of the least perfectly organized fishes, and the most perfectly organized mollusca, as the *Cephalopoda*.

The following are the characters by whieh the animals of this class are distinguished from the other annulosa. They are destitute of internal vertebræ, having white blood; the body divided into various segments (differing in number), incased in a crustaceous envelope, and provided with articulated legs; respiring by means of branchiæ or branchial plates, ordinarily annexed to the base of the legs or lower jaws; having a distinct heart furnished with visible vessels, with legs, of which the number is generally five or seven pairs, and always destitute of wings; head generally confounded with the thorax, furnished with two pairs of antennæ, and a pair of mandibles (often palpigerous); two pairs of lower jaws, and three pairs of foot-jaws (the two posterior pairs of which are transformed into two additional pairs of legs, when there are seven pairs of the latter organs); mouth also furnished with an upper and lower lip, or rather a tongue, the external pair of foot-jaws performing the office of a lower lip; eyes two, faeetted, often borne upon footstalks; sexes distinet; sexual organs plaeed either at the base of the legs or the extremity of the body.

And here may be noticed the great difficulty existing in the determination of the nomenelature of the different organs in the various groups of annulose animals, some of which recede so entirely from those which, by common eonsent, are eonsidered as the types or normal divisions of the class;—and, indeed, the remark is applicable in every other branch of the creation. I mention this subject, because Dr. Johnston, the eelebrated naturalist of Berwick-upon-Tweed, has reeently published some observations bearing upon this view of the question, in the Magazine of Natural History, whieh deserve attention. Speaking of one of the species of the shark parasites (*Pandarus alatus*), he says:—"The student who is anxious to see how ingeniously the few and simple organs of this creature can be analysed and resolved into parts corresponding with the complex organs of the crab and lobster, must consult the interesting memoir of Milne Edwards (in the Annales des Sciences Naturelles, tom. xxviii.) I must acknowledge that the analogies seem not a little imaginary, and the nomenclature derived from them is at least faulty, in so far that it gives, or is apt to give, erroneous ideas relative to function. The feet-jaws are not subservient to manducation in any way; the animal is suctorial, and requires no jaws, and these organs are used solely to obtain fixedness of place; while the thoracic feet again are not organs to walk or creep on, but are only calculated for swimming, which, we can conceive, it may often have occasion to do." Although we may admit to its full extent the soundness of Dr. Johnston's remarks in examining an animal *per se*, we certainly do feel, when investigating the same animal with reference to the structure of the remainder of its class, that the great difficulty with which the subject is surrounded ought to make us hesitate before we condemn a series of names which the strictest analogy has proved to be correct. Let us, however, look at the matter with reference to some of the better known examples of the class. Examine a lobster and a crab, and the mouth is found to be externally composed of several pairs of flattened organs, having a transverse motion, and evidently acting as jaws, whilst the large pair of fore legs is terminated by great and powerful claws. Now, examine the spiny lobster, and the claws are no longer to be seen; in their stead a pair of limbs are found, having indeed the same number of joints as claw-legs, but formed like the following legs, and evidently being employed in locomotion. But will it be said that the least stretch is given to our fancy when we assert that the foreleg of the *Palinurus* is the claw of the lobster in a modified state of developement, or that the former analogically represents the latter? Should we incur the chance of ridicule if we describe the claw of the lobster as a leg, although it be employed only in prehension, and not in locomotion? Let us, however, now examine one of the little leaping shrimps, so common on the sea-coast, and of which one species abounds in fresh water (*Gammarus pulex*), and we find the mouth deficient in a certain number of pairs of organs, but that the legs have obtained an increase of the same number of pairs; whilst the examination of such genera as *Sergestes, Sicyonia,* &c., clearly demonstrate the transition of structure and function from mouth organs to legs. Will it be said that we are adopting a faulty nomenclature, because we employ a term for these thus altered organs, which indicates that they are liable to this singular kind of transition? I am aware that, by the unthinking, (and by those who would lead the unthinking by the employment of arguments resting upon general, and, as we may say, vulgar observation, rather than upon accurate but difficult analysis,) we should be ridiculed in asserting that the sucker of the butterfly, and the underjaws of a beetle, are the same organs in a different state of developement, and in applying to both the same term; but I contend that the arguments which I have above brought forward are applicable to one case as well as the other; that there is no fanciful theory to be built upon this strict application of the rules of analysis and consequent analogies; and that when, by the application of the former, and the adoption of the latter, we arrive with certainty (and here, as I said in the outset, lies the great difficulty) at the conclusion that a certain organ in one animal is the representative of an organ in another animal, we are at liberty, in a strictly philosophic view of the subject, to apply to both the same name, although in common parlance it is necessary, perhaps, to use different terms, indieating the preeise functions of each organ.

The class whieh we are now considering may be regarded as taking the plaee in the water which insects occupy on land. They are very varied in their forms, as well as size, some of them being in faet the giants of the sub-kingdom to which they belong, whilst others are of a microseopic minuteness. Some species are of a globular or oval shape, others square, whilst a few are linear and elongated; some again have the body quite flat, others are compressed, and in a few the covering of the body, instead of being hard and crustaceous, exists in a softened and membranaceous state.

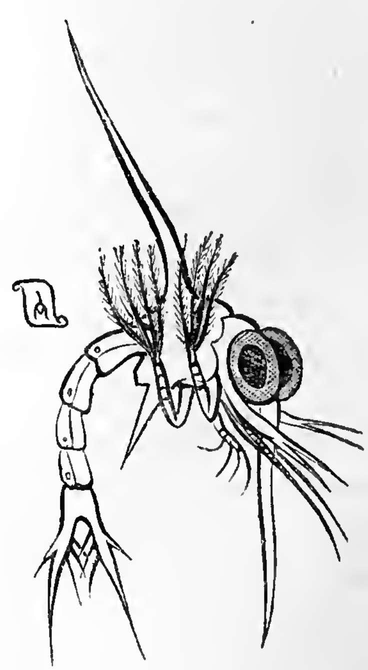
These animals possess the ordinary senses which the inferior animals are gifted with, although, from the great modification in their structure, as compared with that of the vertebrated higher animals, it is difficult, and, indeed, often impossible for us to assign them to their legitimate organs. That they taste is evident from the fact that they are not indifferent to the kind of food which they meet with, and which, indeed, they seek with much assiduity. The very complex organization of their mouths, the developement of which far surpasses that of insects, must doubtless be regarded as indieating the seat of this sense. The organs of sight are very distinct, in the greater number existing as facetted eyes, borne upon footstalks, often of a very great length, as in *Podophthalmus;* often, however, they are sessile, that is, not elevated upon the surface of the head or shell. The structure of the eyes of these animals has lately been studied very minutely by M. Muller (*Ann. Sc. Nat.*, July, 1829). The sense of touch, from the hard envelope in which these animals are ineased, must in all probability be greatly diminished, especially in the more crustaceous species. The circumstanee that they are provided with two pairs of antennæ, as well as several pairs of palpi attached to the jaws and foot jaws, seems to favour the opinion that this sense is transmitted by means of these organs. The sense of hearing has not been distinctly proved to be possessed by these animals; it has, however, been supposed that the seat of this sense was placed in an excavation observed at the base of the external pair of antennæ in certain of the larger species, as the lobster, &c., in which cavity it has been stated that a small sac filled with fluid exists, in the midst of which a nervous thread was fixed: it is certain, however, that the aperture of this cavity is closed by a membrane, and that in some cases there exists (as in *Maia*) a small crustaceous organ or moveable operculum, the use of which appears to be, to distend the membrane which shuts the orifice. Of the distinct existence of the sense of smell we are also equally ignorant, although from analogy we are led to believe that it is possessed by these animals. Its seat is also unknown, although Rosenthals and Robineau considered that it existed in a pair of small orifices at the base of the internal pair of antennæ.

The minute *Crustacea*, whose growth is very rapid, change their coats at very short intervals of time. Thus, Jurine observed that the younger Daphniæ moulted eight times in seventeen days, but amongst the large species, such as the crabs and lobsters, this only occurs once a year. In general, the *Crustacea* having previously obtained such an increased supply of food, as to make their shells too confined for the increased size of their internal organs, they cast their entire skeleton, as we may term it. Previous to doing this, they appear sick, languid, and restless, seeking some secluded place, in which they may securely remain until their new covering shall have attained a sufficient consistence. In casting their shells it is difficult, at first sight, to conceive how it is possible that the inclosed claw, for instance, can be so completely drawn out of the old covering, through the narrow part by which it is attached to the body, so as to leave the shell of the claw entire, and attached to the exuvia of the body, in which state they are constantly found. The new shell, however, is at first quite soft and membranaceous, so that we may thereby account for this circumstance, without adopting the opinion of the fisherman, that the lobster pines so much before moulting, that the flesh of its large claw is reduced to the size of a goose-quill, which enables it to draw its parts through the joints and narrow passage next the body. Still it is evident, that the forcing of the inclosed claw, even if ever so soft, through so narrow a passage, must be exceedingly painful. It is to Reaumur that we are indebted for our knowledge of the precise circumstances connected with this curious phenomenon, that distinguished author having imprisoned several crayfish about to moult, in pots pierced with holes, placed in running water. It is said, that it is easy to perceive when the period of moulting is approaching, by pressing the backs of the animals, when the shells yield readily to the pressure of the finger, not offering that resistance which is common to them. The animals then beat their legs with violence against each other, the body is in a complete agitation, the membranes between the segments being greatly distended, so that the shell is raised considerably from the abdomen, the membrane bursting which connects them. By degrees, the entire shell and external covering is shed, and in the course of two or three days, or even twenty-four hours, the new skin has acquired a proper consistence. Another circumstance of a still more remarkable nature occurs on these renewals, namely, the reproduction of the claws and legs when accidentally broken off. In some species, indeed, the limbs are so slightly attached, that the least touch causes them to shed them. In like manner, it is said that lobsters fear thunder, and are apt to cast their claws on a great clap, and that they will do the same on the firing of cannon; so that when men-of-war meet a lobster boat, a jocular threat is used, that if the master does not sell good lobsters, they will salute him. In the course of a day or two, the naked skin exposed by the wound is found to be covered with a reddish pellicle, which soon assumes a convex surface, grows longer, becomes conical, increases in size, and splitting, exposes to view a soft body, composed of the same number of parts as had been lost. This soon gains the consistence of the remainder of the body, but never acquires the size of the limb lost, although, at every subsequent moulting of the skin, the size increases more rapidly than that of the rest of the limbs.

This curious phenomenon involves, in a singular manner, the principles upon which the moulting of the annulosa takes place. We are taught that the wings of a butterfly exist in the caterpillar state, and that the legs of the larva of a grasshopper envelope the legs of the perfect insect: if, therefore, we admit the theory of Swammerdam, subsequently noticed, as regards the true insects, we shall be compelled to establish another theory for the Crustacea, similar to that of Dr. Herold, also subsequently mentioned. Reaumur has, indeed, attempted to explain the causes of this reproduction of limbs; inquiring, if, at the base of each leg, there may not be a provision of new legs, as in children there is a tooth under the milk tooth! I am surprised that so acute a reasoner as Reaumur should not have perceived the incorrectness of such a supposition. It is perfectly natural that the milk-teeth are one day destined to fall, and it is natural that their places should be occupied by fresh teeth, which are accordingly provided.

But it is perfectly unnatural—merely accidental—that the lobster should lose its elaws ; and it is equally unnatural to suppose, that nature should have provided a series of organs whieh, in the majority of instanees, would be totally useless, depending only upon aecident for their easual developement.

The female Crustacea, after impregnation, deposit a vast number of eggs, which, in many instanees, are retained beneath the abdominal portion of the body, whilst in some, as in the opossum shrimps (*Mysis*), the sea wood-lice (*Isopoda*), they are retained in a kind of a sub-thoracie pouch, and in others they are placed in a membranaeeous bag, or pair of bags, dependent from the base of the abdomen, as in the *Cyclops*, *Branchipus*, &e. It has been generally stated in all works upon this elass, that with a very few exceptions, the young, when hatehed from the eggs, closely resemble their parents in form; these exeeptions oeeurring in *Cyclops*, the young of whieh were regarded by Muller as belonging to two distinet genera (*Amymone* and *Nauplius*), *Argulus*, and *Branchipus*. Indeed, Dr. Leaeh, onc of the ehief investigators of this tribe of animals, has assigned it as one of their prineipal eharaeters, *that they undergo no metamorphosis*. Mr. J. V. Thompson of Cork, has, however, lately published a series of memoirs, in whieh he has announeed "that the greater number of the Crustacca do actually undergo transformations. The eireumstanee of the Crustaeea being supposed to pass through no intermediate form, has been brought forward heretofore as one of the arguments for their separation from insects; but although the fallaey of that opinion may diminish the number of eharacteristics which distinguish these two tribes of animals as *distinct classes*, there yet remains those depending on the anatomieal structure of their respiratory and circulating systems, whieh are quite sufficient to render their separation permanent. It may also be observed, that the changes presented to our notice in the Crustacea are quite peculiar, and of a totally different description from those of insects." Mr. Thompson then proceeds to notice the different extraordinary animals known to naturalists under the name of Zoea, which, from their peculiar structure, had greatly perplexed systematic crustaceologists, and states, "It will no longer be a matter of surprise that all the leading naturalists of the present day should have been at a loss how to dispose of Zoea in their arrangements of the Crustacea, when it is known that this singular type is not a perfect animal, but merely the larva or imperfect state of the crab! and not, as has been imagined, an animal *sui generis*." Subsequently, this author states, amongst other circumstances, that he, "succeeding in hatching the ova of the common crab, during the month of June, which presented exactly the appearances of *Zoea Taurus*, with the addition of lateral spines to the corslet; *the crustacea then indisputably undergo a metamorphosis*, a fact which will form an epoch in the history of this generally neglected tribe, and tend to create an interest which may operate favourably in directing more of the attention of naturalists towards them."* And as the Zoeæ are aquatic animals, furnished with swimming organs, Mr. Thompson concludes, that the circumstance of the young of the Crustacea being thus natatory, enables us satisfactorily to account for the annual



Copy of Mr. Thompson's figure of the Zoea, stated to be hatched from the eggs of the common crab. (The natural size indicated in the scroll)

* Zoological Illustrations, p. 9.

migration of the land crabs of the West Indies to deposit their eggs in the water. Mr. Thompson has subsequently published several memoirs in the Entomological Magazine, and elsewhere, in which he has stated that the eggs of other Decapods produce various kinds of Zoeæ. I have here given Mr. Thompson's observations at some length, because the facts, if fully established, are highly interesting. It is proper, however, to state, that Dr. Rathke has, in a series of microscopic observations, far more elaborate than any hitherto published by Mr. Thompson, clearly shown the gradual developement of the cray-fish within the egg, and which, upon bursting into life, possesses all the form of its parent, and has also announced a memoir* in opposition to Mr. Thompson; whilst the Rev. Lansdown Guilding has expressly stated that the land crabs do not undergo any metamorphosis (*Mag. Nat. Hist.*, May, 1835); and in a memoir which I have published in the Philosophical Transactions for 1835, I have fully confirmed Guilding's statement: thus, two examples in the great divisions of *Brachyura* and *Macroura* are shown to militate against Mr. Thompson's assertion, that the Crustacea universally undergo metamorphosis; and, as the organization of those two animals is so completely analogous to that of the common crab (the young of which Mr. Thompson affirms to be a Zoea) and the rest of the *Decapoda*, I cannot but think that Mr. Thompson must have fallen into some fundamental error in his observations; at least, it is certain that the researches of Mr. Thompson are made without any of that analytical precision which is so obviously requisite in such a matter. It would, indeed, be a remarkable thing,

* "As to the Decapods, so far as I have examined their developement, I must deny such an assertion [as that made by Mr. Thompson]; and of them I can say nothing less than that, at the end of their existence in the egg, they have exactly the same aspect, and are as fully developed, as the full-grown individuals."—RATHKE. 1837. *Annals Nat. Hist.*

that some of the higher Crustacea undergo no metamorphoses, whilst others closely related to them are metamorphotic.

Various modes of distribution of this class have been proposed by different crustaceologists, which it would occupy too much space to detail: I shall, therefore, proceed to give a short sketch of that which appears to be the most natural hitherto published, namely, that by Latreille in the second edition of the Règne Animal, premising, that the distribution of M. Edwards, founded primarily upon the manducatory or suctorial nature of the mouth, appears to be less natural than that given below.

CLASS CRUSTACEA.

SECTION I.—MALACOSTRACA.

Shell of a solid consistence; legs ten or fourteen; mouth with a labrum, two mandibles, four maxillæ, six or ten (according to the number of legs) foot jaws.

SUB-SECTION I.—PODOPHTHALMA.

Eyes on footstalks.

ORDER I.—DECAPODA.

Legs ten; foot jaws ten; branchiæ in a cavity at the side of the thorax.

ORDER II.—STOMAPODA.

Branchiæ not inclosed beneath the shell at the sides of the thorax; legs more than ten.

SUB-SECTION II.—EDRIOPHTHALMA.

Eyes not elevated on footstalks.

ORDER III.—AMPHIPODA.

Body compressed; mandibles palpigerous.

ORDER IV.—LÆMODIPODA.

Abdomen rudimental, with only the rudiments of one or two pairs of appendages.

ORDER V.—ISOPODA.

Body depressed; abdominal appendages flat and plate-like; mandibles not palpigerous.

SECTION II.—ENTOMOSTRACA.

Shell not solid; legs variable in number; mouth very variable.

ORDER VI.—BRANCHIOPODA.

Mouth with a labrum, two mandibles, a tongue, one or two pairs of maxillæ; legs natatory; branchiæ situated anteriorly.

ORDER VII.—PÆCILOPODA.

Mouth suctorial, or destitute of mandibles and maxillæ, but defended by the ambulatory legs which perform this office.

ORDER VIII.—TRILOBITA.

Body 13-23-jointed, divided above into three lobes by two longitudinal impressions.

ORDER I.—DECAPODA.

This order comprises all the larger species of the class, and is well characterized in having ten legs; the head intimately united with the thorax, and covered by a large shell, carapax, or shield; a mouth, consisting of numerous pairs of organs, of which the outer pairs, in some of the species, are elongated; but the most characteristic trait consists in the existence of gills or branchiæ, more or less numerous, fixed in a peculiar cavity beneath the sides of the shell.

This order is divided into two sub-orders, namely,

1. *Brachyura*, having the abdomen shorter than the tho-

rax, beneath whieh it is folded in repose, and not furnished with a terminal fan-like tail. The eommon erab is an example of this sub-order.

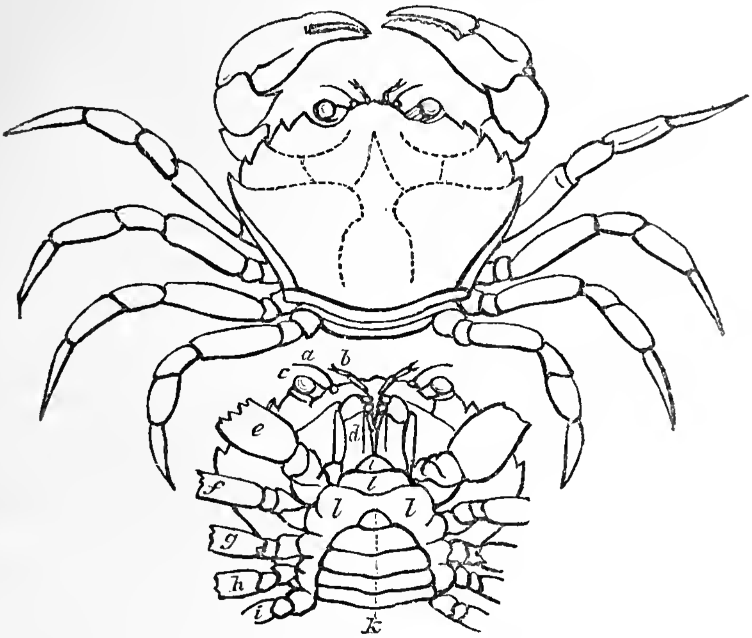
2. *Macroura*, having the abdomen longer than the thorax, beneath which it is not closely folded when at rest, and furnished with a fan-like tail. The lobster, prawn, and shrimp, are examples of this sub-order.

M. Milne Edwards, one of the most celebrated of modern crustaceologists, in a valuable work published at Paris, in 1834, has proposed the establishment of another or third division, under the name of *Anomoures*, forming a passage between the two other groups, and composed of various speeies which appear to belong to neither, and whieh, if introduced amongst them, would violate the spirit of all natural arrangement.

In the various animals which eompose the sub-order Brachyura, the shell or carapax whieh eovers their bodies also conceals the greatest portion of the abdomen, and is in general of a square, oval, or rounded form, its transverse diameter cxceeding,or at least equalling, its length, its upper surfacc exhibiting various areas divided by impressions, which eorrespond for the most part with the insertion of the muscles within the shell, and which form so many regions corresponding with the internal organs immediately beneath the different areas. The front of this shell bears a pair of eyes placed on footstalks (marked *c* in the figure), and two pairs of antennæ (*a*, *b*), and beneath these is perceived a pair of large, flat, and artieulated pieces (*d*), whieh, when raised, are found to conceal a very complex apparatus, composing the mouth, and eonsisting of an upper lip and tongue, a pair of horny mandibles bearing a jointed palpus, a pair of internal* and external maxillæ, and three pairs of foot jaws

* By some accident M. Edwards has described the internal maxillæ as the anterior foot jaws, p. 255.

gradually increasing in size, furnished with palpi, the largest of which is the external pair first mentioned above. Beneath



Carcinus Mœnas (Common small edible Crab).

the antennæ is also placed a pair of apertures, which have been regarded as organs of hearing. The members which immediately succeed the external foot-jaws constitute the legs, and are also five pair in number (*e, f, g, h, i*); they vary considerably in size; those of the first pair are always prehensile, and terminated by a didaetyle and well-formed claw; in general, the four posterior pairs of legs are simply ambulatory or natatory,—they are never didactyle. The abdomen (*k*) is but slightly developed, its length never exceeding three-fourths of that of the entire body, and its thickness not equal to more than one-sixth or one-tenth of the body, being in faet lamellose, and always closely applied to the sternal excavation. It is essentially eomposed of seven segments, but it often oeeurs that some of these are so intimately soldered together, that this part of the body appears to be only five, four, or even three-jointed. In general, it is much larger in the females than in the males, being oval in the former and somewhat triangular in the latter.

The sub-order *Brachyura* comprises a very great number of species, respecting the classification of which, crustaceologists are not yet agreed. Dr. Leach, followed by M. Desmarets, arranged the groups according to the number of pieces of which the abdomen is composed, both in males and females,—a very simple plan, and one of very easy application, but at the same time one which produces the most artificial results, some species belonging to the same natural genus being removed thereby to different families. M. Latreille, on the contrary, founding his earlier classifications upon the general form of the body and the disposition of the feet, established seven families, namely, the *Nageurs* (paddle-legged), *Arqués* (arched front), *Quadrilatères* (four-sided), *Orbiculaires* (orbicular formed), *Triangulaires* (triangle formed), *Cryptopodes* (hidden legged), *Notopodes* (dorsal footed). Subsequently, however, he took into consideration the form of the mouth and some other characters in addition to the preceding, the result whereof was the union of the *Nageurs* and *Arqués* into one family, and the modification of the others. The latter classification appeared the most natural of any hitherto proposed to M. Edwards, who has, however, been induced, from an investigation of the structure of the different groups, further to modify various portions, and to subdivide the *Brachyura* into only four great families, which he terms *Oxyrhynches*, *Cyclométopés*, *Catamétopés*, and *Oxystomes*.

The *Oxyrhyncha* (or *Maiadæ*, *Lithodiadæ*, and *Macropodiadæ* Leach), comprise the various species of crabs known by the name of sea-spiders, or thorn-backed crabs. The legs are long, the shell more or less narrowed in front into a beak, the epistoma (or part of the head between the antennæ and mouth) very large and nearly square. This family comprises three tribes, *Macropodiens, Maiens,* and *Parthenopiens.*

The *Cyclometopa* (or *Canceridæ, Portunidæ,* and *Pilumnidæ* Leach), have the shell very large, regularly curved in front and narrowed behind; the legs are of moderate length; the epistoma is very short, and much wider than long. The abdomen of the male occupies all the space between the hind legs. This family comprises two tribes, the *Canceriens* and the *Portuniens;* the former comprising three sub-tribes, the *Cryptopodes, Arqués,* and *Quadrilatères.* The type is the common edible crab (*Cancer Pagurus*).

The *Catometopa* (*Ocypodiadæ* Leach), have the shell quadrilateral or ovoid, with the front transverse and knotted; the epistoma very short; the abdomen of the male not occupying the space between the hind legs. The common pea-crab (*Pinnotheres Pisum*) is an example of this order.

The *Oxystoma* (*Corystidiæ* and *Leucosiadæ* Leach) have the shell orbicular and arched in front, which is not produced into a point. The epistoma is obsolete. This order comprises the stone-crabs.

The animals belonging to the decapod *Brachyura* are known under the common English name of Crabs, and to which, in the Linnæan system, the name of *Cancer* was applied. The term, however, is not exactly synonymous with the latter name, as the lobster, cray-fish, shrimp, prawn, &c., formed portions of the Linnæan genus. Since the time of Linnæus, however, the study of these animals has greatly increased, so that the animals known now by the ordinary name of crabs compose the sub-order *Brachyura,* whilst the *Macroura* comprise the other species above mentioned; but still, as if to show the total disagreement of the ordinary terms in natural history with their scientific limits, the king crab of the tropical seas belongs to a totally different order of Crustacea than either of those above mentioned, whilst the hermit crab belongs to the *Macroura*.

Crabs are for the most part marine animals, frequenting the rocky shores of the ocean. We regret the very slight attention which has been paid to the habits of these marine animals. They are found in all latitudes, but are more abundant in the warm and temperate climates than in more northern regions. Some genera, as *Ocypoda*, *Gecarcinus*, *Uca*, *Grapsus*, &c., frequent more southern regions, being found in nearly equal latitudes, in the different parts of the old and new world. Others, as the true crabs, *Portunus*, &c., are more generally distributed, extending from the equator to the polar circles.

The local habitations of these animals are, however, very varied. Some species, although having the form of marine crabs, do not quit the fresh water, as in the *Telphusæ*. Again, amongst the marine species, the majority do not quit the shores, whilst others are found at great distances in the high seas, where they can rest only on the floating banks of sea-weeds, so abundant in the tropics. And even in those species which frequent the coasts, the same situations are not congenial to them all: some, as *Dorippe* and the *Inachi*, reside at great depths of the sea, from two to four hundred feet, whilst others keep continually at the surface of the waters, passing a great part of their existence upon the shores continually washed by the waves. Some species, again, frequent only the rocky parts of the coast, abounding in madrepores and difficult of access, whilst others prefer sandy shoals, in which they bury themselves.

Amongst the land crabs some species, as the *Ocypodæ*, make deep burrows, at the mouth of which they ordinarily take their station after the fashion of sentinels, whilst some, as the *Raninæ*, prefer more elevated places, and sometimes even mount the roofs of the huts of the Indians. The crabs are, indeed, the most active animals of the class with reference to their powers of walking, although the *Macroura* certainly excel them in swimming. In those crabs which run fastest the eight hind legs are alone employed, and are terminated by strong pointed hooks. They walk with the same facility, forwards, backwards, and from side to side, indeed in all possible oblique directions. They will also ascend inclined planes, and even almost perpendicular surfaces, provided these planes be not quite smooth. Many, as the *Ocypodæ* and *Gecarcini*, are noted for their rapidity in running; indeed it is said that a man at full speed would be unable to overtake them. The typical species of the genus *Gecarcinus* is the *Cancer ruricola* Linn., a native of the West Indies, and generally known under the name of the violet crab, or *Tourlourous* of the French. They reside in the mountainous district, but as soon as the rainy season sets in, in May and June, they make their way to the sea, in order to deposit their spawn in the water, in such vast numbers that the roads are covered by them. They resemble a vast army marching in battle-array, keeping steadily onwards in a direct line, without allowing any obstacle to impede their steps, scaling even the walls of houses which happen to be in their route, and travelling chiefly by night. When arrived at length at the sea-shore, they are much enfeebled, and dash into the water with great eagerness, which they repeat several times; they then retire to some neighbouring wood or other covert, and, in a short time afterwards, the females again return to the water, and commit their eggs to the waves, which are alive with fishes waiting their annual treat, and by which a very great deal of the spawn is devoured. The crabs then return to their old quarters by the same route, but this, in their still enfeebled state, is a difficult task. When arrived there, however, they have to undergo another annual labour, namely, that of moulting, and which takes place in their subterranean burrows, the mouths of which, it is said, they close. Many species of crabs walk with much less agility than the others, being more decidedly aquatic. They are therefore provided with dilated legs, having the margins furnished with rows of hairs, which are thence converted into natural oars, and by the assistance of which these species are able to perform the same motions in the water as the others do on the shore, and in equally varied directions. Such are the *Podophthalmi*, *Matutæ*, *Portuni*, &c., which have hence acquired the name of shuttle crabs.

Crabs, as well as the generality of the class *Crustacea*, feed upon animal matter, especially when in a state of decomposition. Dead bodies, floating upon the surface of the waves, or cast upon the shore by them, are immediately covered with these animals, and there is every reason to suppose that they are attracted by their powers of scent, although the seat of this sense is not known. Some of the carnivorous crabs even attack living prey, and fight fiercely in order to procure it. In these combats they often lose their claws, which are however soon reproduced, but they never attain the same size as previously.

In the sub-order Macrura or Macroura, the abdomen is elongated, equalling in size the remainder of the body, and not concealed, but simply bent under the breast, and terminated by a fan-like apparatus or swimmeret, having also, on its under side, five pairs of small appendages or false legs, with two filaments at the extremity of each. The abdomen is always seven-jointed, the antennæ generally long and exserted, the outer foot-jaws long, and not entirely covering the inner parts of the mouth. The shell, or carapax, is longer and narrower than in the *Brachyura*, or crabs, and generally terminated in front by a spine. These Crustacea are marine, and do not quit the water like the land crabs.

This sub-order is divisible into five families, namely:—

1. *Hippidæ*.
2. *Paguridæ*, or hermit crabs.
3. *Scyllaridæ*, including the scaly lobsters, *Palinurus*.
4. *Astacidæ*, or lobsters and crayfish, including the *Galatheæ* and *Porcellanæ*.
5. *Palæmonidæ*, or shrimps.

The hermit crabs are of very common occurrence upon the shore, and are well known from their singular and solitary mode of life, which is passed entirely in old and forsaken univalve shells, exhibiting a most beautiful instance of that connexion which is always found to exist between the structure and functions of animals; hence it is that we see the reason why the abdomen of these crabs is of a soft and fleshy nature, since, if it were hard and shelly, like that of the lobster, it would be impossible for it to accommodate itself to its tortuous abode, whereby it is enabled to escape from those dangers to which it would be exposed from the boisterous element in which it resides, if it were not thus amply secured from harm. The species of which this genus is composed are very numerous, and are found in all parts of the globe.

The manœuvres of these creatures, when their habitations have become too small for them, are quite ludicrous. Crawling slowly along the line of empty shells, &c., left by the last wave, and unwilling to part even with their incommodious domicile until another is obtained, they carefully examine, one by one, the shells which lie in their way, slipping their tails out of the old house into the new one, and again betaking themselves to the old one, if this should not suit. In this manner they proceed until they have found a habitation to their liking, which as we learn from Mr. Bennet's Wanderings in New South Wales, is by no means proportioned to their size.

The species of the genus *Scyllarus* are distinguished by the remarkable construction of the lateral antennæ, which are much shorter than the thorax (which is broad and flat), and instead of being slender, are dilated into very broad and flattened plates, having the appearance of a cock's comb; the fore-legs are monodactyle and small, resembling the others; the extremity of the caudal apparatus for swimming is membranous. These crustacea appear in warm climates, and are known by the name of Cigales de mer, which they probably owe to the noise which they make in swimming: they burrow in clayey soils close to the shore.

The genus *Palinurus* includes some of the largest of the macrurous crustacea, comprising the common species sold in our fish shops as the spiny lobster. It is the *Palinurus quadricornis* of Fabricius, the *Cancer elephas* of Fabricius, the *Palinurus locusta* of Olivier, and the *Palinurus vulgaris* of Latreille and Leach. During the winter it seeks the deeper parts of the ocean, but at the return of spring it approaches the shores, preferring rocky situations, where it deposits its spawn, which is of a beautiful red colour.

The common lobster (*Astacus gammarus*) inhabiting the rocky shores of our coast, is the type of the genus *Astacus* of Fabricius, its food consisting of decayed animal matter; and it is with this, as a bait, that the majority of the vast numbers which are annually consumed are caught. It is distinguished generically from the cray-fish by the middle lamella of the tail being composed of a single piece, and by the sides of the abdominal segments being obtuse.

The cray-fish forms the genus *Potamobius* of Leach, although Desmarets and others unite it with the lobster in the genus *Astacus*.

The cray-fish is found in the fresh waters of Europe and the north of Asia. It secretes itself under stones and in holes in the banks, from which it only comes forth to take its food, which consists of molluscous animals, small fishes, and decaying animal matter. It is said to attain the age of twenty years, its size gradually increasing all the time, as each year, at the end of the spring, it sheds its outer covering, shortly after which it is found incased in a fresh coat as firm as the old one, and much enlarged, sometimes having increased as much as one-fifth in its size.

The female deposits her eggs two months after impregnation: these she retains for a considerable time beneath her abdomen, keeping them in such situation by means of a viscid matter with which they are covered, and by which they are attached to the false or swimming legs, with which this part of the body is furnished in its under surface. These eggs increase in size before the exclusion of the young, and are exceedingly numerous. The young ones, when hatched, are extremely soft and small, and entirely resemble their parent, beneath the abdomen of which they shelter themselves for several days. The flesh of this animal is much relished. It has been remarked that those which are caught in clear and running streams are of a better taste than those found in stagnant waters and in lakes. They are caught by sinking a net, or spiny faggots, in the middle of which a piece of putrid meat is placed. We well remember the delight with which, in our schoolboy days, we could escape the trammels of Bonnycastle and Virgil, and go groping, with our shirt-sleeves tucked up, in the holes in brooks where the cray-fish were met with, and can therefore speak from experience of the sharpness of the bite which they can inflict with their claws. The tops of their claws were, in bygone times, employed in medicine, being considered as a valuable absorbent when pounded. Their place is now supplied in our pharmacopœias by the carbonate of magnesia.

The family *Palæmonidæ* (*Salicoques* or *Carides* Latreille) is well exemplified by the prawn (*Palæmon serratus* Pennant), as well as by other species which, in various parts of the world, are much eaten, either by being simply boiled, or salted and potted, and by the common edible shrimp (*Cancer Crangon* Linn., *Crangon vulgaris* Fabricius). There are several species of this genus, but the most common and best known is that above mentioned, and which is found in great profusion swimming in shoals near the shores with great agility upon their backs. Immense numbers of them are eaten, especially by the inhabitants of the western coasts of Europe. They are caught by means of a large open net, held at the end of a long stick, by women and boys, upon our sandy shores. They are also employed as a bait for several kinds of fish.

ORDER II.—STOMAPODA.

This order is of small extent, but very singular structure, which, both as regards the variations of organization itself, and the curious analogies clearly exhibited with other and distant tribes of animals, renders this a very interesting group. The branchiæ are not affixed at the sides of the thorax, and placed in a particular cavity prepared for them, as in the crabs and lobsters; but where there exists particular organs of respiration, they are found under the form of membranous ciliæ, attached to the sub-abdominal appendages. These animals have the teguments slender and transparent, and not of that firm consistence which is found in the lobster. The carapax, or shell, is often divided into two parts, one bearing the eyes and antennæ, the other the appendages of the mouth and the thoracic legs; in other groups it is formed of a single piece, and exposes a certain number of the terminal thoracic segments; the abdomen is in general very much developed, and always composed of seven joints; the eyes are affixed upon moveable footstalks; the internal antennæ are always terminated by two or three filaments; the organs of the mouth are formed nearly as in the *Decapods* (lobsters, &c.), but the foot-jaws have the form of large claw-like legs, those of the second pair (or first pair of leg-like organs) very often much larger than the other legs, and used in prehension.

These crustacea are essentially marine, and die as soon as they are taken out of the water; they are generally natives of tropical seas, not extending beyond the temperate zones. Their economy is not yet ascertained, but it is evident that those which are provided with claws (*Squilla*) employ them in seizing their prey. These species generally frequent very deep water, but the others, destitute of swimming apparatus, and the body very broad and slender, are generally found at the surface of the ocean, where they float about with very little individual motion.

There are two sections, or rather families, in this order, named *Unipeltata* and *Bipeltata*, having respectively for their types the genera *Squilla* and *Phyllosoma*.

In the *Squillidæ* the body is long and semi-cylindric, somewhat resembling that of a lobster, being arched above and flat beneath, the last segment rounded and spined, or toothed, on its posterior margin; the interior antennæ have three filaments, the exterior single, but covered at the base by a broad scale; the thoracic shield is broad, and somewhat depressed; the first pair of legs, or rather leg-like organs, are long and strong, and formed for powerful prehension, the last joint shutting upon the preceding, with strong spines, in the same manner as the fore-leg of one of the *Mantidæ*. The species are somewhat numerous. They are chiefly inhabitants of the seas of warm climates, but one or two of the species have occasionally been taken upon our own coasts; some of them are of considerable size, and are employed for food by the inhabitants of the Mediterranean, in the same manner as lobsters. The typical species is the *Squilla* (Cancer) *mantis* Linn., which is very common in the Mediterranean Ocean. It grows to the length of seven inches.

The *Phyllosomidæ* are called glass-crabs, from the slender and transparent form of their bodies, which is very flat and membranous, divided into two shield-like plates, the anterior very large and oval, forming the head, and the second, or thorax, transverse and angulated. The legs are very long and slender, and each is furnished with a small ciliated branch. These delicate creatures are found in the tropical parts of the Atlantic and Indian Ocean, and one has been discovered in the Mediterranean. When alive they are entirely colourless, except the eyes, which are of a rich blue. There are several species, described by Leach and Guérin.

ORDER III.—AMPHIPODA.

This order is distinguished by the body being generally compressed, and curved upon the sides; the eyes are sessile and immoveable; mandibles furnished with a palpus; and many of them have vesicular bags either between their feet or at their external base, the use of which is unknown.

The first pair of feet, or that which corresponds to the second foot-jaws, is always annexed to a particular segment, the first after the head. The antennæ, which, except in the Phrominæ, are four in number, project and gradually taper to a point; the tail is articulated and styliform.

In this, and indeed in the other groups of sessile-eyed, hard-shelled Crustacea (except the *Læmodipoda*), the body is furnished with seven pairs of legs, attached in pairs to the seven equal-sized segments succeeding the head; but the mouth possesses only a single pair of foot-jaws, so that it is quite evident not only that certain organs which, in the

Decapoda, are mouth organs, are transformed in the *Amphipoda* into legs, but also that the part of the body which, in the former, constitutes the head, is composed of several segments soldered together.

The name *Amphipoda* is given to the group in allusion to another leading character — namely, that of having the legs of different forms, some of them, the anterior, being claw-shaped, and the others simple. Considerable variation, however, occurs in the form of the claws, and also in the particular legs which are clawed; and it is upon these, and various other structural characters, that the genera have been formed. In the typical genus, *Gammarus* (Latreille), the four anterior legs are formed into small claws, and the upper antennæ offer a character which is unique in the order, that of having a small articulated seta at the internal extremity of the third joint. The typical species, *Gammarus pulex* (*aquaticus*, Leach), is a small leaping animal, found in great quantities in ditches, ponds, and springs of fresh water, exceedingly active, and varying much in size. The body of this animal is compressed at the sides, curved, and composed of a series of equal-sized segments, which distinguish it from the prawn and true shrimps. The anterior segments are soldered together into a large thoracic shield or shell, a structure which also prevails in the lobsters and crabs. Its motions are effected in a manner similar to those of the spring-tailed insects, *Poduræ*, by bringing the tail, which is terminated by several appendages, beneath the breast, and then letting it go with force, thus giving, as it were, continual fillips to the water in which it resides, and by which means it is impelled forwards.

Another species (*Cancer grossipes* Lin., *Corophium longicorne* Latreille), is much more slender in its form, and its lower antennæ are very strong, and as long as the body. It inhabits the coasts of various European countries, and is called *Pernys* by the inhabitants of the coast of La Rochelle, where it resides in holes, which it makes in the mud, covered with the woodwork erected by the muscle-catchers. It appears at the beginning of May, and immediately commences warfare against the *Nereids*, *Amphinomæ*, *Arenicolæ*, and other marine *Annelida* which take up their abode in the same places. At the rising of the tide, myriads of these crustacea swim about in every direction, and beat the mud with their long antennæ, and turn it over in order to find their prey. When they have discovered one of these annelida, often ten, or even twenty times as large as themselves, several of them unite together to attack and devour it. They do not cease this warfare until they have thoroughly searched all the mud. They likewise attack mollusca, fishes, and even the carcases of large animals left in the mud. They also ascend the hurdle fences inclosing the muscles, in order to feed upon the latter; indeed, the muscle-catchers pretend that they cut the threads which retain these shell-fish, so as to cause them to fall into the mud, that they may the more easily devour them.

In the genus *Talitrus* (Latreille), the upper antennæ are very short, the lower long, with the terminal division annular, and the four anterior legs not distinctly claw-shaped. The typical species is *Talitrus locusta*, which is very abundant on our sandy shores, burrowing into the sand, and, unlike the majority of the order to which it belongs, seldom or never entering the water. It serves as food to many of the shore birds, which feed upon it with avidity.

ORDER IV.—LÆMODIPODA.

This singular order consists of several curious insects of small size, having the body in general narrow, elongated, or linear, composed of eight or nine joints, with the abdomen rudimental, and furnished with several small anal appendages. They have four simple setaceous antennæ arising from a three-jointed foot-stalk; the mandibles are not furnished with palpi; the legs terminated by a strong hook, except the third and fourth pairs in some species, which are nearly rudimental. They appear to respire by means of several vesicles placed at the base of the four pairs of legs, commencing with the second or third pair, including those of the head, which latter represent the four anterior foot-jaws greatly developed. No other respiratory organs have been observed. According to Savigny, they approach the *Pycnogonides*, and thus lead the way from the *Crustacea* to the *Arachnida*.

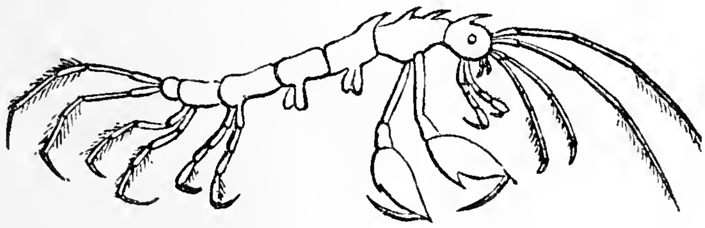
The order is divisible into two families:—

1. *Cyamidæ* (*Ovalia* Latreille), having the body oval, with transverse segments; and,
2. *Caprellidæ* (*Filiformia* Latreille), having the body long and slender, and the segments longitudinal.

The type of the *Cyamidæ* is a curious species, parasitic on the whale.

Sometimes these creatures are so abundant upon the whales, that the infested animals can be easily recognized at a very considerable distance by the white colour which they impart to the whale, and which is visible when it rises to the surface. When these parasites are removed, the surface of the body is found to be deprived of the epidermis, and as it were corroded. They are ovoviviparous, producing eggs which are received into and hatched within the pouchlike plates on the under-sides of the centre of the body, at times eggs alone, at others both eggs and young, and at others young only, being observable in the pouch. *Cyamus ovalis* and *gracilis* are stationary, being found in great numbers agglomerated upon the corneous eminences of the *Balæna mysticetus*. *C. erraticus* is, however, organized for its wandering habits, being of a slender form and with stronger legs serving for prehension. The young ones appear with all the characters of their kind, only the head is rather large, and the supposed branchial appendages, instead of being long and slender, are short and somewhat globose; the females of *C. ovalis* cover their young with their bodies, whilst those of *C. erraticus* abandon their young, conformably to their own mode of life; and in *C. gracilis* the females, males, and young, are all found mingled together. (See the memoir by Roussel de Vauzeme, in the Annales des Sciences Nat., May, 1834.)

The curious insects composing the family *Caprellidæ* are of comparatively small size, seldom exceeding an inch in length. They are generally found amongst marine plants, creeping along, according to Otho Fabricius (*Fauna Grœnlandica*), in manner similar to the looper caterpillars, throwing the head backwards in various directions, and vibrating the antennæ. When swimming, they bend the extremity of the body. The *Caprella phasma* of Montague (*Cancer*



Caprella phasma.

linearis Linn. ?) is described by Mr. Montague in the seventh volume of the Linnæan Transactions, by whom the following observations were made:—The female differs in possessing several plates or valves beneath the body, situated between the two pairs of fins, the use of which is to carry and protect its eggs or young, at which time they extend very considerably, and form a kind of pouch, distended with ova, fifteen or twenty of which are easily distinguished between the transparent plates. In this part a very strong pulsation is visible. Whilst examining a female under a water microscope, this author was surprised to observe not less than ten young ones crawl from the abdominal pouch of the parent, all perfectly formed, and moving with considerable agility over the body of the mother, holding fast by their hind claws, and erecting their head and arms. On a fucus a vast number were collected, of both sexes, and of all sizes, to three-fourths of an inch. When at rest they only held by their hind claws; in motion the arms were also used, and it also struck Mr. Montague that the progression was somewhat similar to that of the larvæ of the *Geometræ*.

ORDER V.—ISOPODA.

This order embraces the Linnæan genus *Oniscus*, with the numerous sectional and generic groups separated therefrom. It is distinguished by the hard envelope of the body, the eyes not raised upon footstalks, the body divided into a series of nearly equal-sized and generally flattened segments, and the legs of nearly equal size, and fourteen in number, the anterior pairs not being cheliferous, or armed with large claws. The legs are terminated by a short curved hook or nail: the under surface of the abdominal portion of the body is furnished with flattened appendages or plates, having the edges fringed with fine hairs, serving, as is supposed, for respiratory organs, and covered by a larger pair. The body is generally flattened, and of an oval form, being broader than it is thick. The females carry their eggs for a considerable period in a membranous bag, under the breast or between the pectoral scales. The young, when hatched, are very similar in form to their parents, and undergo scarcely any other change than that of an increase of size produced by the occasional shedding of the outer envelope of the body. The greater number of species inhabit the water, some of them being parasitic upon fishes. The terrestrial species also require a certain degree of moisture, in order to preserve their branchiæ in a fit state for respiration.

Latreille divides this order into six sections, as follows:—

1. *Epicarides*.—Destitute of eyes and antennæ, legs unfitted for locomotion. This section comprises only a single genus, *Bopyrus* (Latreille), which is often to be found under the shell of the prawn.
2. *Cymothoidæ*.—Four antennæ, terminated by a multiarticulate slender thread; fore legs generally furnished

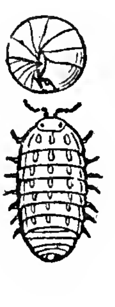
with strong hooks. These are parasitic upon fishes. Genera, *Serolis, Cymothoa, Ichthyophilus, Æga,* and many other genera established by Dr. Leach, including the *Limnoria terebrans,* which is so destructive in some of our ship-yards.

3. *Sphæromidæ.*—Antennæ four, abdomen with two articulations, swimmerets composed of two plates, the lower being moveable. Genera, *Zuzara, Sphæroma,* and other genera of Dr. Leach.

4. *Idoteidæ.*—Antennæ four, placed on the same line, internal small; abdomen with three articulations, destitute of lateral swimmerets. Genera, *Idotea, Stenosoma, Arcturus.*

5. *Asellidæ.*—Antennæ four, inserted in two lines; abdomen composed of a single articulation, without lateral swimmerets, and terminated by two long and slender styles. Genera, *Asellus, Oniscoda,* &c.

6. *Oniscidæ.*—Internal antennæ almost obliterated, abdomen six-jointed, with two or four terminal appendages; some are terrestrial. Genera, *Ligia, Oniscus, Porcellio, Armadillo.*



Armadillo vulgaris.

The most interesting insect in this order is an extremely destructive little animal, forming the genus *Limnoria* (Leach). The only species is the *Limnoria terebrans,* which does not exceed one-sixth of an inch in length, but which, from its wood-eating habits and great powers of multiplication, is one of the most destructive of our insect enemies, attacking piles of wood immersed in the water in our dock-yards, flood-gates, timber bridges, chain piers, &c., and which in a very short time it completely perforates in a most alarming manner, boring to the depth of several inches in every direction. It is found in many parts of the coast, both of

Great Britain and Ireland (see Thompson and Coldstream in the Edinburgh New Philosophical Journal, 1834), and France. From Coldstream's elaborate paper, just referred to, it is evident that the boring of this little insect in the wood has for its object the obtaining a supply of food, as "the contents of the stomach resembled comminuted wood," and that it commences its ravages on an entire piece of wood by fixing upon the soft parts situated between the hard annual layers, and by subsequently working upwards at an angle of forty-five degrees, keeping in preference in the course of the soft layer into which it bored at first: the mandibles appear to be its chief tools. It likewise appears necessary that the hole should be filled with salt water while the insect is at work. Very often, however, the galleries are horizontal, and sometimes perpendicular, the walls being as smooth as if cut by a sharp knife.

A paper by the Rev. F. W. Hope, contained in the second number of the Transactions of the Entomological Society, may also be referred to, in which several useful remedies are suggested. I would also suggest the probability, that the immersion of wood to be employed in submarine works in Kyan's patent solution, would also be very serviceable.

The majority of the species of the family *Cymothoidæ* are parasitic upon various kinds of fishes inhabiting the ocean, to which they attach themselves by means of their strong-hooked feet, and then suck their blood; hence the ancients gave them the names of *Œstrus* and *Asilus*, from the resemblance between their habits and those of the breeze flies. On the under side of the body of the females are fixed several membranous pectoral imbricated scales, covering the eggs, and in which the young are hatched. The type of the genus *Cymothoa* is the *Oniscus œstrum* (Linn.), a species known to Aristotle, who says of it—" Fishes are attacked by a sea-louse, which is not produced from the fish, but from the mud." It resembles a wood-louse, but the tail is larger.

ORDER VI.—BRANCHIOPODA.

This order has for its characters the mouth composed of an upper lip, two mandibles, a tongue, one or two pairs of maxillæ, and branchiæ always placed anteriorly. These crustacea are always wandering in their habits, not being parasitic upon other animals, as is the case with the order *Pæcilopoda*. They are generally covered with a shield-like shell or a case resembling a bivalve; they are furnished with two or four antennæ; their legs are formed for swimming, varying in number, some having only six, others from twenty to forty-two, whilst some have more than a hundred; many have but one eye. They formed in the system of Linnæus the single genus *Monoculus*, but a more precise study of these animals has proved that they present modifications in their structure much more striking than are to be found in the large *Decapod Crustacea*. My friend, W. Baird, Esq., has published a series of papers on these insects in Jardine's Magazine of Zoology and Botany.

This order is divisible into two principal sections; first, the LOPHYROPODA, in which the number of legs never exceeds ten, with cylindric or conical joints; the branchiæ are few in number. Many have but one eye, and the antennæ, which are generally four in number, are employed as locomotive organs. Latreille divides this first section, which is composed of very minute species, into three principal and very natural groups.

1. The *Carcinoida* (*Copepoda* Strauss,) have the shell oval or ovoid, not bivalve; the legs are ten in number, and the eggs are borne by the females in two large external sacks on each side of the base of the abdomen. (*Cyclops,* the water flea, &c. &c.) These little creatures, which

abound in fresh and standing waters, are seldom more than one-eighth of an inch long, and may constantly be observed jerking about by the assistance of their long tails. In their forms they somewhat resemble a lobster in miniature, the thoracic part of the body being of an oval form, furnished with a single eye in front (whence the generic name of the group). This part of the body is divided at its hinder part into several segments, which are succeeded by an articulated tail or abdomen, from the base of which in the females depends on each side a large membranous bag containing the eggs.

From their curious forms, great agility, and odd motions, these little insects form conspicuous objects in the exhibitions of the solar microscope. The upper and longer antennæ perform the offices of legs, and the lower pair of these organs, from their being kept in a continual rapid motion, produce a kind of whirlpool, which brings into its vortex the minute particles upon which they feed. At the period of coupling the males are extremely active. The eggs, which are of a brown, blue, or green colour, varying according to their age, become transparent when nearly ready to produce the young; and it is an extremely curious circumstance, which has been well confirmed, that a single act of impregnation is sufficient for several successive generations. A female cyclops in the space of three months gives birth to not less than ten distinct broods; and if we calculate only eight broods, each having only forty young, it will be seen how immense must be the increase of these creatures. Muller, the celebrated Danish writer upon these and other allied animals, not knowing them to be the young of the cyclops, formed them into a distinct genus, with the name of *Amymone*. Shortly afterwards they acquire an additional pair of legs, and these for the same reason were formed by the same author into the genus *Nauplius*. After the first shedding of their skin they are said to possess all the organs of their perfect form, but of a diminished size, especially as regards the antennæ and legs; and that after the third moulting they become adult; but in this manner of reckoning it will follow, that two pairs of legs must be developed without a corresponding moulting having taken place; and this is so contrary to what is observed amongst the invertebrated animals, that the correctness of such observation may perhaps be questioned. The chief food of these animals consists of minute particles of animal matter floating in the water, but in default of this they will feed upon vegetable substances in a decaying state. There are numerous species belonging to this group, of which the *Monoculus quadricornis* of Linnæus (a name improperly changed by Dr. Leach to *C. vulgaris*) is the type; it is very variable in its colours, being sometimes reddish, at others green, bluish, or whitish. It is a very common species. Some of the species (forming the genus *Calanus* of Dr. Leach, including the *C. finmarchianus* of Muller) have the inferior antennæ obsolete, whilst others (forming my genus *Canthocampus*, having for its type the *C. staphylinus*,) have the abdomen of the females recurved with a spine beneath at the base, and in some there is but a single egg-pouch (forming my genus *Diaptomus*), and of which the *C. castor* is the type.

2. The *Ostracoda* (Latreille; *Ostrapoda*, Strauss,) have a bivalve shell united by a hinge, and closing during repose; with the antennæ simple and setaceous. They have six legs, and only one eye; the mandibles and upper maxillæ are furnished with a branchial plate. (*Cypris*, the water shell flea, &c.) These insects swim about with great velocity in standing and fresh waters, their bodies being inclosed in the bivalve case united by a hinge, which enables them to close their shells on the approach of danger. According to Jurine, who has observed these insects with much attention, the antennæ are employed in swimming, and the two fore legs are used when the animal creeps upon the surface of aquatic plants. He says that the second pair of legs are employed in establishing a motion in the fluid, whereby small particles of food are directed to the mouth; the tail is divided by two fillets, which are folded together when coming out of the shell; the eggs are inclosed in two large bags at the sides of the body beneath the shell: the female is occupied for about twelve hours in depositing them upon aquatic plants. As in the *Cyclops*, Jurine observed that several generations are capable of being produced without more than a single coupling having previously taken place.

3. The *Cladocera* (Latreille), have also the shell bivalve and a single eye, but without a hinge, and terminating in a

point behind, with the head, which is covered by a shield-like plate, exposed; the antennæ are two in number, very large and branched. They have ten legs. (*Daphnia*, &c.)

In the genus *Daphnia* (Muller), the head is distinct, and produced beneath into a kind of snout, furnished with a single central small eye. From each side of the head arises a large antenna-like organ, having a long basal joint, at the extremity of which each antenna is divided into two long articulated branches, each of which supports a number of long bristles. The functions of these organs in swimming, (being, in fact the only external apparatus employed in this motion), has induced M. Strauss to regard them as forelegs, although it is evident, as Muller and Jurine observed, that they represent the upper antennæ of the typical crabs. Within the shell of the *Daphnia* are to be observed ten small leg-like organs, having the second joint vesicular, the eight anterior ones being terminated by a dilated joint, margined with hairs, and serving as oars. By a curious provision the eggs are deposited in a dorsal kind of pouch beneath the shell within which they are hatched; at the end of the fifth day the young have acquired sufficient power to take care of themselves, and are expelled by the female.

These animals, of which there are numerous species, are found in fresh and standing water, where they swim about with very great agility, their large branching antennæ giving them a curious appearance. Their history has been traced, notwithstanding their minute size, by several eminent observers: the works of Messrs. Schaeffer, Ramdohr, Strauss, and the elder Jurine may be especially mentioned. It has been observed, that a single impregnation is sufficient for several (six or more) generations. Occasionally these insects abound in water to such a degree as to impart to it their own tint; and, as one of the species is of a red colour, the hue thus imparted to the water has been supposed to have been caused by blood. The type of the genus is the species above mentioned, or the *Monoculus pulex* Linn. It is about one-twelfth of an inch long, and in spring is of a red colour, which towards summer becomes rosy, but at other seasons it is of a greenish white colour. It is very abundant.

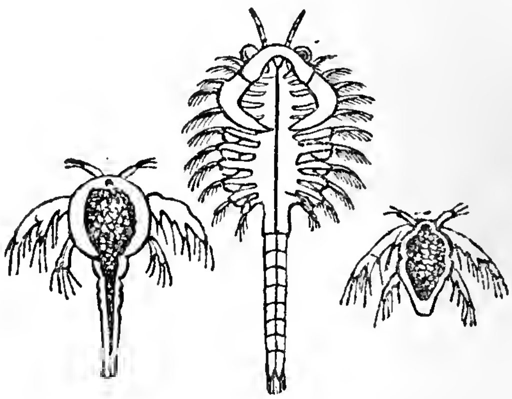
The second principal section of the *Branchiopoda* is named PHYLLOPODA, from the legs, which vary in number from twenty to more than a hundred, being flattened, the joints forming ciliated plates. They have a pair of eyes, and the antennæ, of which there is generally only a single pair, are small, and not fitted for swimming. This section is divided into two principal groups.

1. The *Ceratopthalma,* having the eyes generally carried upon footstalks, ten or twenty-two pairs of legs, the anterior neither much longer than the remainder, nor branched. The eggs are either internal, or carried in a sac at the base of the abdomen. (*Branchipus, Limnadia.*)

In the genus *Branchipus* (Latreille, *Chirocephalus* Jur.), the body is narrow, long, and compressed, the head distinct, with two horns between the eyes, eleven pair of legs, the abdomen long and cylindric, with two terminal ciliated plates. The males are distinguished by a pair of very large horns attached to the mouth. The eggs are borne by the females in a pouch attached to the base of the abdomen.

Jurine, Prevost, and Dr. Shaw, have given very full accounts of the structure and habits of these animals. When full grown they are about an inch and a half long, and are found occasionally in great numbers in small puddles of standing fresh water. They swim well upon their backs, and their legs, which are incapable of assisting locomotion, are kept in a constant undulatory movement, which has for its object the forming of a current of water between the base of these organs, and which, following the canal of the breast, conveys to the mouth the small particles upon which the animal feeds. The eggs are yellowish coloured; they are at first round, but afterwards assume an angular form, which favours their preservation, since it appears that they are enabled to withstand a very considerable degree of drought until a fall of rain sufficient to cause them to hatch takes place. On quitting the egg the body is divided into two globular masses, the anterior of which comprises a single eye, two short antennæ, two large branched organs serving for swimming, and two short and slender legs. After shedding their skin the first time, they have three eyes, the middle one being smooth; the hinder part of the body is elongated, and the tail is terminated by two short filaments. Subsequently the legs begin to appear by degrees, and the branched organs entirely disappear.

The genus *Artemia* (Leach) comprises the *Cancer salinus* of Racket (*Linn. Trans.* v. ii.) or the brine shrimp. J. V.



Brine Shrimp, in various stages of growth.

Thompson and V. Andouin have both published interesting notices of it. The body is oval, and flattened, with the head not separated from it; the tail or abdomen is long, terminated by two small points. "The brine shrimp, or *Artemia*" (not *Artemis,* as Mr. Thompson, from whom I quote the following observations, calls it) "*salinus,* is a very small and delicate animal; when full grown about half an inch in length, of considerable transparency, slightly tinged with yellow, and with a highly polished surface: nature having constructed them with members solely adapted to swimming, they seem to be in perpetual pursuit of prey, gliding with an almost even motion through the water, and moving with equal indifference and facility on the back, belly, or sides: the shape of the animal, the undulating movement of its fins, and the glossy appearance of its coat render it an object of a very interesting description, more especially when apprised, that analogous animals appear to have been the first created conspicuous inhabitants of the primitive fluid, of which these may be regarded as a degenerate or pigmy race." Mr. Thompson has traced the gradual developement of these curious animals, which nearly resemble those of the branchipus.

2. The *Aspidiphora,* having sixty pairs of legs, all furnished at the base with a vesicle, the anterior very large and ramose, three sessile eyes, with two bivalve capsules inclosing the eggs, and attached to the eleventh pair of legs. The body in the singular typical genus *Apus* is covered by a large and flattened membranous plate of an oval form, with a deep cleft at its hinder extremity, and bearing in front two large eyes, placed close together, with a smaller one behind.

These animals are occasionally found in considerable numbers in fresh water, particularly such as is stationary; in which situations they are sometimes observed to be produced in so instantaneous a manner that it is difficult to conceive whence they could have been brought; this is more especially the case in puddles of water caused by heavy rains. It is evident, however, that the eggs of these animals must be endowed with great powers of vitality, by which means alone we are able to account for their sudden appearance. They subsist chiefly upon tadpoles. The distinction of the sexes has not been observed, some naturalists even supposing them to be hermaphrodite. When full grown they are about an inch and a half long.

ORDER VII.—PŒCILOPODA.

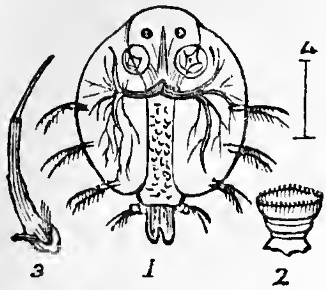
This order has the legs of variable form, the anterior of an indefinite number, being formed for walking, or prehensile, whilst the posterior are lamelliform or pinnated, and either natatory or serving as organs of respiration (*branchiæ*). It is, however, especially by the absence of jaws and under-jaws that they are distinguished from the other crustacea, these organs being either replaced by the basal part (*coxa*) of the six pairs of forelegs, which are furnished with minute teeth, or the oral apparatus, consisting in an external siphon, in form like an inarticulated rostrum, or in other suctorial instruments, whose structure is not well determined. Two of the antennæ (*chelicera* Latr.) are in general cheliform, and perform the office of pincers. They are generally parasites, living upon the bodies of other aquatic animals, especially fishes.

This order comprises two principal sections or sub-orders:—

1. *Xyphosura* (Latreille), in which the carapax is bipartite, the suctorial apparatus wanting, and its place supplied by the dilated bases of the forelegs. The type of this section is the genus *Limulus* (Fabricius), the species of which are known by the common name of king crabs, having the body covered by a large and nearly rounded shell, divided into two parts, the anterior being large and semilunar, and the posterior toothed at the sides, and deeply notched behind, and terminated by a very long and acute spine; the mouth is not provided with any sucker, the coxæ of the six anterior pairs of legs being dilated and spined, and performing the office of jaws. These king crabs sometimes attain the length of two or three feet. They inhabit the tropical seas, frequenting the coasts, and appearing to be found only in the East Indies and the shores of America. According to M. Leconte, they are given to pigs for food, and the long and pointed tail is sometimes employed by the Indians for the points of their arrows. Their eggs are eaten by the Chinese.

2. *Siphonostomata* (Latreille), in which the mouth is evidently more or less suctorial, and the carapax composed of a single piece. It comprises the two families *Caligidæ* and *Dichelestionidæ*.

In the parasitic family *Caligidæ*, the body is covered by an oval or semilunar transparent shield, flattened above, with twelve legs, the four last pairs of which are feathered and pinnate, being admirably formed for swimming. The tail is more or less elongated and exposed, and terminated by two appendages. The genus *Argulus* is established for the reception of a small but very curious (British) animal found upon various small fresh-water fish, upon the blood of which it subsists, sometimes to the destruction of its victim. It is the *Monoculus foliaceus* of Linnæus, and its natural history and structure, in the different stages of its existence, have been detailed by the younger Jurine in the most satisfactory manner, in the seventh volume of the Annales du Museum d'Histoire Naturelle. The first pair of legs is large and short, and shaped somewhat like a cup, since it is by these organs, which probably act like a cupping machine, that the insect attaches itself to small fish. The young resemble their parents in form, though their locomotive organs are very differently constructed. The other genus, *Caligus*, is destitute of the large cup-shaped feet, the anterior pair being hooked. The tail is long, and terminated by two very elongated processes in the females, of which the use has not yet been determined. These animals are termed fish-lice, being parasitic upon various kinds of fishes. The genus has been subdivided into several sub-genera by Leach and Latreille.



Argulus foliaceus.

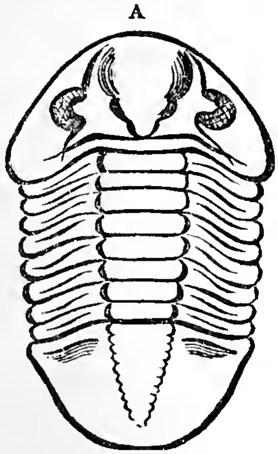
1, the animal magnified; 2, one of the large anterior sucking feet; 3, the rostrum; 4, natural length.

The *Dichelestionidæ* is composed of the single genus *Dichelestium* (Hermann), having the body long and narrow, composed of seven segments, the first of which is larger than the rest, with a pair of slender filiform antennæ, a pair of short didactyle claws, a tubular sucker, three kinds of feelers, four short legs for prehension. These animals insinuate themselves into the flesh and the gills of the sturgeon, as many as a dozen having been found upon one fish, retaining firm hold of their prey by means of their strong frontal pincers.

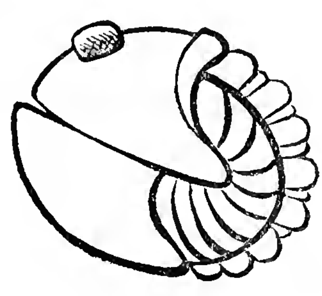
ORDER VIII.—TRILOBITA.

This order consists of a very extraordinary tribe of extinct animals, known in this country under the name of Dudley fossils, having the body composed of three transverse parts, and divided longitudinally by two deep impressions, forming three elevated lobes. The anterior part of the body is generally more or less semicircular or lunate, having on the upper side two large and generally reticulated eyes, shaped like kidneys. This part is succeeded by numerous (from six to twenty-four) transverse segments, and the body is terminated by a large semicircular plate, less distinctly articulated than the preceding part. No organs of locomotion or antennæ have been observed, and it appears to have been the habit of these animals to roll themselves up into a ball by bending the extremity of the body beneath the breast, and bringing it into contact with the head. Much diversity of opinion has been entertained amongst naturalists as to the relations in nature of these curious creatures. According to M. Adolphe Brongniart, who published a good monograph of them, they are most analogous to the *Limuli*, and other entomostracous crustacea, provided with a great number of legs, of a more or less membranous construction, and which, it may be readily conceived, would have been entirely destroyed during the great overthrow which has reduced these creatures to their present state. This opinion has been strenuously maintained by Audouin. It is, however, opposed by Latreille, who observes that, supposing these animals to have been destitute of legs, they would naturally approach the *Oscabrions* (or gasteropodous *Chitons*); or rather, that they constituted the primitive type of annulose animals, uniting on one side the last-mentioned molluscous creatures with the entomostracous crustacea, as well as with the genus *Glomeris* (amongst the myriapodous insects); adding, that no branchiopodous *Entomostraca* has hitherto been discovered capable of contracting itself into a ball, which peculiarity is only observed in the isopodous genera *Typhis, Sphæroma, Tylos,* and *Armadillo,* figured above, and in the apterous genus *Glomeris,* subsequently figured, between which tribes there is a considerable hiatus. The genera *Calymene* and *Asaphus,* amongst the *Trilobites,* on account of their contractility, evidently approach the *Glomeris* and some of the isopodous crustacea (*Sphæroma*); but the *Trilobites* have the terminal segment of the body entire, and not furnished with lateral swimmerets, as in the *Sphæromæ;* the same negative character however exists in the *Glomeris,* and especially in the genus *Tylos,* of which the upper side of the thoracic segments is divided into three lobes. The discovery of the isopodous genus *Serolis* on the coasts of Patagonia has afforded another proof of the correctness of Latreille's idea of the osculant situation of these creatures between the *Isopoda* and the myriapodous insects, the eyes in that genus being situated in the same vertical situation, and of the same lunate form, as in the *Trilobites.* Moreover, the body

A



B



A, Asaphus expansus. B, The same rolled up.

is longitudinally divided into three lobes, like the *Trilobites.* The legs and caudal swimmerets scarcely extend beyond the sides of the body; but the antennæ are very large and distinct. This genus has lately been described and figured in detail in the Transactions of the Albany Institute, by Mr. James Eights, under the name of *Brongniartia*. Much of this diversity of opinion has resulted from the very much worn state of the *Trilobites*, which have, in many instances, been so rubbed, that their eyes have been entirely effaced; but it is questionable whether any *Trilobite* was ever destitute of those organs, which Dr. Buckland has, in his Bridgewater Treatise, described at great detail, in connexion with their fitness for the situations in which the animals are supposed to have resided. Mr. J. V. Thompson, in the last of his Zoological Researches, has adopted the opinion of M. Audouin, considering that the eyed *Trilobites, Calymena,* and *Asaphus* are most approximate to those phyllopodous crustacea of which *Apus* is the type, and that the genera *Bucephalithus, Ogygia,* and *Paradoxides* are analogous to such phyllopodous genera as *Branchipus, Eulimena,* and *Chirocephalus.*

The works of Brongniart, above referred to, and that of J. W. Dalman (Uëber die Palæaden oder die sogenannten Trilobiter, Nurnberg, 1828), and the works therein referred to, must be consulted for the determination of the generic and specific characters of these singular animals.

CHAPTER III.

Class II.—ARACHNIDA.

THE ARACHNIDA, MacLeay (*Arachnides*, Lamarck and Latreille; *Arachnoida*, Leach), compose a class of articulated animals, the name of which is derived from Arachne, under which the spiders, which are the chief species contained in it, were known to the Grecks. The celebrated Cuvier, having by his invaluable discoveries in the comparative anatomy of the invertebrated animals, established the propriety of the removal of the Crustacea, as a *class*, from the apterous insects of Linnæus, *Aranea* and the remaining genera (with the exception of *Pulex*) were shortly afterwards raised to a similar rank by Lamarck, under the name of *Arachnides*, having been previously regarded as a distinct *order* by Fabricius, under the name of *Unogata*, and by Latreille, under that of *Acephala*. The class has been restricted by Latreille, MacLeay, and most modern entomologists, to its present extent. Thus constituted, the Arachnida are distinguished by their comparatively small size, their bodies in general being short and rounded. They consist of two parts only, the cephalo-thorax and abdomen, the head being so intimately united to the thorax, that scarcely the slightest traces can be perceived of their union; whilst in others, even the separation of the cephalo-thorax from the abdomen is almost equally imperceptible. Like the *Crustacea*, they are destitute of wings, and are not subject to those metamorphoses which distinguish the true insects.

The organs of respiration, upon which great stress has been laid as affording some of the primary characters of the group, consist either of internal air gills performing the office of lungs, and inclosed in pouches, or of radiated trachea, the spiracles or passages for the entrance of the air being from two to eight in number, and situated either at the lower part of the abdomen, or the sides of the cephalo-thorax.

The anterior part of the cephalo-thorax generally exhibits on its upper surface a certain number of minute shining points, which are the organs of sight; they vary in number from two to eight, and furnish excellent characters for the distinction of the generic groups. The animals of this class are furnished with eight very long legs, generally terminated by two small claws; in front of the legs are to be observed a pair of very powerful organs, terminated by acute moveable hooks, which are occasionally of large size (as in *Atypus Sulzeri*), and, in many cases, afford passages for the discharge of that poisonous fluid with which some of the insects are provided. These organs have been termed *chelicera* by Latreille, who considers that they represent the antennæ of insects, and the internal antennæ of the decapod crustacea; but so little attention has been hitherto paid to the comparative anatomy of these analogical organs, that it is perhaps the safest course to regard such analogies as undetermined. In addition to such organs, the mouth is furnished with a lower lip and a pair of lateral moveable instruments, similar to the lower jaws of the mandibulated insects, furnished externally with a pair of jointed appendages or palpi. All the arachnida appear to be carnivorous, but some are parasitic upon the bodies of other animals, and in these the mouth undergoes a considerable change of structure, being composed of an instrument capable of suction, although formed of the same typical number of organs as the mouth of the preceding. The portion of the body succeeding the cephalo-

Atypus Sulzeri.

thorax constitutes the abdomen; in general it is soft, more or less globular; on its under surface are to be observed a certain number of apertures or spiracles, and the anal aperture, as well as the spinnerets, when present, are placed at its posterior extremity.

The external covering of the Arachnida may be regarded as of a leathery, rather than a horny texture, but in some species it assumes a considerable degree of rigidity; it forms, however, in all cases, an external skeleton, to which the muscles are internally affixed, as in insects.

Of the senses of the Arachnida, it may be observed that, according to the best of our necessarily imperfect knowledge of such matters, they appear to possess all the five senses with which the higher animals are endowed: that the minute simple stemmata on the crown of the metathorax are eyes, and that these animals possess the sense of sight, cannot be doubted; everybody having observed the hunting spider (*Salticus*) throw itself to a considerable distance upon its prey. Here it is evident that the instinct of the animal, acting upon the impressions produced by the possession of the sense of sight, induces it to do an act for the gratification of another sense—that of taste. In like manner, the sense of touch is possessed in an eminent degree by these animals; and although the accuracy of the poet's observation, that the spider

> "Lives in each thread, and feels along the line,"

has been called in question in a very popular work (Insect Miscellanies, p. 5), I am convinced, from experiments which I have made for the express purpose of ascertaining the relative powers of the senses of sight and touch, that the latter is much stronger than the former. When a fly is caught in the web of a spider, the latter instantly stretches out its legs in the direction of the captured and struggling insect, and feels, for in no other manner can I describe its proceedings, the nature of the disturbance which is taking place in its web. In the work above alluded to, it is stated, "We have tried numerous experiments, by moving and vibrating the lines of the webs of many species, so as to imitate, as nearly as possible, the entrapment of a fly, but in no case have we succeeded in bringing the spider to the spot, because, as we inferred, her eyes always detected our attempted deception." Now the experiments which I have made have produced a result so contrary to the above, that it is not without a repetition of them that I have ventured to adduce them against the statements in question. These experiments were chiefly made upon the *Epeira diadema,* one of the largest of the British species, which, from its very common occurrence, beautiful markings, and elegantly-constructed web, must have attracted the attention of the most casual observer in the autumn. Now from its size it is evident, that, if the intelligence which these insects obtain respecting the entrapment of a fly results from the sense of sight, the epeira would make no use of its legs for obtaining such knowledge, and that its eyes alone would be brought into action; but so far is this from being the case, that I have repeatedly disturbed the lines of the web within an inch of the spider, *and in the direction of its eyes,* but in every instance the legs have been instantly put in motion, which has been continued for a considerable time even after. I have ceased the disturbance in order that, if possible, the spider, by slightly moving the web itself, might set the fly, which it evidently supposed to have been captured, in motion again, so that, by its repeated struggles, it might ultimately fall an easier prey to the inhabitant of the web. But in addition to this fact, it is to be observed, that the den-like retreats of many spiders are so placed that they cannot possibly see any thing which occurs on the web, and yet no sooner is a fly entrapped in any part of the web than the spider instantaneously acquires a knowledge of the fact, evidently by touch, and darts out of its den upon the luckless captive. Thus we frequently find the spider deeply seated in the aperture of a wall, and the web extended to a considerable distance over its surface; and yet by the tension of the cords composing the net-work, the spider is instantly made aware of what occurs on every part of its surface. Two instances are adduced in the work in question in support of the idea that the eyes, and not the legs, are the instruments of knowledge to the spider. First, the long-bodied spider (*Tetragnatha extensa*) is noticed as having probably given risc to the popular opinion under review, notwithstanding it huddles its legs into a close bundle, and which is evidently done with the view of making them appear motionless, although the insect does not the less obtain information by their assistance; and immediatcly afterwards the long-legged house-spider (*Pholcus phalangioides*) is referred to, as giving more countenance to the opinion, because it keeps its legs spread out as if to feel the more readily when any thing is caught, although the more than usual prominence of its eyes is mentioned, as showing the superiority of its powers of sight. I have noticed these contradictions, because, as they occur in a work of great popularity, it is advisable that the erroneous impressions which they must necessarily produce should be counteracted as early as possible.

In the majority of the Arachnida, a complete and very distinct system of circulation exists. The heart is contained in the abdomen, and in many species of spiders its pulsations are easily to be observed. It consists of a large longitudinal vessel, which emits a certain number of arteries, and receives the veins by means of which the sanguineous fluid returns, after having been aerated by the respiratory organs, to be again distributed through the different parts of the body.

In this class, as in the insects, the sexes are constantly distinct, and impregnation is necessary for the fecundation of the eggs. Several striking peculiarities are connected with the act of impregnation, respecting which the most celebrated physiologists are at variance; and though the pages of the present work can hardly be considered a proper field for discussions connected with this subject, it may be proper to state that it was considered one of such importance, that, at the meeting of the British Association for the Promotion of Science at Cambridge, the inquiry as to the true male organs of generation in the spiders was one of the three questions proposed relative to the annulose animals.

The developement of the embryo of the spiders has been traced in a most elaborate manner by M. Herold, of which a notice will be found in the Insect Transformations, pp. 123, 124. (Untersuchungen über die Bildungs-geschichte der Wirbellosen Thiere im Eie. Marburg, 1824.)

From various observations, it is evident that the limbs of the Arachnida are capable of reproduction when mutilated. This faculty, together with the longevity of some species, various peculiarities of structure, and especially the circumstance that some spiders engender more than once during the course of their lives, evidently prove the distance which exists between this class and the insects, and their greater proximity with the crustacea.

As to the classification of this class, it is to be observed, that we are indebted, for the most part, to the works of foreigners for those views which have been adopted in the modern arrangements of the annulose animals. In the work of our countryman Lister, published in 1678, "Historiæ Animalium Angliæ tractatus de Araneis," are, indeed, to be found many very good coloured figures of British spiders, as well as the first attempt at their distribution; but until within the last few years, arachnology seems to have been banished from the studies of British naturalists, and taken up its abode in France, where, under the hands of Savigny, Latreille, and, above all, the Baron Walckenaer, it has arrived at a high state of cultivation. We may now, however, boast of the labours of Blackwall, published in the Linnæan Transactions and the Annals of Philosophy, as well as those of an anonymous writer in one of the numbers of the Magazine of Natural History, from whose admirable pencil and pen, British arachnologists may shortly hope to be furnished with a most invaluable series of memoirs.

The class, as at present constituted, has generally been divided into two orders—the pulmonary and the trachean Arachnida: but, in his last work, Latreille has established a third order, *Aporobranchia*, for a very remarkable group of animals, which Leach regarded as possessing so doubtful a situation, that in the Entomologists' Compendium they were placed at the end of the true insects.

The class may therefore be thus distributed:—

SECTION I.—PULMONARIA.

Having pulmonary sacs for respiration, with six or eight simple eyes: consisting of two orders.

ORDER I.

The *Dimerosomata* of Leach, or the *Araneides* of Latreille, consisting of the great group of spiders, divisible into various families, having the abdomen attached by a footstalk, and not articulated.

ORDER II.

The *Polymerosomata* of Leach, or the *Pedipalpi* of Latreille, consisting of the scorpions, and divisible into two families, *Scorpionidæ* and *Phrynidæ*, having the abdomen attached by its whole breadth, and composed of numerous segments.

SECTION II.—TRACHEARIA.

Having tracheæ for respiration, never with more than four eyes: consisting of two orders.

ORDER III.

Adelarthrosomata, or those trachean species which have the mouth furnished with visible didactyle chelicera, and the abdomen annulated, although occasionally in an indistinct manner.

Consisting of the families *Solpugidæ, Cheliferidæ,* and *Phalangiidæ,* or harvest spiders.*

ORDER IV.

Monomerosomata of Leach, or those trachean species which have the body formed of a single segment, the abdomen presenting no traces of articulation, and the moth either suctorial, or furnished with concealed didactyle chelicera. This order consists of the very extensive Linnæan genus *Acarus,* or mites, divisible into various families.

SECTION III.

ORDER V.

Podosomata of Leach, or the *Aporobranchia* of Latreille. These singular insects are marine; they are not furnished with distinct spiracles, so that it is probable that respiration is effected by portions of the external covering of the body possessing the properties of branchiæ. The body is linear, and seems, as it were, to be composed only of the union of the legs; the mouth is tubular and porrected; and the females are furnished with an additional pair of legs, which serve only for carrying the eggs. This order consists of two families, *Pycnogonidæ* and *Nymphonidæ.*

ORDER I.—DIMEROSOMATA.

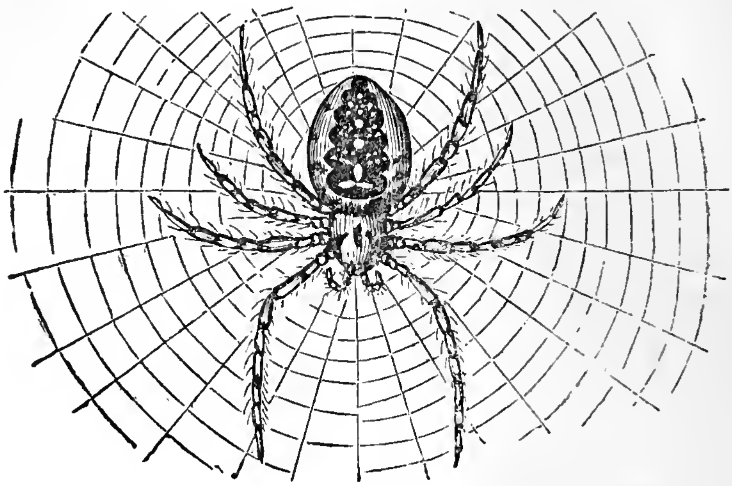
This order corresponds with the Linnæan genus *Aranea,* to which Latreille gave the name of *Fileuses* or *Spinners,* MacLeay that of *Araneidæ,* and Leach that of *Dimerosomata.* The name of *Aranea* has not, however, been dropped, but has been employed to denominate the modern genus, consisting of the domestic spider, *Aranea domestica* of Linnæus.

* In order to preserve the order of the mites entire, as suggested by Dr. Leach in the Supplement to the Encyclopædia Britannica, I have been compelled to establish a new order for the reception of the remainder of the trachean species, which I have named from the comparatively obscure articulation of the abdomen.

The animals of this order are amply provided, by an all-wise Creator, with the means of entrapping and securing insects much larger than themselves for their subsistence, constructing habitations for their abodes, and for the defence of their offspring against the inclemency of the seasons and the attacks of their enemies. The means by which these effects are produced are exceedingly simple—namely, the secretion of two fluids by internal organs, one of which is a gummy fluid exuding from an apparatus near the extremity of the body, and the other is of a poisonous nature, and flows from the mandibles. With the first they are enabled to construct webs or nests of various texture and form, serving for the purposes of habitation, of traps for their prey, or of covering for their eggs and young: and with the latter they are enabled to destroy insects larger than themselves, in a very short time, for food.

A very great diversity exists in the modes in which the nests or webs of these insects are constructed, and the situations in which they are placed. The internal apparatus for secreting the silk is lodged within the abdomen near its posterior extremity, and consists of a small number (four or six, according to the species) of twisted, elongated, and unequal-sized vessels, being thickest in the middle, at the extremity of which is a great number of similar vessels, but of a much smaller size, and considerably shorter, and which are pressed against each other, uniting in a common base, which is in connexion with the *external* apparatus. The latter is visible to the naked eye on the under side of the abdomen, appearing, when pressed, in the shape of a small star, having several small oval-shaped or sub-conical appendages, teats, or spinnerets, as we may call them, placed near the extremity of the body, their extremities, when at rest, being brought into contact. In the greatest number of spiders there are four of these spinnerets, but in some there are six, two of which, however, appear to have neither pores nor papillæ. On examining the spinnerets more minutely, it will be found that each is surrounded with several series of minute bristles, like points, about one thousand to each spinneret. From each of these points or spinnerules is discharged a thread, so that it may be easily conceived of what an immense number of distinct threads the apparently simple thread of the spider consists. The first object which the spider has to accomplish is to attach her thread to some substance, as the commencement of a ground-work for her future operations. In doing this, it appears that she extends her spinnerets as widely as possible, presses them against the object to which it is intended the thread should be attached, and then discharges a thread from each of the spinnerules; the spinnerets are then withdrawn, and the threads, by degrees, are united into a single cord; the insect uses her hind legs as a reel to draw the threads out of her body. It appears, however, that the threads are of different kinds; for in the webs of the geometric spiders, those threads which are arranged in circles are composed of more viscid materials than the radii, the former being evidently intended for securing the prey of the spider, and the latter serving merely as its frame-work, and destitute of gluten. This viscidity is produced by an immense number of globules of viscid matter, arranged at visible distances along the elastic spiral lines of the net, and which are so fluid that they run together the moment they are brought into contact. Mr. Blackwall has given a calculation of the number of these viseid globules in the web of one of the *Epeiræ* of a moderate size, and which conveys some idea of the elaborate operations of the geometric spiders. The mean distance between the radii in one of these nets is about *seven*-tenths of an inch; there are twenty viscid globules on *one*-tenth of an inch, so that there are $7 \times 20 = 140$ globules in a *single* line between two contiguous radii seven-tenths of an inch apart: this product, multiplied by 24, being the mean number of circumvolutions formed by the spiral line, will give 3360, being the number of globules contained on *all* the lines between two contiguous radii: this number, being again multiplied by 26, the mean number of radii, produces 87,360, the total number of viscid globules in a finished net of average dimensions. But larger nets, by a similar calculation, will contain upwards of 120,000 viscid globules, and yet the time occupied in the construction of this net is not more than forty minutes. Moreover, the threads with which the spider composes the retreat in which it takes up its abode, or the nest in which it envelopes its young, do not appear to be of the same nature as the net-threads, neither are the threads of which it forms the case for its young similar to the former, the texture of these cases being in some species quite firm and smooth, resembling parchment. This case is also sometimes covered with a coating of loose flossy silk, which also seems of a different texture: hence it is evident that the vessels at the extremity of the abdomen, which serve for the secretion of the silk, as well as the structure of the spinnerets and spinnerules, require a much more minute investigation than has hitherto been given to them, in order to discover the precise manner in which these various kinds of silk are elaborated and discharged.

The web of *Epeira diadema* is one of the most beautiful and most common of the spider constructions in this country, being found in every bush or tree, between hedges and shrubs, &c., during the autumnal months. The top line of this web appears to be first spun, either by attaching a thread as above described, and then carrying it along until it is of sufficient length, when it is attached to some adjacent object to which the spider has crawled, or by throwing out a floating line, whilst the spider remains stationary, the action of the air carrying this line on until it becomes attached to some object, when, in either case, it is doubled and redoubled until it is of sufficient strength to bear the weight of the intended fabric, together with the spider itself. The other outer threads of the frame-work are then added, and



Epeira diadema.

then cross lines carried from one point of the web to another exactly opposite, forming a complete series of spokes or radii, which she then attaches together by a spiral series of transverse bars of a more glutinous thread, as above noticed. It is quite an amusing sight to watch one of the small geometric spiders engaged in this construction: the rapidity with which the cross spiral threads are fixed in their proper places is quite astonishing.

Mr. Blackwall has noticed the curious fact that those species of spiders which form geometric nests, are furnished with several claws on each foot, whilst some of the jumping spiders, and some others, have only two claws. In several species of *Epeiræ* it will be distinctly perceived that the inferior part of their feet is provided with several claws, which have a degree of curvature, are finely pointed, and are furnished with tooth-like processes in the under side. In *Epeira apoclisa* there are as many as five of these claws, which, in addition to the three upper claws previously known, give a total of eight to each foot. There is also a strong moveable spine inserted near the termination of the tarsus of each *posterior* leg on the under side, which curves upwards at its extremity, and which, by the action of the flexor muscles, is brought in immediate opposition to the claws, by means of which the animal is enabled to hold with a firm grasp such lines as it designs to attach itself to; and hence it is obvious why these spiders usually direct their heads downwards when they occupy the centre of their nets.

Spiders, in regard to the construction of their webs, may be naturally divided into two great groups, which have been named the sedentary and the wandering spiders. The latter do not construct regular webs, but either live a vagabond life, as the genus *Salticus*, or merely throw out a few loose and irregular lines in the neighbourhood of their nest. The sedentary spiders comprise two divisions—those which form nets and those which weave webs. The net-weavers are again divided into the geometric species, and those which construct webs of an irregular form, the meshes being at certain distances apart, but not arranged in concentric circles. This group, which is in general composed of minute spiders, is the most curious on account of the singular and astonishing variety in the operations of the species of which it is composed. The genus *Theridion* may be mentioned as the typical group. The web-weavers spin a closer material than the former, and, like the net-spinners, are divisible into two groups, the cloth-weavers, which suspend their hair or mat-like webs horizontally between plants without any circular retreat (genus *Linyphia*, &c.), whilst the other section may be called tapestry-workers, suspending their webs in the angles of walls, &c., furnished with a circular retreat formed like the rest of the web. The domestic spider is an example of this division.

During the summer and early autumn months, it is not an uncommon circumstance to observe numerous long floating threads in the air, at one end of which a minute spider is found to be attached. The mode in which this is effected has been the subject of considerable discussion. Some authors contend that the spider has the power of directing these threads at pleasure towards a determined object. Others maintain that the thread is discharged independently of any influence from the atmosphere; others again, that it is entirely electrical; but the most generally received opinion is, that the spider, directing its spinnerets in the direction of a current of air, discharges a thread which, being exceedingly light, is carried on by the air to such a length as to be able, from its buoyancy, to support the slight weight of the spider itself. In France, the floating threads which support the small spiders are called *fils de la Vierge*, and it has been supposed that they were exclusively formed by a spider which has been named *Aranea obstetrix;* but this is not correct, neither is the species here noticed any thing else than a young and imperfectly described individual belonging to the genus *Epeira*.

Nearly all the different species of spiders envelope their eggs in a covering of silk. The mass of eggs, thus protected, of the *Epeira diadema*, may be constantly observed during the winter months in the angles of walls of rooms exposed to gardens, frequented by the perfect insects, which, after impregnation, make their way into the houses for safety. These cocoons, as they may be called, differ in the different species. In some they are globular, in others oval, and in some depressed. The care with which these cocoons are guarded by some species is quite astonishing. Some of the species carry them about with them beneath the abdomen, and it is a matter of the greatest difficulty to compel the mother to quit her charge, and even then she wanders about the spot searching for it with the greatest solicitude. The egg cocoon of the very handsome species *Epeira zebra*, as well as the perfect insect, are described and figured in the Field Naturalist's Magazine, vol. ii. p. 57.

The harmony which nature has established between the colours of these insects and the places which they inhabit, must not be passed over in silence. The species of *Epeira* which weave their webs in the air, the *Thomisi*, which hide themselves in flowers, and the *Sparassi*, which run over the green sward, have the body either of an uniform lively green, yellow, or purple colour, or varied with handsome markings; whilst the *Mygale*, *Lycosæ*, and *Araneæ*, which conceal themselves under stones and in obscure situations, are of brown, blaek, or other obscure colours, like the places where they reside. This interesting conformity of colour to habits may also be noticed as reigning in other parts of the insect world.

The most gigantic species of the order compose the genus *Mygale* (Walckenaer), some of which, in a state of repose, occupy a circular space of six or seven inches in diameter. The type of this genus is the *Aranea avicularia* Linn., respecting the habits of which great incorrectness appears to have prevailed amongst naturalists. We are indebted to Mr. MacLeay for a correction of these errors; the following being an abstract of the communication of this gentleman, published in the first volume of the Transactions of the Zoological Society of London. The story of a spider which catches and devours birds appears to have had its origin with Madame Merian, who, in her splendid work upon the insects of Surinam, asserted, that our spider not only caught but devoured small birds, and figured the *Mygale avicularia* in the act of preying upon a humming-bird. Now, the *Mygale* does not spin a net [Madame Merian does not assert that it does do so], but resides in holes under ground, and in all its movements keeps close to the earth, while humming birds never perch except on branches. The food of *Mygale* consists of *Iuli, Porcelliones,* subterranean *Achetæ,* and *Blattæ.* A *living* humming-bird and a small anolis placed in one of its tubes, were not only not eaten by the spider, but the latter quitted its hole, and left it in the possession of the intruders. Mr. MacLeay consequently disbelieves the existence of any *bird-catching* spider.

The type of the genus *Cteniza* is the *Mygale cœmentaria* (Latreille, *Araignée maçonne* of Sauvages), or the mason or trap-door spider, so named on account of the curious structure of its nest, as observed by Sauvages, Dufour, and more recently by Audouin, who has published an interesting account in the "Annales" of the French Entomological Society. These spiders dig in the dry and mountainous districts of the south of Europe subterraneous galleries, of a cylindrical tortuous form, to the depth of many inches (sometimes two feet); they also construct at the mouth of the burrow, formed of silk and earth, a moveable operculum, or trap-door, which is so attached as to exactly fit the entry to the habitation, and to lift up and down.

There are several of these trap-door spiders, one of which is found in the Island of Naxos (*C. ariana*); another in Jamaica (*C. nidulans*); a third at Montpelier (*C. cœmentaria*); a fourth (*C. Sauvagesi,* described by M. Audouin) in Corsica; and a fifth found in various parts of New South Wales, by Mr. Bennet, and described in his Wanderings in that Island (vol. i. p. 328). Mr. Kirby has figured the Jamaica species and its nest in the frontispiece to the second volume of his Bridgewater Treatise, in which he has also copied M. Audouin's figures. M. Dufour is of opinion that it is the females alone which construct these nests, the males being generally found under stones, and their structure not appearing so well adapted for building as that of the females.

Some of the large species belonging to the genus *Mygale* are commonly termed *Tarantulæ,* or *Tarentulæ,* a name which is more strictly applicable to a species of *Lycosa,* found in the south of Italy, and especially in the neighbourhood of Tarentum in that country, whence it has obtained its ordinary name, and which has become famous not only on account of the supposed venomous effects of its bite, which is stated to have been followed by death or tarentismus, but also from the supposition that music and dancing were the only remedies against it. The most elaborate account which we possess of this spider is given by M. Dufour in the Annales des Sciences Naturelles for 1835, and which has been translated in the new series of the Magazine of Natural History.

It is in exposed dry places that the *Tarantula* constructs its burrows in the earth, and which are an inch in diameter and a foot in depth. The ordinary entrance to the burrow is surmounted by a funnel somewhat similar to that formed by some of the sand-wasps (*Odynerus*), composed of fragments of dried wood, united by a little clay, and lined within with a tissue formed of the threads of the *Lycosa*, and which is continued through the whole interior. It is easy to conceive how useful this skilfully fabricated drapery must be both in preventing the crumbling in of the earth, or any such accident, and also in assisting the *Tarantula* in scaling its fortress.

According to the old authorities, the bite of the *Tarantula* accasioned an inflammation in the part, which in a few hours brought on sickness, difficulty in breathing, and universal faintness. The person afterwards was stated to be affected with delirium, and sometimes to be seized with a deep melancholy, the symptoms returning annually in some cases for several years, and afterwards terminating in death. According to others, the symptoms produced by the poison were similar to those of malignant fever; whilst by others the skin exhibited only a few erysipelatous spots. Music, it was pretended, was the only remedy. A musician was brought, who tried a variety of airs, till at last he hit upon one that urged the patient to dance, the violence of which exercise produced a proportional agitation of the vital spirits, attended with a consequent degree of perspiration; the certain consequence of which was a cure. Some authors, indeed, have carried their belief in this matter so far as to note down the tunes which they believed most serviceable for the *Tarentolati*, as persons suffering under tarentismus were called. In the Philosophical Transactions for 1672, a letter from Dr. Cornelio, a Neapolitan physician, was however published, in which it was stated that "all those that think themselves bitten by *Tarantulas, except such as for evil ends feign themselves to be so*, are for the most part young wanton girls, whom the Italian writers call Dolci di Sale, who by some particular indisposition, falling into this melancholy madness, persuade themselves, according to the vulgar prejudice, that they have been stung by a *Tarantula*." And a century afterwards, in the same Transactions (for 1770), Professor Dominico Cyrillo, of Naples, states, that having had an opportunity of investigating the subject in the province of Tarento, where it is found in great abundance, he finds that the surprising cure of the bite of the *Tarantula* by music has not the least truth in it.

The most elegantly marked of the British species of spiders belong to the family *Epeiridæ*, of which each individual forms its own web, which in some of the large exotic species, as the *Epeira clavipes*, a native of the West Indies, is sufficiently strong to hold small birds, which may by accident be caught in it; those of our own country are capable of retaining insects of considerable size, which form the prey of the spider; for this purpose they are suspended vertically between the branches of trees or plants, or in other open spaces frequented by insects: occasionally they are placed obliquely, and even horizontally, as in the *Epeira cucurbitina*. No sooner is a fly or other insect caught in the web, than it is approached by the spider, which in a curious manner envelopes it in a silken shroud, by placing the tips of its fore legs at each extremity of the insect's body, so as to form the points of an axis round which the insect is whirled with rapidity, a dense layer of silk being at the same time thrown round it from the spinnerets.

The order is divisible as follows.

Section 1. *Tetrapneumones*, or those which have four pulmonary sacs and four external spiracles on the under side of the abdomen, (two on each side placed closely together,) and comprising the families of *Mygalidæ* (the gigantic bird spiders, as they have been erroneously termed, of tropical countries), *Atypidæ,* and *Dysderidæ.*

Section 2. *Dipneumones,* or those which have only two pulmonary sacs and two external spiracles, comprising the majority of the order, and divisible, according to the manner of construction of the web, into the families *Araneidæ,* which spin irregular webs having a cylindrical cell in one corner; *Theridionidæ,* comprising sedentary species which make an irregular web without any tubular retreat; *Epeiridæ,* which weave geometric webs; *Thomisidæ,* hunting spiders, possessing the power of walking sideways; *Lycosidæ,* wandering spiders, catching their prey whilst walking about, and not making a web, except for the reception of the egg; and lastly, the *Salticidæ,* differing from the latter in the agility with which they leap upon their prey from a considerable distance.

ORDER II.—POLYMEROSOMATA.

This order is distinguished by having the abdomen attached by its entire breadth to the thorax, and composed of numerous distinct segments. It consists of two fami-families, the *Scorpionidæ* and *Phrynidæ,* in the first of which the thorax is furnished on the under side with two moveable comb-like plates, and terminated by an elongated and knotted tail, the extremity of which is armed with a curved and very acute sting. The breathing pores are eight in number, arranged four on each side along the belly; the arms (or palpi, very greatly developed) are of very large size, serving as instruments of prehension, and terminated by a large claw. The legs are eight in number, of moderate size, and much larger than the palpi. The eyes are eight in number, three on each side of the thorax, and two on the back. The "antennæ-pincers" are terminated by two fingers, one of which is moveable. The abdomen (including the tail) is composed of twelve segments. The use of the curious comb-like appendages has not yet been determined.

The scorpion is one of the most renowned amongst the obnoxious of the insect tribes. Fortunately for our country no species is found amongst us, although in Germany, and several other parts of Europe, it is too well known. It is chiefly in tropical, or at least in hot regions of both hemispheres, that the various species are found, and in the former they occasionably attain a very large size. They reside on the ground on sandy districts, and hide themselves by day under stones, logs of wood, &c., especially in dark places, and often in houses. They run very quickly, and, when alarmed, throw their tail over the back, twisting it about in every direction, and using it both as an offensive and defensive weapon. They make use of their claws to lay hold of insects upon which they feed, and which generally consist of ground beetles, cockroaches, &c., which they first wound with their sting, and then convey to their mouth. They are also especially fond of the eggs of spiders and other insects.

In France the *Scorpio europæus* appears about the forty-fourth degree of latitude, in that zone where the almond tree and pomegranate are capable of cultivation, and nearly equal with the most northern limits of the olive.

There are few animals more obnoxious than the scorpion, especially in tropical climates, where it often attains to a very large size. In Batavia, where they are stated to attain the length of twelve inches, there is no removing any piece of furniture without the utmost danger of being stung by them.

Maupertuis, who made several experiments on the European species, found it by no means so invariably dangerous as had till then been represented. He provoked one of them to sting a dog in three places of the belly, and in about an hour afterwards the poor animal was greatly swollen, and became very sick. Afterwards it fell into convulsions, bit the ground, dragged itself along on its fore feet, and at last died, five hours after being stung. The experiment was repeated, however, upon another dog, even with aggravated cruelty, yet the animal seemed in no way affected, howling only a little when stung, and without showing the smallest symptom of pain. The same experiment was also tried by fresh scorpions upon seven other dogs and three hens, but not the smallest deadly symptom was seen to ensue. Hence it is evident, that although, in the majority of cases, the sting of this insect may not be greater than that of a wasp or hornet, yet, in certain cases, and under certain unknown circumstances, either connected with the state of the animal stung, or of the scorpion itself, a far greater efficiency is given to the sting.

ORDER III.—ADELARTHROSOMATA.

This order, as above indicated, comprises the three following families :—

1. The *Solpugidæ,* having somewhat the appearance of large spiders, but possessing a pair of large compressed claws attached in front of the mouth, with the finger moveable. The palpi are large, and resemble antennæ or legs, and the abdomen, which is fleshy and very hairy, is composed of nine joints. They run with great rapidity, throwing up the head in an attitude of defence when attacked, and are reputed venomous, whence the name of the typical species, *fatalis* (Fabricius). With the exception of a species found near Havannah by M. Poey, the species of this genus inhabit the hot sandy countries of the old world.

2. The *Cheliferidæ,* having very much the appearance of minute scorpions, destitute of tails, the body being oval, depressed, and narrowed in front; the palpi as long or longer than the body, in the form of arms, each terminated by a double claw; the legs are of equal size, and short, being terminated by two hooks; the breast is not furnished with the remarkable toothed appendages to be observed in the scorpions.

As a family, these little animals are highly interesting in respect to the general distribution of the class to which they belong, exhibiting, as they do, the appearance of one group, whilst they in reality belong to another quite distinct. They are found, in general, in moist situations, in moss under stones, flower-pots in gardens, and in unfrequented parts of buildings; they also get into old books, herbariums, &c., where they feed upon other more minute insects, such as *Atropos lignarius, Acari,* and occasionally even venturing to attack the domestic fly, of which circumstance various notices will be found in the Magazine of Natural History. I have captured the largest species which I have hitherto seen of the group, under the bark of trees in Windsor forest, in the act of devouring the hard-cased beetle (*Bitoma crenata*). Goetz also fed them with aphides.

3. The *Phalangiidæ*, distinguished by having the antennal claws very distinct, and terminated by a didactyle claw. They have two filiform palpi of five joints, the last of which is terminated by a small hook. The body is short, and of an oval or rounded form, the abdominal portion exhibiting the appearance of segments. The legs, eight in number, are always very long, and divided as in insects.

These curious creatures are known under the common name of harvest-men or harvest-spiders. They live on the ground amongst grass, under stones, &c., and are exceedingly active, the great length and slenderness of their legs enabling them to proceed with very great rapidity. These insects are evidently rapacious, and feed upon other insects. Their relations are very interesting, appearing to be intermediate between the spiders and mites. Some of the exotic insects belonging to this family are amongst the most extraordinary of annulose beings; the species of *Gonyleptes*, in their threatening form and the singular spines with which the legs &c. are armed, well merit the specific names, *horridus*, &c., which have been given to them, whilst others equally unsightly have been figured by Dr. Perty in the "Delectus Animalium Articulatorum Brasiliæ."

ORDER IV.—MONOMEROSOMATA (Leach).

This order consists of the tribes of mites and ticks, insects referable to the Arachnidous type, although the mode of respiration by tracheæ differs from the more typical *Arachnida*; but in this group the characters derived from the respiratory organs have recently been proved by the researches of M. Dugés to be of but a secondary importance. By Dr. Leach these insects were constituted a distinct class of the articulated animals, in which respect, however, he has had no followers. From the very valuable discoveries lately made by M. Dugés, an indefatigable French naturalist, it has been proved that they undergo metamorphoses, consisting in some groups of an increase in an additional pair of legs, whereby one of the sections proposed in the group by Latreille and Hermann (*Trombides hexapodes*) is found to consist only of insects in an imperfect state, whilst in others the change of form is complete. This is especially the case in the water mites, the larvæ of which have a very large head and six legs: the pupæ are inactive, attaching themselves by a single pair of very short legs to the bodies of other aquatic insects, and being composed as it were of an oval bag with a narrow neck; the insect in this state having been formed by M. V. Audouin into the genus *Achlysia*, and being specifically named *A. Dytici*, from taking up its residence beneath the elytra of the great water-beetle (*Dyticus marginalis*); they also attach themselves to the slender filaments composing the tails of the water-scorpions (*Nepa* and *Ranatra*).

In the recent memoir of M. Dugés the order is divisible into the following seven families: namely,—1. *Trombidiei;* 2. *Hydrachnei;* 3. *Gamasei;* 4. *Ixodei;* 5. *Acarei;* 6. *Bdellei;* 7. *Oribatei.*

Amongst these insects the cheese mite (*Acarus domesticus*) is one of the most common species, and which is so abundantly met with in dry cheese, flour, and meal. They are clothed with long hair, and their feet are armed with strong hooks, enabling them to retain firm hold of the situation in which they abound. The females are oviparous.

Another species belonging to the restricted genus *Acarus* has attracted much attention, from being the cause of a disgusting disease, named *Acariasis*, to which unclean persons are occasionally subject. It is found in the vesicles of the itch, and has recently been the subject of numerous microscopic observations by Messieurs Raspail, Galet, and other French and German writers.

The *Gamasus Coleoptratorum* and *Uropoda vegetans* are two small species, often found in immense numbers upon various ground beetles, the latter being attached to the insect by means of a very long and slender filament arising from the extremity of its body. Mr. R. Patterson of Belfast has communicated to me a species of *Steropus madidus*, so completely enveloped in these minute creatures as to render it impossible to perceive the least portion of its body.

The species of insects of which the genus *Ixodes* are composed are named ticks, and are of small size; the body is swollen and leathery; the head is small, and furnished with a powerful rostrum, composed of two retroserrated plates, which the insect inserts into the flesh of dogs and other animals, upon which it is parasitic, and upon whose blood it subsists. In the West Indies they attack the horse and ass in such quantities, that it is the usual practice to have these animals fetched up from grass once a-week to be "ticked." They especially attach themselves at the base of the ear, and, if neglected, will sometimes become so numerous that the animal loses all power of raising its ears at will. Their powers of reproduction are so great that the animals infested sometimes sink under their attacks.

The typical species is the *Ixodes ricinus* (*Acarus ricinus* Linn.), which is parasitic on the dog. It is serviceable to anoint the infested parts with oil or soft soap. The species of this genus require a more minute revision than has yet been given to them.

ORDER V.—PODOSOMATA (Leach).

This order, as above characterized, is of small extent, and comprises two families—

1. *Pycnogonidæ*; 2. *Nymphonidæ*.

In the former of these families the legs are as short as the body, and robust, and the antennæ and palpi are obsolete. They are parasitic upon the whale, the type, *Pycnogonum balænarum* (pl. 1), being about three quarters of an inch long. Both in respect to their general appearance and habits this genus is very analogous to that of *Cyamus* (amongst the læmodipodous Crustacea).

In the latter family the body is small and linear, the legs very long, with a pair of antennal claws, and two palpi. These are extraordinary marine animals, resembling spiders, but having only four pairs of legs: they are found amongst various aquatic plants, under stones, &c. They appear to be destitute of any appearance of breathing pores, whence Latreille's name *Aporobranchia.* The females are furnished with an additional pair of short filamentous processes, to which the eggs are attached. There are several British species described by Dr. Johnston in the Magazine of Zoology and Botany. Dr. Leach has figured two species, *N. gracile* and *femoratum,* in the Zoological Miscellany.

CHAPTER IV.

Class III.—Ametabola.

The third class, Ametabola, as extended by MacLeay, comprises such of the apterous insects of Linnæus as breathe by tracheæ, have the head distinct, are not subject to metamorphoses (being only liable to a series of moultings, during which an increased number of segments and of legs is obtained), and have a greater or less number of legs than eight: the eyes generally consist of small simple granular lenses like ocelli.

These insects were arranged by Lamarck as a distinct section of the Arachnida, under the name of *Arachnides antennistes,* and comprise the Linnæan genera *Scolopendra, Iulus, Lepisma, Podura,* and *Pediculus.* The first two of these genera were constituted into a distinct order by Latreille, under the name of *Myriapoda,* whilst Dr. Leach raised the three others to a class under the name of *Ametabola,* divided into two orders.

Mr. MacLeay adopted the views of Lamarck, in regarding all these insects as belonging to the same class (but added thereto certain Vermes), and proposing for the class the name given by Leach to a portion of it, as above mentioned.

Rejecting the introduction of the Vermes into the class, it is divisible into the four following Orders:—

ORDER I.—CHILOGNATHA (Latreille).

Body long, cylindrieal; antennæ 7-jointed; two strong mandibles, artieulated in the middle, destitute of palpi; legs very numerous.

ORDER II.—CHILOPODA (Latreille).

Body long, depressed; antennæ, at least 14-jointed; mandibles furnished with a palpiform appendage; legs very numerous.

ORDER III.—THYSANURA (Leach).

Body of moderate length; legs six; abdomen furnished at the sides with moveable pieees, or terminated by appendages for leaping.

ORDER IV.—ANOPLURA (Leach).

Body of moderate length; legs six; abdomen not furnished with lateral or anal appendages.

ORDER I.—CHILOGNATHA (Latreille, MaeLeay).

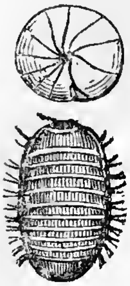
This order, corresponding with the apterous genus *Iulus* of Linnæus, is distinguished by having the body long, erustaceous, and often cylindrie, and the antennæ 7-jointed: they are possessed of a very great number of legs; the abdominal are not distinguished from the thoracic segments: the antennæ are two in number; the eyes are composed of an union of ocelli, and if, in some species, these organs offer a facetted cornea, each of the lenses is much larger and more distinct than in the true reticulated eyes of inseets; the number of the legs, as well as of the segments of the body, increases with the age of the animal. These animals live, and continue to increase in size, for a mueh greater period of time than inseets; and, aecording to M. Savi, two years are required before the organs of generation beeome at all apparent. Hence we may eonclude, that they approach, in some respeets, to the *Crustacea* and *Arachnida*, and in others to the true insects; but, from the consideration of the presence, the form, and the direction of the tracheæ, they must be considered rather as related to the latter. The legs are very short, terminated by a single claw; two short antennæ; the mandibles are crustaceous, without palpi, and 3-jointed; but the more distinguishing character of the *Chilognatha* is the position of the sexual organs near the anterior part, and not the extremity of the body; those of the male being placed behind the seventh pair of legs, and those of the female behind those of the second pair. These animals walk but slowly, and with an undulating motion, produced by the progressive action of the numerous legs; the majority of them, when disturbed, roll themselves up into a ball. They feed upon animal and vegetable substances in a state of decay, and lay a very considerable number of eggs in the earth. From these eggs the young are produced, at first without any appendages to the body; eighteen days afterwards, however (in the genus *Iulus*, according to M. Savi of Bologna, who has made these insects the subjects of two valuable memoirs), the skin is cast, when they appear with twenty-two segments, and twenty-six pairs of legs, of which, the first eighteen serve for locomotion; at the second moulting the animal has acquired thirty-six legs, and at the third forty-three, the body being then composed of thirty segments; and in the adult state, the male has thirty-nine, and the female sixty-four.

A very small species of this group attacks the strawberry, another the endive; others are found in moist places, under the bark of trees, &c.

There are numerous species belonging to this order, some of those from South America acquiring a large size—the *Iulus maximus* being seven inches long. Of the British species, Dr. Leach has given a very good monograph in the Zoological Miscellany.

This order is divided by Latreille, in his last work, into three families:—

1. *Glomeridæ* W. (*Onisciformes* Latr.), having the body of a crustaceous texture and of an oval-oblong form, without pencil-shaped appendages, and capable of being contracted into a ball; the under side of the body being concave. The number of legs is thirty-two in the males, and thirty-four in the females. This family comprises but a single genus, *Glomeris* Latreille, the species of which are found under stones, especially in mountainous and woody districts. This group is highly interesting to the naturalist, from the remarkable analogy which it presents to certain crustaceous animals, to which the name of wood-lice has been given. Indeed, so strong is the relationship, not only in form, size, and general appearance, but also in habits, that it is no wonder that, by the majority of British naturalists, who have in general cared too little for more than the outward appearance of things, the *Glomeris marginatus*, belonging to the ametabolous order *Chilognatha*, should have been regarded as a mere variety of the *Armadillo vulgaris*, belonging to the crustaceous order *Isopoda*. I trust that better times are dawning on natural history, as a science, in its legitimate sense, in this country. For the purpose of comparison I have represented the two animals above mentioned, from which it will be seen how close is the apparent proximity between the two groups. (See p. 111.)



1

Glomeris marginatus.

2. *Iulidæ* W. (*Anguiformes* of Latreille), having the body of a crustaceous texture, but of a long and narrow form, and unprovided with pencil-shaped appendages. Here belong the genera *Iulus* and *Craspedosoma*, having the eyes distinct, and *Polydesmus*, in which they are obsolete. (See Pl. 1, *Iulus terrestris*.)

3. *Polyxenidæ* W. (*Penicillata* of Latreille), having the body soft, oblong, and furnished behind with small pencil-

like brushes. The legs are twenty-four in number. The genus *Polyxenus* Latreille, belongs to this family; the type of which is found in profusion beneath the bark of trees.

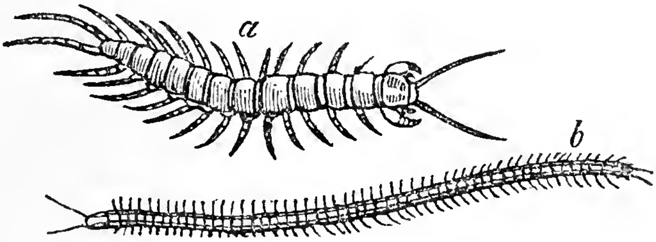
ORDER II.—CHILOPODA (Latreille, *Syngnatha* Leach).

This order, corresponding with the Linnæan genus *Scolopendra,* is distinguished by having the body of a leathery-like texture, and depressed, and the antennæ composed of fourteen or more joints. These insects are commonly termed *Centipedes,* or Hundred-legs. Each segment of the body bears a single pair of legs; the last pair is turned backwards, and lengthened into a pair of tails; the mouth is provided with a pair of strong curved jaws, furnished with a small appendage in the form of a palpus, and exhibiting in the centre the appearance of a soldered connexion; the lower lips are also formed of two dilated basal portions, terminated by a strong moveable claw, which is pierced at its extremity for the discharge of a supposed venomous fluid.

These animals have been considered venomous by all authors, and especially by travellers, because their bite is attended by much pain; but although the bite of the large exotic centipedes is even much more violent than that of the scorpion, it is not deadly. M. Worbe (in the Bulletin of the Philomatic Society of Paris, 1824) has published some statements, which tend to prove that the bite of the *Scolopendra morsitans* of Linnæus (which is termed by the inhabitants of the Antilles "le malfaisant," and "mille pattes" on the coast of Guinea) is dangerous, but it appears that by treating the wound with the application of ammonia, it is easily cured. Amoreux, the author of a work upon poisonous insects, states, however, that the ordinary centipedes of France are not provided with poison, although Leuwenhoeck, who examined the hooks of these insects, observed near their tips an orifice communicating with a cavity, which extends to the base of these organs. The exotic species are of very large size, sometimes reaching a foot in length: Dr. Martin Lister has indeed figured a species eighteen inches long, and three quarters of an inch broad. In Europe, however, few species exceed two or three inches in length.

These insects, unlike the *Iulidæ,* run very quickly; according to

M. Veiss, quoted by Griffith, the *Scolopendra forcipata* (belonging to Dr. Leach's genus *Lithobius*), when walking, successively moves its numerous legs, one portion of which are brought in contact with the line of position, whilst the others are raised up; the latter are quickly put down to the ground, whilst the posterior pair of each division (comprising two segments*) is raised. All these various movements, which follow along the body from the head to the hinder extremity, produce an undulated motion. The insect varies its movements and their degree of force, according to necessity, each foot resting on the line in which it walks, and transporting the body in the same way as do the muscles of the snail, to the distance in which the limb can act. These insects are also



a, Lithobus forcipatus; *b*, Geophilus longicornis.

able to run backwards with much agility, at which time they however make use only of the two hind pairs of legs, which, when walking forward, are dragged motionless after the body.

These animals have been considered to be universally carnivorous; but from the situations in which I have repeatedly found some of the English species, I should be disposed to assign them, at least in some degree, an appetite for decaying vegetable matter. Dr. Leach has also given the name of *Geophilus carpophagus* to one of the species, from its feeding upon fruit. One of the British species, the electric centipede (*Scolopendra electrica* Linn.), possesses the remarkable property of emitting a phosphorescent light

* The segments of the bodies of insects have generally two spiracles. If the bodies of the centipedes, especially those of the large exotic species, be regarded in this point of view, in which there are twenty-one pairs of legs, it will be observed, that the spiracles are placed upon alternate segments, whence, in comparison with the structure of the true insects, these segments must be considered as representing only semi-segments, from whence it is evident that each entire segment is provided with two pairs of legs, but with only one pair of breathing holes, one pair of the former organs, at the tail, being supernumerary. Mr. MacLeay has followed up this theory of M. Latreille, in his memoir upon the thorax of insects, published in the Zoological Journal.

by night, nearly as bright as that of the glow-worm. This insect is found in foot-paths near London, leaving a strong light upon the fingers when handled. It resides under stones and in moss during the day. It is about three quarters of an inch long, of a dirty buff colour, with a black line down the back. It is destitute of eyes, at least the small shining tubercles upon the head of the common scolopendra, which have been regarded by all authors as eyes, are here entirely obliterated. This is a remarkable circumstance with reference to the luminosity of the insect, as it has generally been supposed that the emission of this kind of light by insects, has for its object the enticement of its opposite sex, which in this instance would of course be unable to see or be attracted by the light of its mate. Dr. Leach observed beneath the earth in a garden, in the month of January, a cavity containing a female *Geophilus subterraneus*, and twenty-six young ones, varying very much in the number of their legs; they were of a pale yellow colour, with their heads darker yellow, and the joints of their legs slightly ferruginous.—*Zoological Miscellany*, vol. iii. p. 44.

Dr. Leach, in the Supplement to the Encyclopædia Britannica, has divided this order into three families.

1. The *Cermatiidæ* (*Inæquipedes* of Latreille's Cours d'Entomologie), having the body proportionably short, with the upper surface protected by eight plates, and with the under divided into fifteen semi-segments, each bearing a pair of legs, terminated by a very long and multi-articulate tarsus. This family, which is composed of the single genus *Cermatia*, is formed of exotic insects, frequently found in houses under beams or joists of the wood-work, running with great velocity, and often losing many of its legs when seized.

2. The *Scolopendridæ* (*Æquipedes* Latreille), having the body divided, both on its upper and under surface, into an equal number of segments; the legs short, and of nearly equal size, the posterior pairs being but little longer than the anterior. Here belong the true *Centipedes*, *Scolopendra*, and the genera *Cryptops* and *Lithobius*, of each of which there are British species.

3. The *Geophilidæ* (united with the latter by Latreille), and having a very great number of equal-sized legs, the body being narrow and almost filiform, each segment bearing two pair of legs. Some species are luminous, as the *Geophilus electricus*. Figures of *Geophilus longicornis*, and of *Lithobius forcipatus*, two British species, serving as types of these two families, will be found in p. 155.

ORDER III.—THYSANURA (Leach, *Thysanoures* Latreille).

This order is distinguished by the more or less cylindric form of the body, provided with only six legs, and destitute of wings, undergoing no other change than an increase of size, and furnished on the under side of the body, at the sides or the extremity, with peculiar organs of motion, consisting, in the family *Lepismidæ*, of a double series of moveable appendages like false legs, terminated by articulated setæ, and in the *Poduridæ*, of an elongated appendage, furcate at the extremity, and applied, when at rest, along the under side of the body. These insects are of small size, and very active, the appendages on the under side of the abdomen enabling them to perform long leaps. They are chiefly found in damp situations under stones, moss, &c. They have been much neglected by naturalists; but a valuable memoir is published in the first volume of the Transactions of the Entomological Society of London, upon the Irish species, by R. Templeton, Esq., accompanied with beautiful figures. Some of his species, however, appear to me to be established upon insects in the larva state.

These insects are very interesting, not only on account of their position amongst annulose animals (being regarded by Latreille and Leach as true insects, and by MacLeay as belonging to a distinct class, *Ametabola*), but also from the modifications in the structure of the mouth; some of the species possessing a developement of the trophi as great as in the most perfectly mandibulated insects; whilst in others the mouth is so obscurely organized, that neither Latreille, Savigny, nor Templeton have been able to trace its formation. In some species the eyes are merely rudimental ocelli, but in others they are perfectly reticulated. I may also specially notice the beautiful scales with which the body is covered, and the apparent want of spiracles along the sides of the body, and which Latreille, notwithstanding a very minute examination, was unable to discover. M. Guérin has, however, very recently presented to the French Académie des Sciences a memoir, in which he announces the existence of branchiæ in one of the species of this order. They are placed under the abdominal segments, and by the side of those appendages which are compared to the false legs of the *Crustacea*. They are inclosed in little membranous bags of a similar organization to those of the respiratory organs of a great number of the inferior *Crustacea*. This discovery of branchiæ in these insects appears important in various respects, and more especially because it establishes a link between two classes hitherto regarded as certainly separate as regards their mode of respiration.

This order is composed of two families:—

1. The *Lepismidæ*, having the antennæ setaceous, divided from the base into a great number of small joints; the palpi are distinct and exserted; the abdomen furnished at the sides with a series of moveable appendages like false legs, terminated by articulated setæ, three of which are of a larger size than the rest. (Pl. 1. *Petrobius maritimus.*)

These insects are extremely active, running and leaping with great agility; some are found under stones, and in moss in damp situations, whilst others, as the sugar louse (*Lepisma saccharina*), frequent houses.

2. The *Poduridæ*, having the antennæ composed of four joints; the palpi are not distinct, and the abdomen is not pro-

vided with lateral scales, but is furnished with an elongated furcate process, which is laid under the belly when at rest.

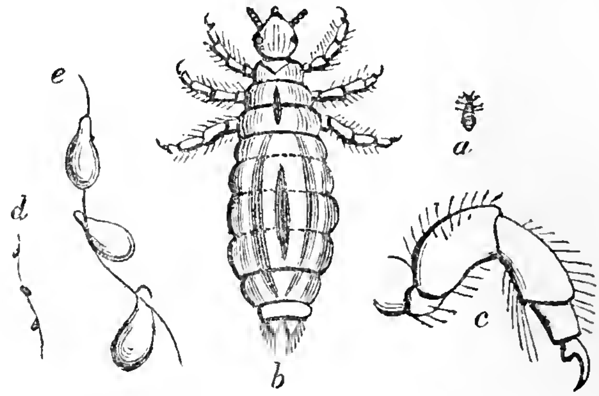
These insects are found upon trees and plants, or under stones, whilst some of small size may be met with upon the surface of standing water.

ORDER IV.—ANOPLURA (*Parasita* Latreille).

This order is distinguished by having only six legs, by the apterous state of the depressed body, which is not furnished with any lateral or terminal appendages. Their eyes consist of two or four simple ocelli. The order consists of the single genus *Pediculus* of Linnæus, comprising the families *Pediculidæ* and *Nermidæ*. Some recent German authors have, however, considered these two groups as belonging to different orders, placing the *Pediculidæ* amongst the haustellated insects (*Hemiptera epizoica* Nitzsch), and the *Nirmidæ* amongst the mandibulata (*Orthoptera epizoica*, &c.). We prefer, however, retaining these insects in a single order (*Anoplura*), on account of their general similarity in structure, as well as in their parasitic habits.

1. The *Pediculidæ* have the mouth minute, tubular, and placed at the anterior extremity of the head, on the underside, in form of a small rostrum, and inclosing an instrument for suction; the tarsi are composed of a single joint nearly as long as the tibia, and terminated by a single claw of considerable size, folding back upon the inside of the tibia, performing the office of a hook.

These insects, which are known under the name of lice, are parasitic upon man and various animals. Of these the *Pediculus humanus*, or body louse, is of a whitish colour, and almost destitute of markings. This species is very abundant in various parts of Europe, although rare in this country. It frequents the garments and bodies of persons of dirty habits, being exceedingly abundant on the lowest classes in Poland and Russia, Portugal and Spain. The species which is the most abundant in this country is the *Pediculus cervicalis*, or head louse, which is marked on each side of the body by a dark line, and inhabits the heads of children and dirty persons, piercing the skin and sucking the blood. They are



a, The common louse; *b*, magnified; *c*, one of the legs magnified; *d*, eggs; *e*, ditto magnified.

easily extracted by a fine tooth comb, or are destroyed by rubbing calomel mixed with bears' grease into the roots of the hair. Its eggs are small pear-shaped bodies, termed nits, which are attached near the base of the hair by a glutinous substance. Swammerdam and Leuwenhoeck, two of the most celebrated of microscopic observers, have made the common louse the object of very elaborate investigation. The former tells us, that notwithstanding the great powers of propagation of this insect, "it is no more than a jest that people say in sport that a louse may see its fourth generation in the space of twenty-four hours;" and Leuwenhoeck, who put a male and female louse under a stocking which he wore day and night to favour their breeding, found that the female lays from fifty to a hundred eggs, and, computing the natural increase from what he had seen, he says that in eight weeks one louse may see five thousand of its descendants. It is requisite that the eggs should be deposited in a place that is warm and moderately moist to produce young, and hence many nits laid on the hairs in the night-time are destroyed by the cold of the succeeding day, and so stick for several months till they lose their external form. In feeding, a constant motion of the intestines may be perceived through the transparent skin, the blood rushing like a torrent into the stomach.

The term *Phthiriasis* has been given to a disease supposed to originate entirely in attacks of the *Pediculi*. Kirby and Spence have collected much information upon this subject, and conclude their observations by doubting whether there be any real *Phthiri-*

asis, and add, "that it does not appear, from any well-ascertained fact, that the species of *Pediculi* are ever subcutaneous;" and that, therefore, the death of the poet Alcman, and of Phresydes Syrius, the philosopher mentioned by Aristotle, must have been occasioned by some other kind of insect; for, when speaking of the lice to which he attributes these catastrophes, he says that they are produced in the flesh in small pustule-like tumours, which have no pus, and from which, when punctured, they issue; but, according to the more recent observations of Alt, published in his Dissertatio de Phthiriasi, at Bonn, in 1820, it appears that another species, *Pediculus tabescentium*, is the real louse of this disease, which, as cited by Burmeister, collect in great numbers upon the skin at particular spots, chiefly upon the breast, the back, and the neck — between folds of the skin, making the surface uneven, so that scale-shaped lappets of the epidermis peel off, beneath which the lice conceal themselves. Of the first appearance of these insects much difficulty exists, both positive and negative evidence being recorded of their non-contagiousness. I cannot, however, adopt the opinion of Burmeister, that they must necessarily be the result of equivocal generation; and by whom it is supposed that the skin, which has precisely the same structure as the mucous membranes of the intestinal canal, gives rise to parasites peculiar to it. The *Pediculis pubis* (or *Phthirus inguinalis* Leach) is a fourth species; and, according to Fabricius, the louse of the negro is a fifth distinct species, of a black colour, with a large flat head. The pig is also subject to a distinct species (*Hæmatopinus suis*, Pl. 1).

The family *Nirmidæ* (Leach) is composed of the various species of lice found upon birds, to which they are exclusively attached, with the exception of one species, found upon the dog. The mouth is placed on the under side of the head, and composed of two lips and two hooked mandibles; the tarsi are distinct, and terminated by two equal-sized hooks; the head is generally large and triangular, semicircular or crescent-shaped, and occasionally with angular projections. The sexes also differ in the size of the head and the antennæ. M. Savigny also observed a pair of maxillæ with a minute palpus, hidden by the lower lip, which has also a pair of palpi. The body is small and depressed, of an oval or elongated form, and often varied with spots of different colours. Some of the species are very peculiar in their forms. M. Leclerc de Laval informed Latreille that he had discovered in the stomach bits of birds' feathers, and hence he believed that this constituted their food. De Geer, however, found the stomach of one of the species filled with blood, with which it had gorged itself. It is certain that they are able to live but a short time upon dead birds, upon which they may be seen crawling, with an evident desire of escaping. The family has found but few authors who have taken any interest in its investigation. Redi, however, long since figured many species in a rude manner; and more recently we find, in the posthumous work of Lyonnet, representations of many others. Dr. Nitzsch, also, has published an elaborate monograph in the Magazin d'Entomologie of Germar; and J. G. Children, Esq., F.R.S., has just published descriptions of some of the arctic species brought home by Captain Back.

CHAPTER V.

Class IV.—Ptilota, or the Winged Insects of Aristotle.

This class of annulose animals is far more extensive than the three already treated upon, and comprises those species which are characterized by the possession, in the perfect state, of six jointed legs and two antennæ, and which are previously subject to a series of transformations of a variable degree, by means of which, in almost every species, organs of flight are developed, the latter circumstance being, as already observed, the grand character of the class. Hence it is that an inquiry into the nature of these changes, and a consideration of the peculiarities exhibited by insects during their progress to maturity, will constitute the first step, and are, in fact, the necessary commencement, of our inquiries into the nature of insects. I propose, therefore, in the following pages, to endeavour to trace the insect through its various stages, first, by a review of the general principles which regulate their metamorphoses; and secondly, by an inquiry into the various peculiarities exhibited by these animals in their passage to the perfect state. To these will naturally succeed, thirdly, a general view of the insect structure, especially as exhibited in such perfect state, both externally and internally; fourthly, a sketch of their physiological and instinctive properties; terminating, fifthly, by a review of the classification of the winged tribes of insects.

SECTION I.

ON THE PRINCIPLES WHICH REGULATE THE METAMORPHOSES OF INSECTS.

It is owing, as already stated, to the developement of wings that the *Ptilota*, or winged insects, are necessarily subjected to a more complete and astonishing series of transformations than the other annulose animals, in which the changes (to which, in fact, in a greater or less degree, all animals are subject) merely consist in a periodical casting off of the outer envelope.

It is true that in a few insects, which are evident exceptions to the general rule, the same mode of moulting takes place as in the other annulosa. Owing to the external envelope of these animals constituting their skeleton, and offering, from its stronger consistence, a complete obstacle to the increase in size of the inclosed animal, it is necessary that this skeleton should from time to time be cast off. We have, therefore, in the first place, to inquire how the animal which throws off so important a portion of its organs as its skeleton can exist, or in what manner a new skeleton is formed. Swammerdam, in his really wonderful series of observations, discovered, in his endeavours to prove that all insects are produced from eggs, and that the caterpillar was but an immature butterfly, that shortly previous to changing to a chrysalis, the various parts of the butterfly were found distinctly incased beneath the skin of the caterpillar; and thereupon he has raised the theory which has been generally adopted by subsequent authors, that every caterpillar, at its first existence, contains within itself the germe of the future butterfly, and all its envelopes, which, successively presenting themselves, are thrown off, till it attains its perfect winged state. This theory has, however, been completely opposed by Dr. Herold, a distinguished microscopic observer, who, from a most elaborate — indeed, it may be affirmed, the most elaborate—investigation of its kind hitherto made—upon the cabbage butterfly in its different states, has arrived at the contrary conclusion—namely, that the successive skins of the caterpillar, the pupa case, &c., do not pre-exist as germes, but are formed successively from the *rete mucosum*, which itself is formed anew upon every change of skin; these formations being attributable to the action of a power which he terms the *vis formatrix*.

Against the latter theory, Messrs. Kirby and Spence have raised various objections, none of which appear to me to be of sufficient weight to overthrow it in favour of the old theory of Swammerdam. The first of these objections is, that Dr. Herold employs the high-sounding term, *vis formatrix*, to conceal his own ignorance of causes, when endeavouring to penetrate within the sanctum sanctorum, which is not permitted to vain man to enter — a plan adopted in all ages, and instanced in the adoption of such words as *Plastic Nature, Epigenesis, Panspermia, Idea seminalis, Nisus formativus*, &c. It is evident from these observations, that these authors would endeavour to fix upon Dr. Herold a charge of infidelity, in supposing that the body of an insect possessed of itself a power to mould itself according to its own formative will and power; and this is evident, because in a subsequent page they adduce the fact, with which every physiologist is acquainted, that the developements and acquisition of new parts and organs, by insects undergoing metamorphoses, have taken place according to a *law* which regulates their numbers, kinds, and times, since the first creation: but surely they are not authorized by Dr. Herold's views and statements, in wielding against him this powerful (if maintainable) argument, since it must be evident, that by the term *vis formatrix*, Dr.

Herold meant not to imply any power independent of the Creator, but simply that principle of developement which, under the guidance of an Almighty hand, is constantly in operation, not only in insects, but in every other branch of the creation.*

But, in the next place, Messrs. Kirby and Spence do not deny the facts stated by Dr. Herold, that the organs of the butterfly are not discernible in the larva, but gradually become visible as the caterpillar throws off its successive coverings. They assert, indeed, that they can easily comprehend that pre-existent germes, by the constant secretion of new matter, in a proper state, may be gradually developed; but find it impossible to conceive how, by the action of second causes, without the intervention of the First Cause, the *butterfly should be formed in the caterpillar*, unless it pre-exists there as a germe or fœtus. The question is not, however, whether the butterfly be or be not inclosed as a fœtus within the caterpillar, but whether, as Swammerdam evidently intended, the various skins of the caterpillar, &c., existed as distinct and visible germes within the newly-hatched caterpillar; and this Messrs. Kirby and Spence endeavour to support by the argument which they adduce from Bonnet, that "organs that have no existence as to us, exist as they respect the embryo, and perform their essential functions; the term of their becoming visible is that which has been erroneously mistaken for the period of their existence."

The question, therefore, now assumes a new form. It is not, as between Swammerdam (contending that the successive skins of the caterpillar exist as distinct and visible

* It is rather remarkable, that Messrs. Kirby and Spence, after having thus endeavoured to brand Dr. Herold as an atheist, should have expressed a supposition that the skins of serpents are formed under the old skin, from the *rete mucosum* (vol. iii. p. 191). The *vis formatrix* of Dr. Herold is of no higher rank than the power implied in this expression.

germes in the newly-born caterpillar) and Dr. Herold (asserting that these skins are successively produced from the *rete mucosum*), but simply whether we are to consider with Kirby and Spence that these germes are pre-existent, though not perceivable even by the application of the most powerful microscope, but which subsequently, "by the constant accretion of new matter in a proper state, are gradually developed;" or with Dr. Herold, that they do not pre-exist as germes, but are successively formed from the *rete mucosum*. Having, however, divested the arguments of the latter from the charge of atheism which has been attempted to be forced upon them, I cannot consider that there are no grounds for the adoption of the latter in preference to the former. It is true that Dr. Herold discovered the organs of sex in the newly-excluded larva; but these and other organs of the perfect butterfly are those which, from their very nature, must be regarded as requiring the greatest and most gradual degrees of developement; but the case is quite different with such temporary organs as the skins of the caterpillar. But let us look to facts: Messrs. Kirby and Spence are unable to adduce any in support of the existence of invisible germes, but, according to Dr. Herold, there is not the least trace in the young larva of the new skin, but this first originates towards the end of the first period of the caterpillar's life, a few days only before the old one is stripped off. It is then observed that the mucous and muscular layers of the skin separate all round from the epidermis, and then clothe themselves upon the superior surface with a new epidermis. The developement of this new external skin occupies two or three days, during which the caterpillar appears sickly, and takes but little nourishment: the old skin then splits longitudinally along the back, and the caterpillar emancipates itself from its old envelope by drawing out the body. The epidermis, all the external visible organs, and even the mandibles and palpi, remain attached to the old skin. This moulting is repeated several times.

Various physiologists, and especially Dr. Virey, have endeavoured to trace an analogy between the transformations of insects and the developement of some of the higher animals, attributing, as Mr. MacLeay observes in his Horæ Entomologicæ, the metamorphoses of insects to the shedding of an envelope analogous to that which contains the fœtus of the more perfect vertebrata; and as every embryo, whether animal or vegetable, is inclosed in a tunic more or less solid (its chorion), so proceeding with the analogy; they conceive there must be some condition for every animal, similar to the state of the fœtus of the more perfect animals, when surrounded by the amnios of this state, and which, in the hexapod insects, they hold to be the larva, according to which the true birth of the animal will be its exclusion from the pupa case. This argument seems to have been derived from an observation of Reaumur—namely, that the larva of insects ought to be regarded as an egg of an extraordinary kind, endowed with organs of locomotion and nutrition; and that this analogy is also retained during the period of the insect's existence in the chrysalis state. When we consider, however, that many species of insects are active in the pupa state, and that on their exclusion therefrom they have acquired their full size, and are fitted for the reproduction of their species, we must admit that the former view of the subject is scarcely maintainable; and that the larva state, which is especially that in which the digestive system predominates, and the greatest supply of food is taken, is more strictly analogous to the period of infancy of the higher animals.

SECTION II.

THE PECULIARITIES EXHIBITED BY INSECTS IN THEIR PASSAGE TO THE PERFECT STATE.

Perhaps none of the phenomena of natural history have attracted a greater share of the attention of mankind in all ages, than those exhibited by insects in their passage to the perfect state. It is perfectly consistent with that innate propensity of the human mind towards the marvellous, that the change of a caterpillar into a butterfly should have been considered by the ancients as a true metamorphosis, in no manner reconcileable with the ordinary process of nature. If this were indeed the case in the darker days of zoological knowledge, when the true nature of these changes was not understood, it is equally certain that the subject has lost none of its interest, although, owing to the admirable researches of Libavius and Redi, Malphighi and Swammerdam, Reaumur and De Geer, all of the marvellous has been removed, and a series of gradual developements exposed, far exceeding in peculiarity those exhibited in any of the other tribes of animals.

But it is not alone in elucidating the nature of the changes, by means of which a caterpillar becomes a butterfly, that the researches of these authors are most valuable; since this discovery naturally led to the equally important truth that the caterpillar is produced from a creature which has at one period of its existence resembled itself; and which, having arrived at its perfect state, and been impregnated, has perpetuated its species by the deposition of eggs, which, when hatched, produce small voracious animals of variable forms, ordinarily termed caterpillars, grubs, or maggots, and systematically larvæ (plural of the Latin word larva), liable to a series of moultings, varying in number. To this state, in the majority of insects, succeeds a quiescent period, during which the appearance of the creature is completely altered. The insect in this state is termed a chrysalis, or aurelia, and more generally and technically a pupa (plural, pupæ). After remaining in this state a certain period, the insect again throws off its covering, and appears in its perfect form. It is now termed a beetle, butterfly, bee, &c., according to its kind, but technically and generally the term imago is applied, to designate the adult state of all insects. These terms—larva, pupa, and imago—were employed by Linnæus, whose nomenclature was often fanciful, although generally applicable: the first, in allusion to the *larvated*, or *masked* appearance of the insect whilst a larva; the second, from the resemblance of the insect, during the pupa state, to the mummy-like appearance of children wrapt up in swaddling-clothes; and the third, because, having laid aside its mask, and cast off its swaddling-clothes, it is now in its perfect state, and has become a true representation or image of its species. Hence the four stages of an insect's existence are the egg, larva, pupa, and imago.

It is true, however, that, in the aphides, blowfly, and a very few other species, the eggs are hatched within the body of the parent fly, and deposited as larvæ; and that, in the *Hippoboscidæ*, the larva even undergoes its change to the pupa state previous to being deposited by the parent; but still these insects have originated from eggs; and it is also true, that in some groups the insect in the pupa state is active, and differs only from the larva in having small tubercular rudiments of wings upon the back (as in the orders *Hemiptera* and *Orthoptera*); and in the apterous individuals of these orders it is next to impossible to assert whether an individual be in the larva, pupa, or imago state. These are, however, but exceptions to the general rule, and do not warrant the opinion maintained in an ingenious paper published by Mr. Newman in the Entomological Magazine, to which I would refer the reader, namely, that insects have but three stages of existence, the fœtal, the adolescent, and the adult, inasmuch as in the majority of insects, the last is preceded by a distinct but variable state, which I have above noticed as that of the pupa. In like manner, I see no sufficient grounds for rejecting the terms larva and pupa, and employing such terms as infancy and adolescence in their stead. Indeed, the setting aside of words employed in a technical sense, and universally understood, merely because they may happen to be in a foreign tongue, or may, even in their origin, have been somewhat fanciful, appears to me to savour somewhat of affectation, or even something worse than this, when the perfectly quiescent and apparently lifeless state of an insect is regarded as analogous to the adolescence of the higher animals.

Our present inquiry, therefore, resolves itself into four distinct heads—namely, the egg, larva, pupa, and imago.

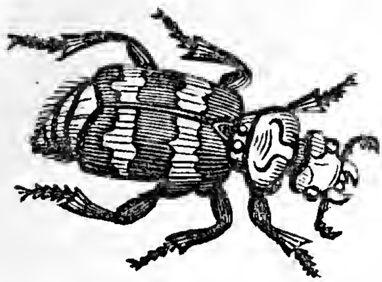
I. *The Egg.* — The theory, omnia ex ovo (although opposed by some writers, who, not only in past times, but also still, maintain the doctrine of spontaneous generation), being, as it appears to me, universally true, the first branch of our inquiry will be devoted to the situation in which the eggs of insects are deposited, and the extraordinary instinct exhibited by the female in this operation, and which has been attributed to the influence of maternal affection. As, however, it happens that, in the great majority of instances, the female dies immediately after depositing, and long previous to the hatching of her eggs; and as, moreover, it is erroneous to attribute such feelings as love or affection to animals so low in the scale of existence as insects, we would refer these proceedings to the operation of that indefinable influence which is ordinarily termed instinct. That this is a correct view of the matter must be evident from a perusal of the details which have been published of the proceedings of the hive-bee and of the ants, where it will be seen that insects incapable of re-production (neuters) are equally active in preparing nests, &c., with the real parent. This branch, therefore, of our inquiry, ought perhaps more correctly to come into the physiological view of insects, although it can hardly be said to be out of place here.

Insects, as regards the situations in which their eggs are deposited, may be divided into two classes: those which, with much labour, form a residence, and lay up a store of food for their progeny; and those which simply place them in situations where the young, when hatched, will be certain to find a due supply of food.

Of the former, the highest place must be accorded to those social insects which build nests of the most beautiful construction, serving not only for the education of their young (which are produced from eggs placed in separate cells), but also for the habitation of the entire community at large. The hive bee (*Apis*), humble-bee (*Bombus*), hornet, wasps (*Vespidæ*), ants (*Formicidæ*), white ants (*Termitidæ*), &c., furnish the most admirable instances of this species of economy.* We are next to notice the sand-wasps, and many solitary species of wild bees and wasps, which construct their nests with great labour in the sand or in rotten wood, forming a succession of cells, generally of an oval or rounded form, in which they deposit a supply of food, either of pollen-paste or other insects, sufficient for the nourishment of the larva when hatched from the egg, which is placed in the cell with this supply. Instances of this mode of proceeding may be noticed in many Fossorial Hymenoptera (*Cerceris, Pompilus, Sphex,* &c.), and in the burrowing bees, *Ceratina, Halictus,* &c. Here also may

* I must refer to the articles upon these tribes in the British Cyclopædia for ample details of their habits.

be ranked the dung-rolling and dung-boring beetles, whose proceedings are exemplified by the *Geotrupes* and *Gymnopleurus*, as well as the sexton-beetles (*Necrophorus*), whose exploits in burying small dead animals, in which they deposit their eggs, are not less indicative of a high degree of instinctive powers. The *Cicadæ* likewise, as well as the saw-flies, may also here be noticed, since the care with which the parent constructs a burrow in the stems of plants, for the reception of her eggs, by means of a most admirably constructed apparatus, is equally remarkable, although the larva, as soon as hatched, is compelled to seek elsewhere for its food, namely, the leaves on the adjoining twigs. But the instinct which is exhibited in the selection of appropriate situations for the eggs, and where the larva, when hatched, will find a supply of food, without the same being laid up in store by the parent fly, is found to be possessed by the greatest number of insects. Many species of larvæ will feed only upon one particular species of plant; and the parent fly, in its perfect state, takes no other food than a little honey from every flower which may be in bloom at the time; still it is only upon that particular plant which suits the taste of her progeny that she deposits her eggs. Here are to be ranked many of the tribes of lepidopterous insects (butterflies and moths). Many species of moths, as well as beetles, reside in the larva state under the bark of trees; the females, therefore, by means of a long and jointed ovipositor, are enabled to place their eggs at the bottom of the crevices in the external bark. In like manner, the carrion flies deposit their eggs upon carrion; the flesh-flies upon flesh; the flies whose larvæ feed upon plant-lice, in the midst of the plant-lice;



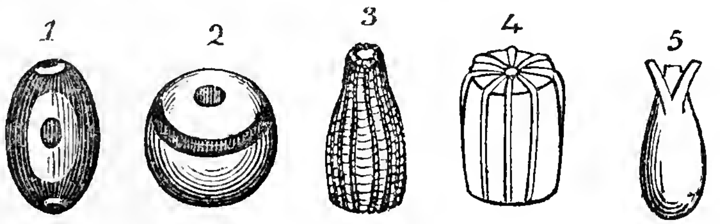
Necrophorus.

and some species of these flies (*Hemerobius*) render the security of their young doubly secure, by placing their eggs out of danger at the extremity of long and slender foot-stalks (fig. 9). In like manner, the boat of eggs formed by the common gnat (*Culex pipiens*), and the egg-pouch of the *Hydrous*, are alike deserving of notice. But it is amongst the parasitic insects that this species of instinct appears most fully developed. Of this numerous instances occur amongst the cuckoo-bees (*Cuculina* Latreille, *Melecta, Epeolus*, &c.), *Chrysididæ, Chalcididæ*, and especially *Ichneumonidæ;* whilst the proceedings of the bot-flies, and the instinct whereby, as in the *Gasterophilus equi*, a particular spot upon the body of an animal is selected for the reception of the egg, is most remarkable. It would, however, be an almost endless task to detail the various modes adopted by insects in order to deposit their eggs in such situations that their progeny may be sure of meeting with an ample supply of food.

If the instinct exhibited by the parent fly be worthy of observation, the number of eggs which she deposits is not less interesting. Thus the queen bee produces from 40,000 to 50,000 eggs in the course of a year; and supposing a swarm to contain 32,256 individuals, and three swarms to take place in the season, the population of a hive would in a single year amount to nearly 100,000 bees; and the *Aleyrodes proletella*, a little homopterous insect, is said to produce in a year more than 200,000 young.* A species of moth, according to Lyonnet, produces in the third generation more than a million of young; and the *Aphis*, observed by Reaumur and Bonnet, produced at the fifth generation 5,904,900,000 individuals, and there may be not less than twenty genera-

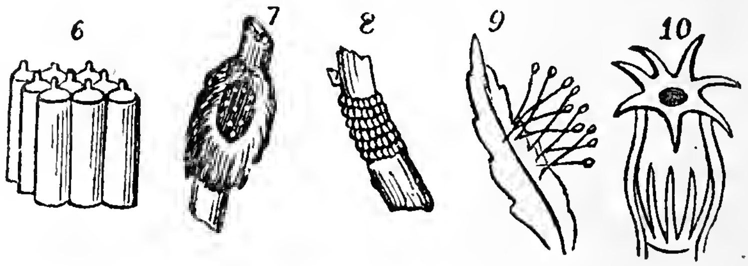
* Kirby and Spence say, that the insect deposits this number of eggs, but Reaumur, from whom their statement is evidently derived, gives a calculation showing that, from the number of generations in the course of a year, one female may be the progenitor of that number of individuals.

tions in the course of a year. The female white ant, whose enormously distended body causes her to exceed her companions many hundred times in size, deposits sixty eggs in a minute, which is at the rate of 211,449,600 in the course of a year. Other insects are, however, less prolific. The silkworm produces only from 400 to 500 eggs, the caddice flies less than 100; the burying beetles about thirty; and the horsefly (*Hippobosca equina*) can only be said to deposit a single egg.

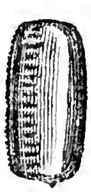


The eggs of insects are generally of an oval form (fig. 1, oval-spotted egg of the fox-moth), the outer covering being sufficiently rigid to resist ordinary external impressions; others are, however, soft and pliant. In some species they are globose, as in many Lepidoptera (fig. 2, globular-banded egg of the vapourer-moth); or conical, as in the large white cabbage butterfly (fig. 3); cylindrical, pear-shaped, barrel-shaped, &c. They are for the most part smooth; but many are very beautiful, ornamented with symmetrical ridges (figs. 3 and 4, egg of the tortoise-shell butterfly), canals, dots, &c., giving them, as Reaumur observed, the appearance of embossed buttons. There are numerous other varieties in the form of eggs, and some are furnished with appendages for peculiar purposes. Thus the egg of the dung-fly (*Scatophaga putris*, fig. 5) has two oblique props at one end to prevent it sinking too deep in the matter upon which it is deposited; whilst those of the water scorpion (*Nepa cinerea*, fig. 10) are furnished with a coronet of spines, forming a receptacle for the egg which is deposited immediately afterwards.

The colour of insects' eggs varies very considerably, although white, yellow, and green are the more prevalent tints; orange, red, brown, and black, with all the intermediate shades, are to be found, as well as blue; and others are banded with pale circles, and that of the pine lappet moths is blue, with three brown zones. The colours of eggs are, however, subject to change as the inclosed larva approaches the period of its escape, this being owing chiefly to the change of colour undergone by the latter being visible through the slender coating of the egg.



In many species the eggs are deposited singly; in others, however, they are discharged *en masse*, of which the most remarkable instance occurs in the cockroaches (*Blattæ*), the egg pouch of which is here figured. Others again arrange them symmetrically (as in the cylindrical pointed eggs of the *Semblis lutea*, fig. 6), and others inclose them in a mass of gluten, especially those species which inhabit the water in the larva state: many species employ a gummy matter to attach them firmly to the substances on which they are placed; whilst some (as the yellow-tail moth, *Arctia chrysorrhœa*) wrap them in a coating of down (fig. 7), which they pull off their own bodies by the assistance of an apparatus fitted for that purpose; and the lackey moth (*Lasio-*



Egg pouch of Blatta.

campa Neustria) deposits her eggs in a spiral coil round the stems of fruit trees (fig. 8).

The period which elapses between the deposition of the egg and the birth of the larva depends upon the temperature of the atmosphere, as well as upon the species of the insect. Thus, whilst the early-laid eggs of the tortoise-shell butterfly hatch in a few days, those which are not laid till autumn will not produce caterpillars until spring. The eggs of the meatfly hatch in a very few days, or even hours: eight days are required by the eggs of the painted-lady butterfly; whilst the caterpillars of the machaon butterfly are not hatched under a month. It is, however, a general rule, that those eggs which are deposited in the autumn are not hatched until the following spring.

The investigation of the developement of the grub whilst inclosed within the egg is attended with so much difficulty, owing to the minuteness of the objects, that hitherto but little progress has been made in this branch of the subject. Dr. Herold, however, whose admirable microscopic observations I have already noticed, has taken it up; and the first part of his magnificent work, intitled "Disquisitiones Animalium Vertebris carentibus in Ovo Formatione," has recently appeared, and will tend to throw much light upon this intricate subject. One peculiarity ought not to be omitted relative to this part of our subject, namely, that the eggs of the sawflies, gallflies, and ants, increase very considerably in their size and alter in form previous to the exclusion of the larva, which is doubtless owing to the membranous covering of the egg and to the growth of the inclosed larvæ. In general, the embryo caterpillar is observed coiled up within the egg, the head being brought into contact with the tail.

We have said that the majority of insects die previous to the birth of their progeny, but this is not the case with the whole. Thus De Geer ascertained that a large species of field-bug (*Pentatoma grisea*) survives this event, and that she leads her brood about, consisting of from thirty to forty young ones, in the same way as a hen does her chickens. Somewhat similar observations have been made upon the common earwig by De Geer, as well as by the author of "Insect Transformations," who has published the following interesting notice in the Penny Magazine:—"About the end of March I found an earwig brooding over her eggs in a small cell scooped out in a garden border, and in order to observe her proceedings I removed the eggs into my study, placing them upon fresh earth under a bell-glass. The careful mother soon scooped out a fresh cell, and collected the scattered eggs with great care to the little nest, placing herself over them, not so much, as it afterwards appeared, to keep them warm, as to prevent the too rapid evaporation of their moisture. When the earth began to dry up she dug the cell gradually deeper, till at length she got almost out of view; and whenever the interior became too dry, she withdrew the eggs from the cell altogether, and placed them round the rim of the glass, where some of the evaporated moisture had condensed: upon observing this, I dropped some water into the abandoned cell, and the mother soon afterwards replaced her eggs there. When the water which had dropped had nearly evaporated, I moistened the outside of the earth opposite the bottom of the cell, and the mother perceiving this, actually dug a gallery right through to the spot where she found the best supply of moisture. Having neglected to moisten the earth for some days, it again became dry, and there was none even round the rim of the glass as before. Under these circumstances, the mother earwig found a little remaining moisture quite under the clod of earth, upon the board of the mantelpiece, and thither she forthwith carried her eggs. The subsequent proceedings were not less interesting; for though I carefully moistened the earth every day, she regularly changed the situation of the eggs morning and evening, placing them in the original cell at night, and on the board under the clod during the day, as if she understood the evaporation to be so great when the sun was up, that her eggs might be left too dry before night. I regret to add, that during my absence the glass had been moved and the mother escaped, having carried away all her eggs but one or two, which soon shrivelled up." De Geer was more fortunate, and, as I have also repeatedly observed, noticed the care of the female in defending her young when hatched.

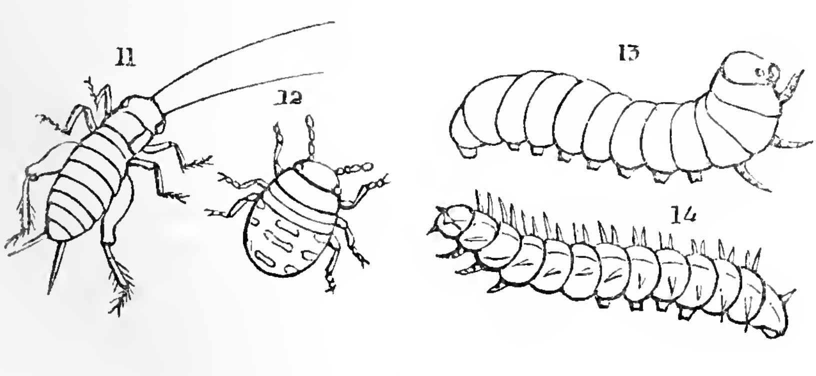
There are other insects whose attention is devoted to the care of the eggs and the education of their young, especially in the social species. When the period is arrived for the hatching of the egg, the inclosed larva bursts through the envelope, either by main force or by gnawing through it with its jaws. Sometimes, however, one end of the egg is provided with a sort of cap, which is easily pushed open.

II. *The Larva.* — The insect has now arrived at an active state of existence; it is now that it is destined, in a more special manner, to grow and to eat. It is to this state that the ordinary terms caterpillar, grub, and maggot are generally applied, in a manner so indefinite, that it is impossible, with any pretension to correctness, to assign these terms to any precise divisions of insects. In general, insects at this period of their lives appear in the form of a cylindrical ringed, and fleshy worm, provided generally with a distinct head and six scaly legs attached to the anterior part of the body. The head, however, in some species is not distinct, and the legs are sometimes wanting; whilst in others the terminal segments are furnished with membranous (false or pro-) legs. In other species (the number of which is but comparatively small), the insect nearly resembles its parents, being, however, destitute of wings. This variation naturally introduces two principal divisions amongst insects, the former having a complete metamorphosis, and the latter an incomplete one; but as these terms have also been employed by Linnæus and Fabricius in a more restricted and totally different sense, and as they have been applied to designate the entire metamorphosis, instead of simply indicating the formation of the larva, I prefer dividing insects, from a consideration of their larvæ, into two divisions, which may be named *Heteromorpha* and *Monomorpha*, from the dissimilarity or resemblance of the larva with the imago.

In all this diversity, however, there is still a general prevailing uniformity of structure, which, under various modifications of form, preserves a tendency towards one typical organization. This typicality in larvæ consists in having the body ordinarily composed of thirteen segments, which are for the most part of an equal size, although, when arrived at maturity, some of these segments become obsolete, being converted into internal organs, or are greatly altered as regards the extent of their individual developement. Here the entire object of the animal's existence consists in its capability of feeding; consequently, owing to the formation of the internal digestive organs, the body maintains throughout its various segments a general conformity, none requiring an extra developement for the support of organs fitted for other purposes. When, however, the insect has arrived at the perfect state, its objects are completely altered,—it has now to seek its mate; it is therefore provided with wings, which, requiring support from the segments to which they are attached, cause these segments to be necessarily developed in an extraordinary degree; the other adjacent segments being losers: the insect has also now to perform the great object of its existence, namely, the continuing of its kind, and therefore the organs of generation become organs of especial importance, and we accordingly find other portions of the body sacrificed for their developement.

The thirteen segments which compose the body of the larva bear the following relation to the distribution of the segments in the imago. The first segment or head of the larva becomes the head of the imago; the three following segments compose the thorax, and the remainder become the abdomen in the perfect insect. Dr. Ratzeburg has, indeed, lately published a memoir, endeavouring to prove that the two first segments of the larva of the aculeate *Hymenoptera* become the head of the imago; but the observations of this author, as I have proved more than once, are incorrect, and founded upon very unphilosophical views.

In the *Monomorphous* division the larvæ greatly resemble the perfect insect, differing chiefly in being entirely destitute of any appearance of the organs of flight. The third segment of the body also does not exhibit the shield-like scutellum which is found in the imago in that situation: here belong the various tribes of locusts, grasshoppers, and crickets (fig. 11, larva of the cricket), bugs (fig. 12, larva of a *Pentatoma*), tree and frog-hoppers, cockroaches, praying mantes, &c., constituting the orders *Orthoptera, Hemiptera,* and *Homoptera,* as well as some portions of the order *Neu-*

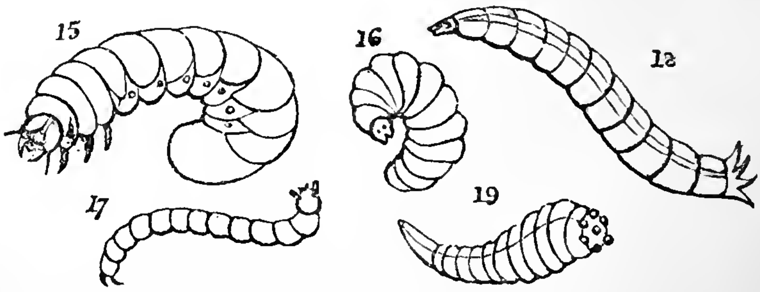


roptera. Some of these insects are, however, remarkable for being destitute of wings in the perfect state, and a difficulty thence arises of distinguishing the larva from the subsequent states. The variation in their size, and the constant absence of occlli, as well as a somewhat less perfectly developed organization of the antennæ, and some other parts of their structure, may, however, serve to distinguish them. From analogy with the higher animals we might perhaps be induced to consider, that these insects, which maintain a constant activity throughout their existence, are much higher in the scale of nature than those species which, like the butterfly, are subject to so long a period of death-like repose.

In the *Heteromorphous* division the larva is totally unlike the perfect insect, being generally more or less vermiform, and, with the exception of the head, of a leathery-like texture. Here belong the tribes of beetles, butterflies, moths, bees, and most other four and two-winged flies, as well as the flea. There are, however, various modifications of form in respect to the head and legs of the larvæ of those insects, so that it may, perhaps, be advisable to give a sketch of their distribution, proceeding from the more fully to the less perfectly developed species.

A. *Larvæ capitatæ*, or those having a distinct head, subdivisible into

1. *Hyperhexapodæ*, or those having six legs, and a variable number of membranous prolegs. The larvæ of butterflies (fig. 14, larva of Camberwell beauty



butterfly), moths and saw-flies (fig. 13, larva of *Cimbex lutea*).

2. *Hexapodæ*, or those having six scaly legs, but being destitute of prolegs. The larvæ of many *Coleoptera* (fig. 15, larva of *Trichius nobilis*), and some *Neuroptera*.
3. *Apodæ*, or those destitute of legs and prolegs. Many *Coleoptera*, *Hymenoptera* (fig. 16, larva of wild bee), gnats and tipulæ (fig. 18, larva of *Tipula*), and the flea (fig. 17, larva).

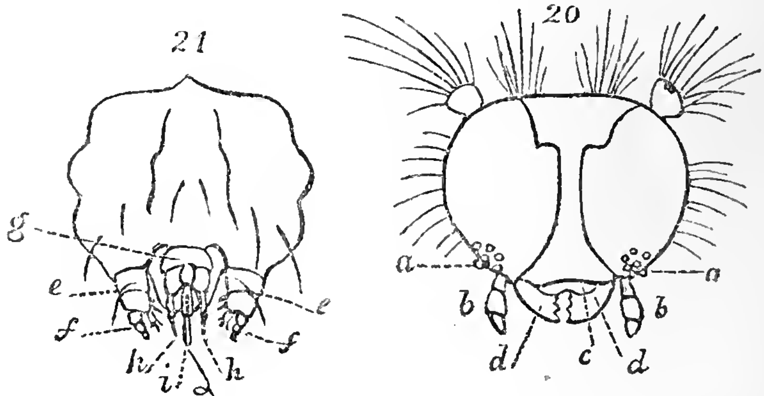
B. *Larvæ ecapitatæ*, or those without a distinct scaly head, including the majority of dipterous insects (fig. 19, larva of the flesh fly), some few of which are furnished with membranous tubercles serving as prolegs.

The head, in the generality of larvæ, is covered with a corneous case, often divided, by an impressed line running down the middle of the face, into two lateral lobes; its form is more or less rounded, but it often assumes a triangular or heart shape; occasionally, as in the caterpillars of some butterflies, the two lobes are terminated by spines or tubercles (fig. 20). There are other variations in the appendages by which this part of the body is distinguished. In the second section above described, the head is generally retractile, membranous, and variable in form, and destitute of eyes and antennæ, as well as of the ordinary parts of the mouth, which appears only to consist of a pair of hooks, or bristles, which are incapable of either cutting or grinding; the insect employs them not only to pierce the soft matters, upon the juice of which it feeds, but also as claws whilst engaged in locomotion.

The *head* of larvæ is generally provided with a pair of short rudimental antennæ, eyes, and organs of the mouth.

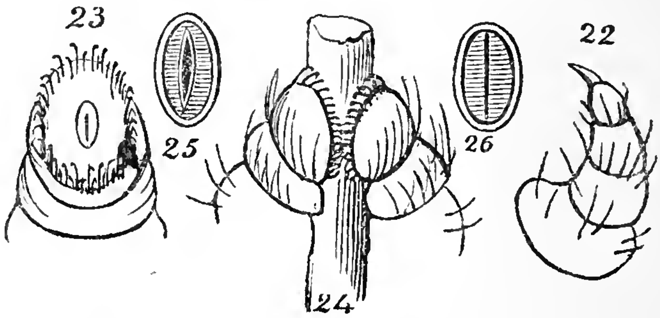
The *antennæ* (fig. 20, *b*) are placed near the base of the mandibles; they are for the most part totally unlike the antennæ of the perfect insect, although in the monomorphous section they are very similar in this respect, although shorter, and composed of fewer joints. These organs are, however, in general very short, and composed of three or four joints; and in many groups they are entirely wanting in the larva state.

The *eyes* of larvæ are not, like those of the perfect insect, formed of an innumerable series of hexagonal lenses, but consist of a small number of simple granular tubercles, placed at the side of the head, in the same situation that the eyes of the future insect are to be developed; they are, therefore, more analogous to the simple eyelets of many insects, subsequently described under the name of ocelli; many larvæ are, however, entirely destitute of them. Their numbers, when present, seldom exceed six on each side, which is the number possessed by the caterpillars of butterflies (fig. 20, *a*). The larvæ of the dragon-flies have eyes somewhat resembling those of the perfect insect.



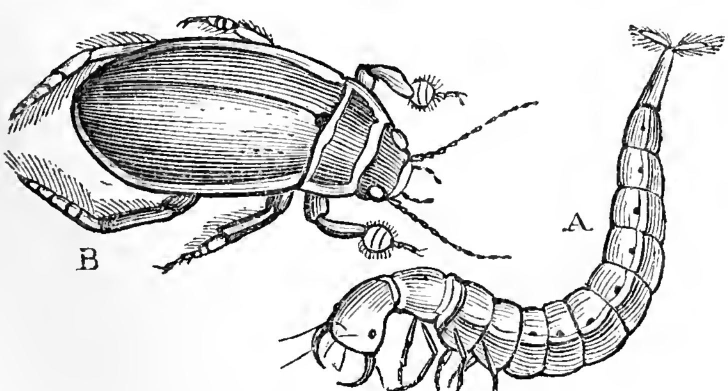
The *mouth* of the majority of larvæ consists, like the mouth of the perfect insect, of an upper lip (fig. 20, *c*), a pair of horny jaws (fig. 20, *d*), a second or lower pair of jaws of less firm consistence (fig. 21, *e*), furnished with an articulated palpus (fig. 21, *f*), and a lower lip (fig. 21, *g*), furnished also with a pair of articulated palpi (fig. 21, *h h*). Here, however, it is to be remarked, that the structure of the mouth of the larva will by no means lead us to a correct idea of the mouth of the imago: thus the jaws of the caterpillars of butterflies are as robust, and not very unlike those of the larvæ of beetles; but the mouth of the butterfly consists of a slender spiral and tubular apparatus for sucking up honey, whilst that of the beetle retains much of the general appearance of the mouth of the larva. There are some peculiarities in the structure of various organs of the mouth, which it may be interesting to notice. Thus the jaws of the ant-lion, and of the larvæ of the predaceous water beetles, are very long, slender, curved, and sickle-shaped, having a small longitudinal aperture near the extremity, which communicates with an internal canal, through which the juices of the prey of the insect pass. Another remarkable peculiarity exists in the elongated elbowed structure of the lower lip of the larvæ of the *Libellulidæ* (dragon-flies), forming a mask over the face, and which is employed like an arm furnished with claws for seizing their prey. Again, in those larvæ which spin for themselves silken cocoons, in which they undergo their transformations, the lower lip is furnished at its extremity with a minute and slender organ (fig. 21, *i*), which Kirby and Spence have aptly termed the spinneret (*fusulus*), composed of several longitudinal slips, alternately corneous and membranous, whereby the insect has the means of contracting the tube, which terminates in a single orifice, and through which it emits its silken threads, which, although elaborated in two distinct silk tubes, unite previous to their emission from the orifice of the tube. Some larvæ, indeed, spin a silken thread for the formation of cocoons from a distinct apparatus at the extremity of the body.

I now pass to the description of the other segments of the *body* of larvæ, and the organs of motion and other appendages with which they are provided. Generally speaking, these segments, which are typically twelve in number, are of a cylindrical and elongated form; but various modifications occur, some larvæ being flattened, others oval, some short and thick, others having the segments very irregular, warty, spinose, or hirsute. The three anterior segments are, however, ordinarily distinguished by each having on its inferior surface a pair of short scaly legs, composed of four or five joints, which are analogous to those of which the legs of the perfect insect are composed, and generally terminated by a small claw (fig. 22). In many larvæ, as I have indicated in the table given above, these are the only legs with which the insect is furnished, although it rarely occurs that these are



wanting, the organs of motion being the merely rudimental prolegs. These prolegs are thick, and of a membranous construction, so that, unlike the true articulated legs, which are capable of motion only at the articulations of the joints, these are completely flexible. They are exclusively adapted to the insect whilst it remains in the larva state, there being nothing at all analogous to them on their arrival at the perfect state. These legs are furnished at the extremity with a multitude of minute bent hooks, which are employed by the larva in retaining its situation, upon whatever substance it may happen to be placed, with very great firmness (figs. 23 and 24). These prolegs are very variable both in their structure and situation, as also in their number, varying from two to eighteen. These variations afford grounds for classifications of the larvæ, but which it would be tedious to detail without entering more fully into minute particulars than my space will allow. The terminal segment of the body is often very different from the preceding in its form, and its under-side in some hexapod larvæ is furnished with a retractile tubercle, which the insect sometimes employs as a seventh leg.

In addition to the organs above described, are to be noticed the spiracles, or apertures by which the larvæ take in a supply of air. These spiracles are not, as in the higher animals, situated in the head, but are arranged in a series on each side of the body, opening into two longitudinal tubular internal vessels called tracheæ, from which an immense number of ramifications diverge to every part of the body of the insect. These spiracles are placed in the first, fourth, and following segments (except the last), and consist of a small elongated opening, surrounded by a callous margin (fig. 25 represents a spiracle open, and 26 a closed spiracle). In aquatic larvæ, however, a variation in the organization of the animal necessarily takes place, as it is not exposed to the ordinary action of the air. In the larva of the *Dyticidæ* the only spiracles which the insect possesses are placed at the extremity of the body, so that it is obliged to rise to the surface of the water, or at least to elevate the extremity of



A, The Larva—B, the perfect Dyticus marginalis.

the body till it reaches the surface. The larva of the dragon-flies is provided with an anal pouch, in which it receives from time to time fresh supplies of water, from which it extracts the air, as represented in a subsequent page.

But in other aquatic larvæ, as in the *Ephemeræ,* the sides of the body are furnished with elongated flattened plates, through which a slender air tube meanders, and which communicates with the longitudinal air tubes above mentioned (fig. 32, p. 200). Other variations occur in the larvæ of the gnats (*Culicidæ*), and midges (*Chironomus*), which we have already described. But the most curious variation which occurs in this respect is found in the very common larvæ of the *Helophilus pendulus,* which has been termed the rat-tailed grub, from the peculiar formation of the extremity of the body, which is very slender and elongated, inclosing a second still more slender air tube, which is capable of being protruded, so as to be pushed to twelve times the entire length of the body. As the insect lives in mud, this structure is eminently serviceable in enabling it to obtain a due supply of air.

There are some considerations resulting from the variations in the form of the larvæ of insects which ought not to be passed over without notice, inasmuch as the subject is one of great interest, hitherto but little cultivated, and one of much importance as regards the classification of the annulose sub-kingdom. It has been observed by some recent physiologists, that the immature state of insects typified the perfect forms of those particular grades which may be supposed to have preceded the winged type in the progress of creation from the lowest to the highest and most perfect forms. Without arriving at this theory, Mr. MacLeay, in his Horæ Entomologicæ, and Messrs. Kirby and Spence, have given a series of analogies exhibited by the larvæ of insects with other annulose groups in the perfect state; the former contending, that it is only by the assistance of such analogies that the real mode of distribution (by which every variation shall have its due weight appropriated to it), and the consequent discovery of the natural system, can be obtained: thus the larvæ of the cockchafer, and other lamellicorn beetles, represent a full-grown *Iulus*, in its peculiar mode of rolling itself into a coil on one side; and the same analogy is exhibited by the larvæ of the sawflies. It would lead me too far to enter more at length into these views, which, however, it would have been improper to have entirely overlooked.

I have said that it is during the larva state that the chief supply of nutriment is taken by the larva. It will be proper, therefore, to enter into a few particulars relative to the voracity of insects at this period of their existence, and which, in proportion to their size, far exceeds that which is exhibited by any of the larger animals. Thus, Redi discovered that the larvæ of the flesh-fly had become, in the space of twenty-four hours, at least two hundred times heavier than at first. And the Count Dandolo gives the following as the result of the most exact calculations made from the observations of the cultivators of silk, who know the exact weight of the leaves devoured by the caterpillars; 1609 and a half pounds weight of leaves being consumed by the progeny raised from an ounce weight of eggs.

First age,	6 lbs. of sorted leaves,		1½ lbs. refuse.	
Second age,	18	,,	3	,,
Third age,	60	,,	9	,,
Fourth age,	180	,,	27	,,
Fifth age,	1098	,,	102	,,
			105 allowed for evaporation.	
	1362	+	247½ = 1609½ lbs.	
Deduct further allowance for litter, uneaten leaves, &c.	155½			
	1206½ lbs. actually devoured.			

It is to be observed, however, that the stomach of these insects, like that of the horse, does not possess the power of dissolving these leaves in the most perfect manner, but only of extracting a juice from them. Indeed, this very circumstance is assigned by John Hunter (Observations on the Animal Economy, p. 221, quoted by Kirby and Spence) as the probable proximate cause for the voracity of herbivorous larvæ. And hence of the 1206 and a half pounds of leaves actually devoured, 745 pounds are deposited as excrement in an indigested state. Hence it is evident, that in comparison with the stomach of the perfect insect, in which state but very little food is in general taken, (and in some cases the insect is even totally destitute of a mouth,) the stomach of the caterpillar, and its apparatus for taking its food, must be fully developed; and this is found to be the case, the stomach occupying a considerable portion of its interior, and the organs of the mouth being very robust. The caterpillar of the goat-moth is three years in arriving at its full size, when it is 72,000 times heavier than when newly hatched: and a silk-worm, weighing, when first hatched, 1-100th part of a grain, consumes in thirty days about 60,000 times its primitive weight.

These particulars may suffice for the voracious powers of individual insects. It is, however, when they have been produced in considerable numbers together that these powers are rendered more widely perceptible; and, in fact, become highly prejudicial, as I have already endeavoured to show in the Introductory part of this volume. An instance or two may not, however, be here out of place. Of these, the first I shall mention is the salt-marsh caterpillar of North America, of which an interesting account has been published by Dr. T. W. Harris, in the Massachusetts Agricultural Repository. This insect is the caterpillar of a moth allied to our ermine-spot moths, being the *Arctia acria* of Fabricius. It is very hairy, somewhat like the caterpillar of the garden tiger-moth, and is endued with a great degree of vitality, for long immersion in water does not destroy life. Being often exposed to that element, they seem provided with the power of enduring its approaches. They feed twice in the day, about ten o'clock in the morning, and four in the afternoon. If overtaken by the tide while feeding, they mount to the top of the grass, and then, if obliged to relinquish their hold, contracting themselves into a circular form, they commit themselves to the water. By this means they are washed to the borders of the marsh, where they are left by the wash of the sea in heaps, but alive, and in a short time ready to recommence their depredations upon the meadows. The hair upon their bodies seems to possess a repelling power, which secures the spiracles from the admission or access of the water, for were the latter to be the case, the insect would be drowned. Their most favourite food is the onion grass, which is very succulent; but they are not fastidious, and eat with avidity "fox" and "bottom grass," and even "thatch" and "sedge." By the 1st of August these caterpillars have attained their greatest size; they now become very voracious, and continue eating all the day and night without intermission, by which means the hay crops are greatly detrimented. Soon they leave the meadows, aggregated in great numbers, and commence their wandering state, or "begin to run," as is the phrase, devouring every thing in their progress. Corn-fields, gardens, and even the coarse and rank produce of road sides, afford them temporary nourishment, until they have found a place of security against the tide and weather. Another moth, belonging to the same group, of whose proceedings an account was published in 1782, by Mr. W. Curtis, under the name of the brown-tail moth, *Porthesia auriflua,* is occasionally not less numerous or injurious in our own country. In the year above mentioned, so vast were their numbers, that the trees were despoiled of their foliage; and it was feared that they would extirpate the growing corn and grass, and starve the cattle to death in the fields. They were regarded as the harbingers of the plague, and prayers were ordered to be read in all the churches to avert the supposed impending calamity. In France, also, the same or a nearly-allied species has so frequently appeared in such prodigious numbers, entirely defoliating the forests, that the legislature have promulgated several ordonnances for their destruction.

The colours of larvæ are very variable; indeed, it would be very difficult to lay down many general rules respecting them. It may, however, be observed, that those species which are destitute of legs, and are of a fleshy consistence, have the body generally of a white or dirty white colour. Many caterpillars also, which greatly resemble each other, produce moths totally unlike, whilst moths, which are so closely allied that it is almost impossible specifically to distinguish them (the shark moths, genus *Cucullia,* for instance), are different in their larvæ, which are consequently resorted to as affording a more certain specific character. Caterpillars also vary in their colours during their growth; and Mr. Sheppard has observed, that the skin of the caterpillar of the privet hawk-moth, after being under ground four days, was changed from a vivid green to a dull red. A similar change of colour also occurred in a caterpillar of the puss-moth (*Cerura vinula*), which I endeavoured to preserve. From what has been said, it will be easily conceived that the colour of the caterpillar affords no criterion for judging of the colours of the future moth; the most beautifully coloured moth, as Reaumur observes (Mem. i. p. 198), producing the dullest coloured moths; and *vice versâ.* De Geer has, however, given two instances in which the moth preserves the colours of the caterpillar; these are the common magpie moth (*Abraxas grossulariata*), and the green *Pyralis prasi-*

nana. Dr. Harris, in his memoir upon the salt-marsh caterpillar, also notices that there are two varieties of the moth, corresponding with the caterpillars from which they are produced; from the dark caterpillar and brown cocoon proceeds a moth with ash-coloured wings, and from the lighter coloured larva and cocoon is disclosed a moth, whose upper, and also sometimes the lower, wings are white, these colours not designating the sex. De Geer also observed, that the brown caterpillars of the yellow underwing moth (*Triphæna pronuba*) produce males, and the green ones females.

Respecting the size and growth of larvæ, it is to be observed as a general rule, that they are longer and heavier, when full grown, than the perfect insect. According to the Count Dandolo, the following is a statement of the progressive increase in the weight of silkworms :—

	Grains
A hundred worms, just hatched, weigh about .	1
After the first moulting . . .	15
After the second moulting . . .	94
After the third moulting . . .	400
After the fourth moulting . . .	1628
On attaining the largest size . .	9500

From what has already been advanced in my observations upon the principles of metamorphosis, it will readily be conceived, that with this rapid growth a continued moulting must be required. Hence we find caterpillars are subject to a greater or less number of these changes of the skin; the great tiger-moth (*Arctia caja*) undergoing as many as ten such moultings, *Arctia dominula* nine, *Arctia villica* from five to eight. The ordinary number, however, appears to be three or four, but it would seem that the grub of the bee, and many other footless grubs, undergo no moulting, although both Reaumur and Swammerdam assert that the contrary is the case. I have already, in my observations upon the general principles of the metamorphoses, noticed the peculiarities which occur in the caterpillar immediately previous to and during its moulting. I may therefore add, in order to complete the subject, that upon quitting its former skin, the caterpillar appears very languid, and its body is soft and easily injured; it speedily, however, resumes its strength, and has increased so much in size, that it appears extraordinary how it could have been packed in its former covering; its wonted voracity returns, and it now feeds with redoubled energy, as if to make up for the time which it had lost.

In this manner, and for a certain period of time, the growth of the insect is continued. The period which is required for the arrival of the larva at its full size is very variable. Perhaps the most general rule is, that insects are annual in their generations; either being hatched in the spring from eggs deposited in the preceding autumn, and becoming chrysalides in the course of the summer, and arriving at the perfect state in the autumn; or else passing the winter in the chrysalis state, and bursting forth as perfect insects in the spring, and then depositing eggs, the progeny of which will not require to undergo their change to pupæ until the autumn. The duration of the larva state of these latter will therefore necessarily be longer than in the former; but there are exceptions to these rules: thus, in many species there are many generations in a year, as in the *Aphides* and the flesh-flies; whilst, on the other hand, some larvæ, as those of the goat-moth and cockchafer, require three years before they attain their full growth, and the larva state of the stag-beetle is stated by Rosel to extend to six years.

Having at length attained its full size, the larva is now to undergo a change more important than any to which it has hitherto been subject.

III.—*The Pupa.* The change to which I alluded at the close of my last section consists in another shedding of the outer skin, when the insect appears in a totally different form, during the period of which it is destined to remain in inactivity and liable to destruction, were it not for the admirable instinct which is exhibited by the larva before its change, in the construction of a case or cocoon, wherein it is safely lodged until its final assumption of the perfect state. A preceding page (p. 8) described the cocoon of the Emperor moth, which will serve as an instance of the ingenuity exhibited by the caterpillar for effecting this object. There are also many larvæ which, although the pupæ are inactive, do not construct cocoons, but merely secrete themselves in some obscure situation, or bury themselves under ground, where they hollow out a narrow cave for their repose. Others, again, as the peacock butterfly, and many others, suspend themselves in the open air. Another class, occurring in the order *Diptera*, retain their larva skin, within which they become pupæ. This period of inactivity is not, however, universal, since there are many insects which retain their activity, and therefore need no cocoon for their defence. This is the case with the grasshopper, cockroach, *Cimex*, *Cicada*, and others.

The state to which the insect is now arrived is technically termed the pupa; and it is this term which we must be still compelled to make use of in speaking of the present state of insects, since there is no English word applicable to pupæ in general. The terms *Chrysalis* and *Aurelia* have indeed been applied to the pupæ of *Lepidoptera*, and that of nymph partially to other pupæ.

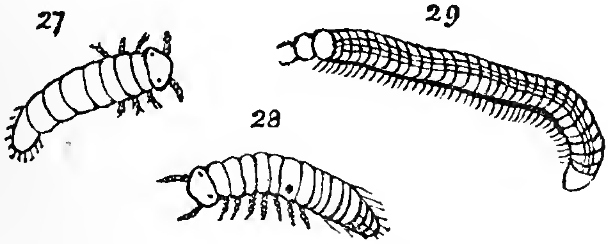
The variations which exist in the pupæ of the different groups of insects are much more striking than those observable in the larvæ; hence it is not surprising that Fabricius and his followers employed the name which characterizes the pupa to designate the general nature of the metamorphosis, a decidedly incorrect mode of proceeding; since by this means the metamorphosis of an insect is said to be perfect when the pupa state is perfect (that is, active, and resembling the perfect insect, except in wanting wings); whereas it must be evident that this kind of metamorphosis must, as compared with other species, be the least perfect and complete; and, on the other hand, the imperfect metamorphosis, or that having the most imperfect pupa, must for the same reason be the most complete and perfect change which any of these insects undergo.

Linnæus first applied these and similar terms, and most appropriately, to designate the variations, not of the nature of the metamorphosis, but of the pupa. They were as follow:—

1. *Pupa completa,* active, with all the parts of the perfect insect. Example, *Aranea, Acarus, Oniscus.*
2. *Pupa semicompleta,* active, resembling the parent, but having only rudiments of wings. Example, *Gryllus, Cicada, Cimex, Libellula, Ephemera.*
3. *Pupa incompleta,* inactive, but with rudimental wings and legs. Example, *Apis, Formica, Tipula.*
4. *Pupa obtecta,* with the thorax and abdomen distinct, inclosed in a scaly covering, i. e., *corticata,* and either naked or inclosed in a cocoon. Example, *Lepidoptera.*
5. *Pupa coarctata,* inclosed within a globular or oval case, formed of the skin of the larva. Example, *Musca, Œstrus.*

Now the true winged insects necessarily suffer only the four latter species of metamorphosis; although in those species of the semicomplete kind, which have no wings in the perfect state, it may with equal propriety be said that they belong to the first section, in which the pupa is complete:

these, however, must be regarded only as exceptions, belonging in reality to the second, and not to the first section. Latreille, to whom Entomology is so much indebted, distinguishes three species of metamorphosis, to which, with a view to obviate the difficulties arising from the Fabrician mode of nomenclature, he has applied a different series of names, calling the first *Metamorphosis inchoata, dimidiata,* and *perfecta.* The first of these terms is applied to wingless insects, such as the *Scolopendræ, Iuli,* &c., and in which the variations of the larva and pupa states are so indistinct



that the terms cannot with propriety be employed, the metamorphosis consisting occasionally of an increase in the number of limbs and rings (figs. 27, 28, magnified; and 29, natural size, representing the growth of an *Iulus*). In the species undergoing the metamorphosis dimidiata, the dif-

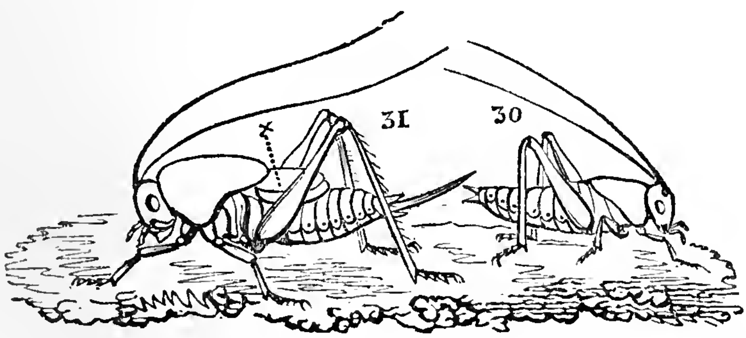
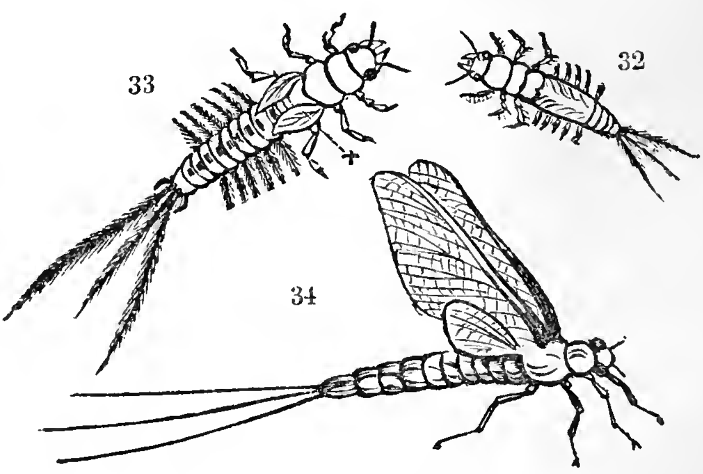


Fig. 30, Larva—31, Pupa of the Great green English Grasshopper.

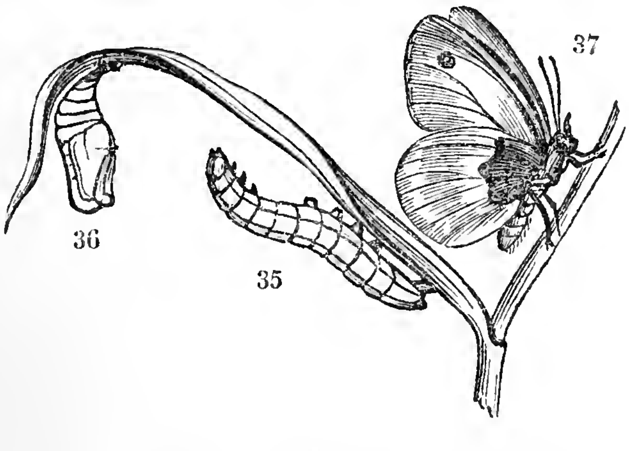
ferences are more observable; the larva (*demi-larve* Latreille) is apterous, but the pupa (*demi-nymphe* Latreille) is furnished with the rudiments of wings. This division, therefore, corresponds with the section *Pupa semi-completa* of Linnæus, or the *Metamorphosis semi-completa* of Fabricius.

The *Hemiptera, Orthoptera,* and many *Neuroptera,* undergo this kind of transformation; but amongst the latter there are some—and they are chiefly aquatic, such as the dragon-flies and may-flies—which are furnished with anal or lateral plates or gills for breathing in the water: these, therefore, require to be formed into a distinct division, the preparatory states bearing in fact less resemblance to the imago than those species which are terrestrial in their larva and pupa states, breathing by spiracles, and greatly resembling the imago. As it is evident, however, that the latter undergo a less decided metamorphosis than the former, we must place the species which have the more decided semi-complete pupa at the head; indeed, Mr. MacLeay has separated the others, and applied to their changes the term *metamorphosis sub-semi-completa.*



Figs. 32, Larva—33, Pupa—34, Imago of Ephemera vulgata.

The third or total metamorphosis (*Met. perfecta* of Latreille) consequently consists of the Linnæan groups having incomplete, obtected, and coarctate pupæ. These are to be regarded as separate divisions. Amongst these pupæ some resemble the perfect insect, but contracted, and as it were destitute of life: they have limbs, it is true, which are separate from each other, but these limbs, as well as the entire body, are covered with a membranous skin. This covering exists in the other pupæ, but is of a firmer consistence, imitating a kind of bark, and to which the term *corticata* may be applied, and more completely inclosing the limbs in one general covering. To this kind of metamorphosis, which Latreille considers as comprising the obtected and coarctate pupæ, he has applied the term *pupa obvoluta*, observing that the expression *obtecta* applies to both, and that that of *coarctata* is too vague; but surely the structure of the dipterous coarctate pupa (i. e., an incomplete pupa inclosed in the skin of the larva) is much more analogous to the structure of the true incomplete pupa of the bee and beetle*, than it is to the obtected pupa of lepidopterous insects; indeed, it appears quite evident, that if the coarctate



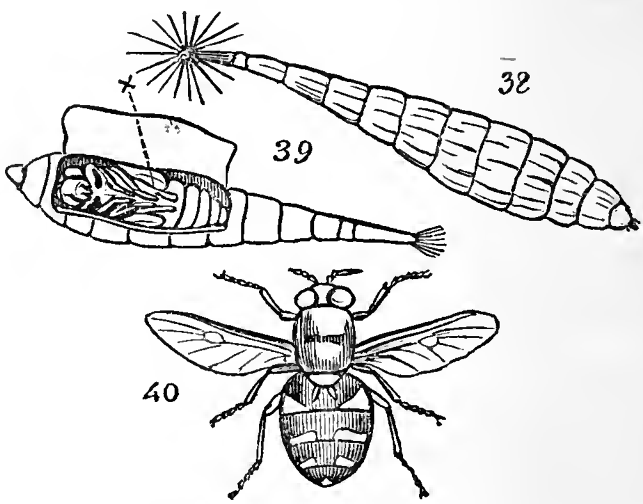
Figs. 35, Larva—36, Pupa obtecta—37, Imago of a butterfly (*Hipparchia pamphilus*).

section must be sunk at all, it must be in favour of the incomplete, and not the obtected section.

* In some species of beetles, the *incomplete* pupa is inclosed in the skin of the larva (*Anthrenus*, *Chilocorus*), thus being, in fact, real *coarctate* pupæ.

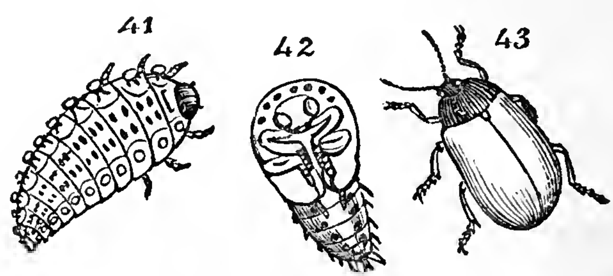
The existence and the number of legs of the larva, the permanent or variable form of the head, the comparative structure of the organs of the mouth with those of the imago, the number of the spiracles and disposition of the tracheæ, the moultings of the skin, and the quiescent or active state of the pupa, are all important considerations, upon which the distribution of insects from the characters of their metamorphosis may be effected.

Hence the *Lepidoptera* (figs. 35, 36, and 37), are distinguished by the number of legs, scaly head, &c. of the



Figs. 38, Larva—39, Pupa coarctata—40, Imago of Stratiomys chamæleon.

caterpillar (*Eruca* Latreille), and the obtected, or, as Latreille prefers calling it, the mummy-formed pupa (*Chry*-



Figs. 41, Larva; 42, Pupa incompleta; 43, Imago of Chrysomela populi.

salis Latreille). The *Diptera* (figs. 38, 39, and 40) are distinguished by their worm-like larvæ (*Vermilarva* Latreille), and their more or less oviform pupa (*Pupa* Latreille); the *Coleoptera* (figs. 41, 42, and 43), *Hymenoptera,* and some *Diptera,* by the sealy head of the larva (*Larva* Latreille), and the disengaged limbs of the pupa (*Nympha* Latreille;) and the *Orthoptera* (figs. 30, 31), *Hemiptera,* &e., by the active imago-like larva (*Demi-larva* Latreille), and active pupa (*Demi-nympha*). Thus, by an ingenious arrangement, we have the following distribution of metamorphoses:—

1. *Metamorphosis inchoata,* equivalent to the Linnæan seetion, having complete pupa.
2. *M. dimidiata,* semi-complete pupa.
   A. Respiration in larva tracheal. *Gryllus,* &e. (*M. semi-completa* Fabricius.)
   B. Respiration in larva branchial. *Ephemera.* (*M. sub-semi-completa* MacLeay.)
3. *M. perfecta.* Preparatory states, *Semi-larva* and *Semi-nympha* Latreille.
   A. Pupa with detached limbs (*Pupa incompleta* Linn.) Preparatory states, *Larva* and *Nympha* Latreille. (*Coleoptera, Hymenoptera,* &c.)
   B. Pupa mummy-shaped (*P. obtecta* Linn.) Preparatory states, *Eruca* and *Chrysalis* Latreille. (*Lepidoptera.*)
   C. Pupa concealed by an egg-shaped eovering, formed of the skin of the larva (*P. coarctata* Linn.) Preparatory states, *Vermi-larva* and *Pupa* Latreille. (*Diptera.*)

Mr. Newman, in the Memoir already alluded to, has given another and equally ingenious arrangement of insects from their preparatory states. The names of his groups are, however, like those of Linnæus, founded merely upon the nature of the pupa state, and therefore cannot be applied as characteristic of the general metamorphosis. His arrangement is as follows:—

Amorpha, in which the penultimate state is provided neither with mouth nor organs of locomotion, consequently it neither eats nor moves, neither does it bear any resemblance to the perfect state.

1. *Lepidoptera.* 2. *Diptera.*

Necromorpha, in which the penultimate state is provided with mouth and organs of locomotion detached from the body, but so inclosed in a case that it can employ neither. The resemblance, therefore, to the perfect insect is very considerable, excepting in total want of motion.

3. *Hymenoptera.* 4. *Coleoptera.*

Isomorpha, in which all the stages are active and voracious, and of a similar form.

5. *Orthoptera.* 6. *Hemiptera.*

Anisomorpha, in which appear the amorphous, necromorphous, and isomorphous characters, together with a typical and distinct character.

7. *Neuroptera.*

The *Amorpha,* although thus divided into the two orders *Lepidoptera* and *Diptera,* are said to be divisible from the metamorphosis into two distinct sections, separated by the fact of their possessing or not possessing, in the penultimate or quiescent state, the last skin of the antepenultimate or previous state. Those which retain such last cuticle are termed *Amorpha dermata,* and those which do not retain such skin are termed *Amorpha adermata,* an evident misnomer, since, if they do not retain this last-mentioned skin, they still are clothed in their own. But in the following page we are informed that the *Amorpha adermata* actually "retain two distinct coverings, thus resembling the *Amorpha dermata.*" When, however, we look more strictly at the character of the metamorphosis of these groups, and observe the ill effect which its employment produces in referenee to the *natural* distribution of insects, we shall at once see that this distribution, ingenious as it is (especially with reference to the septenary elassification of insects, maintained by its author), and indeed any distribution of insects from the charaeter of metamorphosis alone, evinees the absolute necessity of reeurring to other characters. Thus, whilst one division of the *Amorpha* eomprises the *Diptera* with true coarctate pupæ, the other comprises not only all lepidopterous insects, but also many *Diptera,* which must surely be more nearly allied by *nature* to the other *Diptera* than they are to the *Lepidoptera.* Moreover, even amongst the adermatous *Diptera,* many speeies exhibit a neeromorphous rather than an amorphous appearance: when, however, we regard the real eharacter of the coarctate pupa (which corresponds with the *Amorpha dermata*), we are at once eonfirmed that the real charaeter of the dipterous pupa is necromorphous and not amorphous. The pupa of the bees is truly necromorphous: its larva forms, or else is by its parents or their assistants (neuters) inclosed in, a eell, where it is safely guarded, so that it has only to cast off its skin, and appear in its naked, defeneeless, but yet defended pupa state. But the flesh-fly is differently situated: its funetions in nature are such, that the least waste of time would be to their prejudiee. In its first production this is amply provided against, in an anomalous but most effectual manner, by the eggs being hatched within the body of the parent. During its growth as a larva it undergoes no moultings of the skin, which are attended in other insects with a eertain loss of time, and on arriving at its full growth the same charaeter is still retained. The skin is not cast, but, with the most admirable foresight on the part of the Great Contriver of both great and small, beeomes an envelope answering all the purposes of a silken cocoon or a waxen cell, and serves for the protection of the defenceless inhabitant inclosed within, and which, when carefully examined, proves to be a truly necromorphous pupa.

But there are other insects belonging to the necromorphous section, which indisputably prove the real identity of these apparent differences, and show the necessity of looking at the subject in the most general manner. Thus some coleopterous pupæ (example, the *Staphylinidæ*), and some hymenopterous pupæ (example, the *Chalcididæ*), are as truly mummy-formed as the lepidopterous pupæ, whilst other coleopterous pupæ (example, *Anthrenus*, *Attagenus*) do not quit the larva skin, and are therefore amorphous. Again, some necromorphous pupæ (example, the *Trichoptera*), although inactive during a great part of their remaining in that state, become as active, previous to assuming the perfect state, as any of the Isomorpha; and lastly, if we carefully examine the obtected pupa of a butterfly, we shall at once perceive that the only character which separates it from the necromorphous, or incomplete pupa of a beetle, is, that its limbs are laid more compactly upon its breast, each, however, being inclosed in its distinct sheath.

The preceding considerations appear sufficiently to prove that the pupa state of insects is a distinct state, and that instead of being regarded merely as the matured state of the larva, it would be more correct to regard it as the immature state of the imago. This will be still more evident from a more precise investigation of the form and structure of pupæ.

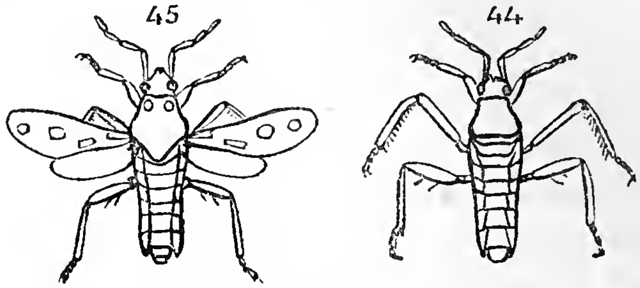
1. Of those species which undergo the metamorphosis inchoata of Latreille, the pupæ differ only from the preceding state by an increased size, and occasionally an increase in the number of segments. Crabs, spiders, Iuli (figs. 27, 28, and 29), centipedes, lice, spring-tailed insects (*Thysanuræ*), are subject to this kind of metamorphosis, which is so slight that it is impossible to decide whether one

of these animals has arrived at its perfect state or not; and hence, as Fabricius observed in his Philosophia Entomologica, it is probable that many supposed species of spiders, &c., have been formed out of the immature states of these animals.

There are, however, some insects belonging in reality to the winged tribes, which form an exception by being destitute of wings in the perfect state: such are the bed bugs, many individuals of *Velia*, *Hydrometra*, and *Gerris*, likewise numerous *Phasmidæ*, and other apterous *Orthoptera* and *Hemiptera*.

2. Of those species which undergo the metamorphosis dimidiata of Latreille, the pupa has been most appropriately termed semi-complete by Linnæus; we therefore cannot approve of the alteration of this term to sub-incomplete, proposed by Burmeister; the pupa being intermediate between the larva, in which the body is completely apterous, and the imago, in which it is furnished with fully-developed wings; and being active like the larva, but provided with these organs, but so wrapt up as to be easily inclosed within four short cases, which arise in pairs from the back of the second and third segments of the body. Here belong the tribes of locusts, grasshoppers, mantes, cockroaches, earwigs, bugs, and treehoppers, in all which the resemblance of the pupa to the imago is very distinct. Here, also, are generally arranged the dragon-flies and the may-flies (*Ephemeræ*), but in these groups the likeness of the pupa to the imago is less distinct, the organs of respiration being quite different, as above noticed, and the structure of the mouth being totally dissimilar. These groups, accordingly, are said by Mr. MacLeay to undergo a sub-semi-complete metamorphosis. There is another peculiarity connected with this species of metamorphosis, which sufficiently proves that here we are intermediate between the merely rudimental and the perfect metamorphosis, and that the perfection of

the animal is not so dependent upon metamorphosis as in the subsequent perfectly metamorphotic division. Thus there are many species belonging to this section, which remain throughout their life in a state of imperfection; of which a common instance occurs in the *Hydrometridæ,* or water-measurers. These insects, which are to be observed



Figs. 44, Apterous imago—45, Winged imago of Velia rivulorum.

skimming along on the surface of the water, are generally found destitute of the slightest rudiments of wings: they, however, continue their kind, but occasionally certain individuals will be found in company with them with the wings fully developed. Now it is impossible to regard the former as pupæ, because they have no rudiments of wings; neither can we consider them as larvæ, because they are as large as the winged individuals, and are able to propagate. Accordingly they have been generally regarded as distinct apterous species; but a more extended investigation of these groups of insects will prove the specific identity of these imperfectly developed, but still perfect* (as regards their powers of propagation), individuals with the winged specimens. Thus, there are many species, which, instead of being generally wingless, are furnished with short rudimental wings, and which are nevertheless capable of reproduction; hence, as well as from the structure of the rudimental wings, it is evident that they cannot be pupæ, and yet it occasionally

* "The true criterion of animal as well as vegetable perfection is the ability to continue the species."—MacLeay, *Horæ Entomologicæ,* p. 446.

happens that in a few individuals the wings are fully developed: here the specific identity is not questioned; why then should it be in the former, the principle in either case being identical?

3. In those species which undergo the perfect metamorphosis of Latreille, the pupa is incapable of eating and walking, and may be considered as a most characteristic state of the insect's existence. Here belong the tribes of *Coleoptera, Hymenoptera, Trichoptera,* and many *Neuroptera* and *Diptera,* having an incomplete pupa; the *Lepidoptera* having an obtected pupa, and the remainder of the *Diptera* and *Strepsiptera* having a coarctate pupa. I have already noticed the distinction of these kinds of pupæ; but as they all (including the coarctate pupæ, when examined without reference to the external covering formed of the indurated skin of the larva) resolve themselves into one general mode of construction, that of being inactive, and having the limbs folded more or less closely upon the breast, it will be convenient to examine them in one general view. Here, then, we find the form of the future insect much more visibly impressed upon the insect than during its previous state; the head, thorax, abdominal segments, and the various limbs, are more or less discernible. The external covering in this state is variable in its consistence, according to the situation in which the pupa state is undergone: thus in those species especially belonging to the coleopterous, hymenopterous, and dipterous orders, which are safely protected from external injuries, the pupæ are soft, and the envelope membranous; but in the *Lepidoptera,* and more especially those which are naked, the pupa (chrysalis) is of a hard texture.

The pupa state of lepidopterous insects is ordinarily termed a chrysalis or aurelia, and differs from those of every other order of insects — a circumstance of some interest as well as peculiarity, since in other instances we find the pupæ of several orders exhibiting the same general form. In the *Lepidoptera,* however, the various organs of motion of the future insect are laid along the breast and sides, but are folded up under a hard skin, whence they are much less distinctly perceptible than in the pupæ of other insects. Linnæus has termed this an obtected pupa. In general, lepidopterous chrysalides are of an oblong-oval form, obtuse at the head, and gradually becoming narrow towards the tail; but in some moths, as in the *Bombyx luna,* the form is shorter, and obtuse at each end. Under this form the insect appears neither to have legs nor wings; it seems even destitute of life, taking no nourishment, and appearing like an unorganized mass, the only sign of life being a slight occasional twitching of the hind part of the body. The outer covering appears of a cartilaginous nature: it is commonly smooth, but in some few instances it is hairy. From the blunt extremity of the body are to be observed various small and narrow compartments, arranged like the bands of a mummy. These are the coverings of the legs and antennæ, disposed along the breast; the part from whence they seem to arise is the head, which is covered by a piece termed the *Cephalotheca.* On the outside of these narrow bands are to be observed two broader scales, which, covering the wings, are termed *Pterotheca,* arising from the opposite side to the breast, and which is the covering of the thorax, or *Cytotheca.* This is followed by the abdomen-case, *Gastrotheca.*

The chrysalis, upon quitting the exuvia of the caterpillar, is soft and tender; by degrees, however, its external envelope becomes hard and friable. Moreover, the surface of the body is at first moistened with a viscid fluid, which exudes from beneath the wings and the other parts which are inclosed between these organs, and which becomes thickened, and hardens rapidly, and in so doing glues together the contiguous parts, which are consequently now inclosed in an additional envelope, this taking place within twenty-four hours after the change: at the same time, also, this fluid not only loses its transparency, but also acquires a colour. Previous to the hardening of this fluid, it is easy to observe as well as to separate the various external organs of which the future butterfly is composed, as the antennæ, legs, wings, &c. There is this difference, however, between the chrysalis and the imago, at least of the butterflies: in the former state, one pair of wings (the upper) are alone to be observed, the second, or inferior pair, being hidden beneath them, the intermediate space in the pupa being filled with this gummy matter, by which they are at length glued together; whereas in the butterfly (but not in the moths, except during flight) the lower pair of wings are exposed, even when the butterfly is at rest upon the bosom of a flower.

Reaumur has divided chrysalides in general into two great divisions—namely, those which, from having various angular projections upon the body, he has termed angular chrysalides, and those in which the body is smooth, and unfurnished with these projections, and which may be termed conical chrysalides, but which Reaumur calls "feves;" and it is a curious circumstance, that all angulated chrysalides produce butterflies, whilst from the conical chrysalides, with a few exceptions, the various tribes of moths and hawk-moths are produced; these exceptions being confined to the small butterflies belonging to the family *Lycænidæ*. Moreover, the chrysalis of the orange-tip butterfly (*Mancipium cardamines*) seems intermediate between the two groups, having the body boat-shaped, with a spindle-formed process arising from the head, as well as the tail. There is a great difference in the situation of the prominences and angulated projections upon the body of the chrysalides belonging to the first of these divisions; and in some of the old works of natural history, we find the representations of them fancifully converted into the singular profile of the human face, the dorsal prominence forming the nose! Amongst the conical chrysalides, there are also various differences to be observed: I shall, however, only notice those offered by the sphinx family, in which the tongue, which in the perfect state is exceedingly long, is inclosed in a thickened cylindric proboscis, which stands off from the breast, and within which the tongue is curled up; whilst, in the genus *Calophasia* (Stephens), a provision of a different kind is made for the unusual length of the organ, by the tongue-case being recurved upon the breast, in which respect it approaches the shark-moths, (*Cuculliæ*).

The fanciful notions entertained by the old naturalists, that insects in their progress to the perfect state underwent a series of real metamorphoses, has in later times been succeeded by an equally incorrect idea (the imago being, in fact, the adult state of the creature), that the bursting forth of the butterfly may serve as an illustration fitting to convey a token of one of the profoundest mysteries of our Holy Religion.

> "Oh, start not! on thy closing eyes
> Another day shall still unfold;
> A sun of milder radiance rise;
> A happier age of joys unfold.
> Shall the poor worm that shocks thy sight,
> The humblest form in nature's train,
> Thus rise in new-born lustre bright,
> And yet the emblem teach in vain?"

The idea is highly poetical, but the simile is not correct when the changes undergone by "the poor worm" have had all of the marvellous stripped from them by the assistance of direct observation; and yet these changes are not, on that account, the less wonderful. To them, indeed, may well be applied the celebrated words of the poet—"Truth is stranger than fiction."

The body of the caterpillar consists of twelve segments, exclusive of the head and anus, and on each side of the 1st, 4th, 5th, 6th, 7th, 8th, 9th, 10th, and 11th of these segments, a small oval spiracle or breathing pore is to be observed, making together eighteen. In the pupa, notwithstanding the great alteration which has taken place in the size and disposition of the segments, we notice, besides the head, first, a small, nearly square, piece, being the remains of the first segment, having, on each side, a small breathing pore; next, a large dorsal piece, giving rise to the large anterior wings, which is the second segment; then a short dorsal piece, giving rise to the second wings, being the third segment; after which, follows another short segment, of which the spiracles are not observable, which is succeeded by seven spiraculiferous rings; then comes another ring, without spiracles, and the body is terminated by a plate covering the anal organs. This description was taken from a living male chrysalis of the splendid large Emperor moth (*Pavonia major*), an inhabitant of France.

The chrysalides of various moths exhibit a singular circumstance, not hitherto satisfactorily accounted for, but which presents an interesting instance of that parental care "which nature so conspicuously manifests towards the most insignificant (if any can be called such) of her productions." The small Eggar moth, *Eriogaster lanestris*, is one of the most remarkable of these species,— doomed to a regular appearance, in the winged state, at the termination of the cold and ungenial month of February, nature (that it may not fail and become extinct) reserves a small portion of it annually, in the pupa state, until the February following that of its pupation, and sometimes even until the third occurrence of that frigid month, denying their emancipation all the intermediate time, and thus effectually securing, by these unusual means, the safety and perpetuation of an animal, small it is true, but whose annual existence, at that inclement season, in the winged state, is probably of more consequence in the intricacy of its great Creator's plans than we are at present aware of, although He constantly exposes it to the dangerous vicissitudes of winter; for

> Each shell, each crawling insect, holds a rank,
> Important in the plan of Him who framed
> This scale of beings, holds a rank, which, lost,
> Would break the chain, and leave behind a gap,
> Which Nature's self would rue."—*Lepidoptera Britannica.*

A clear idea of the arrangement of the limbs in the three principal divisions of incomplete, obtected, and coarctate pupa, will be obtained from the following figures, in which

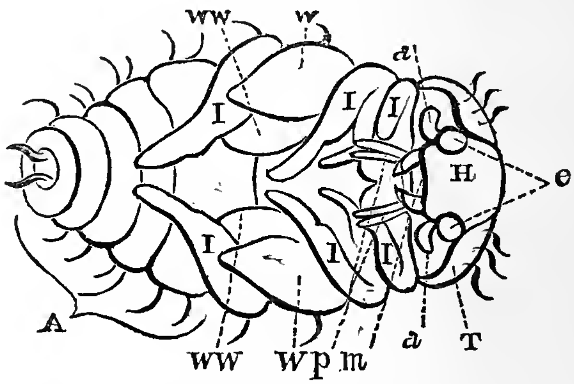


Fig. 46. Pupa of the great water-beetle (*Hydrous piceus*).

the same letters refer to the same organs throughout: fig. 46

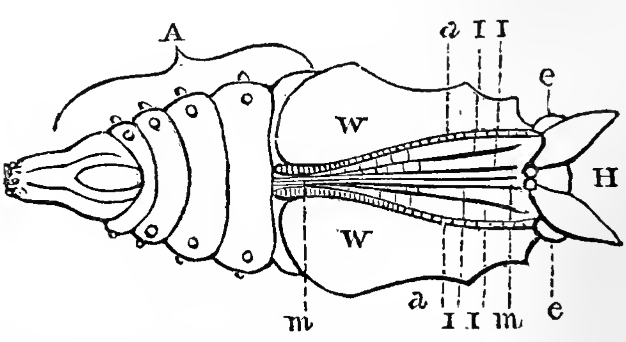


Fig. 47. Pupa of the tortoise-shell butterfly (*Vanessa urticæ*).

representing a coleopterous, fig. 47 a lepidopterous, and fig. 48 a dipterous pupa; the latter stripped from the cocoon-like skin of the larva. The letter H refers to the

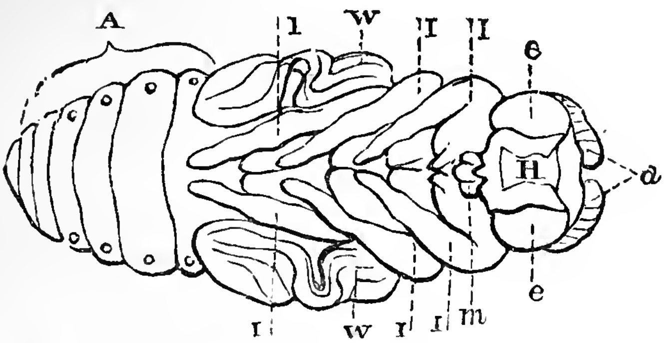


Fig. 48. Disengaged pupa of Stratiomys chamæleon.

head, T the thorax, A the abdomen, a a the antennæ, e e the eyes, m the mouth, p the palpi, w the fore wings, w w the posterior wings, I I I I the legs.

It must, however, be borne in mind, that in these pupæ the limbs have not yet acquired their full size, and the abdomen is not yet reduced to the size which it will possess in the imago state.

Pupæ are ordinarily of an elongated oval form, the thickest part being towards the head; the body is generally smooth, but in some instances various spines or hairs are to be observed upon various parts of the body; and others, especially the chrysalides of butterflies, are angulated. In some aquatic pupæ, as in the midges, forming the genus *Chironomus*, the back of the front part of the thorax is furnished with exserted breathing organs. The structure of the terminal segment of the body is also variable; one of the most remarkable variations occurs in some of the butterflies, in which this part is furnished with hooks, for effecting the suspension of suspended chrysalides; and it may here be noticed, that in those species of *Hymenoptera*, which have the ovipositor long and exserted, it is generally curved upon the back of the abdomen, although in some it is stretched out at length.

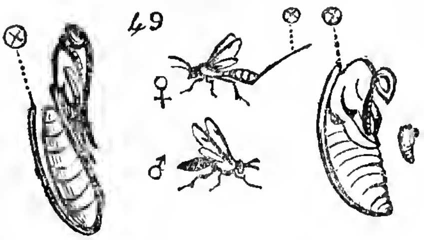
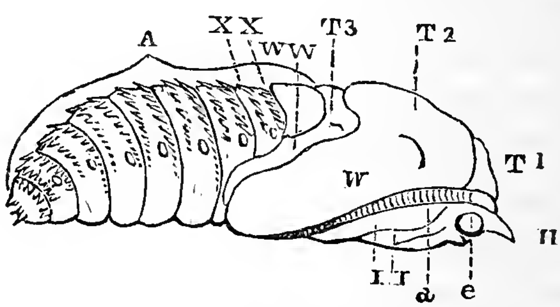


Fig. 49, Pupa of an Ichneumon and Callimome.

In many of the wood-boring species of *Lepidoptera* (as, for instance, the Goat-moth) the abdominal segments of the pupa are furnished with transverse ridges of minute hooks, which are serviceable to the insect, when about to assume the imago state, in working its way to the orifice of its burrow, the hooks, by the alternate contraction of the abdominal rings, being employed as anchors in preventing the insect from falling backwards.



Lateral view of the pupa of the goat-moth, lettered as Nos. 46, 47, and 48; and T 1, T 2, and T 3, being the three thoracic segments; X X, two of the rows of hooks.

There is a curious circumstance connected with the developement of the insect structure, especially interesting as regards the pupa state of insects, which has hitherto received but very little attention. In the larva state the body is composed of the ordinary and typical number of segments, but in the perfect state some of the segments are not to be found. The change, therefore, must take place at the period of the insect's assuming the pupa state. Dr. Ratzeburg, indeed, accounted for the loss of one of these segments, by asserting that the head of the pupa of the bee corresponds with the head and first segment of the body of the larva; but this, as I have already said, is certainly inaccurate, as I have proved by direct observation, and as is further evidenced by the leg-bearing structure of the first segment in many larvæ. The loss must therefore occur in the abdominal segments; but upon this branch of the subject we require more direct investigations than have yet been devoted to its elucidation. As regards the segmental developement of the earwig, in which the male has nine and the female apparently only seven abdominal segments, I have published a memoir in the Transactions of the Entomological Society, proving that the loss in the latter six occurs in the penultimate and antepenultimate segments of the abdomen.

Pupæ, in general, are of a dirty white colour when their situation is under ground, or in cases artificially constructed by the larvæ. Those, more especially, which lie naked under ground, are of a dark bright brown, whilst those which are naked, and exposed to the action of the light, are more variable in their tints, some being gilded, as in the aureliæ, or chrysalides of butterflies.

The period passed by insects in the pupa state is very variable, the variations extending from a few days to as many years. Ordinarily, its extent is determined by the circumstances to which I have alluded in my observations upon the duration of the larva state — that it is chiefly dependent upon the temperature of the atmosphere. Providence has wisely ordained that the developement of the perfect insect shall not take place until the season when proper food for its own sustenance is at hand, or a proper situation for the deposition of its eggs is to be discovered. Hence some insects are produced earlier, and others later, in the season; and in double-brooded species, or those of which there are two generations in a year, the early brood passes but a very short time in the pupa state, whilst the later brood remains throughout the winter as pupæ. Hence

Reaumur was enable by experiments with chrysalides to abridge or extend their lethargic state by artificial heat or cold; the chrysalides of various lepidopterous insects, which would not ordinarily be produced until spring, being placed in a hot-house, and the butterflies being developed in the middle of the winter,—the contrary effects being produced when they were placed in an ice-house. Hence it is evident that by the action of an increased temperature a certain evaporation of the fluid matter, with which the newly-formed chrysalis is filled, takes place; but I can by no means agree with Kirby and Spence, that "this necessary transpiration, other circumstances being alike, must take place sooner in a small than in a large pupa;" and, consequently, "that small pupæ continue in that state a shorter time than those of larger size:" indeed, I am disposed to question the correctness of the latter assertion, and to say, on the other hand, that the duration of the pupa state is totally independent of size. I might adduce hundreds of examples in support of this assertion, but it will be sufficient to observe that the largest lepidopterous insect, the great Death's-head moth, requires, according to Haworth, but one month at the end of autumn, when the weather has been comparatively cold, to undergo its pupa state. If evaporation were the sole operation to which the pupa was subject, there would be sufficient grounds for the theory of evaporation entertained by Swammerdam, Reaumur, Kirby, and Spence; but such is not the case, for Reaumur having inclosed a pupa in a stopped glass tube, collected only several drops of water, which were condensed against the sides of the tube, the pupa having lost only one eighteenth part of its original weight. Hence the developement of the organs of the inclosed animal, by absorption and assimilation, constitutes the great operation which the pupa has to undergo, and this must, of course, be of equal duration, whether the insect be a large or a small one, although it may be accelerated or prolonged according to the degree of temperature of the atmosphere.

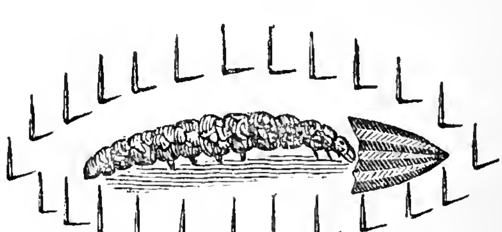
The envelope of silken or other materials formed by the larvæ of many insects, immediately previous to their assuming the pupa or chrysalis state, is termed a cocoon; and perhaps in no department of our knowledge of the lower tribes of animals is there so much skill, or so much of that faculty which we term instinct, displayed, as in the proceedings which characterize the formation of these envelopes. All larvæ, however, do not make these coverings, the cause of which is at once obvious; the pupa of the grasshopper or cockroach, dragon-fly or cimex, is an active animal, continuing to enjoy all the habits of the larvæ, and consequently not needing any other defence than it possessed in its former state; but in other insects the case is entirely different; the pupa state being one of inactivity and total helplessness, and in which the insect is consequently subject to the attacks of any stray bird or mouse, or not less voracious insect, which would feast with as much avidity upon the soft and creamy substance of the newly-formed chrysalis, as the Romans did upon the cossus, (which was a large insect in the earlier stage, and which is considered to have been the larva of the goat-moth, *Cossus ligniperda*). Hence the necessity, not only for retreat to some quiet and unobserved corner or hole, but also for a covering for more complete concealment and defence. At this time many larvæ accordingly make their way several inches deep into the earth. Here, or concealed under leaves, moss, or other like matter, many insects become pupæ, with the mere precaution of fastening the substances which conceal them together with a glutinous secretion from the mouth; but others are far more careful, forming for themselves an entire covering, composed either of silk spun from their own mouths, or of silk united with the adjacent materials. Some few larvæ, however, as those of the ant-lion (*Myrmeleon*), and the lace-winged aphidivorous flies (*Hemerobius*), have the spinning apparatus placed at the extremity of the body.

Some cocoons are formed simply of a few threads, spun into an open-work case, which permits the inclosed insect to be plainly perceived through the meshes; this is the case with the gipsy and satin moths (*Hypogymna dispar* and *Leucoma salicis*), &c. Such is also the case with the cocoons of some of the weevils and chrysomelideous beetles. The cream-spotted tiger-moth (*Arctia villica*) is more careful, forming a much closer cocoon, but which, nevertheless, permits the inclosed chrysalis to be seen through the small meshes. This cocoon is moreover defended, by being formed in the middle of a bunch of leaves; and here it is interesting to notice, that those caterpillars which are furnished with a short supply of silk, are nevertheless very anxious to conceal their slight cocoon in the most effectual manner, by attaching together with silken cords the adjacent leaves; sometimes two or three being drawn together, so as to meet at the edges, and sometimes a single leaf being pulled out of its natural position, so as to form a complete covering to the cocoon. Sometimes, moreover, several caterpillars unite together, so as by their combined strength to secure several leaves more firmly together, within which they then, in company, undergo their transformations. Even many caterpillars, which spin a very compact cocoon, resort to the same kind of manœuvre, rather, I should presume, as a means of support than of defence. Other curious means are adopted by some larvæ, for the purpose of rendering their slightly formed cocoons more opaque; thus by some a kind of paste-like matter is secreted from the anus, which, being applied by the head upon the entire inner surface of the cocoon, hardens and forms a powder, which completely answers the intended purpose: it is probably a similar secretion which gives to the chrysalides of the *Catocalæ* the fine purple bloom with which they are covered in that state. Others, again, as the caterpillars of the garden tiger-moths, rub off the hairs from their bodies, with which they are so plentifully supplied (whence they have obtained the ordinary names of woolly bears), and spin them into the substance of the cocoon in a very ingenious manner, so as not to permit the ends of the hairs to stand upright in the inside of the case, which would, of course, fret the newly-disclosed chrysalis.

The more perfectly constructed cocoons, however, such, for instance, as that of the silkworm, consist apparently of two distinct portions, externally a loose gauze-like covering, and internally a closely woven and compact ball of an oval form. As the insect works from the out to the inside of its case, the former is of course first spun, but the whole is formed of a single thread, disposed in two different ways; and here may be noticed the interesting circumstance, that although the threads of these cocoons are fastened together with gum, they are yet so slightly adherent, that they may be easily unwound: if their union were more perfect it would be impossible to divide the thread, which is as easily unwound as that of a ball of cotton; but it is one of the essential qualities of the gummy matter with which the thread is coated, that it dries very quickly, so that no sooner is it emitted from the spinnerets, than it is almost dry, before it reaches the layer of threads upon which it is about to be placed. According to Malpighi, six distinct layers of silk are distinguishable in the cocoon of the silkworm, but Reaumur suspects there is often a greater number: be this however as it may, a single thread may be unwound from it more than a thousand feet long.

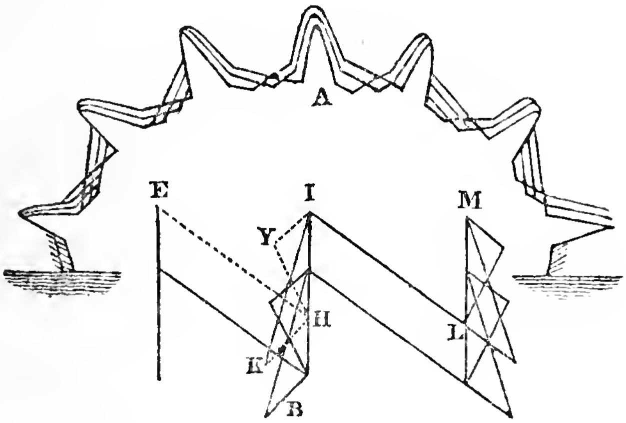
Many interesting instances of the manufacture of various kind of cocoons, not only composed of silk, but also of silk and other materials, as leaves, moss, earth, &c., are detailed by Reaumur and De Geer, and which are introduced into the "Introduction to Entomology," and the "Insect Architecture." I trust, therefore, that my readers will feel more interested in the two following instances, to which, together with the account of the proceedings of the Emperor moth (see p. 9), I shall confine my notice of this branch of the subject, premising only, that much remains to be discovered, and that a wide field of interesting inquiry is open, for the investigation of those who prefer looking at the workings of nature, to the mere getting together of a collection of specimens.

The first of these instances is recorded by Lyonnet in his posthumous researches, lately published, and relates to the *Tinea sequella* of Fabricius, a very small moth, having the upper wings of a white satiny ground, from the base to the middle, with darker markings formed of small scattered black dots. Its caterpillar is extremely small, not exceeding one-sixth of an inch in length, and is found on the underside of oak leaves. Lyonnet, who had observed the proceedings of many caterpillars in forming their cocoons, nevertheless says of this, that it "emploie une adresse *inconcevable*" in forming its case, which is of a white colour, and of a long oval form, having its upper surface ornamented with seven upright ridges. Unlike most cocoons, however, it is applied along the flat under-side to the leaf upon which



it is placed, so that it forms only an arc of a circle. The first step taken by the larva is to erect about a score of small upright silken palisades, arranged in an oval position all round its body; these are in no ways employed in the construction of the cocoon itself, and seem only to be erected to defend the larva whilst working. Near to one end of this inclosure, the larva now commences its cocoon in the manner represented in the above figure.

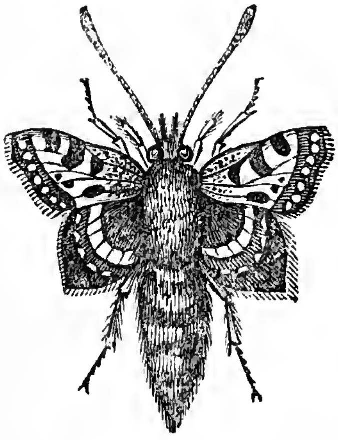
The mode in which the ridges of this cocoon are formed with perfect regularity, is indeed inconceivable. Some idea may, however, be obtained of it from the two following figures.



Here M, I, E, represent three longitudinal ridges, and M I, I E, the intermediate space; the caterpillar, commencing at E, extends a thread to H, from H to I forming an angle, from I it then proceeds to K, and from K to H, forming another acute angle, and then from H to Y, and Y to I, forming another obtuse angle. It then proceeds in the same manner from I to M, as it had from E to I, and in this manner proceeds until it has nearly formed half its case, when turning round it begins at the other end, and at length unites the two halves together, "thus inclosing itself," as Lyonnet says, "en une jolie cage" of net-work, which occupies only half an hour in the construction, but which is subsequently rendered much more firm by a strong layer of silk within.

The other instance which I propose to notice, is that of another small moth (*Microsetia ruficapitella*), the larva of which forms the curious lines of a brown colour, often to be noticed upon rose leaves, by eating away the internal fleshy part of the leaf, leaving the two surfaces entire. When full grown it eats its way out of the leaf, and crawls down the branches and stem, until it has found a convenient place to fix its cocoon, which is formed by stretching out its body, and attaching a thread to the branch; it then crosses its body to the other side, and there fastens it. By proceeding thus on all sides, keeping the hinder part of the body fixed, it forms the upper part of the cocoon, or that exposed to the weather, which is convex, and generally circular; the under part is oblong-shaped, to hold the pupa, and much smaller.

I now proceed to notice the mode in which the insect emerges from its pupa skin. Ordinarily this is effected as heretofore, in consequence of the increased size of some, at least, of the segments of the body, especially those of the thorax; and it is now only necessary for the insect to give to its inclosed body various contortions, when the skin slits generally down the back, and permits the escape of the inclosed insect. In chrysalides, the slit extends gradually down the sides of the wing cases, and on each side of the leg cases, so that the outer skin of the chrysalis may be said to be split into four portions. On its exclusion, the insect is soft, weak, and covered with moisture. The elytra and the wings, at first, are but of a small size; their form however, soon changes, their thickness diminishes, and their ordinary size is acquired, the air tubes distributed throughout the body, and especially in the wing,

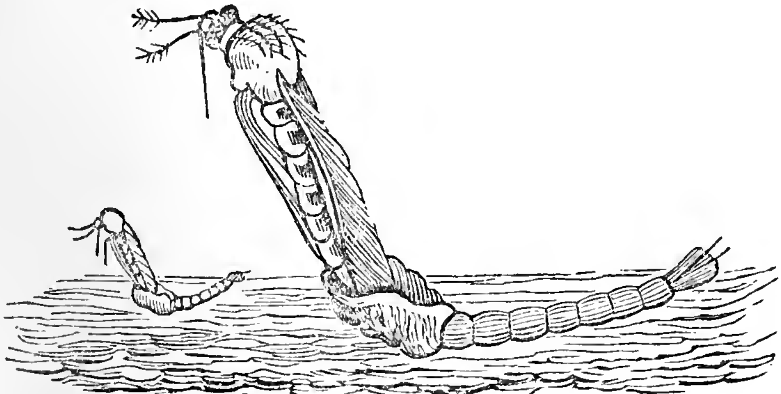


Tortoiseshell butterfly, just emerged from the chrysalis.

performing the important office of inflation, and chiefly assisting in effecting the change, so that in a very short period the insect has arrived at its full size, and acquired the utmost perfection of all its organs.

The wings of lepidopterous insects, as they lie within the pupa skin, exhibit all the future markings of the butterfly and moth, but of course of a reduced size. The wings themselves appear perfectly flat, and it is difficult to conceive how these organs expand to their full dimensions, all these markings retaining their relative sizes. The difficulty is, however, remedied on denuding the wings of their scales, when their surface is discovered to be entirely formed of an innumerable series of minute wrinkles, giving the wings an elasticity, by which we can stretch them to nearly double their size, by moistening them with water. If we imagine the scales to be placed upon the upper edge of each ridge, and that they increase in size as the wings expand, we shall be furnished with a further clue to the solution of this interesting question, as to the mode of expansion of the wings of the *Lepidoptera*.

In the aquatic pupæ, which produce aërial insects, it is necessary for the pupa to quit the water previous to putting on the perfect state; thus the pupa of the dragon-fly creeps up



Gnat emerging from its aquatic pupa.

the stems of some adjacent plant; and that of the gnat half protruding its body above the surface of the water, the skin splits down the back, and the gnat, making use of its pupa case as a boat, gradually draws itself out of its case, upon which it sits until its wings are expanded. In pupæ which are inclosed in cocoons or other cases, different modes of escape are required. How, for instance, can a moth, whose beautiful wings and crested thorax indicate no previous struggle, make its way through the cocoon, often as solid as the hardest wood. This is effected either by the peculiar construction of the cocoon, or by the operation of some fluid emitted by the insect on its arrival at the perfect state. In like manner the pupæ of flies and other coarctate diptera force off a scale, at one end of the dried skin, by inflating the middle of the head into a large membranous vesicle; and the pupæ of the caddice-flies, which are inclosed in the case in which they resided whilst larvæ, make their way through the net-work covering which they had spun to defend its entrance. But the most curious circumstance connected with this subject, is the mode of extrication of the males of the gall insects (*Coccus*), the pupæ of which are strictly coarctate, the imago making its escape backwards from beneath the flattened skin of the larva, its wings being turned backwards over the head.

The developement of insects is very rarely attended with those deviations from the ordinary rule, which are sometimes met with in other tribes of animals. It has, however, been recorded in the Entomological Magazine, No. 12, that a male and female emperor moth (*Saturnia pavonia minor*) were produced from a single larva of an extraordinary size. Kirby and Spence also mention that, according to Kleesius, a German entomologist, two specimens of *Gastropacha quercifolia* (the pine lappet-moth), were produced from one pupa, which was large, being full two inches long, and one thick. These circumstances are sufficiently marvellous, but the most marvellous fact of all is that affirmed by Mr. Dale, in the Magazine of Natural History, Nos. 19 and 54, viz., that he "*once* had a specimen of *Bombyx menthrastri,* and six of *Ophion vinulæ,* hatched from the pupæ of *Bombyx vinulus,* which *is* certainly a curious *fact.*" I should presume from this statement, which is, however, sufficiently destitute of precision, that these various specimens were produced from a single pupa of the puss-moth. On throwing off the pupa covering, the arrival at the perfect state is ordinarily completed; but a remarkable exception to this occurs in the *Ephemeræ,* which, after flying about a short time with the wings fully expanded, throw off another skin. The occurrence of a subsequent moulting in this group does not, however, seem to warrant the conclusion, that the preceding state is not that of the pupa, nor to overthrow the opinion that the pupa state ought not to be regarded as a distinct one. I apprehend, indeed, that as the *Lepidoptera* and the dragon-flies are known to shed a similar pellicle, its existence throughout the winged insects ought, from analogy, to be presumed, until direct observation proves the contrary.

SECTION III.

THE GENERAL STRUCTURE OF INSECTS AS ESPECIALLY EXHIBITED IN THEIR PERFECT STATE.

Our attention must now be directed to the final and perfect state of insects, and in the first place to their structural peculiarities. This branch of the subject will naturally divide itself into two branches: first, the anatomy of the external parts of the body; and secondly, that of the internal organs.

1. *External Anatomy.*

Insects being animals destitute of any interior skeleton, it is necessary that their external covering should be much thickened, and rendered sufficiently strong to give support to the numerous muscles which are internally attached to it. Hence, in the majority of insects, this covering is of a scaly or horny consistence. It is, however, modified by the nature of the habits of the individual. Thus the *Aphides, Hemerobii, Ephemeræ,* and other short-lived insects, have the skin very soft, whilst those which generally take up their abode beneath stones, under the bark of trees, in water, &c., are more strongly defended against accidents, by the solidity of their envelope, than those which live upon flowers. Those also, which reside beneath the bark of trees, or under stones, have a flattened form, whilst those which burrow into wood are cylindrical.

The body of insects consists of a series of rings, connected and articulating with each other by the assistance of muscular membranes, whereby the insect is enabled to contract or lengthen, narrow or dilate, its body, and so give to it all the necessary movements.

I have said that the external integuments of insects exhibited a horny appearance; nevertheless there is no real analogy between the scaly covering of a beetle and horn, their chemical properties being quite distinct, to be convinced of which it is sufficient to apply them separately to the flame of a lamp; and the same distinction is proved by placing them in a solution of potash, of the temperature of boiling water, in which the horn will be dissolved, but the covering of the beetle undergoes no change except that of loss of colour. The base of the latter is found, by chemical analysis, to consist of a peculiar substance, found only in the integuments of annulose animals, which has been termed chitine, and which forms the outer covering. Albumen also, an animal extract, a small portion of carbonate of potash, phosphate of lime and phosphate of iron, and an oil variable in colour according to the colours of the organs from which it is extracted, form parts of the insect integument, but chitine is by far the greatest portion of the materials of which it is composed.

By Linnæus, the body of an insect was divided into four parts: the head, trunk, abdomen, and limbs. The latter, however, more properly belong to the second of these divisions, of which they are appendages; and the term thorax is now generally applied to designate the Linnæan trunk. Hence I have now to treat upon the head, thorax, and abdomen. These three divisions, as respectively comprising the principal organs of sensation, locomotion, and generation, appear to be completely in unison with nature, and have accordingly been universally adopted and employed. That persons ignorant of the comparative anatomy of insects should have blundered in their trivial descriptions of insects, and miscalled any of these parts, can be no argument against their correctness; neither can it be sufficient ground for asserting (as has recently been done) that "their wings are either thoracical or abdominal appendages, as an entomologist pleases," and that, therefore, there are no such parts in an insect as a thorax or an abdomen, which names should consequently be rejected in favour of a series of names for each individual segment.

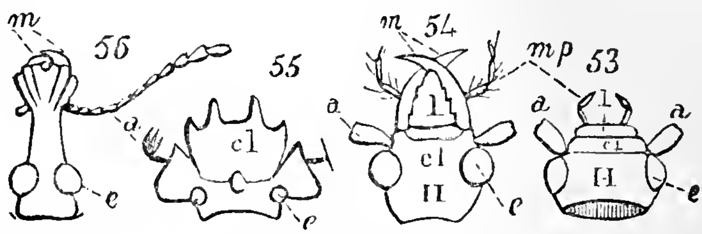
But, in addition to these three primary divisions, the body of insects consists of a series of secondary divisions, or rings, of which the head exhibits no distinct trace. The thorax, on the contrary, is always divisible into three segments; and the abdomen is in general variable in the numbers of its segments, from six to nine, exclusive of the organs of generation. On comparing the different segments of a perfect insect, various striking differences will be observed, depending principally upon the presence or absence of the appendages, or organs, which these segments respectively support, as well as upon the degree of their developement. Thus, when one of these segments has attained its greatest extent and complication, and the appendages which it supports have reached their maximum, it is perceived that the segment itself is composed of a certain number of different pieces, more or less distinct, with which it is essential to possess an acquaintance. To arrive at this result, it is evident that we must examine one of the thoracic segments in preference to the others, because they are most fully developed, and most complicated in their structure. The pieces composing one of these segments are divided by M. Audouin, who has devoted a great deal of attention to this branch of the subject, into three distinct kinds—dorsal, lateral, and ventral. Mr. MacLeay, however, considers them only as dorsal and ventral, uniting the lateral with the ventral. The ventral portion consists of a simple piece, of which the form is very varied: this is named the sternum. Attached internally to this piece, at its posterior margin, is another single piece, variable in its form, but generally resembling the letter Y, and appearing necessary for the support and protection of the nervous system. This piece, as being attached to the head, thorax, or abdomen, is respectively termed the entocephalus, entothorax, and entogaster. The lateral pieces are more complicated, those on each side consisting of two; the one (anterior) articulating with the sternum, and directed upwards, constituting the episternum, behind which the other is situated, and which is in connexion with the base of the leg, and is called the epimeron. The upper surface of the thoracic segment is also composed of a number of distinct pieces, which are respectively named præseutum, scutum, scutellum, and postscutellum, and which successively follow each other. Such is supposed, theoretically, to be the structure of each segment of the body of the insect; and the fixed number of parts thus discovered is supposed to exist in all annulose animals, sometimes being distinct, as when the segment has reached its maximum of developement, but still more frequently more or less rudimental, or soldered to adjoining pieces, as required by the variation of developement.

Some pieces may even entirely disappear, and the segment may appear to consist rather of a single piece, or, on the contrary, of two or even a greater number of segments united together. Modifications of this kind are traceable, not only in different insects, and in the different segments of the same insects, but even in any single determinate segment, when examined in the various states of the same individual. The comparative examination of these segments of the insect skeleton has singularly simplified the anatomical study of these animals, placing it upon a firm basis, and more rigorously compelling the precise determination of organs which had previously been either entirely overlooked, or had only been regarded without reference to the analogous formations of other insects; and hence to any organ which happened to be singularly developed, a name was given without the least reference to the comparative structure of other insects, or the same comparative parts in the other segments of the same individual.

It would carry us too widely into the field of theoretical inquiry, were I to show that the head, and various abdominal segments, are organized in a manner strictly analogous to those of the thorax; neither could this be done effectually without a reference to the typical structure of annulose animals in general—a vast and difficult subject of investigation. We will, therefore, now confine our attention to

A.—*The Head, or the Seat of the Organs of Sensation.*

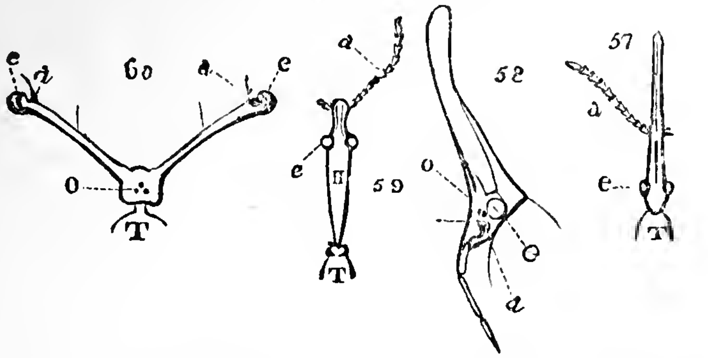
The head, or first segment of the body, is united to the anterior part of the thorax by a distinct articulation, and may be considered as a kind of corneous case or box, having an opening in the centre of its anterior part, where the mouth is placed. It is of a triangular or oval shape, with the narrowed part advanced in front; the middle of the opposite side, or base, being occasionally prolonged into a neck; but there are numerous modifications of this form, and the head is often buried as far as the eyes in the prothoracic cavity. On minutely examining the skull, it will be found that it consists of several regions. These are, the epicranium or skull-cap, composing the greater part of the head, of which it chiefly occupies the upper and posterior



Figs. 53, Head of Dyticus—54, ditto Oxycheila—55, ditto Heliocantharus—56, ditto Acanthothorax.

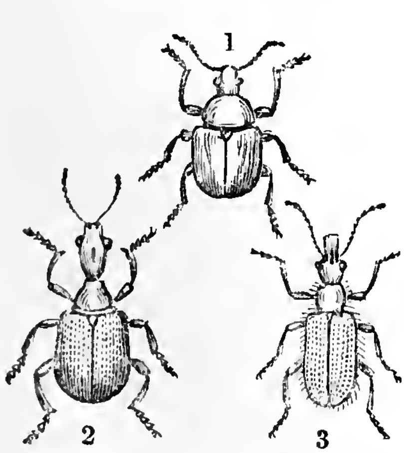
part. This is bounded in front by the clypeus (*c*), or shield of the mouth, which generally lies above the parts of the mouth (*m*), and the under side of the head is covered by the jugulum, or throat. At the sides of the epicranium are situated the large compound eyes (*e*), between which, when present, the ocelli (*o*), or simple eyes, are placed, and the antennæ (*a*) are inserted nearer to the mouth; but all these parts will require a more precise examination.

The head is generally of a corneous, or coriaceous texture, although at times it is membranous or vesiculose; and its form is modified from oval, or globose, to longitudinal, heart-shaped, compressed, cornuted, rostrated, &c. The parts of the epicranium, and its frontal part, the clypeus, have been variously regarded and named by different authors. Thus Kirby and Spence divide the upper surface of the head into the nose (*rhinarium*), hind nose (*postnasus*), forehead, crown, occiput, cheeks, and temples, and the under surface into the lora and jugulum; and it is not to be denied that, in the numerous modifications which occur in the form of the heads of insects, there are to be found portions developed to an extent, and to which, from their analogy with the parts of



Figs. 57, Head of Brentus—58, ditto Fulgora—59, Apoderus—60, Diopsis.

the head of the higher animals, it may seem serviceable to give analogous names; but it is impossible to limit the extent of these parts, and therefore a general definition can only be applied to each: as, that the forehead is that part of the head which is between the eyes, and when the head begins to assume a flattened form; and the cheeks those parts which lie at the sides of the head between the eyes and the mouth. In many insects the head is united to the thorax by a membranous tube or neck, consisting (as in the *Diptera* and *Hymenoptera*, in which the motions of the head are very free) of the attenuated fore part of the thorax. In some beetles, however, the term neck is applied to a narrowed portion of the skull, which forms a kind of rotule, playing in the opening of the thorax. The three accompanying figures represent insects with—1, the head of an ordinary size (*Attelabus curculionoides*); 2, the head posteriorly elongated (*Apoderus avellanæ*); and 3, the head anteriorly produced (*Rhynchites cavifrons*), all being magnified about twice the natural length.



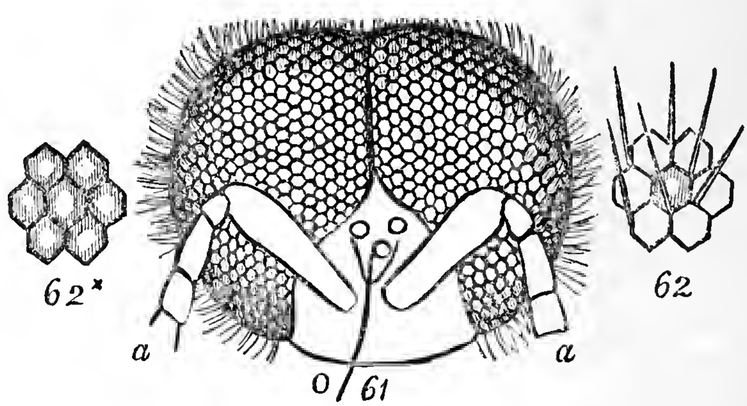
The clypeus (*c*) of Fabricius, or the nose of Kirby and Spence, or the epistomis of Latreille, is an important part of the head, as occasionally, from its developement, and the consequent want of developement of the true upper lip (*labrum*), it takes the functions of the latter, and serves, as the name imports, and as it was at first employed by Linnæus in the lamellicorn beetles, as a shield for the mouth. That there are grounds for not strictly regarding it in every insect as a mouth-shield, cannot be denied; but it would be equally incorrect to reject it on that account, as it would be to reject that of *labrum*, or upper lip, because the latter organ occasionally is quite unserviceable as a lip. Still less do I feel inclined to regard it as a nose. Its form is very variable, according to the form of the head. Thus, in an elongated head, it will be distinct and square, or rounded; and in those with a shorter head it is transverse. In the rose beetle it has a deep frontal notch; in the sacred beetle it is ornamented with several scalloped notches; in the hornet it is subquadrate; in the grasshopper rounded; and in the rove beetle transverse.

The organs of sense affixed to the head are:—

Fixed——(*a*), The composite eyes.
(*b*), The ocelli, or single eyes.
Moveable—(*c*), The antennæ.
(*d*), The trophi, or organs of the mouth.

In relation to the mutual dependence of these organs upon each other, and the general character of the insect, the following admirable passage, by Mr. Newman, extracted from the Entomological Magazine, may be advantageously quoted:—"Professor Rang has prettily observed, that every instrument, whether it be for the generation or transference of power, has a best size and a best form. Nature, in the formation of her instruments, has always adopted that best size and best form. If her creatures wanted but to see, a globular eye floating in space might perhaps be the uniform character of the animal world; if to see and to eat, an eye and a mouth would be given; if to move swiftly in the air were desirable, wings must be supplied; if on earth, legs must be added; if in the water, fins. To carry all these organs, and to contain muscle to guide and govern them, a body must be added. Each part of the body will be of the best size and best form for the functions it has to perform. We have seen that insects in their larva state have a very uniform allowance of muscle to each segment. In the imago, the charge of supporting the whole body in the air is entrusted sometimes to a single segment; and, in order to supply sufficient strength for the purpose, nature robs the neighbouring segments of their muscle, and gives it the one which needs it. In the *head*, the *mouth-feelers* and *eyes* operate in the same manner one on another. Observe the dragon-fly, the emperor of his tribe; his wings rustle as he hovers stationary and hawk-like in the air; his appetite is insatiable; his food the active occupants of his own element; it is given to him in charge to set bounds to the increase of the insect race; he beholds his prey afar off; he darts on it like the rapidity of a lightning flash; to devour it ere life is departed is the work of an instant; he sails round and round; he soars up and down; when the sky is serene, he seeks his prey, like the swallows, almost beyond the reach of human sight. What organs does such an animal require? Are they not these,—eyes, mouth, and wings? How has nature provided for his wants? Regard his head—below, it is all mouth; above, it is one continuous eye. Contemplate his wings—their character is strength and lightness—power and activity. His body is slender and graceful; like a rudder, it serves as an instrument wherewith to shape his course. Porrected feelers, whether cranial, lateral, or maxillary, would be comparatively useless to an animal whose dependence for support is on the keenness of its vision and the velocity of its flight. We find them but little prominent; his every organ of the required size. The same law obtains as certainly and unvaryingly in form. There is truly a best form and a best size, and nature always provides both."

(*a*) *The Composite Eyes.*—The eyes of insects, unlike those of the higher animals, are immoveable, horny, and unprotected by any eyelid, of a large size, and placed at the sides of the head, sometimes entirely occupying the sides, and sometimes being so extensive that scarcely any other part of the head is left perceivable; moreover, it is a curious circumstance that the eyes are sometimes clothed on the outer surface with fine bristles. These organs are generally hemispheric, and of a circular, oval, or kidney-shaped form; and when more closely examined, they are found to consist of a very great



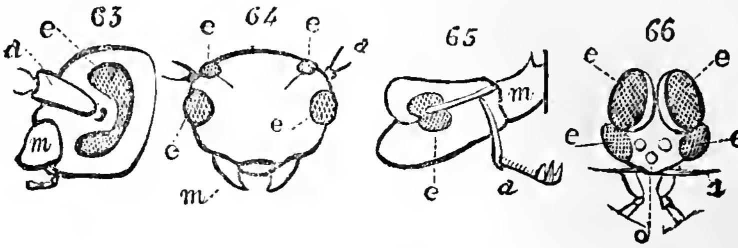
Figs. 61, Head and eyes of the male bee—62, Part of the facetted portion, showing the hairs between the facets—62, Facets denuded.

number of minute hexagonal lenses, giving the eye a reticulated appearance. Each of these lenses operates as a distinct organ of vision, and hence the number of the eyes may be said to correspond with the exact number of these hexagonal facets; various calculations have been made as to the number of these organs. Muller has given a list of their number as derived from the observations of Swammerdam, Leeuwenhoeck, Andre, Baster, Reaumur, Lyonnet, Goetz, Puget, and Schelver.

	Lenses.
In the ant there are	50
In the convolvulus sphinx	1300
In the common house-fly	4000
In the silk-worm moth	6236
In the goat-moth	11300
In the dragon-fly	12544
In a butterfly	17355
In a mordella	25088

And, according to a calculation cited by Geoffroy, there must be not less than 34,650 of such facets in the eye of a butterfly. When one of the eyes is detached from the head and cleaned, the lenses are found to be as clear as crystal. Reaumur fitted one of them thus removed to a lens, and found that he was able to sce through it distinctly, the object being, however, greatly magnified. Ordinarily the eyes are entire, but sometimes the antennæ are inserted so close to their inner margin that the eyes are thrown out of their ordinary form, and more or less surround the base of the antennæ (fig. 63). Sometimes even the eye is thus completely divided into two parts by the antennæ being inserted in the middlc (fig. 64). The same thing occurs in both respects, when the lateral margins of the head become acute, in which case they enter the anterior limb of the eye, and either partially, as in Dorcus (fig. 65), or entirely, divide it in two parts; thus forming an upper and an under eye: hence these insects may be said to have four composite eyes, which in fact appears to be the case in the whirlwig-beetles (*Gyrinus*), and in the males of some may-flies (*Ephemeræ*, fig. 66).

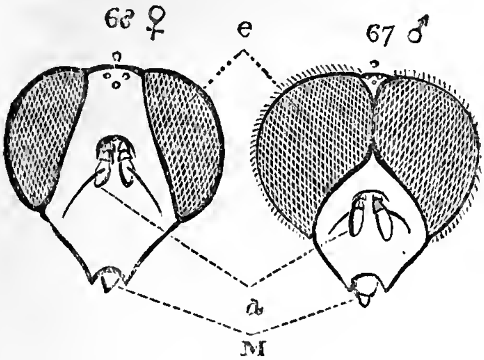
Ordinarily the eyes are sessile, that is, attached by their entire breadth to the head; but in some instances they are placed at the extremity of footstalks formed of a continuation of the corneous covering of the head, and consequently inca-



Figs. 63, Head of Coptocephalus—64, Ditto of Tetraopes—63, Ditto of Dorcus—66, Ditto of Ephemera bioculata.

pable of separate motion. This is especially the case in the dipterous genera, *Achias*, *Diopsis* (fig. 60), *Plagiocephala*, and others, in some of which the footstalks are nearly as long as the entire body; the same occurs in some species of strepsipterous insects, as well as in some exotic bugs (*Heteroptera*). Again, the eyes of insects are generally either almost flat, or but very little elevated above the surface of the head (fig. 53); but in many cases they are almost globose and very prominent (fig. 54), a peculiarity respecting which, and connected with their habits, has been noticed by the late celebrated Swedish entomologist Dalman, who observes that the very prominent eyes of insects generally indicate their habitation to be either in sandy situations or upon the margins of water; this is exemplified in the coleopterous genera, *Cicindela*, *Elaphrus*, *Omophron*, and *Stenus*, and in the hemipterous genera, *Salda* and *Alydus*. Moreover, insects with prominent eyes seem to be especially rapacious in their habits, as in the genera above mentioned, as well as *Libellula*, *Hemerobius*, &c.

In many dipterous insects a remarkable diversity exists in the size of the eyes in the two sexes, those of the males being very large, and united upon the crown of the head, whereas those of the females are much smaller, leaving a space between them upon the top of the head (figs. 67 and 68). The same also occurs in the male hive-bee, and a few others.



Figs. 67, Head of male—68, Ditto of female Syrphus.

In some insects, however, the eye appears to be completely wanting. This is asserted to be the case in the remarkable parasitic insect, thence named *Braula cœca*, in the genus of beetles, *Clinidium*, Kirby; and in the ants forming the genus *Ponera*. In like manner I have been unable to observe the least trace of eyes in more than one exotic species of ant; and in some of the *Centipedes* the same is stated to be the case.

(*b*) The *Ocelli* or *Simple Eyes* (*o* in the figures).

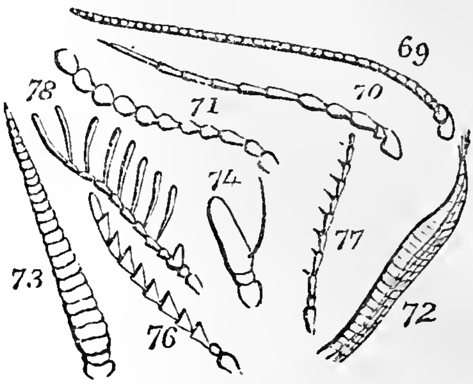
These organs (sometimes also named *Stemmata*) are minute, nearly globular lenses, placed upon the crown of the head or the forehead, between the upper region of the eyes. Unlike the composite eyes, they are often entirely wanting, and are never present in the imago unless as accompaniments to the latter. In their organization they appear to be similar to the lateral point-like eyes of caterpillars or the eyes of spiders. In general they are three in number, placed in a triangle, or more rarely almost in a line. Occasionally, however, there are but a pair of these ocelli, as in many lepidopterous insects, where they are present, although concealed by hairs, in the mole-cricket, in many bugs and smaller frog-hoppers (*Cercopidæ*); in some of the sand-wasps (*Larra*, &c.) the hinder pair are almost obsolete; and in some of the coleopterous insects, belonging to the family *Dermestidæ*, there appears to be but a single ocellus. They appear in the ants to be connected with the developement of the sexual character, since the neuters are entirely destitute of them. They are also entirely wanting to the great mass of *Coleoptera* (having been only noticed in a few small *Brachelytra, Paussus cruciatus,* and some of the *Dermestidæ*), in many bugs and water bugs, and also in many neuropterous insects. That these ocelli are in fact supplemental eyes, appears evident from the experiments of Swammerdam and Reaumur; the latter of whom varnished the back of the head, covering the ocelli, in more than twenty bees, which he then set at liberty three or four paces from the hive, but not one of them knew where to find it again, nor appeared to search for it. They flew at random to the adjacent plants, but never to a distance; and though they seemed to have no difficulty in flying, he never saw them rise in the air as those did whose facetted eyes he had varnished over. The internal anatomical structure of the ocelli also proves that they are distinctly organs of vision.

(*c*) The *Antennæ* (*a* in the figures).

We are now to turn our attention to a pair of organs perhaps the most characteristic of the insect tribes. These are two articulated appendages of a most variable character, affixed at the sides of the head, and generally between the eyes and the mouth. Although occasionally wanting, and generally rudimental in the preparatory states, these organs are never absent in the imago state. I shall have occasion subsequently to enter into the question of the use of these organs, which have been the subject of much dispute amongst naturalists. It will be sufficient here to notice that they are exceedingly sensitive, and are evidently of the highest degree of service to the insect. From their great diversity of structure they are employed by entomologists as affording the most satisfactory characters to distinguish the various genera, &c. It will therefore be essential to enter more into detail respecting their peculiarities. I will therefore describe them according to their various distinctions, and, first, of their situation.

Antennæ are inserted into the head, and connected therewith by means of a ball-and-socket-like articulation, arising generally in the face between or beneath the eyes; sometimes also, as already described in treating of the eyes, they arise within a notch on the inside of these organs, which are sometimes thereby entirely divided into two parts. They are likewise, as regards their connexion with each other, contiguous or inserted close together, so as almost to touch each other, or distant when far apart; sometimes they arise from a produced part of the head, serving either solely as a peduncle for their support, as in the dipterous genus, *Ceria;* or as an elongated rostrum, as in the weevils (fig. 56), at the extremity of which the mouth is placed, the antennæ being inserted at its sides; or as a footstalk for the eyes, as in *Diopsis* (fig. 60), in which the antennæ are placed close to the eyes; whereas in *Achias* they are frontal, and the eyes pedunculated.

As to their composition, they are formed of a variable number of small and generally cylindrical pieces, externally covered with a horny or leathery integument, according to the general consistence of the body of the insect; and internally softer or vesiculose, having an internal cavity extending throughout the whole length of the organ, inclosing nerves for sensation and muscles for motion; thus forming a series of tubes connected by a membrane, and attached end to end, varying often as to their respective forms, and having generally but a common motion. As to their form, antennæ may be regarded as equal or unequal, according to the equality or inequality in the length of the respective joints: they may also be regular or irregular, according as they exhibit a uniform appearance, or have the various joints irregularly constructed. Definitions of a few of the more important modifications of form will be serviceable to the beginner, who would otherwise have to contend against a series of technical names, which would be unintelligible to him, unless acquainted with the Latin language, from which they are generally derived.



Variously formed antennæ.

Filiform, when the antennæ are of equal thickness throughout their whole length, like a thread (fig. 69).

Setaceous, when they insensibly diminish in thickness to the tip (fig. 70).

Moniliform, when they are formed of globular joints, resembling a necklace of pearls (fig. 71).

Cylindrical, when they are of equal thickness throughout, with the joints scarcely discernible.

Prismatic, when they resemble a prism, or are formed of three sides (fig. 72).

Ensiform, angulated at the sides, large at the base, but gradually terminating in a point, like a sword (fig. 73).

Subulated, short, and pointed at the tip.

Fusiform, narrowed at the two extremities, and thickened in the centre, like a spindle.

Aristate, when the antennæ are terminated by a fine bristle (fig. 74).

Dentate, when the joints are armed with short spines (fig. 77).

Serrate, when the joints are triangular, one of the angles being internally produced, like a saw (fig. 76).

Pectinated, when the joints are furnished with a long and slender tooth, generally arising from the base or extremity of each, thus resembling a comb (fig. 78).

Bipectinated, when each joint produces two long teeth, or filaments.

Flabellated, when the branches are very long, and flattened like the rays of a fan (fig. 78, beneath).

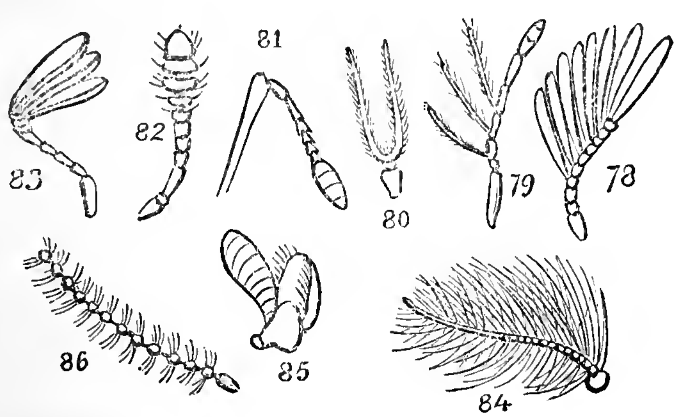
Ramose, when several of the joints throw out branches (fig. 79).

Furcate, when the antennæ are divided into two branches like a fork (fig. 80).

Geniculated, when they are bent at an angle, generally at the extremity of the long basal joint, like an elbow (fig. 81).

Clavate, when they gradually thicken to the tip, like a club (fig. 82).

Capitate, when they are terminated by a knob-like mass or head.



Perfoliate, when the terminal joints of the club are not closely applied to each other.

Lamelliform, when they are terminated by a club greatly produced on one side, the joints of which form plates applied against each other (fig. 83).

Fissile, when they are terminated by a cleft knob.

Plumose, when they resemble a feather (fig. 84).

Auriculate, when one of the basal joints is dilated into a shield or ear partially covering the rest (fig. 85).

Palmated, when the antennæ are short, broad, and divided by deep incisions.

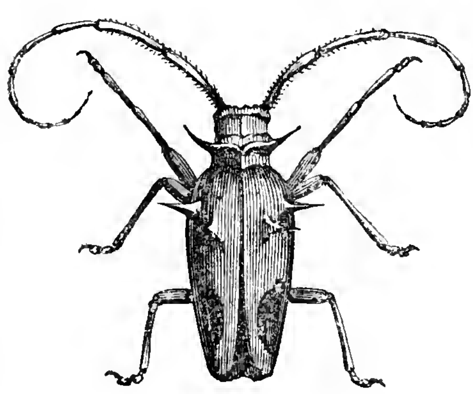
Nodose, when they are thickened in various parts, like knots.

Verticillate, when whorls of hair are placed at equal distances upon the joints (fig. 86).

Fasciculate, when a bundle of hairs is placed on one side of each joint.

Scopiferous, when a single or very thick bundle of hair is placed upon one of the joints.

As to their size, antennæ are exceedingly variable, as they are also in their length, being sometimes shorter than the head, and at others as long or several times longer than the entire body, especially in the longicorn beetles, whereof *Acanthocinus speculifer,* from Brazil, is an example; in many instances they are as slender as a hair, and at other times nearly as thick as the body. As to their direction, they are generally porrected in front of the head; others throw them over the back; in some they are stiff, in others flexible; they are straight, deflexed, or spiral, and are often, when at rest, lodged in particular cavities prepared for their reception on the under side of the head or thorax.



Acanthocinus speculifer.

The number of joints of which these organs are composed merits a few observations. Coleopterous insects have in general eleven joints; the *Heteroptera* from four to six; the stinging *Hymenoptera* twelve in the females and thirteen in the males; but in the *Lepidoptera, Ichneumonidæ, Orthoptera,* and many others, the number of the joints is much more considerable, sometimes reaching fifty or sixty; and in some *Orthoptera* the number is still far more numerous.

In a few insects the antennæ are very short and destitute of joints, as in the *Hippoboscidæ,* and in Dalman's genus *Articerus; Bi-articulate* (two-jointed) antennæ are found in *Paussus,* triarticulate antennæ in many *Diptera.* The large sawflies (*Cimbices*) vary in the number of their joints from five to eight.

It still remains to be noticed, that a very great diversity often exists in the structure of the antennæ in the opposite sexes of the same species; this is especially noticed in the greatly increased length of these organs in the males, and in the various hairs, feathers, or branches with which they are adorned in this sex. Numerous other variations occur, such as the incrassation of certain of the joints, or their greater developement, to enumerate which would occupy too great a space; but in all which, these advantages are always in favour of the male sex.

(*d*) *The Mouth** (M in the figures).

If the structure of the antennæ has required a considerable portion of our attention, a still greater share must be now devoted to the various and variable organs of which the mouth of insects is composed, since it is upon these variations that the most valuable arrangements of insects hitherto proposed have, in a great measure, been established. If a beetle and a butterfly, a house-fly, or an aphis be examined whilst feeding,

* *Obs.*—In the various figures representing the mouth of insects, the same letter indicates the same organ throughout: *l* 1, is the upper lip, labrum; *m,* mandible; *mx,* maxilla; *mp,* maxillary palpi; *c,* chin or mentum; *l* 2, labium, or lower lip; *lp,* labial palpi; *t,* tongue, lingua, or paraglossæ.

a totally different apparatus will be found in each, although perfectly adapted for the mode of feeding. The beetle is employed in gnawing and tearing in pieces hard or fleshy substances: its instruments of manducation are therefore horny and robust. The butterfly, on the contrary, has to suck its food at the bottom of the tubes of flowers, and here in the glowing beams of the sun it revels in its existence, and sips the most delicious nectar. It is necessary for this purpose that it should be provided with a long and slender instrument; but from the very structure of this apparatus, it is essential for its defence, that so soon as the insect has ceased feeding, the instrument should be lodged in a place of safety. It is therefore rolled up in a beautiful spiral direction, and laid to rest between a pair of hairy appendages which will defend it from injury. If we observe a common fly sipping up a drop of spilt wine, or revelling upon a morsel of sugar, it will be found that its mouth is totally unlike either of the former: it is short, thick, and fleshy, and acts as a sucker, the nutriment ascending through the canal which runs upwards into the

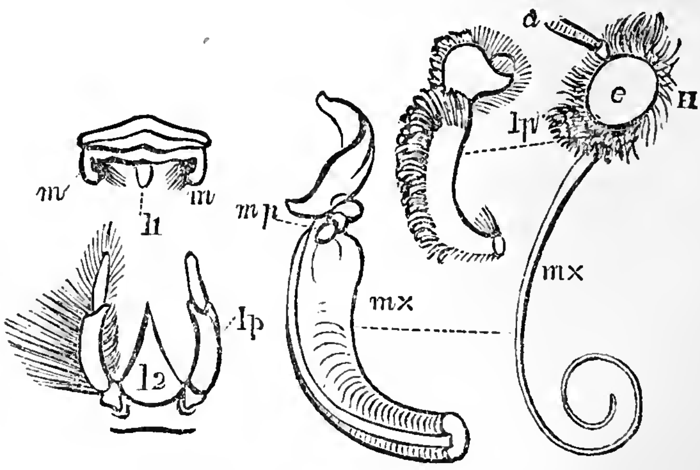
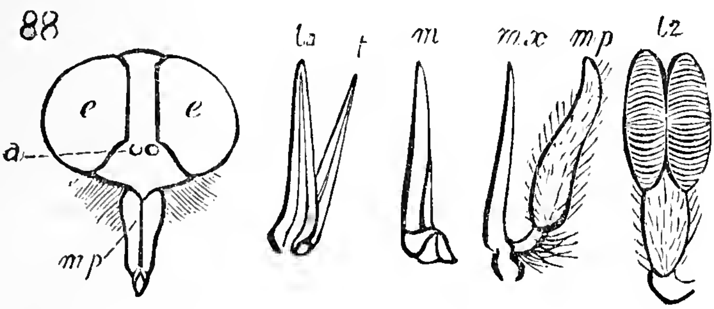


Fig. 87, Antlia of Lepidoptera (Sphinx).

throat. The aphides, and all their brethren, have a mouth still differently constructed, being a long and slender-jointed canal of a fleshy or leathery substance, but furnished internally with several slender bristles, which the insect employs as lancets to wound its prey. In the flea again the structure is quite different.

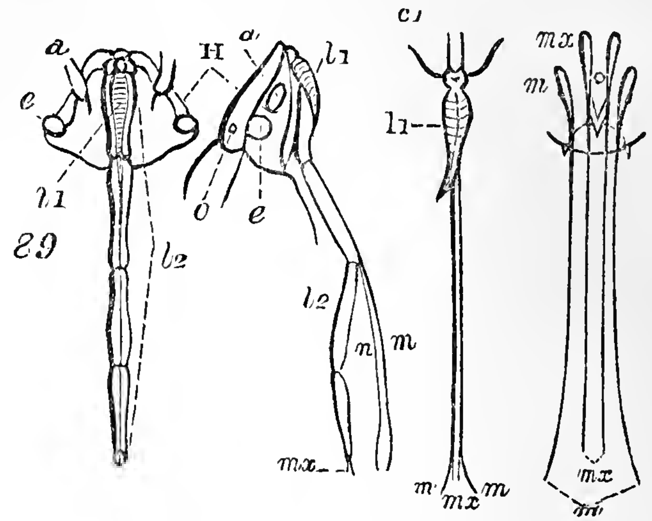
These insects may be cited as affording examples of the chief variations which occur in the general structure of the mouth, and to each of which, as a variation of the mouth, a name has been applied. Thus the mouth of the butterfly, and other lepidopterous insects (fig. 87), is termed by Kirby and Spence *antlia;* by Fabricius *lingua* (an evidently exceptionable term, being only strictly applicable to a single organ of the mouth); and by Latreille *spirignatha.* The mouth of the fly (fig. 88) is termed by Kirby and Spence, Linnæus,



Proboscis of Diptera (Tabanus).

and Fabricius, *proboscis.* The mouth of the aphides and bugs (fig. 89) is denominated by Kirby and Spence a *promuscis;* but by Fabricius, Olivier, and Latreille, *rostrum,* a term more properly applicable to those insects which have the head produced in front into a beak or snout, as the weevils or scorpion-tailed fly (*Panorpa*), but which latter Latreille, for distinction, terms *proboscirostrum.* The mouth of the flea is termed a *rostrulum* by Kirby and Spence, and *rostellum* by Latreille, the latter name having been proposed by Kirby and Spence for the suctorial organs of the louse tribe (*Pe-*

diculidæ), but which Latreille terms *siphunculus*. Moreover, the mouth of the bee, which is chiefly organized upon the same plan as the biting mouth of the beetle, but has its



Promuscis of Hemiptera (Pentatoma).

parts elongated so as to sip up the honey of flowers, is termed by Latreille a *promuscis* (although that term had been given by Kirby and Spence to the mouth of the bug tribes).

Throughout this great variation of structure, however, the strictest uniformity is maintained, the same number of parts existing in all, although occasionally rudimental or modified in various degrees, so as to correspond with the functions which they have to support. As, however, these modifications of structure are permanent throughout entire groups, serving, in fact, for the establishment of orders, according to some authors, it would surely be absurd to deny the propriety of assigning to each variation a distinct and fixed name.

The mouth of the hexapod winged insects being thus composed of a certain number of parts, may much more easily be referred to one general type of form, than the mouths of the other annulose animals, some of which have a much more complicated organization of the mouth than is to be found in insects: thus in the crabs we find not less than five pairs of jaws, whereas there are but two pairs of these organs in insects.

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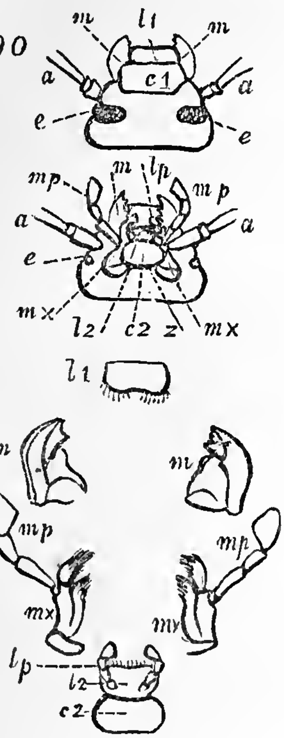


The different parts of the mouth of a beetle (Blaps)—*l* 1, upper lip—*m*, mandibles —*mx*, maxillæ; *m p*, maxillary palpi; *c*2, chin or mentum; *l*2, labium; *lp*, labial palpi.

The parts of which the mouths of all insects are composed may be reduced to six; namely, four lateral pieces disposed in pairs, and two other organs opposed to each other, but in an opposite direction, and which meet each other, so as to close the mouth from above and below; the upper one being placed above the upper pair of lateral organs, and the lower one below the under pair of lateral organs.

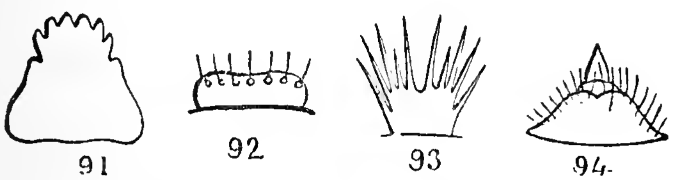
As regards the mode of taking their food, insects have been divided by many authors into two groups; namely, those in which the mouth is furnished with mandibles fit for biting, and those in which the mouth is suctorial. All the various modifications of form to which we have above alluded may be referred to one or the other of these sections; and it is upon this character that the leading division of insects into *Mandibulata* and *Haustellata* has been adopted by various authors; although, since in one period of an insect's life its mouth is fitted for biting, and in another for sucking honey (as in butterflies), it may perhaps be alleged that too great a weight has been assigned to the structure of the mouth. The jaws of biting insects have a horizontal motion; the mandibulated insects must, of course, be characterized by the horizontal motion of their jaws, and not, as might, perhaps, from the names of the two groups, be supposed, upon the presence of mandibles in the *Mandibulata,* or their absence in the *Haustellata;* because, as I have already said, the mandibles or their representatives are to be found in all insects. It would, indeed, perhaps be advisable to adopt other terms in lieu of these, but as they are generally understood, I shall continue to speak of the mandibulated and haustellated insects, in alluding to the species distinguished by the biting or sucking mode in which they take their food.

Moreover, instead of treating of these two groups separately, as has been generally done, it will perhaps be more advantageous, as enabling us more readily to show the modifications which each organ undergoes, to take the various organs seriatim—prefacing their description by the following general observations.

In biting insects, or those which feed upon solid matters, the four lateral pieces perform the office of jaws, and move in a horizontal direction, the two other pieces being regarded as lips; the upper jaws are more particularly denominated *mandibles;* and the lower jaws are named *maxillæ,* and, in general, each of the latter is furnished with a slender-jointed appendage termed a *palpus,* which is never found attached to the mandibles of winged insects; in some of the wingless insects the mandibles are, however, also palpigerous. The *maxillæ* are generally terminated by two lobes, the outer one being very variable in form. The upper lip is termed the *labrum,* and the lower lip *labium;* but the latter is a much more complicated instrument than the former, and is furnished, like the *maxillæ,* with two short articulated palpi.

In the sucking insects, the nutriment being essentially fluid, the neeessity for biting jaws is obviated. They are therefore either obsolete, or they assume the form of laneets, and as sueh have a motion quite different from that of the jaws of biting insects. The mouth of these insects exhibits two distinct modifieations of form. In the first, the four lateral piecces, or the mandibles and maxillæ, are converted into slender, setiform, or lancet-like pieces, forming a kind of sucker, which is received into a membranous conical or cylindrieal and articulated gutter, as in the bugs; or are lodged within a thick, elbowed, and fleshy sheath, as in the flies. In the second modification, the upper lip and the mandibles are either obsolete or but very minute; the lower lip is no longer a distinct and loose organ, but is attaehed to the head, and is distinguished only by a pair of large palpi; the maxillæ, on the eontrary, arc greatly elongated, but very much attenuated, being transformed into two tubular threads, which, uniting at the edges, form a kind of sucker, gencrally rolled up in a spiral direction, and furnished at the base with two minute palpi. I will now take the organs of the mouth scriatim, aeeording to their position, commeneing with that which lies uppermost, or,

The Labrum, or upper lip (*l* 1 in the figures).—This organ is, in biting inseets, a horny or leathery flattened plate of variable form, attaehed, by an articulation, to the clypeus,

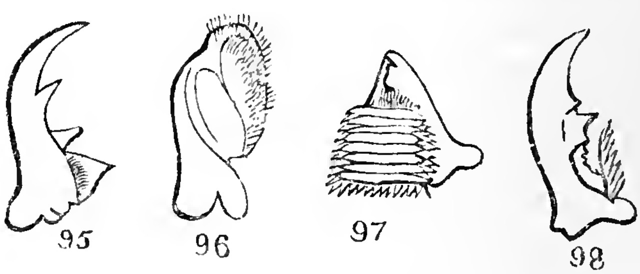


Figs. 91, Labrum of Megacephala—92, ditto of Aploa—93, Perilampus—94, Banchus.

and serving as an upper covering to the rest of the mouth: unlike the lower lip, this organ is never furnished with palpi.

In many insects, however, it is quite membranous, and is in such cases completely concealed by the clypeus, with which, indeed, it was sometimes confounded by Fabricius, who also gave to it the name of that part. It is generally fringed with hairs. In some few *Hymenoptera* it is furnished with a slender appendage, to which indeed Illiger applied the name of *labrum*. In the *Hemiptera* the upper lip is in the form of an elongate triangle, which falls upon the base of the canal of the lower lip (fig. 89, *l* 1). In the *Lepidoptera* it is so minute as not to be discernible without great care, appearing as a small triangular piece extending downwards towards the base of the labial palpi (fig. 87, *l* 1). In the *Diptera* it is either obsolete, or exists in the shape of a corneous, slender gutter, hollowed beneath, and receiving the other slender lancet-like organs (fig. 88, *l* 1).

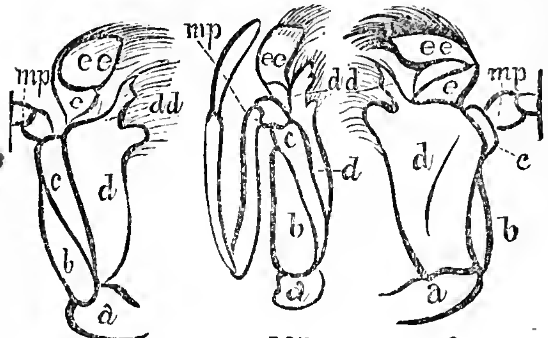
The Mandibles, or upper jaws (*m* in the figures).—These organs, in the generality of biting insects, are the chief



Figs. 65, Mandibles of Therates—96, ditto of Hyboma—97, ditto Mimela—98, ditto Goerius.

instruments by which the food is bitten into pieces. They have been considered analogous to the jaws of the higher animals, but they have a much greater resemblance to a pair of large and robust, horny, and notched teeth. They are inserted at the sides of the oral aperture, immediately below the lower lip, to which, indeed, they appear to bear the same kind of relation as the lower jaws do to the lower lip. They are composed of a single piece, and are destitute of any appendage. In some of the *Brachelytra* (especially the species ordinarily termed the devil's coach-horse, fig. 98) their inner surface is, however, furnished with a small moveable exarticulate process, as is also the case in *Passalus* and *Hydrous*. By Linnæus they were termed *maxillæ*. In beetles these organs are generally of large size, and of a horny substance. The large and powerful instruments with which the head of the stag-beetle is armed are the mandibles immensely developed; but these organs, like many others, exhibit great variations, according to the sexes. In the last-named insect, for instance, the jaws of the females are so short that this sex was long regarded as a distinct species. They are usually symmetrical, but in many cases are dissimilar in form, and more particularly in the structure of the teeth, with which they are commonly furnished. In some of the lamellicorn beetles, the internal base of these organs is dilated into a broad and flattened square plate, having numerous transverse ridges, serving for the purpose of bruising the leaves upon which these insects feed (fig. 97). In some beetles also, which subsist upon the juices of flowers, or upon the flowing sap of wounded trees, &c., the jaws are of a membranous structure, and quite unfitted for mastication. In the *Hymenoptera* also, the jaws, although of the ordinary form, cannot, in many cases, be regarded as masticating organs, but appear solely to be employed in the construction or the provisioning of the nest. In the *Lepidoptera* they are very minute, membranous, and triangular, and placed on each side of the labrum. In the *Hemiptera* they are very long, slender, and employed in conjunction with the maxilla as lancets. They have also the same character in the *Diptera;* but here they are often entirely wanting. They are, however, particularly distinct in the gnats and gadflies (*Tabanidæ*, fig. 88, *m*).

Maxillæ, or lower jaws (*m x* in the figures).—These organs are two in number, and are placed beneath the mandibles, from which they differ in their less firm consistence and more complicated structure, being formed of several parts, and especially by the possession of a slender articulated appendage or palpus, attached to each. They appear to be more especially connected with the lower lip, serving, in some instances, as a sheath for its defence; in the beetles, however, they are generally quite detached. In a table of the comparative variation of the chief insect organs, Mr. MacLeay has shown that the maxillæ are less liable to vary than any other; hence it is important to note the modifications to which they are subject.

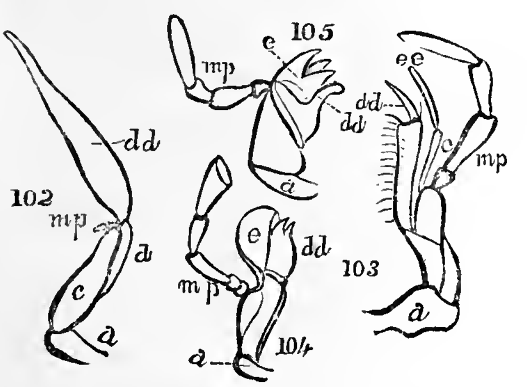


100 101 99

Figs. 99, Maxilla of the great water-beetle (*Hydrous piceus*) seen from above—100, from below—101, from the back.

The maxillæ appear typically to consist of five pieces, exclusive of the maxillary palpi; at least, those maxillæ which are the most complicated in their structure exhibit this number of parts. They are the *cardo* or hinge (figs. 99, 100, 101 *a*), a most appropriate term, designating a transverse horny piece by which the jaw is affixed within the mouth by membranes. Strauss calls this the *branche transversale*, Savigny the support, Burmeister the base, and Newman the *insertio*. This piece is especially distinct in beetles and bees. The two following pieces (*b* and *c*) are closely soldered together, and compose the horny pillar between the basal hinge and the terminal lobes. Of these two parts, the external portion (*c*), as first noticed by Latreille, and since named *la pièce palpifère* by Strauss, and the *squama* by

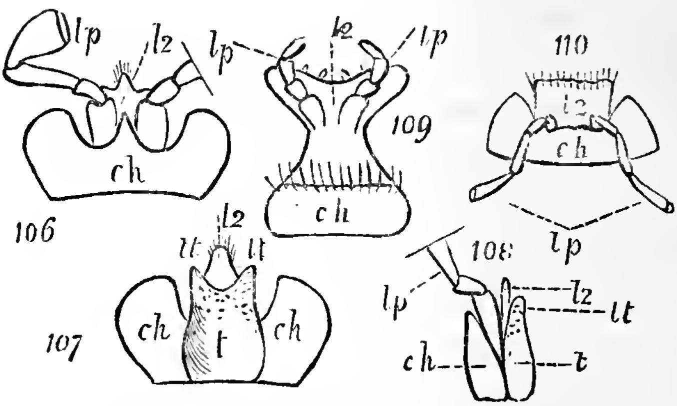
Burmeister, bears at its extremity the maxillary palpus (*mp*): the internal or dorsal piece (*la pièce dorsale* of Strauss-Dürckheim, *b*) occupies the space between this and the membrane which runs parallel therewith, forming the basal part of the internal terminal lobe (*d*). Conjointly, these three pieces (*b*, *c*, and *d*) are termed the stipes or stalk of the maxillæ by MacLeay and Kirby. The last of these, or the fourth piece of the maxillæ (*d*), is more important, extending not only along the internal side of the maxillæ, but also often considerably beyond the former pieces, and being very variable in its form: its terminal portion (*d d*) has been named the internal lobe of the maxillæ by MacLeay and others, but it is not distinct from the basal part (*d*). In the predaceous beetles it is long, slender, curved at the tip, and internally clothed with fine hairs or bristles, and sometimes terminated by a hook, which is either entire, as in *Carabus*, or articulated, as in the tiger-beetles (fig. 102). This part is termed *la pièce intermaxillaire* by Strauss-Dürckheim,



Figs. 102, Maxilla of Cicindela — 103, ditto of Bombus — 104, ditto of Blatta — 105, ditto of Melolontha.

and *lacinia* by MacLeay. In some biting insects it is of a very large size, as in the bees, in which it forms the sole terminal lobe of the maxillæ (fig. 103). In many instances, however, it is greatly reduced in size, not extending beyond the base of the palpus, in which case another organ is developed at its expense, which, as in the large water-beetle (*Hydrous piceus*), joins the terminal part of the maxillæ (figs. 99, 100, 101 *e*). In the predaceous beetles this external lobe, as it is generally called, is often of equal size with the terminal portion of the lacinia, or the internal lobe, and is here articulated both at its base and in the middle (fig. 102 *e e*), and is generally termed thence the internal maxillary palpus. In the order *Orthoptera*, this same outer lobe is equally developed, but is not articulated, except at the base (fig. 104); its inner surface is somewhat hollowed, so that it falls upon the terminal lobe of the lacinia, and defends it laterally. It is hence termed by Fabricius the galea, a term applied theoretically by Strauss-Dürckheim to the outer lobe of the maxillæ of all insects. In many insects the two lobes are soldered together into a large flattened membranous plate. Numerous other variations of form occur in these two lobes, which, from their situation, are necessarily the part most serviceable to the insect, and consequently modified and adapted to the functions and habits of each of these variations. Perhaps the most remarkable are those exhibited by some of the leaf-devouring lamellicorn beetles, in which the extremities of the lobes are very broad, horny, and armed with several strong teeth, having somewhat the appearance of a large double tooth (fig. 105), and by some other beetles which feed upon the pollen or honey-flowers, and in which the outer lobe of the maxillæ is nearly half the length of the body. In the stag-beetles it is prolonged into a fine pencil of hairs, serviceable in licking up flowing sap. It is at the external extremity of the stipes, and intermediate between it and the base of the outer lobe of the maxilla, that the *palpus* (or *mp*) of each maxilla is attached. This is a slender appendage, somewhat similar in its construction to the antennæ, but much shorter, and composed of fewer joints, varying in the latter respect from one to six articulations. The latter number is often found in the *Hymenoptera*, but in the *Coleoptera* four appears to be the prevalent number. In the *Orthoptera* and *Trichoptera* it is generally five. These palpi vary very considerably in the size and form of their respective joints, although they are generally slender and filiform: hence they are eminently serviceable in characterizing genera, now that naturalists have discovered that smallness of size does not form an objection to the value of the characters derived from an organ. In the suctorial mouth, the maxillæ are still important organs, although completely changed in the structure: thus, in the *Lepidoptera* (see fig. 87), they constitute the two long and very slender instruments which compose the tubular, and, when at rest, spiral apparatus, which the insect employs for collecting honey. That these instruments are really modified maxillæ is proved by the modifications which these organs undergo, even in the biting insects, and likewise by the possession of a minute palpus attached to each at the base, which in most *Lepidoptera* is so small as to be easily overlooked, being concealed by the hairs of the labial palpi. In other moths, especially in some of the *Pyralidæ*, they are, however, very distinct; and hence these insects are ordinarily described as having four palpi. In the *Diptera* and *Hemiptera* the maxillæ are horny, setiform, or lancet-shaped. In the former order they are sometimes almost obsolete, and are generally furnished with a palpus, varying in the number of its joints from five to one, but in the latter they resemble the mandibles, and are not palpigerous. In the flea they are dilated and palpigerous. In the *Trichoptera* they are rudimental, but furnished with long palpi.

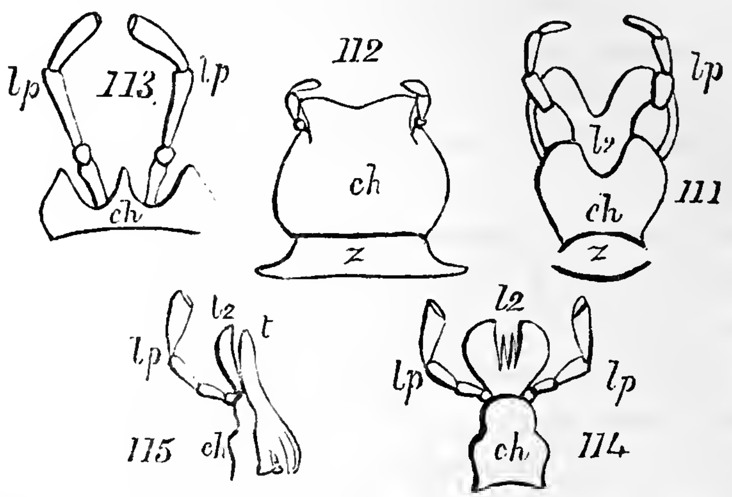
The Labium, or lower lip.—We have now arrived at a very complicated organ, which generally serves to close the mouth from beneath, and therefore corresponds with the upper lip. This organ, if regarded analogically, with reference to the structure of the mouth of other annulose animals, appears to be composed of a pair of maxillæ, united together internally, furnished with a pair of palpi, and covered, in a great measure, by a large horny plate, which is generally termed the mentum. The parts of which this organ is composed are numerous, and the greatest confusion has arisen in the works of authors, as to their nomenclature, owing to the numberless modifications which they undergo, whereby the relative proportions and the consequent relations of the various parts with each other, and with the head, are greatly altered. On examining the under side of the



Figs. 106, Labium of Carabus outside—107, ditto inside—108, ditto laterally—109, ditto of Necrophorus—110, ditto of Dyticus.

head of a beetle, the parts of which this lower lip will be found to consist are, first, a broad horny plate (*ch* or *c* 2) articulated at its base, and connected at its extremity by membrane, with a leathery piece (*l* 2), within which arises a fleshy organ (*t*), occasionally having its anterior angles elongated (*t t*): the labial palpi (*l p*) take their rise between the first and second of these pieces. The first named piece is attached to the head by a horny piece (*z*), which, although apparently articulated in some beetles (as, for instance, in the cockchafer, the common Chinese *Mimela*, &c.), is immoveable, and forms a portion of the throat or jugulum, but which MacLeay regards as part of the lower lip, and calls it stipes. It is the *pièce prebasilaire* of Strauss-Dürckheim.

Mr. Newman calls it mentum and insertio, and regards it both as a terminal part of the throat, and as a basal part of the lower lip,—at least if I understand him correctly, which it is certainly difficult to do, from the abrupt manner in which his definitions of these organs of the mouth are drawn up. The chin, or mentum (the broad horny plate above mentioned), is very variable in its form (*ch* or *c* 2), sometimes, as in the lamellicorn beetles, serving exactly as a lower lip, and closing the mouth; but in other beetles it is shorter and more transverse, and cannot be in the least degree effectual in performing this office. Sometimes even its base is soldered to the jugulum, the stipes being entirely obsolete, and thus, in fact, becoming the anterior edge of the former. This is the case in *Paussus*, *Siagona*, &c.; but its true nature may be known by the position of the labial palpi, which always arise between its extremity and the base of the terminal portion of the lower lip, to which (if with MacLeay, Kirby, Curtis, &c., we continue the analogy with the human face) we must restrict the name of lower lip or labium, although the same name is also applied to the whole apparatus. This difficulty may be obviated by terming this piece, with Fabricius and others, *ligula*. The latter piece is more membranous, and of a smaller size than the mentum, and often serves to close the mouth as effectually as the former. I therefore see no sufficient reason, on this account, for not giving to it the name of the labium, or lower lip. The form of this organ is very variable, and sometimes, as in the tiger-beetles, it is completely concealed by the mentum. On examining the lower lip internally, a distinct membranous or leathery lining (*t*) will often be found, the angles of which are protruded beyond the front margin of the lower lip, in the form of little protuberances (*t t*). These are very conspicuous in many *Carabidæ*, and are termed paraglossæ, although they can only be regarded as the produced angles of the internal organ, which, from analogy, may be termed the lingua, or tongue, and which is very distinct in many orthopterous, and some neuropterous, insects, in which orders the general structure of the labium, and its various parts, is very similar to that of the beetles, except that in the former, the part to which I have restricted the term labium, or ligula, is divided longitudinally into four branches.



Figs. 111, Labium of Geotrupes—112, ditto of Melolontha—113, ditto of Cicindela—114, ditto of Gryllus outside—115, ditto laterally.

In the *Hymenoptera*, however, the labium has reached its fullest developement; and this is more especially the case in the bee tribes, to which (without going through the other hymenopterous families) it will be advantageous to direct our attention. I have said that in these tribes the maxillæ co-operate with the labium, in order to enable the insect to suck the nectar of flowers. The machinery by which the lower parts of the bee's mouth (to which, from analogy, the term tongue is often, but not very correctly, applied) are protruded, is exceedingly beautiful. On referring to the figures given of the mouth of the bee in various states, in a subsequent page, the maxillæ and their very minute palpi will be observed to be extended on each side of the central piece, which, it will be seen, arises from a short triangular piece, which appears analogous to the part which I have noticed above, as the stipes of MacLeay, although here, for evident purposes, it is articulated and moveable. The next piece is the thickened horny tubular piece, or mentum, at the extremity of which arise the labial palpi, remarkable for the elongation of the two basal joints, and between which, at the base, are two short processes, which are termed paraglossæ; the apparatus terminating in a long and slender many-ringed instrument, which, in a following page, I have called the tongue, or lingua, but its true analogy has not been determined. By some authors it is called the labium.

In the lepidopterous insects, the structure of the mouth, although having a function similar to that of the bee's, is completely altered as to the form of its individual organs. In the latter, the maxillæ and labium conjointly operate in sucking up honey; but in the former (see fig. 87), the maxillæ (*m x*) alone perform this office, the labium (*l* 2) being rudimental, and attached to the head, and only distinguishable by bearing the pair of large palpi (*l p*), which bend upwards, and form the defence of the spiral maxillæ. In the *Diptera* (see fig. 88), on the contrary, as well as the *Hemiptera* (see fig. 89), the labium (*l* 2) is the most conspicuous part of the mouth, forming the elbowed and fleshy, or articulated and membranous, tube or canal, in which the other organs of the mouth are inclosed. In these orders, moreover, the labial palpi are obsolete: great variations occur in these orders, and especially in the *Diptera*, as regards the form of this lower lip; but it would lead to too great a length were I to notice them more in detail. The forest flies, *Hippoboscidæ*, and the flea, exhibit other modifications of form of the lower lip.

Such are the various and important head-organs with which Nature has supplied insects for the due support of their existence. Of their uses I shall speak more at large in treating of the physiology of insects, when I shall state my reasons for employing the terms antennæ and palpi, which indicate no decided use, in preference to that of feelers, which is, by many authors, assigned indiscriminately to these two kinds of organs. I will, therefore, only observe, that much still remains to be done before we arrive at a perfect knowledge of the structure of the various organs of the mouth throughout the insect tribes. Savigny has effected much in clearing away the obscurity in which the subject had long remained; but there is still an ample field for the employment of a steady eye and hand, in dissecting, and especially in delineating, the many modifications of form to which the parts of the mouth have been so fully shown to be subject. Until this have been done in the most careful manner, it will not be easy to arrive at a true knowledge of the mode in which these modifications of form are effected, and which alone will enable us satisfactorily to trace the analogies of the various parts throughout the various orders.

B.—*The Thorax, or Seat of the Organs of Locomotion.*

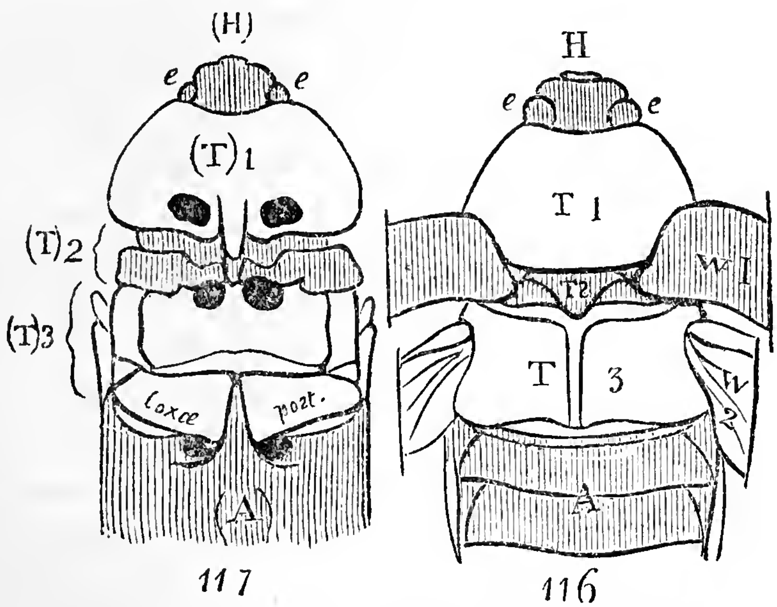
This portion of the body lies between the head and the abdomen, and supports the three pairs of legs, and the two or four wings with which perfect insects are in almost every case furnished.

In the early efforts made by scientific entomologists to determine the various parts of the body of insects, too much attention was paid to an organ when it happened to be fully developed, too little to the mode in which this developement was effected. Thus it sometimes happened that the same organ received various names, according to its extent of developement; and it was not till a rigid attention was paid to the various forms which the same part exhibited in its various modifications, that a fixed nomenclature could possibly be applied. This has been especially the case with the thoracic segments of insects; and it is only within a very few years that entomologists have given any extended attention to this part of the subject, or have endeavoured to introduce a fixed series of names. Audouin, Kirby and Spence, MacLeay, and Burmeister, have especially laboured in this field, in which much still remains to be effected. Linnæus thus described this part of the body, which he called the trunk:—"TRUNCUS, inter caput et abdomen, pedatus, *thorace*, supra *dorso*, postea *scutello*, subtus *pectore sternoque*." In his descriptions, however, he applies the term thorax either to the large shield which covers the first thoracic segment in beetles, or to the entire trunk, as in the *Hymenoptera*. This mode of description was, notwithstanding its evident impropriety and want of precision, adopted by most entomologists. Illiger endeavoured to correct this nomenclature by giving to the trunk of Linnæus the term thorax, designating its upper part *thorax superior*, and its lower surface *thorax inferior*. Latreille and others divided this part of the body into three distinct sections, the two posterior of which, from bearing the wings, Chabrier united under the name *tronc alifère*, which Kirby and Spence adopted, naming those two segments alitrunk; and the first segment, which bears the fore legs, which these authors rather regard as arms or hands, manitrunk. This nomenclature has not, however, been adopted, although Strauss-Dürckheim adopts this division of the thorax, calling the first segment corselet, and the two others the thorax. Most of these authors, however, regard the three segments following the head as sufficiently separate to require separate names; and the terms prothorax, mesothorax, and metathorax, originally proposed by Nitzsch, have been applied to them. Indeed, Audouin, MacLeay, and Burmeister, regard them as segments of equal rank, but as conjointly uniting to form the thorax; whilst Kirby and Spence employ these terms for the upper surface only of the thoracic segments, giving to their under surfaces the names of antepectus, medipectus, and postpectus. MacLeay applies the term tergum to the upper surface, and pectus to the lower: thus we have "tergum of the prothorax, pectus of the mesothorax, &c." Burmeister, with more uniformity and philosophic acumen, gives the following series of names:—

Thoracic Segment.	Upper Surface.	Under Surface.
1. Prothorax.	Pronotum (T 1).	Prosternum (T 1).
2. Mesothorax.	Mesonotum (T 2).	Mesosternum (T 2).
3. Metathorax.	Metanotum (T 3).	Metasternum (T 3).

This being the most simple system of nomenclature hitherto proposed for these thoracic segments, I shall adopt it, leaving it optional for the reader to regard the segments either as entirely distinct, or as conjointly constituting the thorax, or as divisible into two portions, corresponding with the manitrunk and alitrunk of Kirby and Spence. I will only observe, that the blunders of unphilosophical describers of insects—who contented themselves, in many cases, with no more anatomical knowledge than would enable them to distinguish one species from another, and who have, consequently, employed names without knowing or caring for their precise meaning—can be no ground for disputing the existence of organs, still less for asserting, as has inconsiderately been done, that the researches of such men as Lyonnet, Léon Dufour, Chabrier, Herold, Strauss-Dürckheim, Savigny, Audouin, and MacLeay, "tend to illustrate a theory, in itself evidently false, rather than to find out and establish plain and solid truths."

The complicated machinery requisite for the due performance of the two chief kinds of insect locomotion,—namely, leg-movements, including creeping, running, swimming, climbing, as well as prehension, and wing-movements or flying, and likewise the great volume required by the organs of motion themselves, have necessarily produced a great increase in the size of the three segments of the body forming the thorax, which in the larva state were but equal in size to the remaining segments: hence we find that the thorax in the perfect insect has become the most robust, yet compaet, as well as the most complieated in its structure, of all the body-segments of an insect. Morcover, the great diversity in the organization of the wings, and the oeeasional transfer of wing motion to a single pair of wings, this pair being either the anterior, as in the *Diptera*, or the posterior, as in the beetles, have necessitated a eoneurrent modification in the form of the thoracie segments according therewith, as well as similar modifications resulting from the varying motions of the legs.



Figs. 116, upper, and 117, under side of the thorax of a beetle (*Buprestis*): T 1, pronotum (T) 1, prosternum; T 2, mesonotum; (T) 2, mesosternum, marked with lines to distinguish its boundary; T 3, metanotum; (T) 3, metasternum; H, head; A, abdomen; W 1, elytra; W 2, posterior wings.

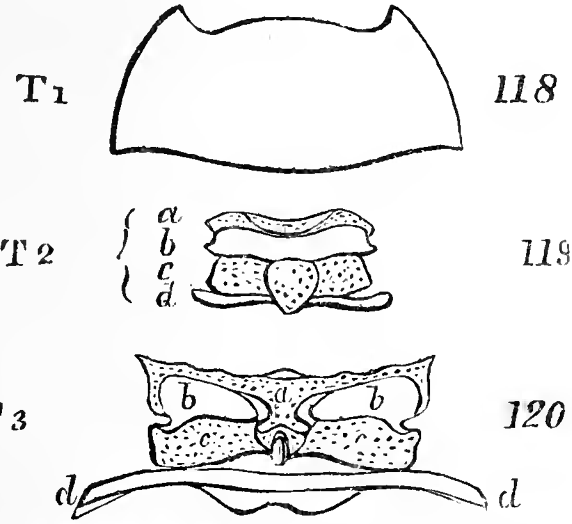
It is further to be noticed, that the many parts of which the thorax is thus composed, were provided by entomologists with separate names, whereby the nomenclature of this part of the body has become very complieated, more especially as the same part has reeeived more than a single name, according to the greater or less degree of its developement. This has been more partieularly the case in the " Introduction to

Entomology," wherein, although Messrs. Kirby and Spence do not describe much more than twenty of its distinct component parts, about forty different words are used for them in the nomenclature of the thorax. The chapter on Orismology is nevertheless, as Mr. MacLeay observes in the Zoological Journal, "more particularly valuable, and, making allowance for the nomenclature of parts, deserves the special attention of entomological students."

Much of this confusion has been obviated by M. Audouin, who, from his admirable comparative investigation of the structure of the segments of the body, ascertained that they were respectively composed of the same essential parts, and consequently that the same series of names might be applied to each. The following is a table of the thorax, as theoretically supposed by him to exist in all insects.

				Lettered
Thorax. (Truncus, Linn., Fabr. and Kirby).	*Prothorax.* (Manitrunk, Kirby; Corselet, Strauss).	*Tergum.* (Pronotum, Burmeister; Prothorax, Kirby). T 1.	Præscutum.	T 1
			Scutum.	
			Scutellum.	
			Postscutellum.	
		Pectus. (Prosternum, Burmeister; Antepectus, Kirby). (T) 2.	Sternum.	h or h 1
			Episterna.	i or i 1
			* * * *	
			Epimera.	k or k 1
		Furca, called Antefurca.		
	Mesothorax. (Meditrunk, Kirby; Prothorax, Strauss).	*Tergum.* (Mesonotum, Burmeister; Mesothorax, Kirby). T 2.	Præscutum.	a or a 2
			Scutum.	b or b 2
			Scutellum.	c or c 2
			Postscutell.	d or d 2
		Pectus. (Mesosternum, Burmeister; Medipectus, Kirby). (T) 2.	Paraptera.	
			Sternum.	h or h 2
			Episterna.	i or i 2
			Epimera.	k or k 2
		Furca, called Medifurca.		
	Metathorax. (Protrunk, Kirby and Sp.; Metathorax, Strauss).	*Tergum.* (Metanotum, Burmeister; Metathorax, Kirby). T 3.	Præscutum.	a or a 3
			Scutum.	b or b 3
			Scutellum.	c or c 3
			Postscutell.	d or d 3
		Pectus. (Metasternum, Burmeister; Postpectus, Kirby). (T) 3.	Paraptera.	
			Sternum.	h or h 3
			Episterna.	i or i 3
			Epimera.	k or k 3
		Furca, called Postfurca.		

"It must not be imagined, however," observes Mr. MacLeay, "that the pieces of the thorax mentioned in the above table are all perfect and distinct in every insect. Pieces of the thorax may disappear, being evanescent, owing to the great developement of the contiguous segments, or by being confluent or soldered together with the next adjoining pieces. To know the pieces which are thus lost, it might be thought that, on comparing the larva with the perfect insect, the position of the stigmata (spiracles) ought to afford some clue; but in truth these are unsafe guides, as it is well known that the situation of the stigmata in the perfect insect varies very generally and considerably from what it was in the larva."

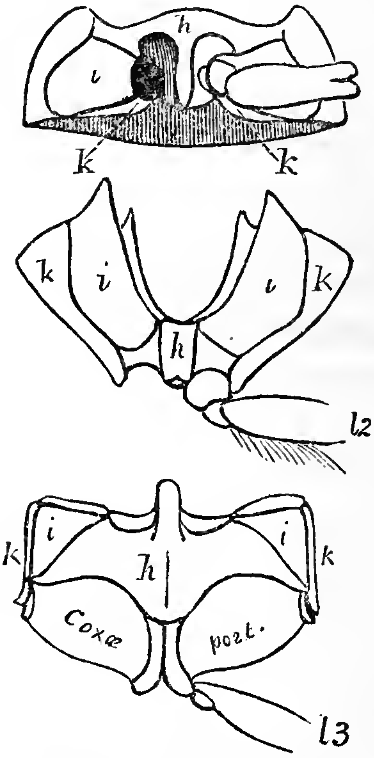


Figs. 118, Pronotum—119, Mesonotum—120, Metanotum of a Dyticus. In 118 the subsegments are confluent. In 119 and 120 the alternate subsegments are dotted to show their extent.

We have indeed found a clue for getting out of the difficulty above mentioned; but from the little attention hitherto paid to the subject, another difficulty of a not less formidable, but of a far more philosophical kind, has presented itself, namely, that of proving, by careful study, the relations of the several parts in the different orders, and the variations they are subject to.

The total number of parts in the thorax, according to

Audouin, amounts to thirty-six; but if the simple pieces, as the sternum, &c., be supposed to be divided by the medial

(T) 1  121

(T) 2 122

(T) 3 123

Figs. 121, Prosternum—122, Mesosternum—123, Metasternum of a Dyticus.

line, the number will be fifty-two; and Mr. MacLeay, by supposing that each of the three sterna consists, like the terga, of four transverse pieces similarly divided by the medial line, considers the whole number of pieces in the thorax to mount up to seventy-two. Authors, however, who have looked at the composition of the thorax, without having any theoretical views to maintain, have found the really distinct number of its parts much fewer in number than either of the last-named authors: thus Chabrier and Burmeister reckon only eighteen, Kirby and Spence twenty, and Strauss-Dürckheim twenty-two. We will now confine our attention successively to the primary segments of the thorax, and show the chief modifications which they exhibit, and then describe the organs of locomotion.

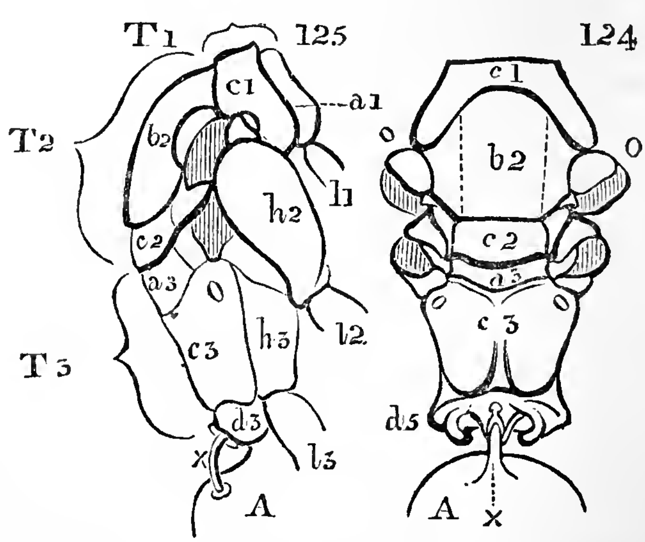
1. *The Prothorax* (*Manitrunk,* Kirby), T 1, upper, and (T) 1, under surface.—This is the segment which immediately follows the head, and precedes the segment bearing the anterior pair of wings. On its under side it bears the anterior pair of legs. It is generally larger than the head, and smaller or narrower than the following segment; the reason whereof is obvious, since it has only to support one pair of limbs, whereas the following supports two. It is to the upper surface of this piece, when most fully developed, that Linnæus gave the name of thorax, Kirby that of prothorax, Audouin that of tergum, and Burmeister that of pronotum; but the four dorsal pieces are here confluent*, although, as in some locusts, their situation is indicated by transverse impressions across the prothoracic shield.

The size of the pronotum (T 1) varies very considerably as well as its form; thus, whilst in the *Coleoptera, Orthoptera,* and heteropterous *Hemiptera,* it is of a very large size, and forms a strong horny shield (see figs. 116, 118, T 1), (sometimes produced over the whole body, and in others furnished with the most remarkable protuberances, as in many *Homoptera,* lamellicorn beetles, &c.), in the *Lepidoptera* and *Trichoptera* it is nearly evanescent, forming in the first of these orders a narrow ring. In some *Hymenoptera* it is more conspicuous, forming, as in *Xyphidria,* a narrow neck, by which the head is attached to the thorax. In this order, the front of the thorax is covered by a narrow plate (see figs. 124, 125, *c* 1), which often laterally reaches as far as the base of the wings. This is the collare of Kirby, who contends

* Hence MacLeay says, that in all future descriptions the four confluent dorsal pieces of the prothorax, which are almost invariably (at least in the Coleoptera, &c.) described as the *thorax* by the describers of species, should no longer be called the thorax, but the *prothorax ;* but this must surely not be correct, since the latter name would imply both upper and lower surface of the first thoracic segment, although the descriptions are applicable only to the tergum or upper surface of this segment. Burmeister has obviated the difficulty by proposing the term pronotum.

that it ought not to be regarded as a part of the pro-thorax. MacLeay, Burmeister, and others, however, give it as a portion of that segment, the former considering it as the scutellum of the prothorax, and observing that, as these insects are essentially fliers, this piece of the prothorax is employed to add strength to the mesothorax in its support of the upper wings.

The under surface of the prothorax, (T) 1, consists of a central piece or prosternum (antepectus K.), which is generally horny, and extends in a point between the fore-legs, as is especially the case in the spring beetles (*Elateridæ*), and two lateral pieces, which are very distinct in the predaceous beetles. These are the epimera and episterna of Audouin, and sometimes the ora of Kirby and Spence. In addition to the various horns or protuberances which arise from the prothorax, but which are only continuations of the external crust, there are several distinct appendages to be noticed. Of these, the legs are the most important, the basal piece of which often appears to form a constituent part of the prosternum, but is, nevertheless, moveable; the first pair of spiracles are also parts of the prothorax.

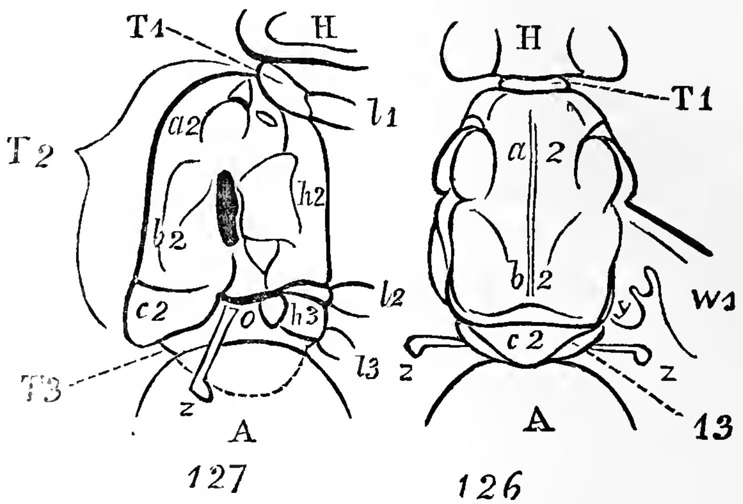


Figs. 124, dorsal view of the thorax of a wasp; 125, lateral view of ditto, lettered as in figs. 118—123.

Moreover, in some of the longicorn beetles there is a pair of moveable spines (umbones, Kirby and Spence), arising at the sides of the pronotum; and in lepidopterous insects there is a pair of scales covered with hair, quite distinct from the wing-covers (tegulæ), and which the same authors term patagia, or tippets; but which have been overlooked by all other authors except Chabrier, who first discovered them, or else confounded (as by Burmeister, p. 77), with the true tegulæ. They are described as vesicles appearing full of liquid and of air, and are placed at the sides of the pronotum.

2. *The Mesothorax* (*Prothorax,* Strauss-Dürckheim), T 2, upper, and (T) 2, under surface.—This is the second segment of the thorax (or the first of the alitrunk of Kirby and Spence), and bears the anterior pair of wings, or their representatives, and the middle pair of legs. In insects which have the four wings of equal size, the mesothorax and the metathorax (the following segment), are equally developed; but when, on the contrary, one pair of these organs is more particularly developed, the segment to which it is attached is consequently increased in size. If this pair of wings be the anterior pair, the mesothorax is greatly enlarged; this is, therefore, the case in the *Diptera* (fig. 126), where the mesothorax almost occupies the entire thorax. In the *Hymenoptera* (fig. 124), the second pair of wings exist, but of a smaller size than the fore pair; the metathorax is accordingly more developed than in the *Diptera,* but is smaller than the mesothorax. If we now look at those orders which have the second pair of wings enlarged, we find the mesothorax diminished, and the metathorax increased in size to a corresponding extent; this is the case in the beetles, but more especially in the extraordinary parasitic order, *Strepsiptera,* respecting which so much incorrect matter has been published.

The four pieces of which the upper side of each thoracic segment is typically composed, are sufficiently distinct in the mesonotum; the first, or the præscutum (*a* 2) (prophragma, Kirby and Spence); and the second, *b* 2, scutum (or the dorsulum, Kirby and Spence), are both distinct, but not conspicuous parts in the *Coleoptera*, in which order the third piece,



Figs. 126, dorsal view of the thorax of a Tabanus; 127, lateral view of ditto, lettered as in figs. 118—123.

(*c* 2), is very conspicuous, being the triangular part which is found at the base of the elytra, where they unite together, and is ordinarily termed the scutellum; but more properly the scutellum of the mesothorax or mesoscutellum. Some beetles, indeed, are said to be exscutellated, or destitute of scutellum; and so far as its occupying the ordinary exposed situation is concerned, they are exscutellated; but the same part is to be found in a diminished form in all these beetles.

In some few insects, as the *Scutelleræ* (*Tetyræ*), the scutellum is so much enlarged, that it completely covers the abdomen. The postscutellum of the mesothorax, (*d* 2) or the *frænum* of Kirby and Spence, is also distinct, but not very conspicuous, except by dissection.

In insects having the upper wings transformed into horny or leathery wing-covers, the mesoscutellum is very distinct and elevated, being evidently serviceable in giving some kind of support to these wing-covers. In insects with membranaceous wings, the mesoscutellum is not so conspicuous an organ.

The upper surface of the mesothorax is very variable in its consistence, according to the degree of exposure to which it is subject. Thus in the beetles, where it is almost entirely covered by the prothoracic shield, or by the base of the wing-covers, it is leathery or horny, with the exception of the exposed mesoscutellum. If, on the contrary, it is naked, as in the *Hymenoptera, Diptera*, &c., it is more solid in its construction. In the *Diptera*, the præscutum and scutum of the mesothorax are soldered together (see fig. 126, *a* 2, *b* 2), forming the larger part of the upper surface of the thorax; the scutellum (*c* 2) is also distinct. In the *Lepidoptera* the præscutum is also small, but the scutum (dorsulum, Kirby and Spence) very large and distinct. In the *Hemiptera*, as in the *Coleoptera*, the præscutum and scutum are covered by the pronotum. In the *Hymenoptera* the scutum and scutellum are similar to those of the *Diptera*.

The under surface, or the mesosternum, is generally horny, and extends between the middle legs, sometimes, as in some *Coleoptera* (*Elateridæ*), having an impression to receive the spine of the prosternum ; at other times, as in the *Cetoniæ*, the mesosternum itself is produced into a spine extending between the anterior legs.

On each side of the mesosternum extend the epimera and episterna of the mesothorax, the former being termed scapularia by Kirby and Spence; they are generally of small size, except in a few instances, such, for instance, as the *Cetoniidæ*, in which the former are very conspicuous, forming the horny plate intervening on each side between the shoulder of the clytra and the posterior angles of the pronotum.

In addition to the above pieces, the paraptera, or tegulæ, being the small scales at the base of the upper wings (see fig. 124, *o o*), which sometimes, as in some of the *Proctotrupidæ* (especially *Galesus,*) are of a large size, must be noticed. They also acquire a large size in the *Lepidoptera.*

The mesothoracic appendages are the anterior pair of wings, the middle pair of legs, and the mesothoracic spiracles. In dipterous insects the base of the wings is often furnished with a membranous scale, termed the alula or winglet, which Kirby and Spence regard, but incorrectly, as the true analogue of the second pair of wings, and consequently as attached to the metathorax (see fig. 126 y).

3. *The Metathorax,* T 3 upper, and (T) 3 under surface, (*Protrunk,* Kirby and Spence).—This is the last of the three thoracic segments (or the second of the thorax of Strauss, or alitrunk of Kirby and Spence), and bears the posterior pair of wings, or their representatives, and the third pair of legs. Its developement and consistence are variable, dependent upon the principles already stated to regulate the developement of the mesothorax. It consists of the same number of pieces as the preceding segment, the dorsal pieces (composing the metanotum), being the præscutum (mesophragma of Kirby and Spence in *Coleoptera;* postdorsulum of the same authors in *Hymenoptera*), scutum (postdorsulum of Kirby in *Coleoptera,*) scutellum (postscutellum and postfrænum of Kirby), and postscutellum (metaphragma, Kirby and Spence). The scutum and scutellum are the most conspicuous parts in *Coleoptera,* being channelled longitudinally. In *Hymenoptera,* (see fig. 124, T 3), the metathorax is reduced in size, and this is more especially the case in *Diptera,* (see fig. 126, T 3); but in the parasitic *Strepsiptera,* the fore-wings are very minute and twisted appendages, and the second pair of wings of very large size, the metathorax being so greatly increased in its dimensions that it may be almost said to constitute the entire thorax.

The under surface of the metathorax or the metasternum is generally a horny covering, divisible, like the mesosternum, into various pieces; of these, the central metasternum is generally the most enlarged portion: sometimes being produced into a point extending beneath the abdomen, as in *Hydrous;* sometimes it is flat, and occupies nearly the entire under surface of the metathorax; at other times, as in *Dyticus,* the posterior coxæ or basal parts of the hind legs (which are of a large size), are soldered to it, and hence the points of these parts of the hind legs have been often termed the bifid mucro of the metasternum (see fig. 123). The sides of the metasternum in the *Coleoptera* are laterally margined by a pair of longitudinal pieces, which are the episterna, or the parapleura, of Kirby and Spence. The construction of the various parts of which the metasternum is composed, would require too much minute description to be available in a work like the present: I shall, therefore, only further notice, that in winged insects having a pedunculated abdomen, Messrs. Audouin and Latreille consider that the piece which terminates the thorax behind is not a portion of the metathorax, but, on the contrary, is the basal segment of the abdomen. This opinion appears to me to have been successfully refuted by MacLeay and Burmeister.

The appendages of the metathorax are the posterior pair of wings, or their analogous organs, the third pair of legs, and the metathoracic spiracle.

It still remains to notice a curious apparatus, consisting of a ligament, which passes through a slit at the extremity of the postscutellum in the pedunculated *Hymenoptera,* (see fig. 124, 125, *x x,*) in the middle of which is an elevation of a horse-shoe form, having two apparent and one real central aperture. This ligament is termed by Kirby and Spence the funiculus, and is serviceable in elevating or depressing the abdomen.

I now proceed to the description of the *Organs of Lo-*

comotion; these are either wings, or their representatives, or legs.

1. *Wings, or the Organs of Aërial Progression.*

These organs, unlike the wings of birds, consist simply of a double membrane, of a very slender and generally transparent consistence, inclosing numerous nervures or veins of a firmer substance. These nervures are a kind of solid tubes, inclosing the tracheæ, or aëriferous vessels in their interior, of which I have already spoken in the account of the escape of the perfect insect from the pupa skin. Some appear, indeed, to be real veins.

These organs undergo very great modifications of form and structure in the different orders of insects; their number is also liable to corresponding variations; I say corresponding, because, as one pair of wings is sometimes so completely modified as to be no longer serviceable as an organ of flight, the number of these wings is necessarily reduced from four to two. These modifications occur either in the anterior or posterior pair of wings; thus in the *Coleoptera,* the fore-wings, although ample, are transformed into a pair of scales, serving for the defence of the wings, and unserviceable as instruments of flight. The same occurs in a greater degree in the *Strepsiptera.* In the *Hemiptera* (*Heteroptera*), the four wings are of a leathery structure at the base, but are membranous at the tip; whilst in the homopterous *Hemiptera* and *Orthoptera,* the upper wings are of a membranous nature, but much thicker than the lower wings throughout. In the *Hymenoptera, Neuroptera,* and *Lepidoptera,* all the wings are equally membranous. In the *Diptera* the fore-wings are alone to be found as organs of flight, the posterior wings being reduced to a pair of slender knobbed filaments. There are many cases in which the wings are totally wanting, as in the glow-worm, many *Orthoptera* and *Hemiptera,* &c.; but these are to be accounted only as casual exceptions.

The same may be said of many beetles, which have the elytra, or upper wings, soldered together; in which case, as wings would be useless, they are not given to the insect.

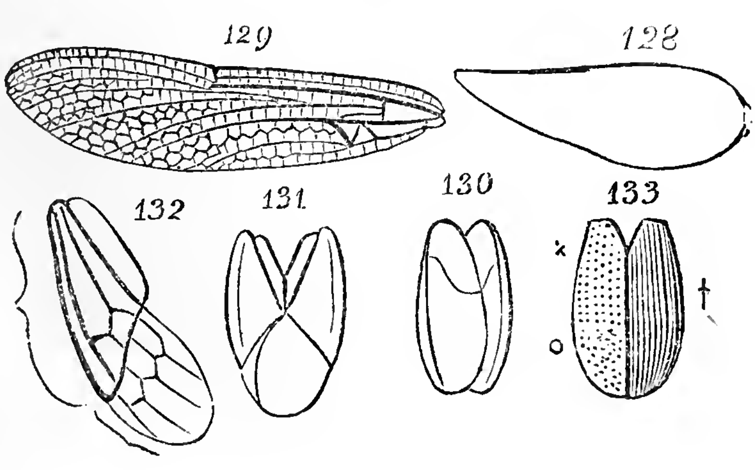
The only recorded instance in which the posterior pair of wings have been ascertained to be developed, without there being the least rudiment of the anterior pair, is found in one of the spectre insects (*Phasmidæ*), described in the last number of the Zoological Journal, under the name of *Aschiphasma annulipes*.

The wings arise respectively from the anterior lateral angles of the meso- and metathorax, articulating with the scutum and episternum, that is, just at the place where the dorsal plates of the meso- and metanotum unite with the lateral plates of the meso- and metasternum.

With respect to their consistence, the organs of flight may be divided thus:—

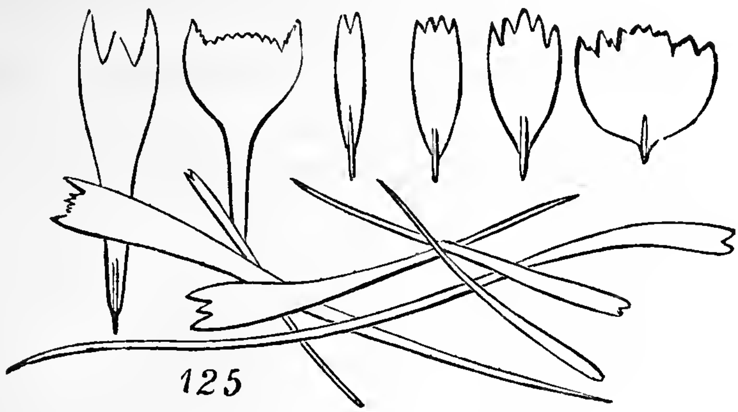
(*a*) Membranaceous wings.
(*b*) Tegmina.
(*c*) Hemelytra.
(*d*) Elytra.
(*e*) Halteres.
(*f*) Pseudhalteres.

(*a*) *Membranaceous Wings.*—It is by means of these membranous appendages that flight is chiefly effected, the other



variations of these organs serving more especially as organs of defence to the true wings. In their most simple form, as in some of the minute *Hymenoptera*, especially the genus *Psilus* (fig. 128), the wing consists but of the two layers of membrane, without any visible air-tubes, or veins, which, in the more advanced structure of the wing, are developed, dividing it into more or less numerous divisions, like the frames of a window. This formation is more and more complete, and the divisions more and more numerous, until we find the wing exhibiting a network of meshes too numerous to be counted; this is the case with the dragon-fly (fig. 129). In the *Hymenoptera* and *Diptera*, the wings are essentially similar in the construction; but the nervures, especially of the posterior wings of the former, are less numerous, forming but few spaces, or cells, as they are termed. The second wings of the *Hymenoptera* are smaller than the anterior, whilst in the dragon-flies, and some other neuropterous insects, they are of equal size. If, therefore, we regard the developement of wings as the chief characteristic of the *Ptilota*, or winged insects, those species which exhibit the wings of equal consistence and size, must be regarded as the types of the tribe.

The external margin of the posterior wings exhibits, also, in many insects with naked wings, minute hooks for retaining the wings on each side together during flight. These are especially found in the *Hymenoptera*, and are called hamuli. In the lepidopterous insects, another structure prevails for the like purpose; the margin of the posterior wing being furnished at its base with a long and curved bristle, which is received into a little hook on the under surface of the anterior wings, in which it plays. The wings in this same order offer another peculiarity, since, instead of being naked and transparent, they are clothed with a double layer of minute scales, somewhat resembling those with which fishes are covered. These scales, upon which the beauty of lepidopterous insects so entirely depends, are easily detached in the form of a fine dust, which, when examined with the



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Feather-scales from the Goat-moth.

microscope, are exceedingly variable in their form, but generally more or less wedge-shaped, or oval; sometimes toothed, or notched, at the broadest end, some having a slender foot-stalk. The membranous surface of the wing itself exhibits the appearance, when similarly examined, of numerous minute impressions arranged in lines, in which the base of the scales are planted, being laid upon each other like the tiles on the roof of a house. The derivation of the name of the order, *Lepidoptera* (scaly wings), expresses this character. It has been suggested, that the form of these scales might be serviceably employed in furnishing specific characters, for the determination of the various species of lepidopterous insects; but this is quite impossible, since scales of every possible form are found upon a single individual, as may be seen from the preceding figures, all of which represent scales from the goat-moth.

Here it will be serviceable to notice a few of the more characteristic variations which occur in the markings of the wings of lepidopterous insects (see fig. 134); these are,—

Spots (*Maculæ*), which are patches of one colour appearing on the differently coloured wings (134, *a a*).

Dots (*Atomi*), which are very minute points of a different colour; when scattered over the entire surface of the wings they are said to be irrorate (*b*).

Puncta, gutta, pustula, and plaga, are words used for spots of various sizes.

Lines (*Lineæ*), narrow, generally straight marks of different colour (*c*).

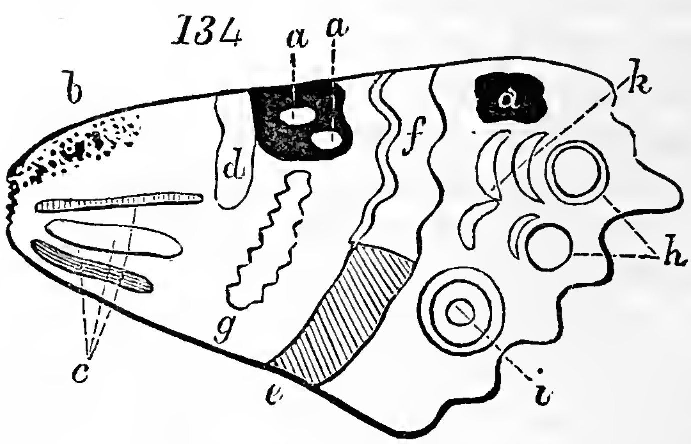
Streaks (*Strigæ*), somewhat broader lines, generally transverse (*d*).

Bands (*Fasciæ*), broad transverse marks (*e*).

Vitta is a longitudinal fascia.

The four last terms are said to be undulated when alternately curved like waves (*f*), and dentated when toothed (*g*).

Annulets (*Annuli*), ring-like marks (*h*).



Imaginary wing of a Butterfly.

Eyelets (*Ocelli*), circular spots upon a differently coloured wing, with the centre also differently coloured (*i*); the latter is termed the pupil (*pupilla*), and is surrounded by the iris.

Lunulets (*Lunulæ*), crescent-shaped marks (*k*).

Adjectives derived from these words are employed in describing lepidopterous and other insects. Thus we have such words as maculated, fasciated, ocellated, &c.

In the caddice flies, the wings are clothed with fine hairs, whence the name of the order given to them by Kirby, *Trichoptera;* the wings of the gnat are also beautifully ornamented with scales along the nerves of the wing. These organs, in a general sense, are of an elongated triangular form, the longest side being the exterior, or anterior, margin; the opposite angle is the posterior, or internal, angle; the side between the base of the wing and this angle, is the basal margin; or, in the posterior wings, the anal margin; the other side is named the apical, or terminal, margin. There is, however, the greatest diversity in the shape of the wings, especially the posterior pair in the *Lepidoptera;* some are notched, and many terminated by one or more long tails. A small group of moths have been termed *Plumes,* from the wings being divided into numerous feathers, the divisions extending to the base of the wing; some are five-plumed, and others twenty-plumed.

Adjoining the external margin of the wings, at some distance beyond their middle, a callous point is to be observed, formed by the union of the nervures of this anterior or costal margin, which is termed the stigma.

In the orders *Hymenoptera* and *Diptera* the form of the cells, originating in the nervures arising from the stigma, has been much employed in distinguishing the various groups of insects. That it is, in certain families, highly important, cannot be doubted; but we must not rely implicitly upon it as an absolute character, since many groups, having very different habits, and varying in other important characters, are identical in the neuration of their wings. The credit of having selected these variations in the form of the cells, as affording good generic characters, has ordinarily been given to Jurine, a celebrated Swiss entomologist, who arranged the *Hymenoptera* in accordance therewith. Frisch, however, a German, and Harris, an English author, had long previously made use of the same characters.

In general, membranous wings remain expanded at all times to their full extent: but this is by no means a constant character. Thus in the *Hymenopterous* family of the wasps (*Vespidæ*), and the species of the genus *Leucospis*, they are folded throughout their whole length when unemployed. In the *Lepidoptera* the same occurs in the family of the plume moths, already mentioned. The second wings of orthopterous and homopterous insects are also longitudinally folded beneath the wing-covers; and the wings of coleopterous insects are folded both longitudinally and transversely when unemployed. The posterior wings of the earwig are similarly folded, the nervures, when the wings are extended, forming a most beautiful object. The position of the wings when shut afforded to Linnæus the chief character by which he divided the moths into various sections. Thus they were said to be depressed, deflexed, horizontal, extended, divaricate, &c.

Some lepidopterous insects appear to have six wings, and have hence been specifically named *Hexapterata*, &c., forming the genus *Lobophora* of Curtis; a name indicative of the real character of the wings, of which the posterior pair are furnished with a large membranous lobe.

It still remains for me to mention a small membranous appendage connected with the base of the wings in the majority of dipterous insects, to which the name of alula, or winglet, is generally given, consisting of two concave and convex membranes united together, and surrounded by a fine fringe, which fold over each other like the valves of a bivalve shell, and upon which I have seen the halteres act, in a manner similar to a drumstick beating on a drum. Kirby and Spence regard them as analogous to the posterior wings; but they are decidedly parts of, and connected with, the large wings. Somewhat similar organs have been noticed in the large water-beetle, *Dyticus marginalis;* I have also found them equally developed in the *Hydrous piceus,* at the base of the elytra.

(*b*) *The Tegmina.*—This term was proposed by Illiger to designate that variation of wings, in which the substance is intermediate between the true membranous wings and the hard coriaceous elytra. To the substance, of which these kinds of wings are composed, Kirby and Spence gave the name of pergameneous, as somewhat resembling parchment, or vellum; and the *Orthoptera* and *Homoptera* are the only insects which exhibit this kind of wing, or rather wing-cover, since the posterior wings in these orders are membranous. From elytra, the possession of very numerous nervures sufficiently distinguishes the tegmina, whilst their thickened substance equally separates them from the membranous wings. Tegmina are also distinguished from elytra by the inner edges, or anal areas folding over each other, instead of meeting in a line down the back (see fig. 130, tegmina of a *Blatta*). Like many (or rather, theoretically, all) membranous wings, tegmina are divisible into three areas, separated from each other by strong longitudinal nerves; the external or costal, the intermediate, discoidal or apical, and the anal. The position in which these organs are placed in repose, varies according to the form of the body. Thus in flat insects they are horizontal, but in thick or compressed insects they are deflexed at the sides, sometimes at a considerable angle. We have seen, that in insects having the mesothoracic scutellum very prominent, the anterior organs of flight are more or less horny, and of very little service in locomotion, requiring some kind of support, which is afforded by the scutellum. They are thus circumstanced in beetles, and in the heteropterous *Hemiptera;* but in the tribes in which tegmina are present, the scutellum is not a prominent organ; they are therefore more essentially organs of flight than elytra or hemelytra, which we now proceed to describe; commencing with the former, as being intermediate in their formation between tegmina and elytra.

(*c*) *The Hemelytra* (see fig. 131, 132, hemelytron of *Heterogaster urticæ*).—Under this name, Latreille described (*Hist. Nat. Crust.* &c., ii. p. 164) the anterior organs of flight of the *Cimicidæ,* or heteropterous *Hemiptera,* the basal portion of which is thick, opaque, and coriaceous, and the terminal part thin and membranous; the transition between the two kinds of membrane not being gradual, but sudden. The wings covered by these limbs are membranous, and of the size of the hemelytra. On examining an hemelytron, the three areas of which wings and tegmina are composed are here distinct; but they do not extend beyond the corium (or basal coriaceous part); hence the apical membrane seems a piece added to the ordinary structure; sometimes being, in fact, absent, although the corium is distinct. In some instances, the entire hemelytra are formed of membrane, or rather the substance of the corium is so much diminished that it resembles the apical membrane. When at rest, the apical membrane of one hemelytron folds upon that of the other, and the position is usually horizontal. As to their neuration, the basal corium, as may be conceived from its similarity to the substance of the elytra, is generally almost destitute of nerves; but the apical membrane differs in having more or less numerous nerves, which serve for the distinctions of genera and sub-genera.

(*d*) *Elytra* (see fig. 133).—This is the name given to the hard scaly or horny wing-covers, or anterior wings of beetles;

they are thickened opaque plates, generally carried, when the insect is not on the wing, in a horizontal position upon the back, with the internal (or anal) margin (or suture, as it is technically termed) straight, and in the direction of the middle line of the body. They are destitute of nerves, and are internally lined with a thin membrane. As to their consistence, they are variable, although generally very hard and horny; sometimes even so firm as to be with difficulty pierced by a pin. In other instances, however, they are flexible, or elastic, yielding to pressure; and in others, even soft, varying according to the variations in the consistence of the body. As to their form, they are generally in the figure of an oblong square, having the posterior angles more or less rounded; at other times they are more triangular, oval, or even almost hemispheric. Sometimes they entirely cover the abdomen; at others they leave the extremity of this part exposed; and sometimes, as in the *Brachelytra*, they are very short. As to their surface, they are flat, convex, gibbose. They are also variable as regards their clothing; some being quite naked, others hairy, woolly, silky, spiny, squamose, and rugose, like shagreen, or with impressed or elevated spots, either placed irregularly (fig 133, *o*), or disposed in lines (*Lineato-punctate*, fig. 133, *x*), or with impressed lines (*Elytra striata*, fig. 133, †). Their colours are very variable, according to the habitation of the insect. Thus beetles, living in dark places, under ground, and stones, &c., are generally black, whilst those which are exposed to the light are more variegated in their tints. As already observed, these organs, during flight, are but little serviceable as locomotive instruments; and unless it were for the manner in which they are carried at such times, it must be evident that, from their size and substance, they would necessarily present a great obstacle against quick motion in the air; but this is provided against by their being carried either in a horizontal direction, where they are extended laterally, or in a vertical position, where they do not extend laterally (as in the burying beetles, *Necrophorus*). Ordinarily, as their name imports, they cover the wings; but in some beetles the wings are not thus defended, owing to the small or irregular form of the wing-covers. In the *Brachelytra*, however, in which the elytra are of the least size, and the wings large, they possess their ordinary function, the wings being very much folded. In some beetles the wings are entirely wanting; and here the elytra are firmly soldered together, thus becoming a defence for the abdomen, the upper surface of which is, in such cases, soft and membranous.

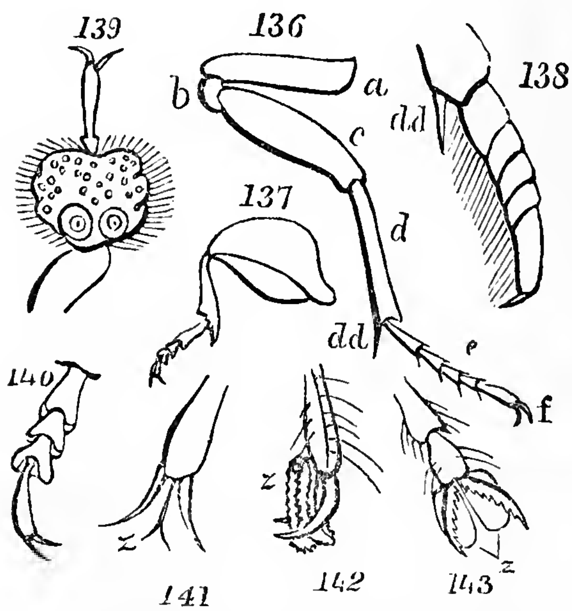
(*e*) *Halteres* (see figs. 126 and 127, *z z*).—These organs, which are usually termed balancers or poisers, are a pair of short threads arising behind the base of each of the wings in the *Diptera* (to which order they are exclusively confined), and terminated by a small oval or triangular knob. These organs are capable of a very rapid motion; and it has been usually supposed that by their beating upon the winglets (alulæ), they produce the humming noise so distinctly heard in this group of insects during flight. That they do thus beat upon the winglets, I have already observed; but it appears doubtful whether this action be the cause of the sound in question, because those *Diptera* which do not, either by nature or artificially, possess winglets, make a buzzing noise. The same is also the case with the bees and other *Hymenoptera*. Other naturalists have supposed the noise to originate in the motion of the wings themselves, or (with more probability) in the rushing of the air through a spiracle near the base of the halteres; in which case, the sole use of the halteres will be as poisers to keep the body steady in flight. Thus Schelver cut off the halteres from a fly, and found that it could no longer fly; hence (and from other circumstances) he considered that the halteres are connected with respiration. For this reason, apparently, Kirby and Spence have regarded these organs as not being the analogues of the lower pair of wings, but as organs per se; an opinion likewise maintained by Latreille (*Cours d'Entomol.*, p. 241*) Their insertion upon the metathorax, in a position with reference to the metathoracic spiracle analogous to that of the lower wings of *Hymenoptera*, together with their occurrence in an order where only two mesothoracic wings are developed, are reasons amply sufficient to induce me (regard being especially had to the law of relative and proportionate developement already alluded to, in speaking of the variation in the size of the thoracic segments) to consider the halteres as analogous to the second pair of wings, and not as anomalous appendages.

(*f*) *Pseudhalteres* (*præhalteres,* Latreille). — I have applied this name to a pair of organs somewhat similar in their construction to the halteres, but placed in front of the wings, in the order *Strepsiptera*, a name signifying twisted wings, and proposed by Mr. Kirby for the extraordinary group of bee and wasp parasites, in allusion to this pair of narrow, elongated, curved, and channelled processes, which (notwithstanding the observation of Mr. F. Bauer, that they were connected with the fore-legs,) he regarded as analogous to elytra. Subsequent authors, however, doubted this analogy, and Latreille changed the name of the order to *Rhipiptera*. More recent observations have, however, demonstrated that these organs are attached to the mesothorax, which, as well as the prothorax, are extremely short; and that the large pair of fan-shaped wings are representatives of the lower wings of the *Orthoptera*, which are folded longitudinally in a similar manner, although the structure of the thorax is very different. Latreille, however, regards these organs as ana-

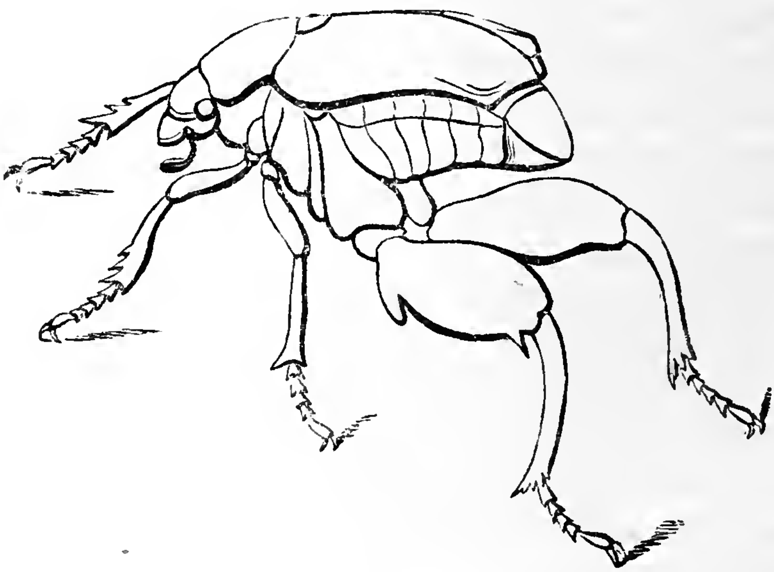
* Latreille consequently also regards the winglets as the true analogues of the lower wings, although he admits that "ils me semblent néanmoins partir d'un point un peu plus élevé que les ailes."

logous to the mesothoracic tegulæ, or basal wing-covers, of the *Lepidoptera.* He likewise considers them as somewhat analogous to the lateral prolongation of the prothorax, observed in some species of *Psychodæ* and *Scenopinus* (dipterous genera). As already observed, however, they have been demonstrated to be the only mesothoracic appendages found to exist in these insects (the wings being metathoracic); consequently they must be regarded as analogues of the mesothoracic organs of flight. During the short time that these insects live in the winged state, the pseudhalteres are observed to quiver very intensely.

2. *Legs, or the Organs of terrestrial or aquatic Progression.*—If we have found the organs of flight constructed in a manner totally unlike those of birds, we shall discover equally great differences in the construction of their legs. Thus, whilst the former are provided with but a pair of organs for progression on the land, winged insects have three pairs, spiders four pairs, crabs five pairs, and centipedes and millipedes more than a hundred legs. These organs arise from the sternum of the various segments of the thorax in the true insects, and are employed not only in walking, running, creeping, and climbing, but also in running and swimming, as well as in various operations connected with their economy. They consist of a series of tubular joints, formed of a similar substance with the remainder of the external parts of the body, and



are provided with internal muscles and nerves. The joints have received a series of names analogous to those of the legs of the higher animals. They are the coxa, trochanter, femur, tibia, and tarsus. The *coxa* (136, *a*) is the basal joint articulating with the sternum, and very variable in form. The *trochanter* (136, *b*) is a very small piece connecting the preceding with the thigh or *femur* (136, *c*), which in general is the thickest part of the leg, and in leaping insects greatly thickened, and sometimes toothed beneath. The next piece is the shank or *tibia* (136, *d*), a piece generally somewhat shorter and more slender than the femur, and often gradually thickened towards the tip, where it is armed with one or two spurs or spines (*calcarea*, 136, 138, *dd*), varying in their number and size in adjacent groups. The terminal part of the leg is termed the *tarsus* (136, *e*), divided into several joints, never exceeding five, which is the number always found in the majority of insects with membranous wings, undefended by wing-cases. In many beetles the number is variable, from two to five, and the same is the case in the *Neuroptera*, &c. The under surface of these tarsal joints is generally clothed with short hair or down, often forming a kind of cushion or brush; sometimes, also, the under-side exhibits several small circular membranous plates or soles (fig. 139, fore tarsus of a male *Dyticus*). The penultimate joint is also often divided into two lobes, and the terminal joint is also generally terminated by two small bent hooks (*ungues*, 136, f), between which, in many insects, there are one, two, or three small, often membranaceous, appendages, termed *pulvilli* (fig. 141, 142, 143, *z,z,z*). In some coleopterous insects the penultimate joint is very minute (fig. 140). Messrs. Kirby and Spence regard the fore-legs of insects as arms rather than legs, and accordingly term the anterior tarsus the hand, calling the basal joint the planta or palm. That the fore-legs are highly important in performing the economy of the insect cannot be doubted; they are also often of a very different form in the individuals of different sexes of the same species. They are often formed for seizing the prey of the insect, and are then called raptorial (*pedes raptorii*), the thigh being thickened and spined, and the tibia closing upon it. The hind legs are also often peculiarly organized, as in the bees, where they are pollinigerous (*pedes polliniferi*), or in the grasshoppers, &c., where the femora are greatly thickened, and used in leaping (*pedes saltatorii*, fig. 137).* Occasionally the hind legs are greatly enlarged, but the insect is not saltatorial, as in the *Chrysina chrysochlora* (*Melolontha chrysochlo-*



ra, Latreille). In some other insects they are terminated by a broad, flattened, and strong ciliated tarsus, admirably formed for swimming, as in the water-beetles (*pedes natatorii*, fig. 138). The tibia in the anterior legs are often dilated and notched on the outer edge, as in the mole cricket. These legs thus become proper for burrowing (*pedes fossorii*). In

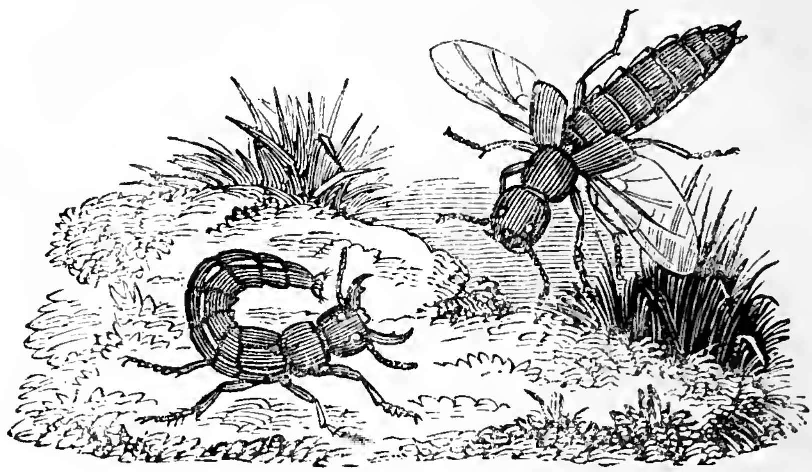
* I may refer to the article CERCOPIDÆ, in the British Cyclopædia, where I have entered into various details relative to this subject.

some lepidopterous insects, especially amongst the butterflies belonging to the family *Nymphalidæ*, the fore-legs are very short and rudimental, the tarsi being almost obliterated, and quite unfitted for walking. In some insects the various parts of the leg fold upon each other when unemployed, and are then received into certain channels prepared for their reception on the under side of the thorax. This is the case with the pill-beetles (*Byrrhidæ*), mimic-beetles (*Histeridæ*), &c. As regards the relative proportions of the legs of insects, the general rule is, that the anterior are the shortest, and the posterior the longest; and as regards their length, the shorter and more robust the body, the shorter are the legs, and *vice versâ*. In running insects, also, the legs are longer than in those which crawl. Generally, the legs do not much exceed the body in length, but occasionally they are much longer. As regards their direction, the anterior legs are generally directed forwards, and the four posterior backwards. It would, however, occupy far too much space were we to enter into a detailed notice of all the variations in form which occur in the legs of insects.

C.—*The Abdomen, or the Seat of the Organs of Generation.*

We have now arrived at the third and last principal division of the body, which incloses the greater portion of the intestines, the organs of generation, and their appendages. Unlike the preceding part of the body, the abdomen, from being destitute of locomotive organs, necessarily exhibits a much less complicated organization in the various segments of which it is composed than those of the thorax, and typically consists of nine segments, exclusive of the anal apparatus, each being composed of two arcs, or half segments, one upper and the other under. These rings are attached together by membrane, and either meet at the edges, or slide into each other like the tubes of a telescope. The dorsal ones are termed the back (*dorsum*), and the ventral ones the belly (*venter*). We have already seen that, in the larva state, several segments exist which are not found in the imago; and the examination of the abdomen in various insects clearly proves, that these last segments are abdominal ones. Thus, if a male earwig be examined, it will be perceived that there are nine distinct abdominal segments, exclusive of the anal forceps; but, in the female it will be perceived, that although, with great care, the nine segments be discoverable, two of the terminal ones have assumed a rudimental appearance. The abdomen of some beetles exhibits a curious character in this respect. Thus in *Carabus*, if the under surface of the abdomen only be examined, it would appear that there are but five abdominal segments; but if the back of this part be viewed, nine joints will be discovered: another peculiarity exists in the stinging *Hymenoptera*, in which the males have seven and the females only six abdominal segments. The union of the abdomen with the thorax is effected in two different modes in the different groups. Thus, in all insects which have the wings defended by wing-covers, *hemelytra*, or *tegmina* (beetles, bugs, tree-hoppers, &c.), as well as in many insects with entirely membranous wings, the base of the abdomen is as large as the extremity of the metathorax, and is united to it by membrane throughout its entire breadth or circumference, in which case the abdomen is said to be sessile. In the hymenopterous order, the saw-flies and *Siricidæ* are distinguished by this character from the other tribes. In the other mode, the abdomen is connected with the thorax only by a slender portion of its base, and this is the case with those insects to which I have alluded in the account of the curious apparatus for elevating the abdomen, in describing the metathorax. Insects thus distinguished are divisible into two sections; first, those in which the union is effected by a very short piece, and the abdomen is as broad as the posterior part of the thorax, so that, as in the hairy-bodied bees, it appears to be affixed by its entire breadth; and, second, those in which the connecting piece is elongated into a peduncle, and the base of the abdomen itself is narrow. This is the case with many exotic wasps, sand-wasps (*Ammophila*), &c. In the latter division the abdomen is said to be pedunculated or petiolated. The peduncle itself is liable to great variation. Thus, in some ants, it consists of two knots (*petiolus binodosus*); in others only of one. Sometimes it is disproportionately long; at other times it is saucer-shaped, bell-shaped, &c.

Of the shape of the entire abdomen little in general can be said. It is, however, more generally triangular, ovate, or quadrate, with the posterior angles rounded off; generally, too, the upper surface is more or less depressed; sometimes it is very short, at others disproportionately long; sometimes wider than the thorax, but more commonly narrowed. The extremity of the abdomen is generally pierced by the anal aperture. The terminal segment is very variable in its form, being formed with reference to the coupling of the insects, or to facilitate the deposition of the eggs in appropriate situations. Sometimes, also, it is organized in a manner to become an instrument of defence or offence. The various organs to be noticed below form part of this segment. It still remains for me to notice the motions of this part of the body. Unlike the thoracic segments, which, from bearing the organs of locomotion, are necessarily required to be as firm as possible, and are not, consequently, capable of much distinct motion, the abdominal segments being destitute of such organs, and having important functions to perforn, are, on the contrary, gifted with a considerable but variable degree of motion. Thus, in those species which have the extremity of this part of the body furnished with offensive or defensive instruments, it is capable of very considerable movements in every direction. This is the more noticeable in insects which have a very much elongated abdomen; as, for instance, the earwig, the *Staphylinidæ*, &c. Insects which, on the contrary, have the ab-



Gærius olens.

domen short, and especially those in which it is defended by the wing-covers, possess but very little power of motion in this part of the body. Another circumstance, also, has much influence in the same respect; when the segments of the abdomen simply touch each other at the margins, the motion is very limited; but in those which have the abdominal rings formed to slide into each other, the motion is much more extensive.

The organs of generation (with the exception of those of the male *Libellulæ*, which have been considered to be placed beneath the first abdominal segment) are situated at the extremity of the abdomen.

As the sexes of insects are distinct, and coupling requisite for the continuance of the species, it is essential that the males should be furnished with organs for the elaboration and discharge of a fecundating fluid, and the females with organs proper for its reception, for the developement of eggs, and for the deposition of these eggs in the most convenient situations. The last-mentioned organs (which are by far the most conspicuous of the generative organs) are of very varied construction, the saws of the saw-fly, the long ovipositor of the ichneumons, the sword of the grasshopper, and the sting of the bee, exhibiting some of their chief modifications. Besides these, the extremity of the abdomen is sometimes furnished with additional appendages, such as the forceps of the earwig, common to both sexes, but considerably larger in the male than the female), and of the scorpion-fly (*Panorpa*), in which it is only found in the male: the long and slender threads of the may-flies (*Ephemeræ*), which seem to be of service to these insects in their alternate rising and falling flight, being brought into contact when ascending, but expanded during the descent; other shorter and broader appendages are found in the dragon-flies, cockroaches, spectre-insects, &c. Sometimes these appendages are articulated, in other insects simple and entire.

We have now brought our review of the external organization of insects to a close. That it has extended to a considerable length I am aware, and that it must be, to a certain extent, comparatively uninteresting to many readers, I much fear; but it appeared impossible to dismiss the subject at shorter length, consistent with the increased number of organs exhibited to us by insects, and which so far exceed those of the higher animals. I have endeavoured, as far as possible, to keep clear of those minute details which may be said to have reference to a specific instead of a general sketch of Entomology. I have, therefore, in the next place, to direct attention to

Sub-section 2.—The Internal Anatomy of Insects.

Having already stated that the skeleton (upon the variations of which much importance is placed in the higher animals) is in insects external, we at once perceive that our labours on arriving at the internal anatomy of the latter are considerably diminished.

This, indeed, is one of the chief charms of this branch of zoology; for whilst it is almost impossible to preserve other invertebrated animals, except in spirits, and the vertebrata, except by stuffing the skin, whereby the form of the body is entirely dependent upon the fancy of the person who "puts up" the specimen, insects, in almost every instance, preserve their form and colour with a freshness often quite equal to the life. It remains for me, therefore, to notice (which I shall do in the most concise manner) the internal systems of sensation, digestion, circulation, respiration, motion, and generation.

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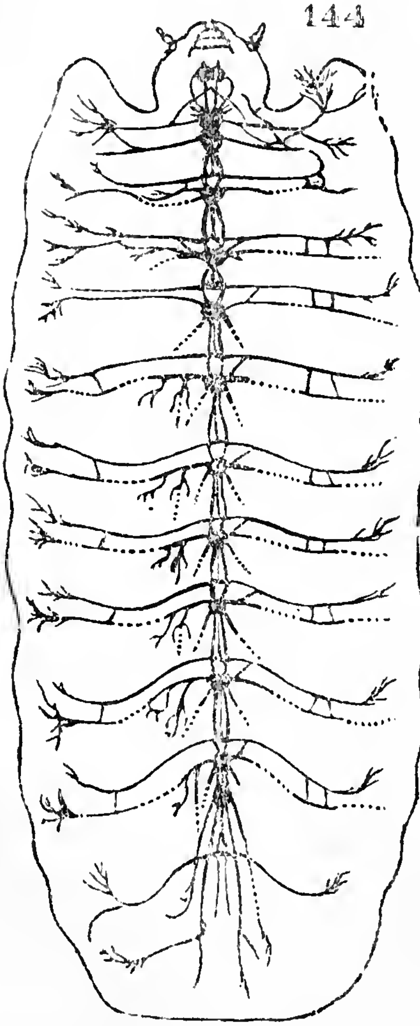

Nervous system of the Caterpillar of the *Cossus ligniperda*. The dotted lines indicate the situation of nerves concealed by the incumbent muscles.

A. *The Sensitive or Nervous System.* — The chief means whereby the intercourse of animals with the external world, by the instrumentality of the senses, is maintained, is the nervous system, originating in the brain or the spinal cord.

Hitherto this branch of our subject, and indeed the internal structure of insects in general, has received too little attention from entomologists, of whom we are compelled to say, that mere external form and the collecting of specimens occupy their chief attention. Swammerdam was the first author who carefully traced the nerves of several insects, as the bee, the silkworm, and the *Oryctes nasicornis*; but Lyonnet was far more elaborate in performing the same operation in the caterpillar of the goat-moth. More recently Strauss-Durckheim, L. Dufour, and Burmeister, and especially, with reference to its gradational modification at various periods, M. Herold in the white butterfly, and our own countryman, Newport, in the *Privet Sphinx*, have laboured assiduously in the same field.

In insects, as in the other articulated animals, this system is quite unlike that of the higher animals, and consists of two medullary cords or threads, exhibiting a series of knots or ganglions, whereby they are united together at certain distances, occupying the lower surface of the internal part of the body, and being defended from the action of the thoracic sternums by the internal Y-like processes above described, as the pro-, meso-, and metathoracic furcæ. Sometimes the two ganglia of each segment are more or less distinct, and sometimes they are united together side by side, occupying the medial line of the body; and the same occasionally occurs with the communicating threads themselves. The nervous ganglia or knots are placed at more or less equal distances from each other throughout the entire length of the insect, sometimes, indeed, so close, that they constitute but two or more ganglia. This is the case in the perfect state of the hemipterous insect, *Ranatra linearis*, for a figure of which I am personally indebted to John Anderson, Esq., of Richmond, by whom a most elaborate series of preparations of the nervous system throughout the entire range of the animal kingdom has been made, in illustration of a very valuable paper recently published by him with reference to the remarkable analogies exhibited by the human embryo in the various

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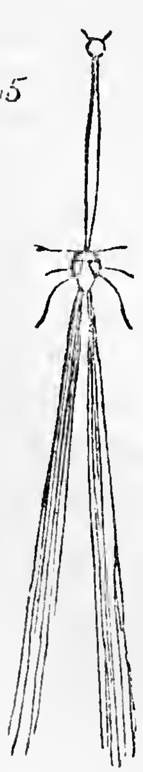


Nervous system of Ranatra linearis.

stages of its passage to perfection, with the perfect state of the inferior animals.

In the larva there are thirteen knots, corresponding with the number of rings of the body; but these organs, like the other internal systems, are modified during the passage to the perfect state. Thus Dr. Herold, in his celebrated work upon the Internal Anatomy of the White Garden Butterfly, ascertained, as the larva approached maturity, that the second ganglion became united with the first; the fifth and sixth approach and unite, then the third and fourth, whilst in the pupa the seventh and eighth have entirely disappeared; so that, instead of thirteen, the imago possesses but eight ganglia.

On examining the invertebrated, or rather the externally vertebrated structure of an insect with that of the internally vertebrated animals, we find no part corresponding with the brain; or rather the organ which in the former might be regarded as analogous thereto, and which, indeed, has been called the brain, namely, the ganglia of the head, is repeatedly represented along the entire length of the body: consequently it has been supposed that the nervous cord of the insect represents the great sympathetic nerve of the latter, although, perhaps, it would be more correct to regard it rather as the spinal cord.

The matter of which the nerves are composed is a soft pulpy substance, inclosed in a simple and transparent membrane.

The first pair of ganglia is always situated in the head of insects, above the digestive canal, and is furnished with nerves extending to the eyes, antennæ, mandibles, maxillæ, and labrum. The other ganglia are lodged in the thorax and abdomen, or in the former alone, and similarly placed above the alimentary canal; the two thick nervous filaments connecting the head ganglia with the prothoracic ganglia are deflexed, so as to surround the œsophagus, forming a kind of nervous collar. From the thoracic and abdominal ganglia are emitted nerves which communicate with the legs, wings, and other organs of the body. In the larva of the goat-moth, Lyonnet counted forty-five pairs of these nerves, besides two single ones, thus making a total of ninety-two, which is considerably more than are found in the human body, namely, seventy-eight.

In the vertebrated animals the nerves proceed from the brain, which is inclosed in the head; in insects, on the contrary, we have seen that nerves proceed from the various knots, whether belonging to the head, thorax, or abdomen; hence we might analogically call the various ganglia and their connecting filaments an elongated brain. In the vertebrated animals sensation originates in the brain; and hence, from the concentration of this organ into one mass (for so we may call it, although divided into two lobes), sensation is more concentrated, and the feelings rendered highly acute. In insects, on the contrary, owing to the want of concentration of the nervous ganglia, sensation is necessarily much less acute; and, as the nerves laterally emitted by one ganglion generally serve for the segment of which it forms a part, the connexion with the preceding or subsequent ganglia being at the same time slight in proportion to the slightness of the connecting filaments, we are enabled satisfactorily to account for the apparent want of sensation in insects, as exhibited, for instance, by the cockchafer, which will walk about, although some bird has nearly emptied the body of its viscera; or by the head or abdomen of a wasp, which will continue to bite or sting long after they have been separated from the rest of the body; or by the headless trunk of a male mantis, which has been known to unite itself to the other sex, as recorded by Dr. Smith, and quoted by Kirby and Spence. Another instance is recorded by the Rev. Mr. Bird, in a memoir published in the Entomological Magazine, intitled, "On the want of Analogy between the Sensations of Insects and our own."—"When I was young in entomology," observes this kindly-hearted writer, "I wished anxiously to find the quickest mode of killing an insect. Having captured a pretty beetle (*Malachius æneus*), it struck me that by cutting it in two at the junction of the thorax and abdomen, the part which gives rise to the name insect (*Insectum*, Εντομον), I should kill it in a moment. I took a pair of scissors and divided it: the parts fell on a piece of white paper which lay before me. Far from being dead in an instant, I was grieved and surprised to see the head, with the two fore-legs attached to it, begin to run about the paper. It occasionally stumbled, but rose again, and exhibited, if I may so speak, perfect self-possession. It made for the edge of the paper; but arriving there and looking over it, seemed to think it too precipitous, and so coasted along in quest of an easier descent, which, nevertheless, it did not seem able to find. This coasting and searching for a convenient place of descent, suited to its curtailed condition with respect to legs, of which it appeared perfectly aware, occupied the head incessantly. I regarded it with astonishment—'Here, then,' I said to myself, as I watched its motions, 'here lies the vitality of an insect: the body at any rate is dead.' But in this I was quickly undeceived, for in about a minute after the body had fallen upon the paper, I saw the hind-legs brought upward, and employed in deliberately brushing and cleaning the wing-cases, exactly as a house-fly may be seen to clean its wings on a window pane. The legs were then withdrawn, the cases raised up, the true wings expanded from beneath, and all made ready for flight, which, indeed, I expected to see; but the body seeming then to become aware that there was no guide, the head, its former companion, being in possession of the eyes, the design was abandoned, the wings folded up in their usual beautiful manner, and the attitude of rest again assumed. This whole process was repeated with perfect regularity at intervals of about a minute, if I rightly remember.* A more perfect act of a sentient creature could not be exhibited: the head continued to run about, and the body to clean and expand its wings, the one for about twelve and the other for sixteen hours, their energies gradually decaying, till they appeared to perish, or rather to sleep. And now, I ask, which was the beetle?—Where was the original creature?—Had not the head and the body an equal right to be taken as its representative?—Is not all analogy between insects and ourselves destroyed by such a phenomenon?" And in the same view of the subject it has been considered better to consider each nervous ganglion as a separate and independent centre of volition. But surely we have no authority for adopting such a view, the ganglia being united together, and the insect constantly dying when thus divided, instead of each portion forming itself into a new being, like the planaria and some other invertebrated animals.

The nerves, as before observed, form the medium whereby the notice of the various transactions of the external world is conveyed to the seat of the instinctive or intellectual organs. The perceptions thus obtained constitute the senses,

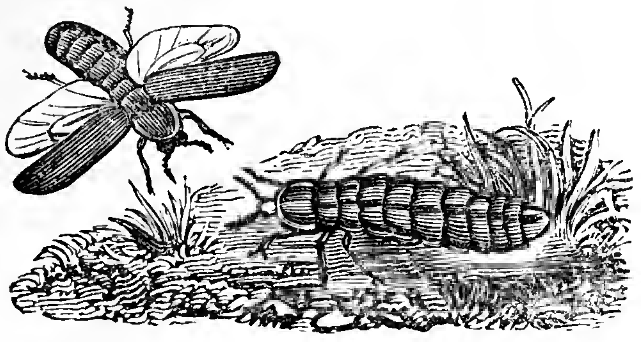
* This fact apparently controverts the conclusion of Burmeister, that after the separation of the nervous cord at any part, the voluntary motion of the organs seated beyond the point of incision is lost, but that the irritability of the muscles—that is to say, their power of reaction upon external excitement—is retained by these organs as long as life remains. I say apparently, because when the increased size of the muscular system of the wings in Malachius, which is a strong flier, is considered (just as in the swimming motion of the hind legs in a Dyticus deprived of its anterior ganglia, recorded by Burmeister, and in which the muscles of the hind legs are very greatly developed), the unfolding and folding of the wings may be explained, without reference to instinct supposed to be possessed by this remnant of the body.

of which *sight, hearing, smell, taste,* and *touch,* are those which are generally allowed to prevail. Some physiologists (Dr. Virey, &c.) add to these, *love,* and the internal sense of *thought* or *instinct.* The former of these, as a perception distinct from the mere physical act of propagation, can scarcely be allowed to insects. In this point of view the subject cannot be discussed in a work like the present. The instinctive powers of insects also appear to me to be on a very different footing compared with the other senses. I shall, therefore, defer my observations thereon to the subsequent section.

That insects possess several of the senses is certain, but the seat of these senses is not ascertained; neither can we, by any possibility, arrive at a certain conclusion that the senses of these animals are identical with our own,—their entire organization having been shown to be so totally different from that of the vertebrated animals. Indeed, as Mr. MacLeay has observed in the Horæ Entomologicæ, there is no reason why animals constituted upon a plan so totally unlike our own should not possess senses of which we have no idea. I will, however, adopt the general opinion, and speak of the senses of insects as analogous to our own, the consideration of which will form so many distinct sub-sections.

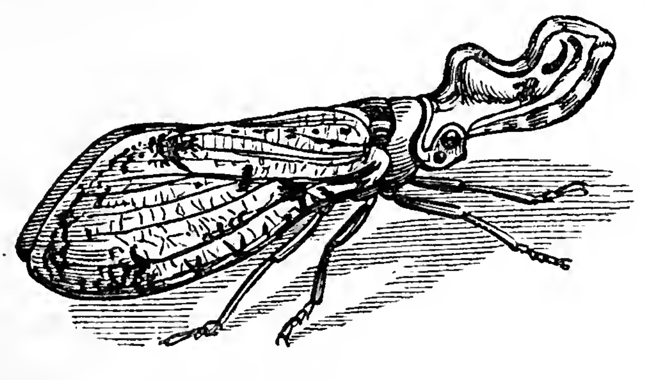
(*a*) *The Sense of Sight.*—The eyes of insects are the only organs which we can with any certainty refer to the sense of which they are the seat. We have already described the external structure of the eyes, and ocelli or eyelets, and shall therefore now notice their internal organization, and the mode in which vision is effected. On making a perpendicular incision into the eye, it is found to consist of various layers; the external membrane is hard, transparent, and composed of a multitude of hexagonal facets, each forming a more or less distinct conical cylinder, running towards the centre of the eye; beneath this external membrane is a layer of coloured matter, often of a blackish violet hue, but sometimes green, red, or banded, pierced with as many holes as there are facets or pupils; beneath this is a varnish of a black colour, within which is another belt, the inclosed space receiving the optic nerve, with its numberless ramifications, a branch probably going to each facet. The structure and functions of the eyes of insects have been investigated with great accuracy by Müller, who has proved that the refractive powers of the ocelli must be very great, each ray of light suffering a four-fold refraction: the first produced by the convex cornea, the second by the anterior convex surface of the lens, the third by the posterior convex surface of the lens, and the fourth by the convex surface of the glassy body itself; hence a very distinct short sight, suitable for small objects, is possessed by these eyes. In the compound eyes the effect is different: here, owing to the convexity of these eyes, and the consequent obliquity of the lateral facets and their cylinders, a much wider horizon must be embraced, each individual facet surveying but a small space of the entire field of vision: each thus contributing to the perception of objects comprised within the view, those rays of light only that fall in a right line upon a facet, *which itself forms the segment of a circle,* can reach the optic nerve of this facet, whereas all others are withheld by the pigment which separates the individual glass cases from each other, and partly circularly surrounds the margin of the crystalline lens beneath the cornea. According to Müller, each nervous filament conveys to the bulb of the optic nerve the impression of the ray which it has individually received; and as all the nervous filaments at first separated by the pigment are at length united together into one common and continuous bulb or nervous expansion, the impression received by each filament is united to those of the others in the bulb of the optic nerve, and so a common and continuous image is produced. This author, however, further considers, that rays coming from one point of a remote object *will illuminate throughout more than a single cone*, and thus to each luminous point without there will correspond in the interior of the eye, *not exactly a single illuminated point*, but rather a little circle of diffused or dispersed light; and in consequence an image of but little distinctness will be reproduced on the internal surface or retina, the distinctness of the image increasing in proportion as the object approaches the eye. It is, however, admitted, that the distinctness of the image will increase in proportion to the number of facets and the length of the cones; for the longer the cones are, the more completely will all rays entering them obliquely be prevented from reaching their internal extremity or apex. Upon these remarks I would, however, be permitted to observe, that, from the fact of each facet being the segment of a circle, as well as from the exceedingly minute size of the pupil-like aperture of the pigmental division of each facet, those rays only which fall upon the centre of each facet, and pass down the axis of each cylinder, can reach the nervous filaments in the centre of the eye, and thus there may not be the dispersion of the rays and consequent indistinctness of vision above noticed. I submit this opinion with great deference, and because it appears to me, that in the various experiments made upon this subject, due allowance has not been made for the external circularity of each facet of the cornea.

Immediately in connexion with the sense of sight ought to be noticed that remarkable property which many insects possess of emitting a peculiar light, and which, as is apprehended, must be regarded as displayed by insects with a view to its perception by the eyes of their associates, just as the chirping of a cricket is adduced in favour of the hearing of its fellows. Amongst insects, the *Lampyridæ*, or glow-worms,



Male and Female Glow-worm.

and the *Elateridæ*, are the only families which are decidedly proved to possess this faculty, although it has been asserted to prevail in the *Fulgoridæ*, and some isolated species of



Fulgora laternaria.

other groups; but there is no distinct evidence of its existence in these latter insects.

(*b*) *The Sense of Hearing.*—Linnæus describes insects in general as "*Muta* nisi alio proprio instrumento, sonora; *Surda* stridorem ætheris licet percipiant." From many facts, however, it is evident that insects distinguish sounds in some manner or other, although the greatest uncertainty prevails amongst naturalists as to the organ of this sense. Without presuming to offer any opinion of my own upon a point on which so many learned physiologists are at variance, I shall simply notice the production of sounds caused by insects, which has invariably been employed as an argument in favour of the possession of the sense of hearing by these animals, and then allude to the opinions which have been entertained as to its seat.

Unlike the higher animals, insects possess no distinct vocal apparatus terminating in the mouth. The noises made by insects may be divided into three kinds, according to the mode in which they are produced. In the first, the sound is produced by the mere friction of one part of the external integument against another, whereby, when an insect is disturbed, it forcibly rubs one portion of its body against another in its endeavours to escape. In this manner, by the friction of the prothorax against the base of the mesothorax, or the abdomen against the elytra in beetles, a continuous and rather loud sound is produced. The second kind of sound is produced by numerous flying insects, and which our bard of the Seasons has alluded to in his lines,—

> "Yet not unpleasant is the ceaseless hum,
> To him who wanders in the woods at noon."

The mode in which this sound is produced has been endeavoured to be explained in a variety of ways. I have already alluded to these opinions in my account of the *Halteres*, and shall only add, that the experiments of Burmeister and others, together with the fact that bees produce as loud a sound as dipterous insects, although unprovided, like the latter, with winglets or halteres, seem satisfactorily to prove that it is owing to the rushing of the air through the thoracic spiracles that the buzzing is produced. The third kind of sound is produced by a distinct modification of certain organs for their express emission. The Linnæan genera *Gryllus* and *Cicada* comprise the only insects thus circumstanced, and which are confined to the males. The death's-head moth also produces a plaintive kind of cry; and another kind of noise is produced by the death-watch (*Anobium striatum*), by beating the front of its head against the surface upon which it is stationed. Swift thus satirically alludes to this insect:—

Death-watch, natural size and magnified.

———— "A wood-worm, [beetle]
That lies in old wood, like a hare in her form,
With teeth or with claws it will bite or will scratch,
And chambermaids christen this worm a *Death-watch*,
Because, like a watch, it always cries click;
Then woe be to those in the house who are sick,
For sure as a gun they will give up the ghost,
If the maggot [beetle] cries click when it scratches the post."

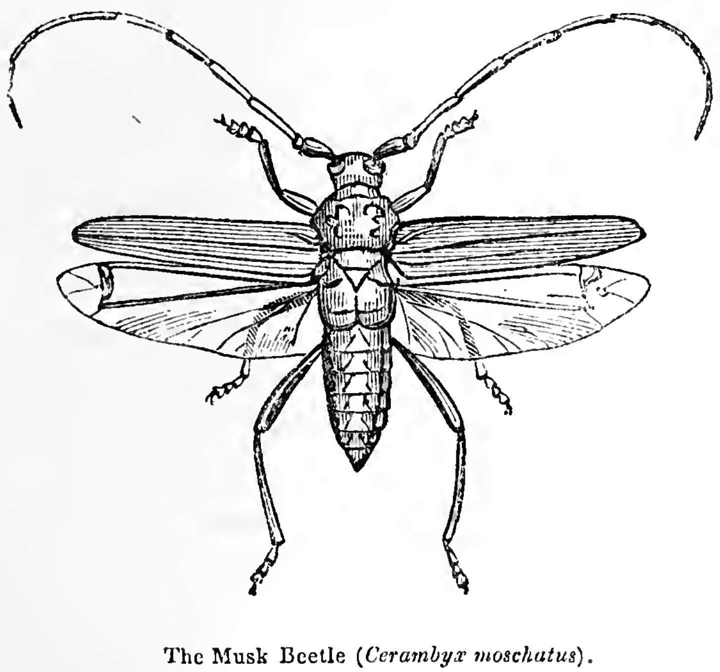
In many works we find the effects of other sounds upon insects described, an instance of which has been especially recorded in the great green grasshopper by Lehmann.

As to the organs supposed to be the means whereby this sense is enjoyed, we find that the opinions of the majority of authors may be divided into those by which the seat of this sense is asserted to be wholly unknown, and those who consider that the antennæ, in some way or other, perform the functions of organs of hearing. Other opinions have, indeed, been maintained by several other and distinguished authors. Thus Treviranus described a small drum-like membrane* on the forehead in front of the base of each antenna

* Did not Treviranus here mistake the ocelli for ears?

in moths, to which nerves extend, but no analogous organ has ever been discovered in other tribes of insects. Müller, in like manner, regarded part of the chirping apparatus of the grasshopper as an organ of sound; whilst Rudolphi considered the anterior salivary glands of bees as similar organs. Of continental authors who have regarded the antennæ as analogous to ears, the most celebrated are Sulzer, Scarpa, Schneider, Berkhausen, Reaumur, Bonnsdorf, Carus, Strauss-Dürckheim, Oken, and Burmeister. Kirby and Spence adopt the same view to a certain extent, considering it probable that the primary function of the antennæ may be something related to hearing: they further conceive that antennæ, by a peculiar structure, may collect notices from the atmosphere, receive pulses or vibrations, and communicate them to the sensorium, which, though not precisely to be called hearing, may answer the same purpose. It is true that the antennæ have, by other authors, been regarded as the organs of smell and of touch, the grounds for which I shall notice in my observations upon those senses. Moreover, in the higher crustacea (crabs, &c.), the organs of hearing distinctly exist in the shape of oval apertures, inclosing moveable plates, and placed at the base of the larger pairs of antennæ—a circumstance which has been considered as affording a strong analogy in favour of the opinion that the antennæ are organs of hearing.

(*c*) *The Sense of Smell.*—That insects possess, in a high degree, this sense, is evident to every one who knows with what pertinacity the blow-fly discovers meat, even when concealed under napkins, in safes, &c. That butterflies will fly down to flowers from a considerable height, may be accounted for by the action of their eyes: indeed, I have seen butterflies fluttering on the outside of windows, within which were coloured bits of paper, which they evidently mistook for flowers. In the two preceding senses we have seen that their existence might be presumed from the existence of luminous properties in certain species, or by the emission of sounds in others. In like manner the discharge of numerous and varied scents by many insects, induces us to admit the sense of scent in insects, although the organ of this sense is as little ascertained as that of hearing. Thus the disgusting odour of the bug, the cockroach, or the lady-bird; the rose-like scent of the cicindela; the musk-like scent of the musk-beetle; the garlic scent of many andrenæ;



The Musk Beetle (*Cerambyx moschatus*).

the goat-like scent of the caterpillar of the goat-moth, or the strong acid smell of many of the ants, sufficiently prove a keen perception of effluvia in insects. As to the organ of this sense, the majority of naturalists—Baster, Lehmann, Cuvier, Dumeril, Audouin, Strauss-Dürckheim, and, to an extent, Burmeister, from analogy with the vertebrated animals—regard the lining of the spiracles as exercising this function; whilst Christian, Reaumur, Lyonnet, De Blainville, and Latreille, consider the antennæ in this light. Marcel de Serres and Bonnsdorf, as well as Christian, conceive the palpi to be smelling organs. Comparetti described various cavities and cells in the front of the head, which he regarded as performing the office of a nose; but his assertions have never been confirmed. Treviranus considered the entire mucous lining of the mouth as the organ of smell; whilst Kirby and Spence give the name of rhinarium, or nostril piece, to the membrane connecting the skull and the clypeus (which they call the nose), and have described a pair of circular pulpy cushions under the clypeus and rhinarium, covered by a membrane transversely streaked with beautifully fine striæ, as the organs of smell, which they discovered in the burying-beetle (*Necrophorus vespillo*) and some others. But these discoveries are not confirmed by other and more elaborate insect anatomists, who have discovered no similar organ, nor do Kirby and Spence indicate how scents can pass through the rhinarium.

(*d*) *The Sense of Taste.*—If we have noticed the flesh-fly, as affording a proof of the existence of scent in insects, the same insect may be again cited to prove that insects are not deficient in the sense of taste. Indeed, to suppose that animals, having such a beautifully constructed and complicated oral apparatus as is exhibited by the mouths of insects, which also exhibit such discrimination and fastidiousness in the choice of their food, should be deficient in this sense, seems not to be very philosophical, although such has been asserted by Rudolphi and some other physiologists. That this sense is seated in some part of the mouth or digestive organs is, however, generally admitted. Some authors, indeed, have supposed it to exist in the palpi, whilst others regard it as seated in the pharynx, or at the commencement of the throat. The tongue, however, is more generally regarded as its real seat, this being a fleshy organ in many insects, and provided with a great abundance of nerves, and furnished with saliva from the mouths of the ducts of the glands lying beneath this organ. It must, however, be admitted, that there are many insects in which the analogue of the tongue is not developed, or exists merely as a horny seta.

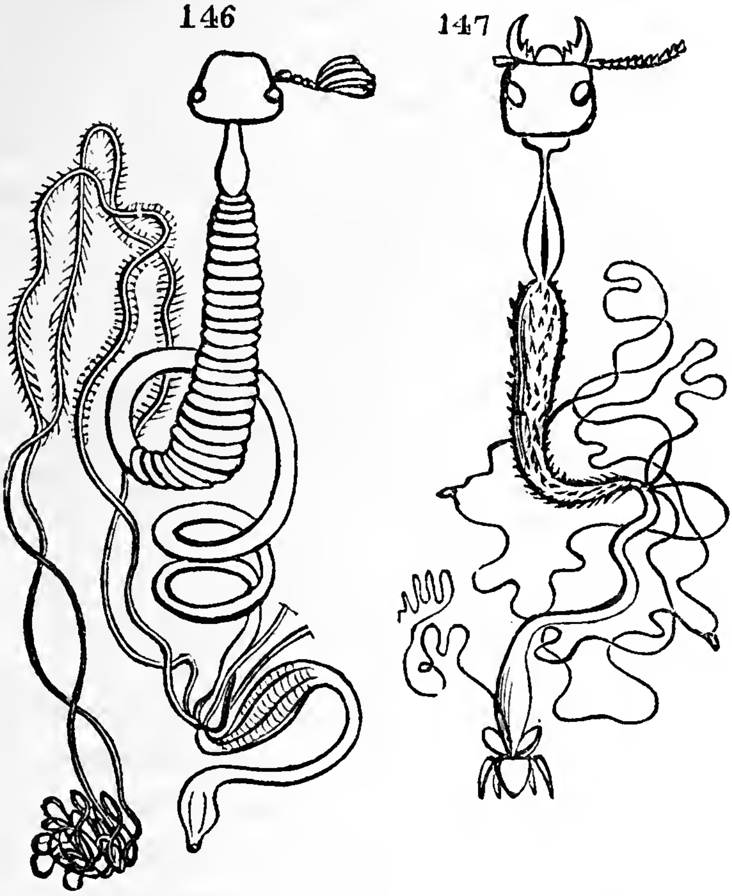
(*e*) *The Sense of Touch.*—In the higher animals the outer envelope of the body is, from its peculiar construction, generally, and in all parts, adapted to receive impressions by this sense; but in insects, the hard scaly texture of the external covering necessarily prevents such a general system of touch, and we are therefore compelled to search for organs which may, in an especial manner, be regarded as the organs of this sense. Here, too, however, we find difficulties similar to those which have met us in our researches relative to the other senses: thus the antennæ, palpi, wings, and tarsi, and particularly the anterior tarsi, have been regarded as the organs of this sense; and, indeed, the opinion, that the first-named organs constituted the real feelers, has been maintained by some writers with so much zeal, that even violent abuse has been heaped upon persons professing a different view of the subject. It is true that the antennæ have been generally termed feelers, and the proceedings of some of the *Ichneumonidæ* have been adduced as instances in support of these organs being capable of feeling; but here, as Kirby and Spence observe, either by means of its antennæ, it may hear a slight noise made by the latent grub, perhaps by the action of its mandibles, or else that, by its motions, the grub generates a motion in the atmosphere of its habitation, which, striking upon the antennæ of the parasitic ichneumon, are by them communicated to its sensorium. Moreover, the ovipositor of these insects is much longer (in *Fœnus* and *Pimpla*) than the antennæ; so that, by inserting the latter into the holes in walls, posts, &c., it is impossible that they can reach the latent grub. Strauss-

Dürckheim, and some others, on the contrary, regard the articulated tarsi as the organs of touch; Kirby and Spence considering them also as organs of *active touch;* whilst the same authors, together with Knoch, Lehmann, Cuvier, and Burmeister, regard the palpi as the organs of touch, these parts being, without intermission, applied to every surface, and being terminated by a minute transparent membrane, which is supposed to be the precise seat of this sense; although Strauss-Dürckheim, who carefully examined it, considered it as the organ of a distinct double kind of sense, partaking both of touch and taste. In some bees which I am at present experimenting upon, and which thrive upon moistened white sugar, I notice that the maxillary palpi are applied to the surface of the sugar all the time that the insect continues to feed.

B.—*The Digestive System.*

After the food has been taken into the mouth, and been submitted to the action of the trophi, it passes into the pharynx, or entrance to the stomach. The digestive organs are opened at each end, extending from the mouth to the anus: sometimes they are straight, and at others bent or twisted together; and, as in the higher animals, they are short in the predaceous species, but elongated in those which feed upon plants; sometimes they are of an equal diameter throughout, but at other times variously constricted. Where the number of these constrictions is the greatest, the digestive tube consists of—1st, the pharynx; 2nd, the esophagus, or gullet; 3rd, the craw, or jabot; 4th, the gizzard, or ventriculus; 5th, the stomach, or duodenum; and 6th, the intestines, including the intestinum tenue, or small gut, the cæcum, or blind gut, and the rectum, or vent gut. In addition to this variously-divided digestive tube, there is a number of slender membranous tubes filled with a fluid apparently analogous to the bile. They are, for the most

146 147

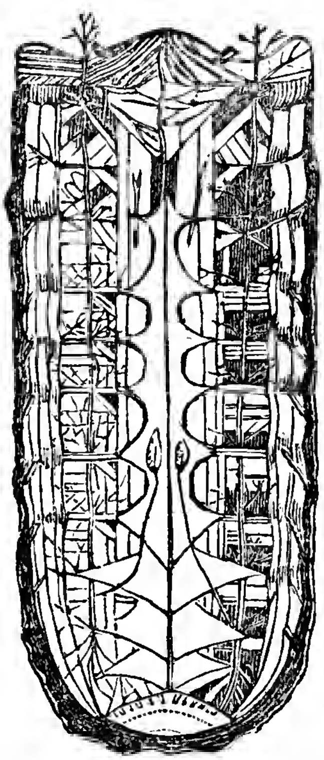


Figs. 146, Digestive system of Melolontha—147, ditto of Staphylinus (from L. Dufour).

part, inserted into the stomach near its outlet, where the secretion, which is thus discharged, acts upon the already partially dissolved food, and converts it into a pulpy mass or chyle, the nutritive parts of which, as it passes into the small gut, are taken up by the inner membrane of the latter, and passed into the cavity of the abdomen, lying upon and around the parts to be nourished by absorption. The indigestible parts of the food are collected in the cæcum, and thence passed out of the body.

C.—*The Circulatory System.*

It has been generally considered that insects were destitute of a real and direct circulation analogous to that of the higher animals; but the recent observations of many distinguished authors (Comparetti, Carus, Bowerbank, Burmeister, &c.), appear to have fully proved that they do possess such a system. Although there is no part in insects strictly analogous to the heart, yet this name has been ordinarily given to a series of large reservoirs forming a longitudinal tube, extending throughout the entire length of the body (commencing at the first thoracic segment) beneath the dorsal integuments and muscles, and which is easily distinguished by its alternate contractions and dilatations, similar to those of the heart in the higher animals, which may be constantly observed in the silkworm and other naked caterpillars. In this dorsal vessel, as it has been called by some physiologists, the blood is contained, and which, unlike that of the vertebrata, is cold, transparent, and often entirely colourless. It was, however, considered, that as no outlet had been discovered, there could be no circulation, and yet it was supposed that the fluid in some way or other made its escape, and was disseminated amongst the various internal organs, which it penetrated by imbibition. Strauss-Dürckheim, however, discovered that there exists in the cockchafer a series of ori-



Muscular system of the Caterpillar of the Goat-moth (*Cossus ligniperda*).

fices opening into each side of the dorsal vessel, and furnished with valves.

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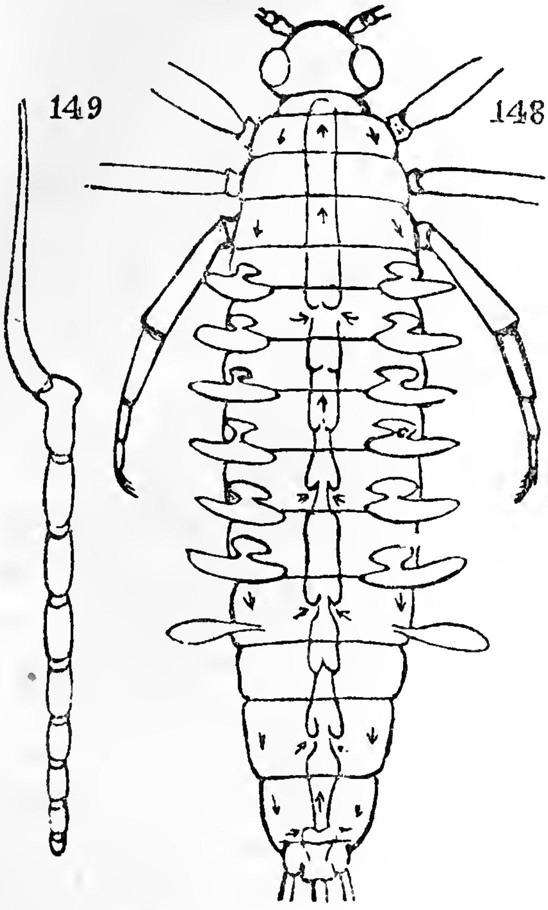


Figs. 148, Larva of Ephemera, showing the central dorsal vessel, some of the valves being opened, the current of the fluid being indicated by arrows (from Mr. Bowerbank)—149, Lateral view of the dorsal vessel of Melolontha.

The dorsal vessel consists, according to Strauss-Dürckheim, of eight successive chambers in the cockchafer. Mr. Bowerbank says, "they are about equal in number to the sections of the body" in the larva of an *Ephemera*, separated by converging valves, which allow the blood to be propelled forward towards the head, but prevent its returning. The blood abounds in very minute oat-shaped particles, and is seen circulating in every part of the body, from whence, upon each pulsation and opening of the lateral apertures, it rushes into the dorsal vessel, and is conveyed into the anterior part of the body. When the terminal chamber is filled, the blood which it contains causes the lateral valves to close, and the blood to be propelled into the next chamber, which, at the same time, also receives a flow of blood from its own lateral openings. In this manner the blood is forced towards the prothoracic chamber, where it terminates, according to Strauss-Dürckheim, in a single artery, without branches, which carries the blood into the head, where it is poured out, and thence flows back into the cavity of the body (in distinct arteries, according to Mr. Bowerbank), to be again taken into the heart, which consists of two membranes, the external one of which is furnished with numerous ramifications of the air-tubes. The various air-tubes, also, which are distributed throughout the body, communicate with the blood as it is discharged from the prothoracic chamber, and thus it receives a supply of oxygen. The number of chambers in an imago appears to be smaller than in a larva; we have also seen that the number of segments in the latter are more numerous than in the former. It would therefore form a very interesting subject of inquiry to ascertain the mode in which, and the period when, this loss takes place. The circulation of the blood is most distinctly seen in the aquatic larvæ, and in the wings of insects, owing to their transparency.

D.—*The Respiratory System.*

The systems of circulation and respiration are necessarily dependent upon each other. In the higher animals the lungs are the receptacles of the air, and the blood rushes into these organs to be oxygenated. In insects we have, however, seen that the circulatory system extends throughout the body, the great dorsal vessel equally extending from one end of the body to the other: hence it is requisite that the respiratory apparatus should be developed to an equivalent degree, and we accordingly find that respiration in insects is effected by means of two great longitudinal vessels or canals called tracheæ, running along the sides of the body beneath the outer integuments and muscles, and which open to the outer atmosphere by means of short tubes, terminating in breathing pores (spiracles or stigmata). The number of these spiracles is various; those of the larva, in which the body is composed of a more regular and uniform series of segments, being more numerous than the spiracles of the imago. In the former they amount to eighteen, that is, nine pairs; whereas, in the generality of perfect insects, the number is, or appears to be, diminished; moreover, in the latter, the spiracles, owing to the greater developement of external covering, are generally more or less concealed. Spiracles are of two kinds, simple or composite. In the former the aperture is a simple orifice, guarded only by hairs, which prevent the passage of any foreign substance which might be injurious: but in the composite spiracle the aperture is closed by two horny valves, which move backwards and forwards like a pair of folding doors at each inspiration. The former sort of spiracles are generally found at the sides of the abdomen, where the upper and lower arcs of each segment are united together. The composite spiracles are, on the contrary, appropriated to the thorax.

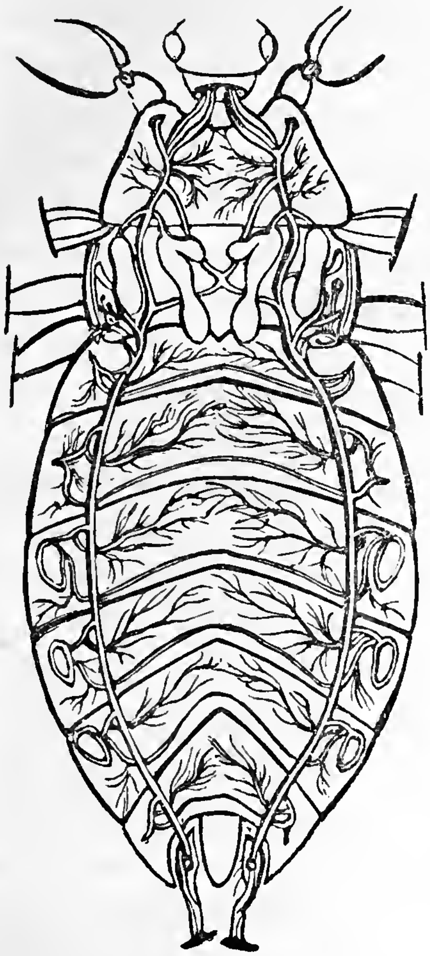


Fig. 150, Respiratory apparatus of Nepa cinerea, in which the only pair of spiracles are placed at the sides of the anus, the lateral spiracles being obsolete or rudimental.

The tracheæ, which originate in the spiracles, are connected with the two great longitudinal air-tubes above mentioned, which likewise emit an infinite number of ramifications, extending to all parts of the body, like the branches of a tree. These tracheæ are of two sorts, tubular or vesicular: the former are tubes composed of three distinct membranes, the external and internal layers being of a cellular texture, and the central being composed of a cartilaginous thread, rolled in a spiral direction, and very elastic. The vesicular tracheæ are destitute of this spiral cartilage, and are small bags of a cellular texture, which, when not distended with air, naturally become flaccid. The tracheæ often communicate with each other, and penetrate all the organs, such as the legs, wings, &c.; they are also distributed throughout the intestinal parts of the body, so that the air circulates freely in the most obscure parts.

The *Dyticidæ*, *Culicidæ*, *Chironomus*, *Ephemera*, and other insects, which are chiefly aquatic, exhibit various modifications in their respiratory apparatus, and in which we perceive two principal modifications:—1st, A series of large lateral organs, which act upon the water, and abstract from it the oxygen; and, 2ndly, a concentration of the respiratory functions by means of an apparatus placed at the extremity of the body, whereby the insect is enabled to obtain a supply of air, by protruding this part of the body above the surface of the water, whilst it still remains with its greater part submerged. M. Audouin has also recently noticed another remarkable modification of the respiratory apparatus in insects, which, although terrestrial, are occasionally covered for a great length of time with water. (See his Memoir upon *Aëpus fulvescens* in the "Nouvelles Annales du Museum.")

E.—*The Motive, or Muscular System.*

The varied structures described in the preceding pages relative to the external anatomy of insects, are but the visible expression of certain principles which constitute the economy of the various species, and which are regulated in the performance of their various functions by a series of internal muscles, attached to the internal surface of the external covering of the animal. Of the extent of this system of muscles, some idea may be entertained, when it is stated that Lyonnet discovered 4061 in the caterpillar of the goat-moth, 228 being attached to the head, 1647 to the body, and 2186 to the intestines; whereas, in the human body, only 529 have been discovered; so that this insect possesses nearly eight times as many muscles as there are contained in the human frame. This, however, will not appear so extraordinary, when the greater number of legs, &c. in the insect are remembered.

The construction of insect muscles is similar to those of the higher animals, each being formed of muscle and of tendon; the former is fleshy, whilst the latter, which forms the coating and extremities of the muscle, is firm, and not liable to contraction. According to Lyonnet, the muscles are composed of many parallel bands, consisting of bundles of fibres enveloped in separate membranes; these fibres appearing to be twisted in a spiral direction. These muscles are attached at one end to the various processes of internal surface of the outer covering, which serves as their fulcrum, and the other end is attached to the organ to be moved. The size of muscles is proportioned to the movements

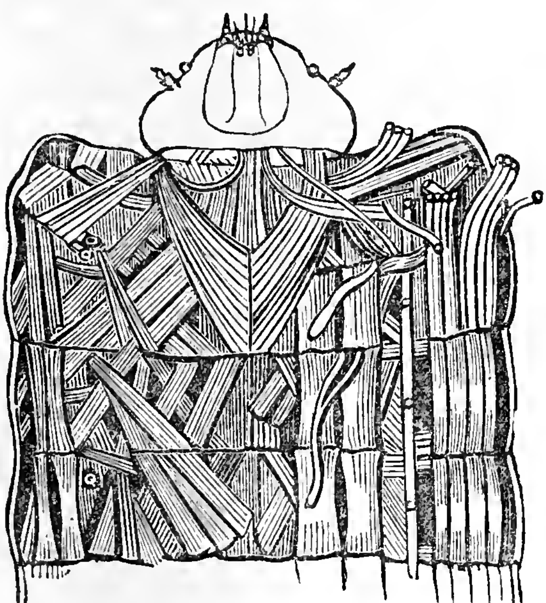


Fig. 151, Dorsal muscles of the anterior segments of the caterpillar of Cossus.

to be performed by the organs to which they are attached: thus, the muscles of the mandibles are much more robust than those of the maxillæ: in like manner the comparative size of the various organs influences that of the corresponding muscles. Thus when the anterior wing is enlarged at the expence of the posterior, the mesothoracic muscles are more developed than those of the metathorax; and *vice versâ;* in like manner, the muscles of the hind-legs of a leaping insect, as a grasshopper, are more extensive than those of the simple walking legs. Muscles, as regards their action, are either flexors or extensors, levators or depressors: by the flexors, which are attached to the inner surface of a limb, it is drawn towards the base, and consequently as it were folded up; extensors, on the contrary, are attached on the exterior part of the cavity of the outer covering of a limb, and act in an opposite direction, so as to extend the limb. In like manner levator muscles cause the elevation of a limb, whilst depressors bend it downwards.

F.—*The Generative System.*

It will be sufficient to refer to what has been stated in preceding pages relative to the general nature of the generation of insects, as a description of the numerous and greatly complicated internal organs would occupy far too great a space in a work like the present.

SECTION IV.

THE PHYSIOLOGICAL AND INSTINCTIVE PROPERTIES OF INSECTS.

Having brought to a close our review of the general structure of insects, as exhibited not only in their preparatory and perfect states, but also in their external and internal organization, it would naturally remain for me to lay before the reader the modes of operation by which each of these various structures is rendered serviceable towards the fulfilment of the ends for which the insect has been produced. This would comprise every physiological peculiarity presented to us by the insect world, independent of mere structural modification. But in treating of the internal systems of organs, and, indeed, partially, in the review of the external form of insects, I have thought it might be more agreeable to the majority of my readers to blend together effects with causes —operations with the apparatus whereby they are effected. It still, however, remains for me, as previously observed, to notice the operations of that power, or principle, which seems totally independent of organization, and to which the name of Instinct is generally applied.

It is necessary, however, in the first place, to premise, that it is not my intention to enter into any disquisition upon the nature of instinct. We know, indeed, nothing of the real nature thereof beyond what is exhibited to us by the various phenomena of insect life, and which have been well described as the result of a power "enabling an animal to do that which, in those things that man can do, results from a chain of reasoning; and in things which men cannot do, is not to be explained by any efforts of the intellectual faculties."*

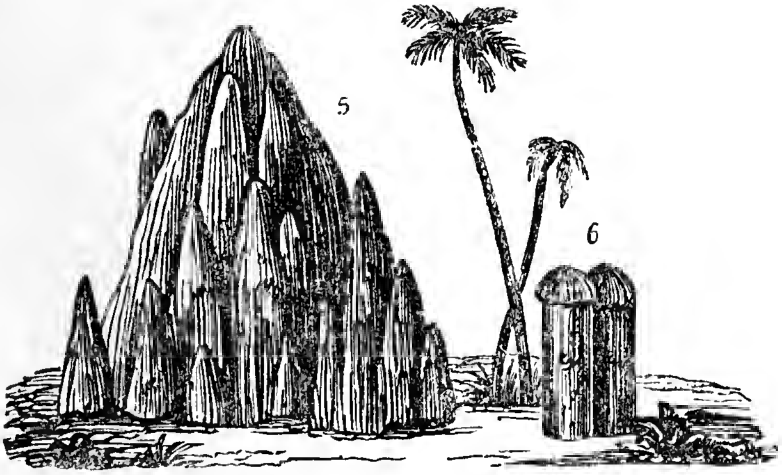


Fig. 5, Nest of Termes fatale (ten or twelve feet high)—6, Nest of Termes atrox.

* Lieut. Col. Sykes, in Trans. of Entomol. Society, p. 106.

Now these varied phenomena are manifested to us in an endless variety of methods; in the affection of insects for their offspring; in the numerous distinct modes in which the parent insect deposits her eggs in the most appropriate situa-

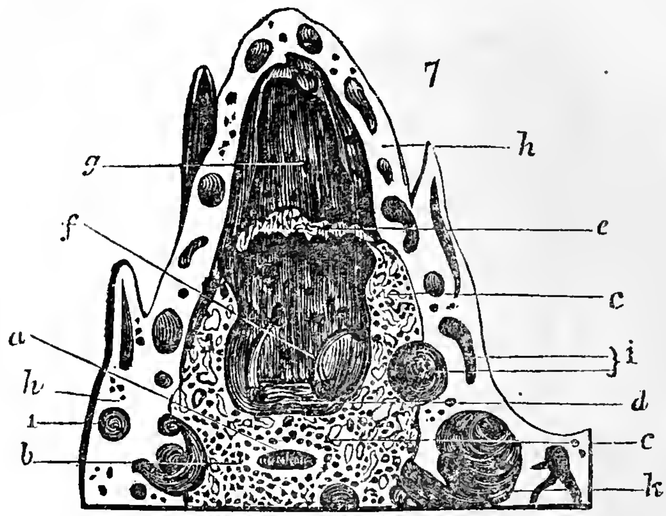
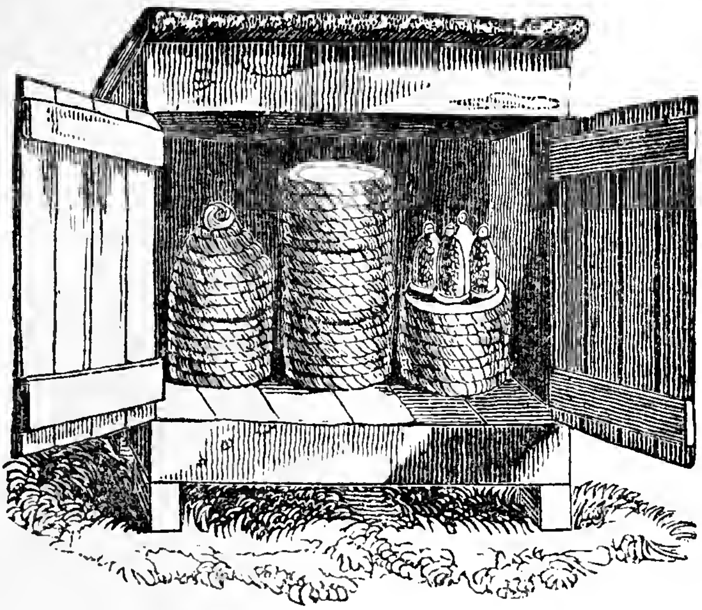


Fig 7, Section of the nest of *Termes fatale*, on a scale of one inch to eight feet—*a*, the royal chamber—*b*, the apartments of the royal attendants—*c c*, the nurseries and magazines extending up the sides of the nest—*d*, the lower roof—*e*, the upper roof—*f*, two bridges reaching from apertures in the lower roof to some of the upper nurseries—*g*, the hollow dome—*h h*, the thick mud walls of the building, penetrated in various directions by passages, *i i*, of various sizes, chiefly in a spiral direction from the bottom of the nest to the upper parts—*k*, one of the great under-ground outlets of the nest.

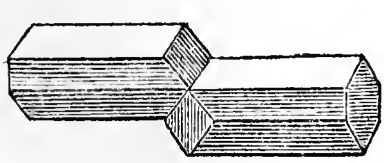
tions; in the construction of nests; in the various stratagems by which insects procure their food; in the modes of defence employed by insects either against their ordinary enemies or accidents; but, more than all, in the varied economy of social insects—bees, humble-bees, wasps, ants, white ants. All these varied phenomena appear, however, to be resolvable to two principal heads—the continuance of the species, and the preservation of the individual: indeed, the great end and final care of the endless labours of the social insects can only be traced to one or the other of these causes.

If we confine our attention to the first of these grounds of inquiry, viz. the perpetuation of the species, we find that here, as elsewhere, the great command "Increase and multiply" is obeyed to the fullest extent, as is manifested by the various circumstances connected with the pairing of insects, and especially by the precautions which the parent female exhibits in the careful deposition of her eggs, as al-

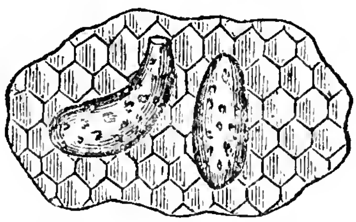


Apiary.

ready noticed in the early pages of this work; whilst the often extraordinary and always interesting peculiarities ex-



Cells of the hive bee, showing manner of uniting at base.

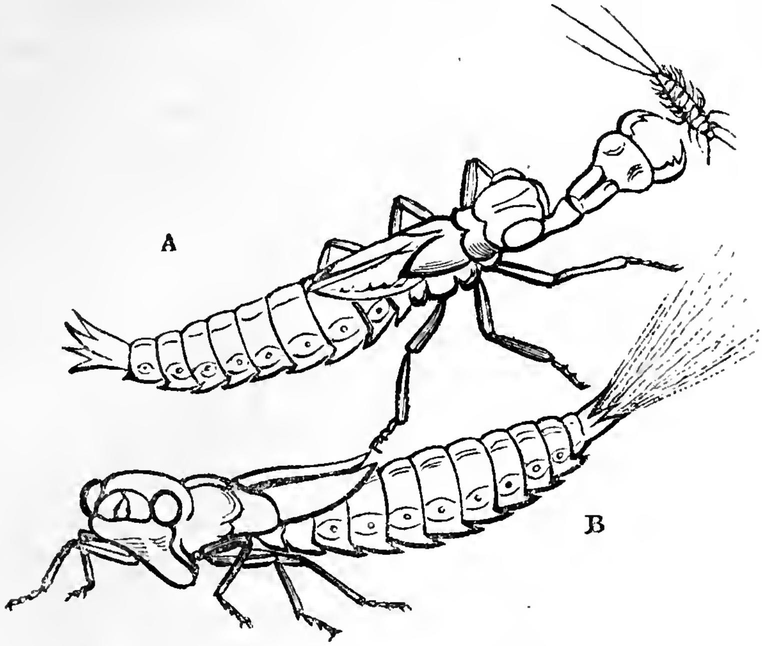


Hexagonal cells of the hive bee, with royal cells attached.

hibited by social insects in the construction of their nests, for their own habitations and the rearing of their offspring, the collecting of food, and the feeding of young.

If, on the other hand, we direct our attention to the preservation of the individual (and many of the peculiarities of social insect life conduct us to this branch of our inquiry), we find the subject also divides itself into two sections, namely, the various stratagems employed for obtaining a supply of food, and the means of active or passive defence adopted by insects. With a few notices of some of the most remarkable of each of these instinctive peculiarities, I shall close the present branch of our subject.

We have seen in the early part of this work that, from the very nature of the functions of the insect tribes, it is essential that the consumption by them of animal and vegetable matter should uninterruptedly be carried on. Hence, as well as from the nature of insects in general, and the great care shown by the female in depositing her eggs in the most fitting situations, there is but little occasion for any exhibition of instinctive reasoning on the part of these animals, with the exception of those which prey upon living animal matter. Here pursuit, search, or some equivalent thereto, is necessary for insuring a due supply of food; and hence we find that the predaceous tribes of insects, like their analogues among beasts or birds, are more fitly organized for rapid movements than the lazy inactive herbivorous species. If this be the case with the perfect insects, there must be some other mode of obtaining their food by their predaceous larvæ (especially since it is during this period that feeding is the great object of an insect's existence), which are not furnished with sufficiently powerful organs of locomotion. The extraordinary mask of the larva and pupa of the dragon-flies, exhibited both at rest and in action in the accompanying figures, is a most admirably contrived instrument applicable for such purpose; and the raptorial structure of the fore-legs of many predaceous insects, the great strength of muscles by which these organs are moved, and the many strong spines with which they are armed, are in like manner auxiliaries, supplying the want of powerful locomotive organs. But there is still an-



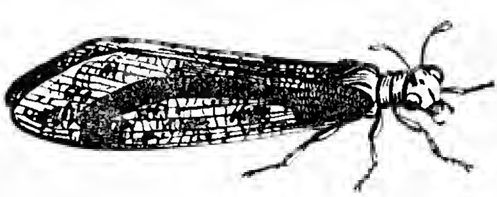
A, The Pupa of the Dragon-fly, with its mask extended—B, the same, with the mask closed, and discharging a current of water.

other class of predaceous larvæ which are compelled, in order to obtain their own food, to resort to actual stratagems for this purpose, which the more developed structure of the preceding insects rendered unnecessary. The constructions of the spider, and especially the manœuvres of the jumping spiders, so constantly to be noticed on every sunny wall, leaping from a considerable distance upon their prey, will also occur to the reader; but these have been more especially noticed in preceding pages.

The larva of a somewhat rare British species of the Linnæan genus *Cimex* (*Reduvius personatus*), is asserted to feed upon the bed-bug; like it, it is found in houses, but its appearance is so extraordinary, that it is impossible to have the least idea that it is an insect, were it not for its slight and awkward movements. It covers itself completely with a coat of dirt and dust, so that it more resembles a lump of earth.

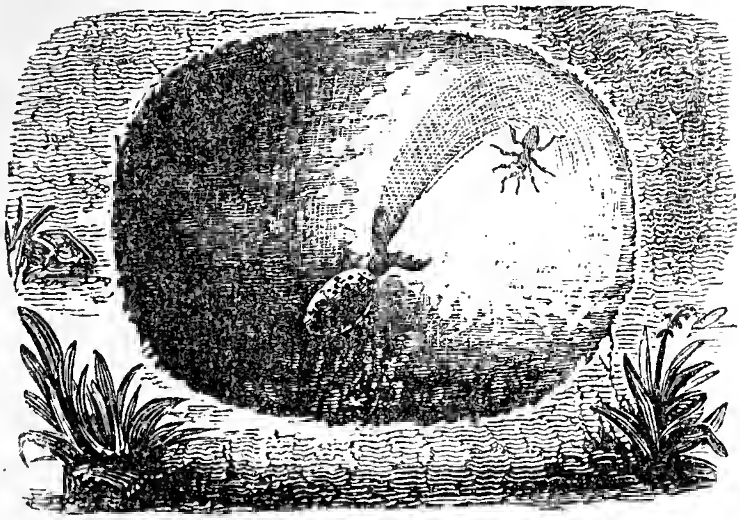
Neverthelesss the antennæ and rostrum are similar to those of the perfect insect, and enable us to decide what it really is; moreover, on touching it with the point of a pencil, its coat falls off at once, which, however, the insect soon again renews. In this dress it is enabled to approach its prey without their being alarmed at its coming.

There are, however, three species of insects belonging to as many distinct orders, *Coleoptera*, *Diptera*, and *Neuroptera*, which in their larva state exhibit a greater degree of instinct than any of the preceding, by the construction of pitfalls, in which they lay in wait for every stray insect which may be hapless enough to come within their reach. The burrow of the larva of the tiger-beetle (*Cicindela*,) consists of a long and tubular passage, at the mouth of which the voracious larva stations itself, its head just fitting the opening of this retreat, with its jaws expanded, ready to seize on every passing insect. The two other species referred to are the ant-lion (*Myrmeleon*) and a fly (*Rhagio vermileo*). These construct large funnel-shaped burrows in sandy situations, at the bottom of which they take their station, ready to seize any ant or other insect which may chance to slip down the sides. The grub of the latter lies motionless at the foot of the burrow, and, snake-like, twines itself round its prey, piercing it with its strong hooks or mandibles. But the ant-lion is more wary, its form is most unprepossessing; it therefore buries itself in the sand at the bottom of its hole, leaving only its long curved jaws exposed; and it has the additional instinct, in case any of the insects which fall down the sides of its trap should endeavour to escape, to bring them within its reach by a shower of sand. When full



Perfect Myrmeleon.

grown, it forms a globular cocoon of sand, within which it becomes a small inactive pupa, and in a short time bursts forth under the perfect and beautiful form represented in the preceding page.



Pitfall of the Ant-lion.

The various modes of active or passive defence adopted by insects, present us equally with many of the most interesting phenomena of insect instinct. Here we find Nature ever rich in resources; the smallest as well as the largest objects of the animated creation are equally beneath her care. We will run through the various orders of insects, and notice a few of the more remarkable of these peculiarities. We find the predaceous beetles well enabled to defend themselves, not only by the hard scaly covering of their bodies, and the powerful organs of their mouths, especially their strong and hooked jaws, but also by the emission of a black and fœtid fluid, which is well calculated to ensure them from the attacks of their enemies. It is this fluid, which is occasionally volatilized on coming into contact with the air, that the bombardier beetle employs when in danger from the attacks of its enemies. The pre-

Bombardier Beetle.

daceous water-beetles also, by similar emissions, but more particularly by their capability of flight in the air, swimming in the water, or creeping on the land, are enabled to avoid the attacks of enemies which might assault them in any of these elements. We have seen that many beetles, as the pill-beetles (*Byrrhidæ*), the death-watches (*Anobium*), and the mimic-beetles (*Histeridæ*), with many others, possess in a remarkable degree the power of counterfeiting death, by folding up their limbs and keeping them in a state of inactivity. Other beetles, by the similarity of their appearance to the sand or earth in which they reside, readily elude our observation, as in many sand heteromera. The emission of similar fœtid scents and fluids by many other beetles, as the *Silphidæ*, *Chrysomelidæ*, and especially the lady-birds, is a very ordinary means of defence; whilst the similarity in the colouring of others to the leaves, stems, or bark of plants and trees, is equally serviceable. The threatening aspect of some, as the devil's coach horse; the rapidity of the movements of others, as the *Halticæ*, joined to their minuteness, all tend to the same end. The larvæ of the *Cassidæ* and *Crioceridæ* cover themselves with a cloak formed of their own excrements, which serves as a protection against the sun, and conceals them from their enemies.

In the Orthoptera we find great locomotive powers, as exhibited by the locusts and grasshoppers, whose strength in leaping is known to every schoolboy; but there are other insects belonging to the same order equally well defended, although their locomotive powers are but slight. Here we are to notice the walking-leaf insects and the walking-stick insects, objects which to an ordinary observer would appear but detached leaves or twigs rustling with every breath of air; but they have life, and Nature has given them their strange appearance with a view to its preservation, by deceiving those animals which might otherwise make them their prey.

Nothing indeed can be more complete than the deception produced by these insects; the walking leaf is flat, semi-transparent, narrowed at the head, or stalk part of the leaf, the antennæ forming the stem; the abdomen is dilated at the sides, notched, like the margin of a leaf, and, to complete the resemblance, the wing-covers lie flat upon the back, forming by their union a straight central line, from which proceed various oblique nerves, like the principal veins of a leaf.

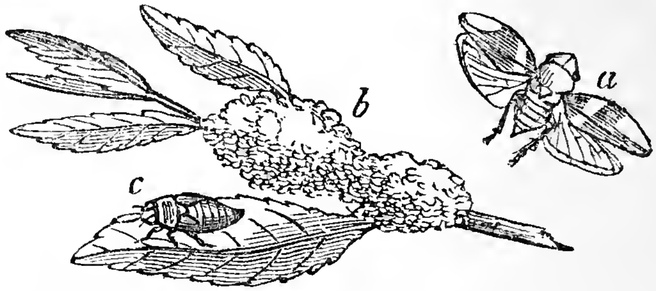
In the neuropterous and trichopterous orders, we find equally successful means of defence. In the dragon-fly, we have already seen how completely, by means of wings, eyes, and mouth, it is enabled to escape from its enemies. The delicate gauze-winged golden-eyed flies (*Hemerobius*), which seem too slight to encounter even a breath of air, come forth only at dusk: they, moreover, omit a most disgusting scent; and as a still further defence, they have the instinct to place their eggs out of danger, at the extremity of long and slender footstalks, and their larvæ cover themselves with a coat formed of the skins of their victims. The Phryganeæ encase themselves in the larva state in firm cases of earth, stones, shells, &c., fastened together; and thus their soft and fleshy bodies are secured from the attacks of fishes, which, as every angler is aware, deem them a tempting morsel.

Who is there that has not experienced how well some of the insects of the hymenopterous orders are enabled to defend themselves by the assistance of their stings, the construction of which is described in a preceding page?

The Lepidoptera are perhaps the most defenceless amongst insects; but here we find many larvæ having the instinct to enrol themselves in the leaves of plants, or to form for themselves tents or tubes of various materials for their abodes; whilst others, by their resemblance in colour to the plants upon which they are found, or by the hairs by which they are clothed, are amply defended against their foes.

In the Hemipterous insects we find a very numerous tribe, composing the Linnæan genus *Cimex* (bugs), able effectually to defend themselves by the emission of a powerful scent, which, although occasionally in a few species not disagreeable, is in general very disgusting.

In the Homoptera many species, as the frog-hoppers (*Cercopidæ*), are enabled to leap very great distances, thus avoiding their enemies; whilst some in their larva state conceal themselves beneath a curious coating of froth.



a, The Cuckoo-spit insect (*Aphrophora spumaria*). *b*, The mass of froth. *c*, The pupa.

The Diptera do not present any very striking instances of insect defence; the rapidity of their motions, as well as those of the insects composing the order *Aphaniptera* (fleas), ought not, however, to be omitted.

From this review of the means of defence in the various orders of insects, it will be seen that distinct organs for active defence are not possessed by the majority of these creatures, but that they are amply compensated by equally effective modes of counteracting the attacks of their foes, consisting either in powers of evasion, as rapidity of flight, strength in swimming, power in leaping, and velocity in running; or in powers of repulsion, as emission of powerful odours, hideousness of appearance; or powers of simulation, whereby the appearance of death, or of some other objects, is assumed. Thus we perceive that here, as indeed throughout nature, the desire to prolong existence, and to perpetuate the species, are the greatest ends of action. The constant destruction to which, from their small size, insects are so pre-eminently liable, and against which their instinct, in all states of their existence, is brought into full play, is nevertheless necessary to preserve a just proportion between all the tribes of the creation. Hence we may firmly believe

> "All discord" to be "harmony not understood;
> All partial evil, universal good."

SECTION V.

CLASSIFICATION OF INSECTS.

Having already given, in the introductory part of this volume, a sketch of the rise and progress of Entomological science, which necessarily included a concise notice of the various plans suggested for the classification of insects, I shall here confine myself to a sketch of the Linnæan system, as having been very generally adopted, until lately, in this country, and to the more material changes which have been subsequently introduced.

Linnæus adopted the structure of the wings as affording the characters of his orders, which were as follows:—

1 Coleoptera.—Wings, four; the upper pair crustaceous, with a straight suture. (Beetles and earwigs.)

2. Hemiptera.—Wings, four; the upper pair semi-crustaceous and incumbent. (Locusts, bugs, tree-hoppers, plant-lice, &c.)

3. Lepidoptera.—Wings, four, imbricated with scales. (Butterflies, moths, &c.)

4. Neuroptera.—Wings, four, membranaceous; anus unarmed. (Dragon-flies, &c.)

5. Hymenoptera.—Wings, four, membranaceous; anus armed with a sting. (Bees, wasps, ants, saw-flies, &c.)

6. Diptera.—Wings, two; halteres, two, in the place of the posterior wings. (Flies.)

7. Aptera.—Wings, none. (Spiders, crabs, centipedes, lice, fleas, &c.)

The incongruous nature of this last-named order has been already commented upon. The names of these orders are compounded from the Greek word πτερον (*pteron*), a wing, in conjunction with some other prefixed to it. We have thus *Coleoptera*, sheath, or case-winged; *Neuroptera*, nerve-winged, &c.

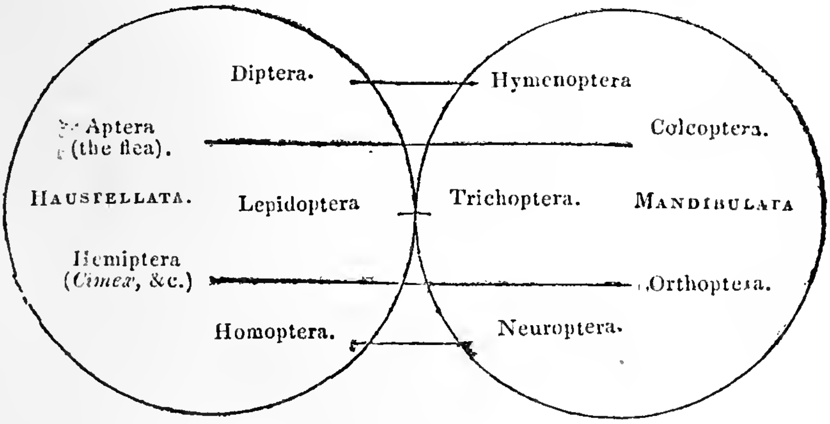
It soon, however, became evident that the characters of the wings were too general, and Fabricius, a disciple of Linnæus, fell into the opposite error of regarding the variations of the mouth as alone affording the most satisfactory distribution of insects. In the system of the last-named author, a number of new orders (or, as he chooses to term them, classes) were established, and to which, in addition to such of the Linnæan orders as he retained, he gave a series of exceedingly harsh names, founded upon the structure of the mouth; dividing the orders into two primary groups, founded upon the masticatory or suctorial habits of the insects.

But, as the Linnæan system, founded upon the wings, was found to violate nature by uniting masticating and suctorial insects in the same order, so the Fabrician system was, in some respects, even more artificial, as where the wingless sugar-lice (*Lepisma*), which undergo no metamorphosis, were introduced amongst the metamorphotic lace-winged flies, &c.; and the lice and octapod mites (*Acari*), were united with the two-winged flies (*Diptera*), into the class *Antliata*. The system of Fabricius has met with but few followers, except in Germany; his chief merit consisting in his definition of a great multitude of new species.

It is to the labours of the French naturalists, Cuvier, Lamarck, and Latreille, and to our venerable Kirby, that we are mainly indebted for the great advances made towards a more natural mode of distribution, wherein the natural affinities of the various groups are more or less clearly pointed out and adopted. It would occupy too much time to trace the gradual improvements, or suggestions for improvements, which have been made during the present century, in which Entomology has made such rapid strides towards perfection.

The breaking up of the heterogeneous mass of the Linnæan apterous insects, by the establishment of the classes *Crustacea, Arachnida*, and *Ametabola*, together with the proposal of the order *Orthoptera*, by Olivier, for the masticatory *Hemiptera* (grasshoppers, &c.), *Strepsiptera, Trichoptera*, and *Aphaniptera*, by Mr. Kirby, the separation of the *Cicada*, &c., from the other *Hemiptera*, under the name *Homoptera*, by Latreille, together with the proposal of several other orders of minor importance, subsequently noticed, must not be forgotten. Neither ought the system of MacLeay here to pass unnoticed, established with the view of obviating the difficulties which constantly attend our endeavours to arrange our species in a continuous linear series of affinity, and which evidently prevents our harmoniously combining their varied relations.

The following diagram will be sufficient to explain, as far as the true insects are concerned, the manner in which this is proposed to be effected by Mr. MacLeay.



It will be seen by this figure, firstly, that each group consists of five divisions (whence the system has been termed the quinarian system); secondly, that the series of orders in each group consists of a circular series of affinities; thirdly, that by means of the parallel lines, the series of analogical relations are kept up. Moreover, each order was supposed to be connected with the two adjacent orders, by means of intermediate osculant orders, such as the *Strepsiptera*, &c. Modifications of this system have been subsequently proposed by Messrs. Swainson aud Newman, which it would occupy too much space here to detail.

Although, in my Introduction to the Modern Classification of Insects, I have adopted a mode of arrangement founded for the most part upon that of Mr. MacLeay, it may, perhaps, be more useful in the present work, to present to the reader the most recent classification proposed by Latreille, especially as the views upon which my arrangement of the orders subsequent to the *Coleoptera* is founded, are not yet laid before the public.

The following is, therefore, the arrangement of the winged insects published by Latreille, in his *Cours d'Entomologie*, which appeared shortly before his decease (the characters being abridged).

I. Wings, none; metamorphoses complete; mouth suctorial. (Parasites. The flea.)

Order SIPHONAPTERA (or more properly *Aphaniptera*, Kirby; *Suctoria*, De Geer; *Aptera*, MacLeay.)*

II. With wings, which are sometimes, however, obsolete; eyes facetted, and occasionally with ocelli.

1. *Elytroptera*. Posterior wings covered by the crustaceous or coriaceous anterior pair.

* The apterous order APHANIPTERA, Kirby (*Siphonaptera*, Latreille; *Suctoria*, De Geer; *Aptera*, MacLeay), is united by Latreille with the *Thysanura* and *Anoplura*, and formed into a primary division of the true insects.

A. Mouth with four jaws; elytra of uniform consistence.

Order COLEOPTERA. Elytra crustaceous, horizontal; with a straight suture; wings transversely folded; metamorphosis complete. (Beetles.)

Order DERMAPTERA.* Elytra horizontal; suture straight; wings folded longitudinally and transversely: pupa complete and active. (The earwig.)

Order ORTHOPTERA. Elytra [tegmina] coriaceous, folding over each other at the tip; wings longitudinally folded: pupa complete and active. (Locusts, grasshoppers, cockroaches, &c.)

[Order THYSANOPTERA, Haliday, is probably to be placed next to the *Orthoptera*.]

B. Mouth proboscidate; pupa complete and active.

Order HEMIPTERA.†

2. *Gymnoptera* (naked wings).

A. Four wings.

a. Mouth with four jaws; wings not farinose.

Order NEUROPTERA. Wings thickly reticulated; the posterior as large as the anterior; no exserted ovipositor, nor sting; metamorphosis various. (Dragon-flies, &c.)

[Order TRICHOPTERA, Kirby, is here to be introduced, forming part of the *Neuroptera*, according to Latreille. (Caddice-flies.)]

Order HYMENOPTERA. Wings with large areas;

* This term has been completely misapplied by English entomologists, having been originally proposed for the *Cimicidæ*. I have, therefore, employed the term *Euplexoptera* in its stead for the earwig.

† In most of his works, Latreille has separated the rostrated *Hemiptera* of Linnæus into two orders—*Hemiptera* (*Cimex*, &c.), and *Homoptera* (*Cicada*, &c.), the characters of which are at least as important as those which separate the earwig from the grasshoppers.

the posterior smaller than the anterior; an exserted ovipositor or sting in females of the majority. (Bees, wasps, saw-flies, &c.)

b. Mouth transformed into a spiral tongue; wings farinose.

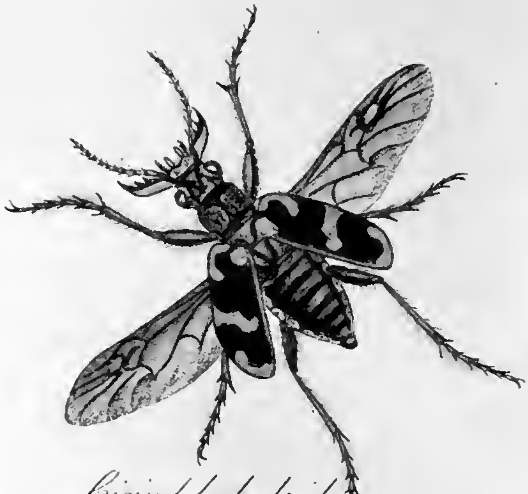
Order Lepidoptera. (Butterflies, moths.)

B. Wings, two.

Order Rhipiptera, Latr. (or more properly *Strepsiptera*, Kirby.) Halteres, two, placed in front of the wings, which are folded longitudinally.

Order Diptera. Halteres, two, placed behind the wings. (Two-winged flies.)

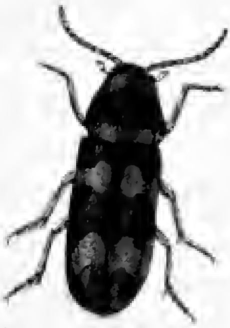
Miscodera arctica



Cicindela hybrida

Sperchius emarginatus

Clythra Hordei?



Abdera 4-fasciata

Saperda Carcharius

Orectochilus villosus

Agabus serricornis

J. O. W. Sci.

CHAPTER VI.

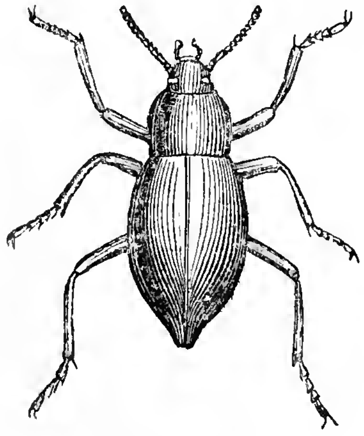
ILLUSTRATIONS OF THE ORDERS OF PTILOTA.

The first order, *Coleoptera,* is of very great extent, and is distinguished by having the wings inclosed in a case, composed of a pair of scaly pieces, meeting along the back in a straight line. The wings themselves are of large size, and of a membranaceous texture, and when unemployed are shut up in several transverse folds, the first of which occurs beyond the middle. These scales are termed elytra, and, shutting upon the back, they conceal the upper surface of the abdomen, as well as the wings, from view. The insects themselves are, for the most part, known by the name of beetles, although the term is not exclusively applied to them. Thus the blister-fly (*Cantharis*) is a coleopterous insect, as well as the turnip-fly (*Haltica nemorum*). On comparing a butterfly with a cockchafer or dor, it will be easy to perceive that the latter is distinguished by the following character,—*Wings two, membranaceous, folded transversely beneath two horny elytra,*—which character precisely

Shard-borne beetle.

corresponds with the Greek name *Coleoptera,* and the Latin one of *Vaginipennes,* given by the Latin naturalists to beetles. When, however, we attend to more minute differences of structure, we perceive the necessity of still more rigorously fixing the limits of our groups, by the employment of other characters, without which we should confound the locust, the grasshopper, the cicada, and the cimex, with the Coleoptera; and, indeed, in the early works of the great Swede, Linnæus united the two former insects, together with the generality of those which form the modern order of *Orthoptera,* with the beetles; and even in his last work we still find the earwig united with them, although the others were separated to form the ill-assorted order of *Hemiptera,* which order Linnæus had at first well defined, to comprise only those species which have an elongated tubular rostrum, articulated and bent beneath the breast. Now the Coleoptera, as well as the Orthoptera, differ from these in having the mouth formed of jaws and other organs for mastication. If, therefore, to the above character we add, *mouth with jaws,* all doubt as to the admission of the suctorial hemiptera is removed.

But it is further requisite to add to the character, *metamorphosis, or rather pupa, incomplete,* which will not only separate the Coleoptera from the fly, the butterfly, the cimex, &c., but also from those insects which have been by some authors united therewith. It is to be observed, however, that the first of the above characters does not exist throughout the entire order: thus in certain, although few, instances, both wings and elytra are entirely wanting, as in the glow-worm and the female drilus; in others, the elytra,



Blaps mortisaga.

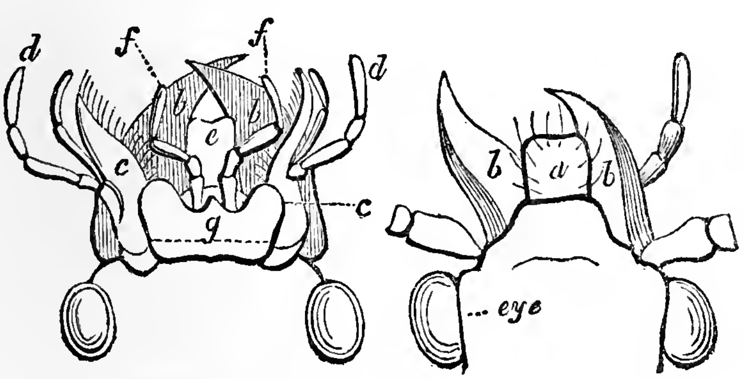
though existent, are soldered together without any wings being concealed by them, as in many of the *Carabidæ*, *Blapsidæ*, and other terrestrial darkling beetles, which have no use for wings. There are, in like manner, to be found exceptions to the transverse folding of the wings, in the *Buprestidæ*, and some of the longicorn beetles; whilst in *Meloe* one elytron partly laps over the other, and in *Sitaris*, *Ripiphorus*, &c., the suture is not straight, the elytra not shutting together, and in *Atractocerus*, *Molorchus*, &c., the wings are not covered by the wing covers, from the reduced size of the latter. Still there are sufficiently strong indications of direct affinity between all these insects, and others belonging strictly to the order; so that it is impossible not to perceive that they equally belong to it, although they form exceptions to *one* out of *several* of its leading characters.

Scarcely any branch of natural history has been so much investigated as this order of insects: indeed, many students, as well as amateurs, have exclusively devoted themselves to this group. The amazing variety of form; the richness or agreeable disposition in their colours; the great number of modifications which their external organization presents to our view, and which consequently afford so many additional aids towards their classification; the circumstance that these animals generally surpass in size the remainder of the class to which they belong; and the ease with which they are preserved, owing to the greater consistence of the outer covering, all tend to render the Coleoptera interesting to the student; but to these circumstances may be added the vast extent, as regards the number of species contained in the order. It would, indeed, be difficult correctly to judge of the number of these insects distributed over the surface of the globe, each arrival from foreign climes bringing hosts of novelties to our cabinets; and not only is it from the little frequented countries either of the old or new world that these importations are derived, but every year adds considerably to the lists of our indigenous species, by the discovery of undescribed beetles.

It is, indeed, unquestionable that the Coleoptera exceeds, in point of number of species, any other order of insects, although the Diptera and Hymenoptera—now that more attention is being bestowed upon the minute species — are not far behind the beetles in point of numbers. The French collections are estimated to contain not fewer than 30,000 distinct species of Coleoptera, and it is by no means improbable that at least 20,000 more are contained in the cabinets of other countries, wanting in the former. Thus 50,000 species may be considered as actually existing in our collections; and when it is known that immense tracts of country in Asia, Africa, North and South America, New Holland, and the Islands of the Southern Ocean, exist, from which not a single insect has been received, we may, without exaggeration, conclude that there are from 100,000 to 150,000 species of beetles in existence. This number, however, will scarcely be considered overrated, when it is further mentioned that in our own little island upwards of 3,500 native species have been actually described.

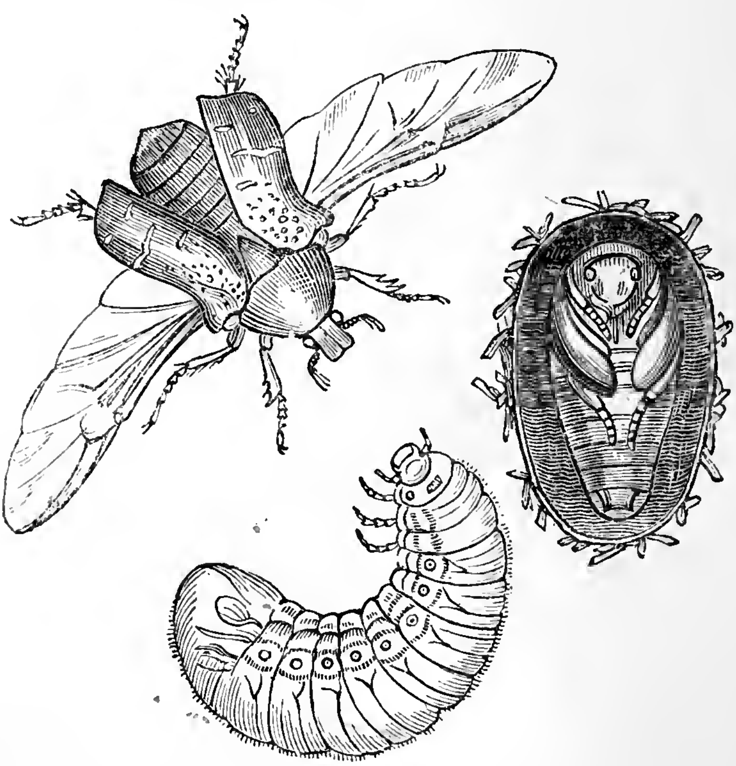
In the series of insects the Coleoptera also seem to possess a certain degree of superiority, which places them in the foremost ranks of the class to which they belong. An eminent French naturalist, M. Marcel de Serres, has not indeed adopted this opinion; the Orthoptera, whose anatomy he has profoundly investigated, being, in his ideas, entitled to be placed at the head of the class, his opinion being founded upon a consideration of the superior developement of the locomotive organs. Latreille, however, has considered that too much weight has been given to this character; and has suggested, from a *general* consideration of their comparative anatomy, that the Coleoptera are the most perfectly organized of insects, and consequently as being entitled to the highest rank.

The body consists of the head; a large segment, which has been generally termed the thorax; two short inconspicuous segments, which support the wing-covers and wings, and the two posterior pairs of legs, and which are the meso- and metathorax; and lastly, a continuous series of rings which compose the abdomen, and which are not furnished with locomotive organs. The head is generally of a rounded form, furnished with a pair of antennæ, extremely varied in their form in the different families, but which, in the majority, consist of only eleven articulations: they often differ in the sexes, those of the males being larger, longer, or laterally more developed than in the other sex. The eyes, which are always composite and facetted, are generally larger and globular in the earnivorous species, as well as in those which, from the slowness of their habits, have great need of defence against their enemies. Some few species have been asserted to possess *ocelli*. The mouth consists, as in all masticating insects, of an upper lip (labrum, *a*), a pair of horny upper jaws moving horizontally (mandibles, *b b*), two lower jaws (maxillæ, *c c*) of a less firm



consistence, but more complex in their organization, bearing a palpus (*d*) or feeler, and furnished moreover with a lateral lobe, which occasionally assumes the appearance of an additional palpus; and lastly a lower lip (labium, *e*), furnished with a pair of palpi (*f f*), and implanted upon a broad horny basal piece, which is termed the chin or mentum (*g*).

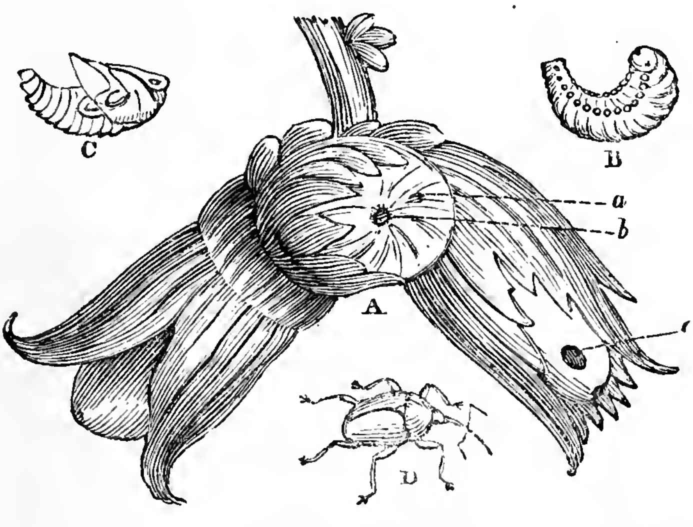
The abdomen is attached to the mesothorax by its entire breadth, its inferior portion, or the belly, being always more solid in its consistence than the upper surface, owing to the latter being defended by the wing-covers: it is moreover provided, on the under side, with only six segments, whilst on the upper seven or eight are visible. In some insects, however, as the rove beetles (*Brachelytra*), which have the abdomen, for the most part, exposed, the upper surface is as firm as the lower. The additional segments of the body, two or three in number, which are to be observed in the body of



Metamorphoses of the rose-chafer (*Cetonia aurata*).

the larva, compose, in the perfect beetle, the organs of generation.

The metamorphosis of the Coleoptera, or rather its character, as derived from the state of the pupæ, is termed incomplete. The larva resembles a soft fleshy worm, having the head and upper surface of the thoracic segments scaly, and provided with six legs, attached in pairs to the three anterior segments of the body. The head of the larva exhibits, in an undeveloped manner, nearly all the parts of the mouth of the perfect insect. In the place of the facetted eyes are to be seen a number of small granular tubercles, which somewhat resemble the ocelli of the hymenoptera, &c., being often six in number on each side of the head. The jaws are much more developed than the other parts of the mouth, which is, doubtless, owing to the circumstance, that it is in the larva state that the greatest supply of nourishment is taken by the insect. The antennæ are very small and conical, and generally only four-jointed. The more inactive and concealed these larvæ are, the more they exhibit the appearance of a worm or grub, as in the nut-weevil; those



A, a branch of the filbert tree; *a*, a healed wound caused by the introduction of the egg of the nut weevil; *b*, extremity of the nut; *c*, exit hole of the grub; B, the grub of the nut weevil; C, the pupa of the same; D, the perfect insect (*Balaninus nucum.*)

of the more carnivorous species are generally more alert, and in the rove beetles we have seen that they exhibit very much of the appearance of the perfect insect. The extremity of the body of these larvæ is often furnished with a fleshy retractile tubercle on its under side, which is employed as a seventh leg. When the larva has attained its full size, it generally burrows into the earth, where it hollows out an oval cell, within which it is transformed into an inactive pupa, of an uniform whitish colour, with the wings and legs folded upon the breast. The pupæ of some of the species are, however, naked, as in the *Chrysomelidæ*, whilst others, as *Clythra*, pass this state within the case which had served for their abode whilst larvæ. The duration of these transformations, the habitations and economy both of the larva and perfect insect, varies, as may well be supposed, in so extensive a group, in the different families and genera. Arrived at their last state, they possess their full degree of developement, and now the reproduction of their kind is their chief employment.

Hardly any coleopterous insect has been employed in the arts, but it is questionable whether some of the species might not be rendered useful. The *Meloe* and the *Coccinella* emit from the mouth and legs a gummy fluid of a fine yellow colour, which might be employed in painting. The former insect is of a large size, and sufficiently abundant for experiment, if some of our celebrated chemists would not think the subject beneath their notice. In like manner the *Mylabris*, *Cantharis*, or *Carabus*, might furnish an useful extract of a fine colour. The medicinal properties of the *Cantharides* are too well known to require detailed description. It is not improbable that many other species possess similar powers. Less useful, but highly ornamental, the metallic coverings of many species may be, and indeed have been, employed in decorating various kinds of trinkets, giving an effect equal to that of gold or precious stones of every shade. By the Indians they are employed to decorate the head-dresses and necklaces, as well as for ear-rings, &c.; and I have seen, in large warehouses in London, entire dresses decorated with the elytra of the *Buprestis chrysis.* The larvæ of the *Coccinellidæ* are eminently serviceable in checking the swarms of *Aphides,* whilst the *Silphidæ,* and many other insects, by feeding upon decaying vegetable and animal matter, are active agents in keeping up the regular succession of changes in the creation.

The Coleoptera have been divided in different manners by various authors. By Linnæus, the construction of the antennæ formed the character upon which the sections were established; but the distribution more generally adopted by modern authors is founded upon the number of joints in the tarsi, as follows:—

Sect. 1. *Pentamera,* all the tarsi having five joints.

Sect. 2. *Heteromera,* the four anterior tarsi having five, and the two posterior having only four joints.

Sect. 3. *Tetramera* of the French authors, having apparently only four joints in each tarsus.

Sect. 4. *Trimera* of the French authors, having apparently only three joints in each tarsus.

It is to be observed, however, with respect to the two latter groups, that there is a minute rudimental joint at the base of the terminal joint, which has been overlooked, and which renders the names *Tetramera* and *Trimera* incorrect; still the general structure of the tarsus in these two groups is so well marked, that I have not hesitated to adopt them; and, secondly, that the section *Dimera* of Latreille, founded upon an incorrect examination of insects supposed to have only two joints (the *Pselaphidæ*), is equally incorrect, and must consequently be rejected.

The following is the arrangement of this order given by Latreille, in the last edition of the *Règne Animal,* the names of the families employed by English writers being introduced, and the English names added :—

1. Pentamera.
   A. Carnivora.
      a. Cicindélètes (*Cicindelidæ*, tyger-beetles).
      b. Carabiques (*Carabidæ* and its sub-families,—ground-beetles).
      c. Hydrocanthares (*Dyticidæ* and *Gyrinidæ*, water-beetles and whirlwigs).
   B. Brachelytra (*Staphylinidæ* and its sub-families,—rove-beetles).
   C. Serricornes.
      a. Sternoxi.
         1. Buprestides (*Buprestidæ*).
         2. Elaterides (*Elateridæ*, skip-jacks).
      b. Malacodermes.
         1. Cebrionites (*Cebrionidæ* and *Cyphonidæ*).
         2. Lampyrides (*Lampyridæ*, glow-worms; and *Telephoridæ*, soldier-beetles).
         3. Melyrides (*Melyridæ*).
         4. Clairones (*Cleridæ*).
         5. Ptiniores (*Ptinidæ*).
      c. Xylotrogi (*Lymexylonidæ*).
   D. Clavicornes.
      a. [Terrestrial species].
         1. Palpatores (*Scydmænidæ*).
         2. Histeroides (*Histeridæ*).
         3. Silphales (*Silphidæ*, sexton-beetles, &c.)
         4. Scaphidiles (*Scaphidiidæ*).
         5. Nitidulaires (*Nitidulidæ*).
         6. Engidites (*Engidæ*).
         7. Dermestini (*Dermestidæ*).
         8. Byrrhiens (*Byrrhidæ*).

b. [Subaquatic, or aquatic species].

1. Acanthopodes (*Heteroceridæ*).

2. Macrodactyles (*Elmidæ*).

E. Palpicornes.

a. Hydrophiliens (*Hydrophilidæ* and *Helophoridæ*).

b. Sphæridiotes (*Sphæridiidæ*).

F. Lamellicornes.

a. Scarabæides (genus *Scarabæus,* Linn., chafers).

b. Lucanides (genus *Lucanus,* Linn., stag-beetles).

2. Heteromera.

A. Melasoma.

a. Pimeliares (*Pimeliidæ*).

b. Blapsides (*Blapsidæ,* darkling beetles).

c. Tenebrionites(*Tenebrionidæ,*meal-worm beetles,&c.)

B. Taxicornes.

a. Diaperiales (*Diaperidæ*).

b. Cossyphenes (*Cossyphidæ*).

C. Stenelytres.

a. Helopiens (*Helopidæ*).

b. Cistelides (*Cistelidæ*).

c. Serropalpides (*Serropalpidæ*).

d. Œdemerites (*Œdemeridæ*).

e. Rhynchostomes (*Salpingidæ*).

D. Trachelides.

a. Lagriaires (*Lagriidæ*).

b. Pyrochroïdes (*Pyrochroidæ*).

c. Mordellones (*Mordellidæ*).

d. Anthicides (*Notoxidæ*).

e. Horiales (*Horiidæ*).

f. Cantharides (*Cantharidæ,* blister- and oil-beetles).

3. Tetramera.

A. Rhynchophores (*Bruchidæ* and *Curculionidæ,*weevils).

B. Xylophaga (*Scolytidæ, Paussidæ, Bostrichidæ, Cucujidæ*).

C. Longicornes (genera *Cerambyx* and *Leptura*, Linn. including *Prionus*, Geoffr.).

D. Eupodes.

a. Sagrides.

b. Criocerides (*Crioceridæ*).

E. Cycliques.

a. Cassidaires (*Hispidæ, Cassididæ*).

b. Chrysomelines (*Chrysomelidæ*).

c. Galerucites (*Galerucidæ*).

F. Clavipalpes (*Erotylidæ, Agathidiidæ*).

4. TRIMERA.

A. Fungicoles (*Endomychidæ*).

B. Aphidiphages (*Coccinellidæ*, lady-birds.)

C. Pselaphiens (*Pselaphidæ*).

ORDER II.—EUPLEXOPTERA.

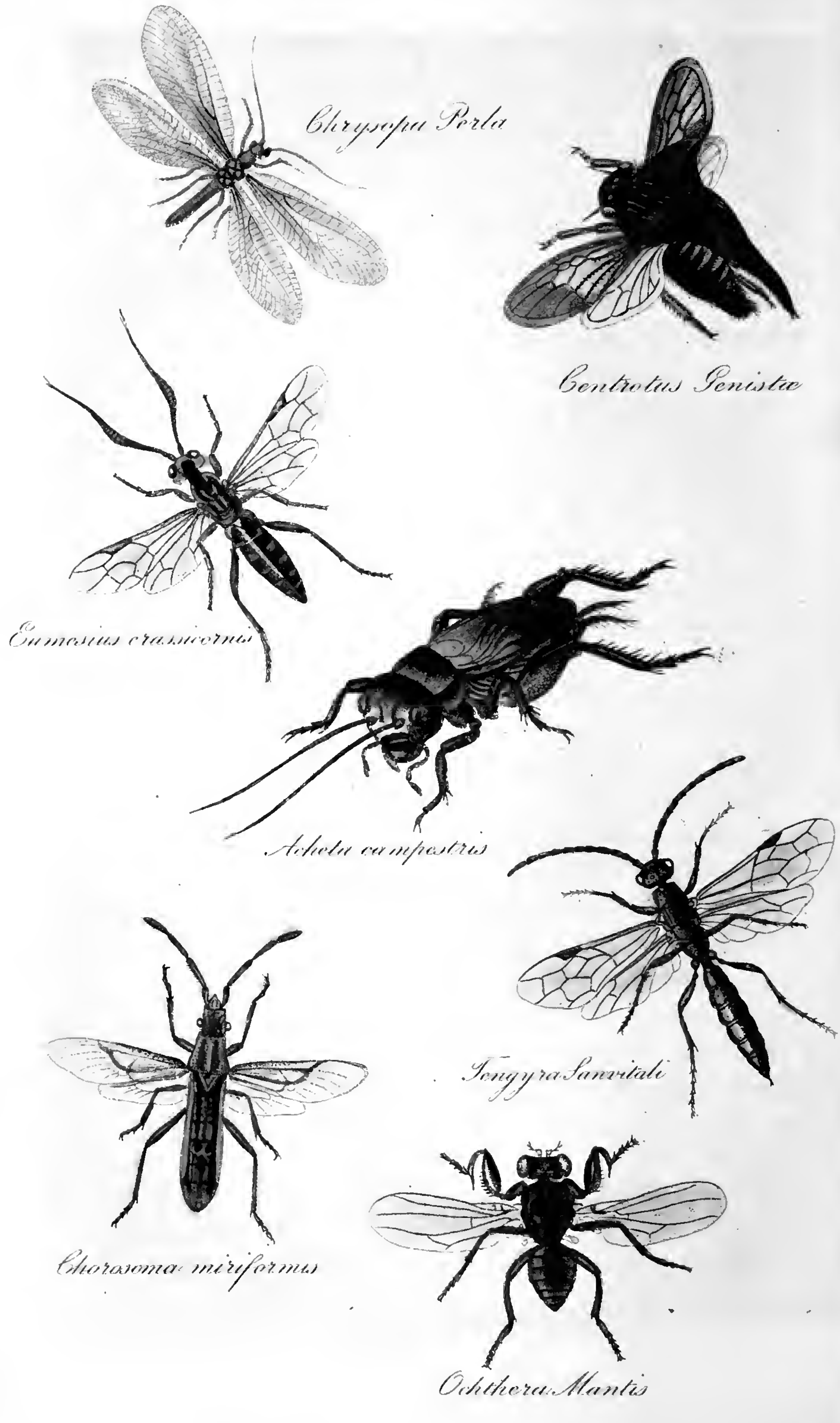
This order, which is the *Dermaptera* of Leach and Latreille, but not of Retzius, comprises the family of the earwigs, and is distinguished by having the body of an elongated form, and terminated by a scaly forceps formed of two long and curved horny appendages, pointed at the tip, and having several small teeth on the inner margin; the tarsi are three-jointed. The wing-covers are short and square, not covering more than one-third of the abdomen; the wings are of large size, although but seldom seen, being shut up by means of numerous longitudinal and transverse folds, so as to occupy but a very small space. This insect has so much the appearance of some of the *Staphylinidæ*, that Linnæus was induced to place it in the order *Coleoptera*, with which it indeed agrees, in having the wing-covers united (when closed) in a straight line; the transformations, however, which it undergoes do not agree with those of the beetles, the insect retaining its powers of locomotion, and, consequently, of feeding, during the pupa state; in which respect, as well as in the structure of the mouth, it resembles the grasshoppers and other orthopterous insects. From these, however, it differs so much, that Dr. Leach, M. Leon Dufour, and others, have formed it into a distinct order, whilst Latreille and his followers unite it with the Orthoptera, but form it into a distinct section. In this respect, therefore, it will be seen that the despised earwig assumes a considerable degree of interest, which will not be lessened when we learn that the generally received opinion, that it creeps into the brain of sleeping persons through the ears (an opinion current in most countries, as we learn from the names of *perce-oreille* given to it by the French, *oren-wurn* by the Germans, and *oren-metel* by the Dutch), is one of those popular errors which are so difficult to root out. That the earwig may, on some occasion or other, introduce itself into the ear of a person sleeping on the grass, or in outhouses, is not more unlikely than that any other insect which resides in holes and crevices in such situations should do the same; but the structure of the human ear would completely prevent any insect from entering the head, whilst the situation itself would evidently be as uncomfortable to the insect as it would be to the person annoyed.

The food of the earwig consists of vegetable matters. It does much mischief in gardens, devouring not only fruits, but also the petals of flowers; indeed, they are one of the greatest pests to the florist. I have observed that they are especially destructive to the noble flowers of the dahlia, but I am unable to give any more effectual recipe for their destruction than is contained in the following quaint extract from Old Mouffet:—"The English women hate them exceedingly, because of the flowers of clove gilliflowers that they eat and spoyle, and they lay snares for them thus: they set in the utmost void places ox-hoofs, hogs'-hoofs, or old cast things that are hollow, upon a staff fastened into the ground, and these are easily stuffed with cloathes or straw; and when by night the savages creep into them to avoid the rain or hide themselves, on the morning these old cast things being suddenly taken away and shook forth, a great multitude of them fall, and are killed with treading upon them." The modern Londoners have supplied the place of these ox-hoofs in their trim-kept gardens with the hollow claws of lobsters, which give their borders a very droll appearance.

As a set-off against the mischievous propensities of these insects, may be mentioned the peculiar and almost unique instance which the females afford of maternal care for their young progeny. In general, the care taken and the labours undergone by female insects in the construction of nests, are but the result of instinct, the parent dying long before the birth of her progeny; but in the earwig, the reverse of this takes place. Not only do these females take great care of their eggs, covering them over with their bodies, brooding over them like a hen, and collecting them with great care when scattered about, but show great affection to the young when hatched. These young ones differ only from their parents in their small size, want of wings and wing-covers, and the slenderness and straightness of the forceps at the extremity of the body. In the pupa state they are equally active, and have the wings and wing-cases distinct, but inclosed in flat sheaths of a small size, applied closely to the back. The attachment existing between the parent and her young is reciprocal; De Geer having discovered a female in the month of June under a stone sitting upon her progeny, which appeared to be just hatched, and which nestled under their parent like chickens under a hen. Having removed this family into a box with earth, he observed that, instead of burrowing into the ground as might have been expected, the young ones crowded under the body and between the legs of their parent, who remained quiet, and allowed them to continue in this position for hours together. He fed his captives with morsels of ripe apple, upon which they thrived, casting their skin several times like caterpillars. The mother did not live long in confinement, and the young ones had the cannibalism to eat the dead body of their parent. After this the number of the brood diminished, without any remains of the dead bodies being observed: whence it is to be inferred that the survivors had also devoured their dead bodies. This, however, would most probably be occasioned by the want of their proper food, as they never thus prey upon each other in a state of nature. After the final moulting, the wings are expanded to their full size, in which state they are very beautiful objects, not only for their delicate structure, but from the singular direction of the nervures, which are quite unlike those of any other insect.

There are numerous species of earwigs, six or seven of which are inhabitants of this country, composing the genera *Forficula*, *Apterigyda*, *Labia*, and *Labidura*.

PLATE 3.



J. O. W. del.

ORDER III.—ORTHOPTERA.

This order was at first united by Linnæus with the Coleoptera, and afterwards arranged by him with the haustellated Hemiptera, from the construction of the wings. By Geoffroy it was also arranged with the Coleoptera, forming the third primary division of that order.

De Geer, however, saw the impropriety of retaining these insects in either of these two classes, from each of which they differed in the structure of the wings and mouth, or in the nature of their metamorphoses, and accordingly raised them to the rank of a distinct order, to which Olivier subsequently gave the name of *Orthoptera*, from the longitudinal or straight (ορθος) folding of the wings (πτερα). Fabricius had also raised these insects to the rank of an order, which he termed *Ulonata*, from the Greek ουλος, an outer gum, and γναθος, a jaw, the lower jaws being laterally armed with a helmet-like plate, which is in fact but the greatly developed external lobe of the maxillæ.

The body in these insects is generally of a large size, less firm in its consistence than in the Coleoptera, with the tegmina or wing-covers more coriaceous, provided with numerous nervures, and not uniting when closed in a straight line down the back; the wings are membranaceous, and furnished with equally numerous nerves, arranged longitudinally, with transverse threads, so that they fold up something like a fan; the mouth is furnished with a very considerably developed organ, which is the analogue of the tongue. These characters alone would suffice to point out their differences from the Coleoptera, in which the outer lobe of the maxillæ is not helmet-like, and the wings are transversely folded, whilst the mouth in the Hemiptera is not formed for mastication, being unprovided with jaws, and the wings are simple, extended, when at rest, beneath the wing-eovers, without being folded.

The head of orthopterous insects is in general large, and almost perpendicular in the majority, the antennæ being placed on its upper part, and which are of variable length and structure, but often long and multi-artieulate; the eyes are large and lateral; and the ocelli, which are found in the majority, are placed on the forehead, sometimes widely apart: the thorax, or, more strictly speaking, the pronotum, is large, being in many species extended eonsiderably backwards; the abdomen is long, generally of a conical form, and terminated in the females of many speeies by an exserted apparatus for depositing the eggs, in the shape of a sword or cutlass.

The legs of the *Orthoptera* are very long, and are employed in giving eonsiderable activity to these insects, in some of whieh these organs are simply organs fit for walking (*Blatta*); in others, the fore pair of legs become instruments for seizing the prey (*Mantis*); whilst in the rest, the hind legs are greatly increased in size, supporting strong internal muscles, enabling the insect to effect leaps of great extent; these legs are also employed in some species to produce a loud ehirping noise by their friction against the base of the wing-covers (*Locusta*), which noise appears to be a eall of the males, by which sex alone it is produced. The tarsi vary, in the number of the joints, from three to five; generally speaking, the body is long, and often much compressed.

The nature of the metamorphoses of these insects is also another great character by which they are distinguished from the Coleoptera, the larvæ and pupæ differing only from the imago, either by entirely wanting, or having only rudiments of wings. The larva and pupa of the great green grasshopper are represented in page 197. In these states the insect is as active and as voracious as in that of the imago.

If we shall find cause, in investigating the Hymenoptera, and some other orders, to admire the admirable displays of instinct which they afford us, we are compelled to admit that the present order cannot bear any thing like a comparison in the means of attracting our attention. They, however, amply perform their work in the great labours of the economy of nature, for they are amongst the most voracious of the insect tribes. The cockroach, the mantis, and the locust, are too well known in this respect to require more than the insertion of their names, to bring before us the great and occasionally overwhelming ravages which they commit. Their food, for the most part, consists of vegetable substances, and, being less serviceable for the purposes of animalization than animal matters, it is necessary that a much greater quantity of food should be taken, in proportion to the size of the insects, than is consumed by the predaceous species which feed on other insects, or upon carrion. Hence, from their great size, the *Orthoptera* may be regarded as the most pre-eminently herbivorous of the insect tribes, and their voracity is excessive. We need only refer to the locust for a confirmation of this statement, whilst the cockroach furnishes sufficient proof of the in-door devastation which the insects of this order are capable of performing. The internal anatomy of this order is organized in a manner adapted to their herbivorous qualities. The alimentary canal is greatly elongated, and divided into several chambers or stomachs; four of these have been attributed to the mole-cricket, whose internal structure has been long ago investigated, and more recently by Dr. Kidd, of Oxford. From this circumstance it has been supposed that the *Orthoptera*, analogous to the ruminating quadrupeds, had the power of bringing back into the mouth aliments which had already passed into the stomach; but according to M. Marcel de Serres, these chambers are not in fact stomachs, but merely contain a salivary and biliary fluid, which the animal often disgorges when seized. The internal structure of the larva does not differ from that of the imago.

All the known species of this order are terrestrial. Stoll has, indeed, represented an extraordinary insect, belonging to this order, as an aquatic species, but there is no confirmation of this circumstance.

The species found in our part of the world deposit their eggs but once in the year, which takes place at the end of the summer, when they have assumed the perfect winged state. They perish at the approach of winter, and the species are perpetuated by the eggs remaining unhatched, during the winter, in the earth where they were deposited, the larvæ coming forth in the following spring.

It is difficult to preserve the insects of this order, without considerable attention, in our collections, the body, being moist and fatty, attracting destructive insects, such as the *Anthrenus*, *Dermestes*, &c. It is on this account that some of the species which are natives of Africa are eaten by the negroes, who have thence obtained the name of *Acridophagi*.

The order, excluding the earwigs and including the cockroaches (which Dr. Leach separated as an order under the name of *Dictyoptera*), is divisible as follows :—

Section A. Cursoria.—Hind legs formed for running or walking; wings and wing-covers generally horizontal; females not provided with a horny exserted ovipositor.

Fam. 1. *Blattidæ*.—Tarsi five-jointed; head hidden beneath the shield of the thorax; body flattened and oval or rounded. (Cockroaches.)

2. *Mantidæ*.—Tarsi five-jointed; head exposed; body long, and generally narrow; fore-legs raptorial. (Soothsayers.)

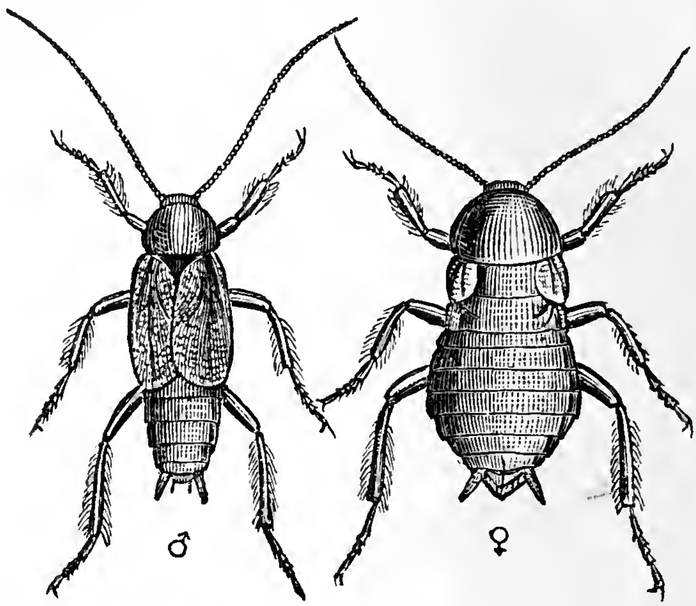
3. *Phasmidæ*.—Tarsi five-jointed; head exposed; body long, and generally narrow; fore-legs not raptorial. (Spectre insects.)

Section B. SALTATORIA.—Hind legs formed for leaping; wings and wing-covers generally deflexed at the sides; females generally provided with an exserted horny ovipositor.

4. *Achetidæ.*—Antennæ very long; wings and wing-covers horizontal; tarsi three-jointed. (Crickets.)
5. *Gryllidæ.*—Antennæ very long; wings and wing-covers deflexed; tarsi four-jointed; ovipositor long, sword-shaped. (Grasshoppers, with long antennæ.)
6. *Locustidæ.*—Antennæ short; wings and wing-covers deflexed; ovipositor short. (Locusts and grasshoppers, with short antennæ.)

The *Blattidæ* or cockroaches are nocturnal in their habits, extremely active, and the majority reside in the interior of houses, where they delight to take up their abode in the neighbourhood of fire-places in kitchens, &c., but especially in bakehouses and other situations where much cooking takes place, where they inhabit the clefts of walls near ovens by day, coming forth by night in myriads, but retreating with the utmost precipitation to their holes immediately that a candle is intruded amongst them. They are extremely voracious, destroying almost all sorts of provisions, but more particularly bread and other vegetable matters. It is very difficult to extirpate these disgusting insects, which, in addition to the destruction which they cause, emit an exceedingly disagreeable odour, which attaches to whatever they have crept over. Perhaps the most advantageous method of destroying them is to use a small wooden box with sloping sides, having a circular aperture at the top with glass edges, out of which it is impossible for them to escape. This should be nightly baited, and the contents thrown the following morning into scalding water. This plan is certainly superior to the employment of red poisoned wafers.

The species which are truly indigenous in England are of comparatively small size, and are generally found in woods; but the species which frequent our houses, occasionally in such myriads as to cover the floors of the lower apartments in the metropolis at night, are of more southern origin, the ordinary species (*B. orientalis*) being a native of Asia. It is probable that its

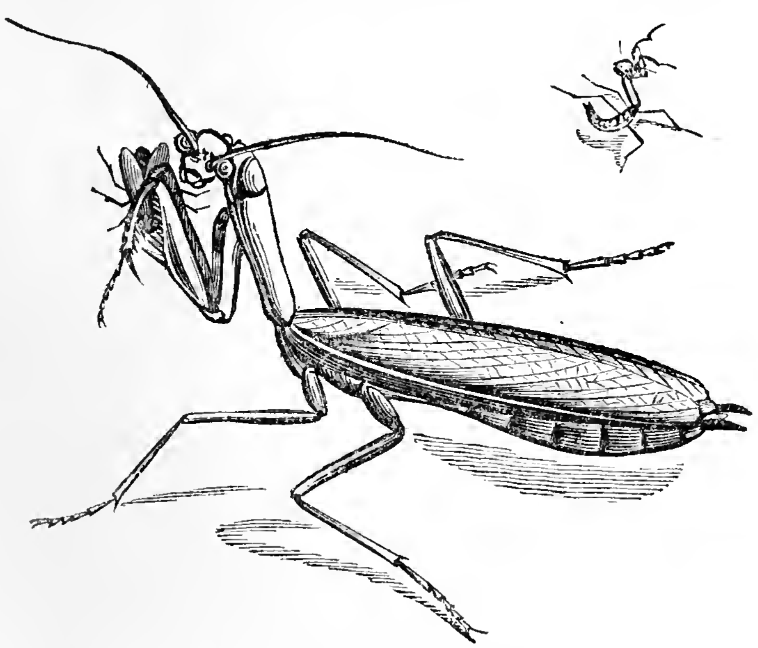


Blatta orientalis (male and female).

introduction was owing to the navigation of the Levant, being brought over in ships' cargoes. It is to the same cause that the American cockroach (*B. americana*), a much larger species than the ordinary one, is gradually acquiring a settlement in London and other ports. But the ravages of these insects in warm climates appear to be far greater than amongst us, as appears from the account given by Drury of the *B. gigantea*, which is an inhabitant of the West Indies.

But the most singular circumstance connected with these insects consists in the manner in which the eggs are deposited. Instead of these being laid singly, as is generally the case amongst insects, nature has given the females a most curious instinct for the preservation of their offspring. In fact, the females deposit a large oblong mass, convex at the sides, and flattened at the edges, which serves as a case for an entire family of young blattæ. This mass, which is of large size, being nearly half the entire size of the abdomen of the female, is borne about by her for a considerable period. At first it is white, but gradually becomes dark brown. Although composed of a single piece, the edge along one side is slit, the margins of each side of the slit being denticulated and fitting into each other, and being cemented together so strongly that the other portions are even less strong than at the union of the sutures. Nature has, however, provided the inclosed insects with a key to this prison, enabling them to escape at the fitting period; this consists of a fluid which they emit, which softens the cement of the denticulated margins, and affords to the young captives the means of escape from a situation in which they had previously attained a sufficiency of strength to enable them to follow their habits. On their quitting the case the cleft shuts again, so accurately that it appears as entire as before. This singular proceeding occupies the female about a week, and suggests several interesting points of inquiry as to the manner in which the eggs are arranged by the female, the nature of the envelope, the cause of its being so long borne about by the parent, &c. The larvæ and pupæ are equally active with the imago, and not less destructive, differing only in their smaller size, and in entirely wanting or having but the rudiments of wings and elytra.

The family *Mantidæ* consists entirely of exotic insects, of which the general appearance will be seen in the accompany-



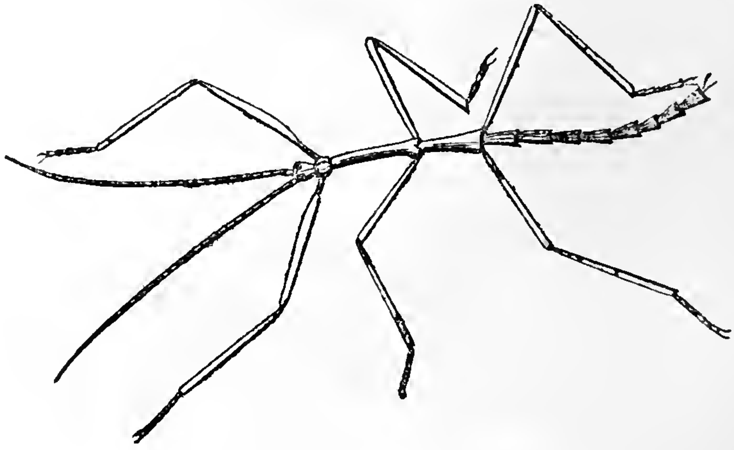
Mantis, in the act of seizing a fly, with a young one just hatched.

ing figure. They have obtained their ordinary English name of soothsayers (*prie Dieu* in France) from their curious attitude when at rest, appearing to be engaged in prayer with uplifted hands.

They are the only orthopterous insects which subsist upon other insects, and for this end their entire structure indicates strength and agility, the most curious part of the structure of this group of animals consisting in the organization of the fore-legs, which are much stronger than the posterior legs, and ordinarily used in the prehension of their food; and nothing can exhibit a more beautiful adaptation of structure to functions than is to be observed in the fore-leg or hand of the mantis.

These interesting insects are extremely numerous in species, inhabiting the warmer districts of the earth, and reaching as far north as the middle of France. None, however, have been found in this country. They are extremely variable in their forms.

The *Phasmidæ* are ordinarily termed spectres, leaf insects, walking-stick insects, from their singular forms, reminding the observer more of vegetable than animal productions.



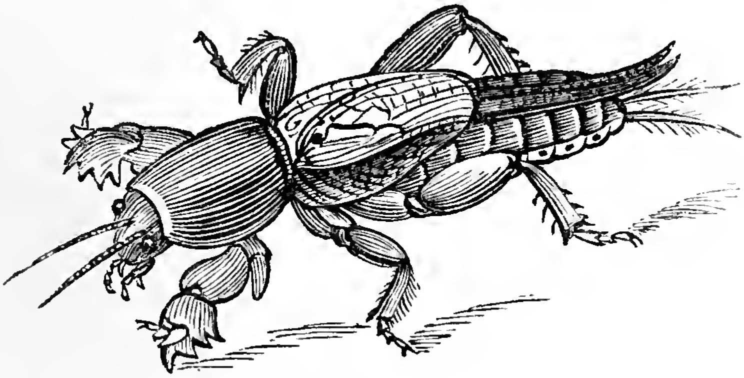
Bacteria fragilis (New Holland).

They are inhabitants of tropical climates, a very few species, of comparatively small size, being found in the south of Europe. They delight in remaining stationary upon the branches or twigs of plants, upon which they feed, the structure of their legs being simply ambulatory. The student must consult the Synopsis of *Phasmidæ*, of Mr. G. R. Gray, for fuller details and a notice of the various species, distributed into many sub-genera.

The family of the Criekets (*Achetidæ*) comprises several well-known species of insects: the common house cricket (*Acheta domestica*), the field cricket (*Acheta campestris*), and the mole ericket (*Gryllotalpa vulgaris, Gryllus Gryllotalpa* Linn.) All these insects are eminently distinguished by the chirping, ereaking kind of noise whieh they produce, whence evidently the origin of the English name.

The cricket family is distinguished from the loeust family, as well as from that of the grasshoppers having long antennæ, by having the wings and wing-covers carried horizontally when at rest, the former extending beyond the latter in slender fillets, and the latter having a small circular space eovered with a glassy membrane in the males, which is employed in producing the noise whence the inseets have derived their name. As the females are destitute of this, they do not possess the power of chirping; the tarsi are composed of only three joints.

The house cricket (*Gryllus domesticus*, Linnæus, *Acheta domestica*, Fabricius), is too well known to need description.

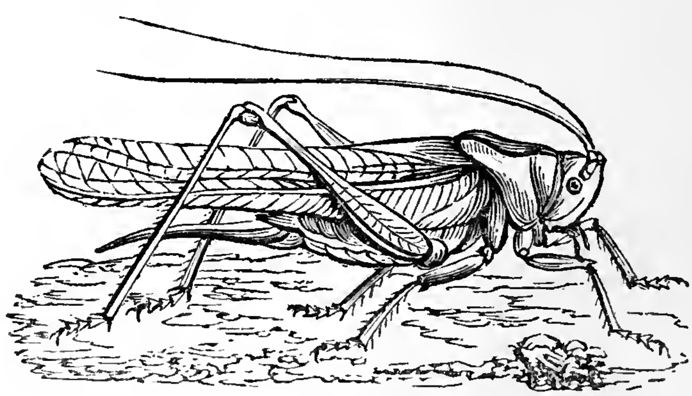


Gryllotalpa vulgaris.

The mole cricket is a curious animal, deriving its name from the similarity both of its structure and habits to the mole. The antennæ are short and slender, and the fore legs very broad and notched, being very powerful and well adapted for burrowing under ground; the abdomen is terminated by two long slender and hairy bristles. This insect, which, with some trifling variations in structure, is found all over the globe, is an inch and a half or two inches long, nearly cylindric, and of a brown colour.

It is a noxious animal, committing much injury in gardens and cultivated ground, burrowing a short distance beneath the surface, with the assistance of its large palmated fore-legs. In this manner it loosens the roots of vegetables, upon which, indced, it is said to subsist.

The family *Gryllidæ* comprises the grasshoppers with long and slender antennæ, of which the great green grasshopper (*Gryllus viridissimus,* Linn.) is the most conspicuous example. In insects of this, and the preceding and following family, the powers of leaping are prodigious, being performed by means of the peculiar structure of the hind legs.



Great green Grasshopper.

The noise which these insects produce is made by means of a round plate, made of very fine transparent membrane, resembling a little mirror or piece of talc, of the tension of a drum. This membrane is surrounded by a strong and prominent nervure, and is concealed under the fold of the left wing-cover, which has also several prominent nervures answering to the margin of the membrane or ocellus. There is every reason to believe that the brisk movement with which the grasshopper rubs these nervures against each other, produces a vibration in the membrane, and thus causes the sound.

In the family *Locustidæ* (comprising the locusts and grasshoppers with short antennæ) the base of the wing-covers (tegmina) of the males is not furnished with a circular spot of membranous texture, and the chirruping noise which they make is produced by rubbing the hind femora against the margins of the wing-covers. These insects are exceedingly active, leaping to great distances, and flying with equal agility, and at considerable heights, feeding voraciously upon vegetables, to which they are sometimes very destructive, and amongst which the too renowned locust of the Scriptures (*Locusta migratoria*) is the most redoubtable. In this country we possess about twenty-five species of this family, but all of small size.

ORDER IV.—THYSANOPTERA (Haliday).

This order consists of the Linnæan genus *Thrips*, comprising a considerable number of minute but very curious insects, placed by Linnæus in the order *Hemiptera*, by Latreille in the *Homoptera*, but recently separated by Mr. Haliday as a distinct order. The body is long, narrow, and sub-depressed, resembling that of a *Staphylinus;* the antennæ short, and composed of eight joints, the terminal joint being unarmed with a seta; the four wings are of equal size and form, long and linear, deeply fringed with hairs on all sides, and laid horizontally upon the back; the tarsi are short, and terminated by a vesicle instead of the ordinary ungues; the rostrum is described by Latreille as being small or scarcely distinct, but the mouth is not rostrate, strictly speaking, but armed with mandibles and palpigerous maxillæ, and thus entirely differing from the other haustellated insects.

These insects are of exceedingly minute size, few exceeding a line (one-twelfth of an inch) in length; they are very active, seeming to leap rather than fly when disturbed. At such times, also, they elevate the posterior extremity of the body like a *Staphylinus*, giving it various movements. They are found upon flowers and plants, and under the bark of trees. The different species of this genus are well known to gardeners, from their attacks upon different trees, cucumbers, &c., their punctures upon the leaves giving them a dead appearance, curling them up at the sides, and appearing as soon as the least verdure is seen, at which time they are in the larva state, although some are perfect. The larvæ are long and of a faint yellow, and when fully grown are nearly the size which they attain in the winged state. For some time after the insect has attained the winged state, it retains nearly its original colour, but afterwards turns nearly black. They especially infest melons, cucumbers, vines, kidney-beans, &c., particularly attacking the blossoms; the marks which they produce being in patches, and deeply scalloped. They also attack the young leaves of peaches and nectarines as soon as they appear in the spring, which causes them to shrink up, and they also prey upon the bloom before it expands. They feed in the interior or fructification part, which weakens it materially, and causes the blossom-bud to fall off before it is formed into fruit.—*Major on the Insects injurious to Fruit Trees.*

The student must consult Mr. Haliday's Memoirs upon these insects, published in the Entomological Magazine, where numerous species are described.

ORDER V.—HEMIPTERA.

This order is characterized by the *jointed, sucker-shaped mouth,* the *wings membranous,* covered by *wing-covers,* either *entirely membranous* and deflexed, or *partly coriaceous* and *partly membranous* and horizontal, and the *tarsi never composed of more than three joints.* The mouth is composed of a fleshy articulated canal, terminating in a point inclosing several fine bristles, which are employed as lancets in wounding the substances upon which the insects feed; it is also furnished externally at the base with a small conical piece transversely striated, which represents the upper lip of the other orders. When unemployed, this proboscis is laid along the breast, often reaching to or even extending beyond the base of the hind legs; when employed it is protruded forwards.

All the insects belonging to this order undergo a series of moultings, analogous to those of other insects, although less in degree. They are produced from eggs as small, active, six-legged larvæ, having nearly the resemblance of the perfect insects, but entirely destitute of wings or wing-covers. After shedding the skin several times, gaining thereby only an increase of size, they appear as pupæ, but still active, and differing only from the larvæ in having the wings and wing-covers concealed in small cases placed upon the back. Another moulting brings them to the imago state, in which their wings are fully developed. In the apterous, or wingless species, the transformations merely consist in a gradual increase of size at the successive moultings. The pupæ of the *Hemiptera* take as much nourishment as the larvæ.

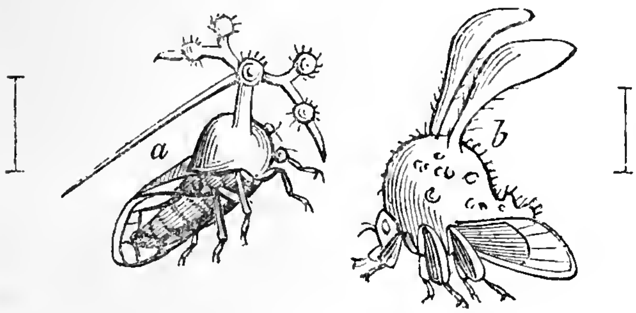
The majority of these insects are found in their various states upon plants, the juices of which serve for their nourishment: some few, however, inhabit the water (as the *Nepidæ* and *Notonectidæ*), whilst others reside upon its surface, as *Gerris*, *Hydrometra*, &c. These appear to prey upon other dead or floating insects: others fly in the air with great agility, although they walk but slowly; and some leap to a great distance, as in the *Cercopidæ*. A few of the species, one only of which is found in our climate, attack man, namely, the *Cimex lectularius*. The majority are varied in their colours; a few only (as the *Nepa grandis* and large exotic *Cicadæ*) attain a large size; the majority being less than an inch in length.

As above characterized, the order *Hemiptera* is divisible into two sub-orders, or primary classes, the *Heteroptera* and *Homoptera*, the first having the wing-covers horizontal and of unequal consistence, the basal portion being coriaceous, and the terminal half membranous; and the second section having the wing-covers deflexed and of equal consistence throughout. Moreover, in the first of these divisions the rostrum, or promuscis, as it is termed by Mr. Kirby, arises at the front of the under-side of the head, whereas in the second it springs from its posterior portion, near the base of the fore legs, and sometimes appearing pectoral. In the former, the hemelytra, besides their different substance, as well as the wings, cross each other; while in the latter, the organs of flight are deflexed, and do not lap over each other at all. The antennæ, also, of the former are often long, and do not terminate in a bristle; whilst in the other, with few exceptions, they are very short and setigerous. In the *Heteroptera* the body is depressed and flat; in the *Homoptera* convex and thick. In the former the scutellum is one of the principal features of the trunk; in the latter not at all remarkable.

The first of these sub-orders, *Heteroptera*, is divisible into two primary divisions, namely, 1. the *Geocorisa*, having the antennæ long and exposed, and 2. the *Hydrocorisa*, having antennæ short and concealed.

The former comprises the very numerous species of field and house bugs, divided into numerous families or rather sub-families; the latter comprises such species as reside in the water, and which are predaceous in their habits, feeding upon other insects, which they seize by means of their fore-legs, serving as claws, the extremities folding upon the basal portion. The latter division comprises two families, the *Nepidæ*, or water-scorpions, so named from the cheliferous structure of the fore-legs; and the *Notonectidæ*, or boat-flies, so named from the boat-like form of the body, and the oar-like structure of the hind legs.

The second sub-order, *Homoptera*, consists of numerous species which subsist upon the juices of vegetables, which they obtain by the assistance of their articulated proboscis, and sometimes, as in the case of the aphides and sugar-cane fly (*Delphax sacharivora*, Westw.), the mischief which they occasion is very extensive. The forms of many of the species are most extraordinary, as may be seen from the accompanying figures. The females are furnished with a scaly ovipositor, composed of three toothed saws, lodged, when at rest, in a bivalve sheath at the tip of the under side of the abdomen. With this apparatus they are enabled to make an incision in the leaves or stems of plants, into which they afterwards introduce their eggs.



a, Centrotus globularis; *b*, C. cruciatus (Brazil).

Latreille divides this sub-order into the three following divisions :—

1. The *Cicadariæ*, having the tarsi three-jointed, and the antennæ very short, terminated by a fine bristle, comprising the families *Cicadidæ*, *Fulgoridæ*, and *Cercopidæ*.
2. The *Aphidiens*, having the tarsi two-joined, and the antennæ longer, without a terminal bristle, containing the families *Aphidæ* and *Psyllidæ*. Latreille also here places the *Thripsidæ*, but its organization renders this location doubtful.
3. The *Gallinsecta*, having the tarsi one-jointed, terminated by a single claw. The males have two wings, and are destitute of a mouth. The female is wingless, and furnished with a sucker. Comprising the single family *Coccidæ*.

ORDER VI.—NEUROPTERA.

This order belongs to the division having the mouth formed with mandibles for mastication, and chiefly distinguished by the structure of the wings, which are naked; that is, not inclosed by elytra or tegmina, but often having the anterior and posterior pairs of equal size, and furnished

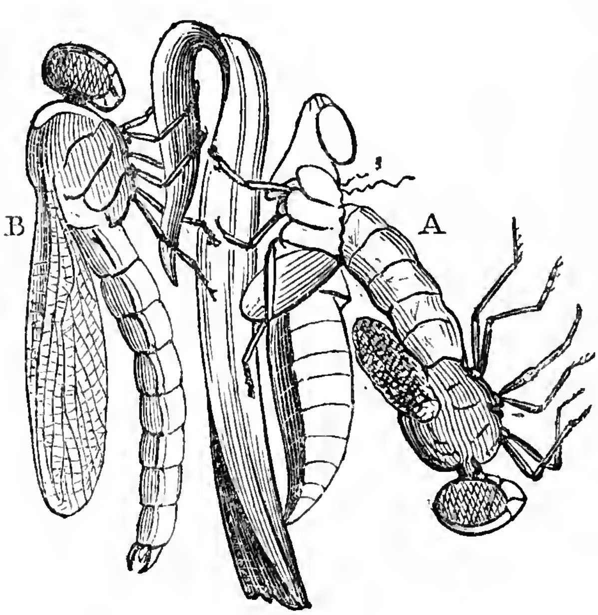
Dragon-fly.

with a great number of nerves, which gives the wings the appearance, under the microscope, of a piece of the most beautiful net-work; whence, indeed, the name of the order is derived, *neuron* signifying a nerve, and *pteron* a wing. The membrane inclosed between these nerves is very fine and transparent, often exhibiting a reflection of the prismatic tints, or marked with spots or bands of various colours. The situation of these organs during repose is various; in some they are horizontally extended at right angles from the body, as in the larger *Libellulidæ;* in others, as in the smaller species of the same family, their inner surfaces are applied against each other; whilst in the *Perlidæ* they lie flat upon the back, or are deflexed at the sides like the roof of a house, as in *Hemerobius, Psocus,* &c. In many species the wings are of equal size, as in the dragon-flies, *Panorpa*, &c.; in others the posterior pair are considerably smaller than the others, especially in the *Ephemeridæ;* in which, indeed, the posterior wings occasionally are entirely evanescent. In *Nemoptera* the posterior pair are much longer than the anterior, and very slender.

These insects have the head of a large or moderate size; the eyes, which are lateral, sometimes occupy nearly the whole of this part of the body; the ocelli are placed on the forehead; the latter are, however, wanting in some species, as in *Myrmeleon, Osmylus*, &c.; the antennæ are frontal, and of very different forms, being very short, and resembling a fine bristle, in the *Libellulidæ* and *Ephemeridæ;* long and clubbed in *Ascalaphus* and *Myrmeleon;* and filiform or setaceous in the others. The mouth consists of the ordinary organs composing a mandibulated mouth, the maxillæ being very robust, and the tongue well developed, in the dragon-flies. In some species, as the *Perlidæ, Hemerobiidæ*, &c., the construction of the trophi is almost identical with that of the *Orthoptera*. In the *Ephemeridæ*, which are destined to live but a day in the final state, the mouth is rudimental and almost obsolete. In the dragon-flies the palpi are also very minute, whilst in the *Myrmeleonidæ* they are long and slender. In the *Panorpidæ* the front of the head is prolonged into a kind of rostrum, at the extremity of which the trophi are placed.

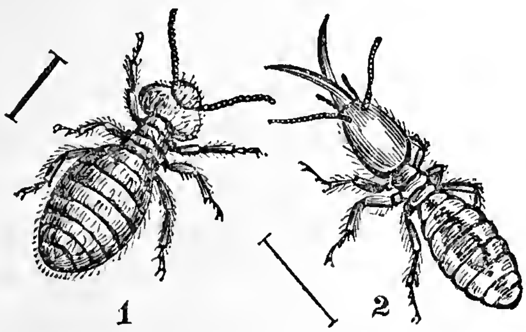
The legs of these insects are of a moderate size; flight being the chief mode of locomotion in the imago state, the legs do not acquire that degree of developement which we find in some of the cursorial and saltatorial species; the tarsi vary in the number of joints in the different species, there being five in the *Hemerobii, Panorpæ*, &c., four in the *Raphidiæ*, three in the *Libellulæ*. In all they are terminated by two small hooks. The abdomen is long, cylindrical, or compressed, with the segments distinct, and terminated in the males of many species by hooks which are employed during coupling. In some species both sexes are provided with two or three very long and slender hairs or bristles, as in the *Ephemeræ,* whilst the female *Raphidia* has a single long and sword-like appendage. In none of the species, however, do we find any instrument acting as the sting of the *Hymenoptera.*

There is considerable diversity in the transformation of this order; the larvæ are hexapod, and very variable in their habits and habitations. Many of them reside in the water, where they are either predaceous or vegetable feeders, some few feeding upon decayed plants, others in holes which they form in the sand. The majority are carnivorous, and feed upon other insects; the aquatic species are provided with an apparatus for obtaining a supply of fresh air, which has some resemblance to lateral series of external gills, but which are, in reality, the tracheæ greatly dilated externally. The pupæ are as active as the larvæ in the dragon-flies and some other species; but in both these states of these insects the mouth undergoes a remarkable modification of form. In the *Ephemeridæ* there is another curious modification in the transformations, the insects, after arriving at the winged state, throwing off a thin

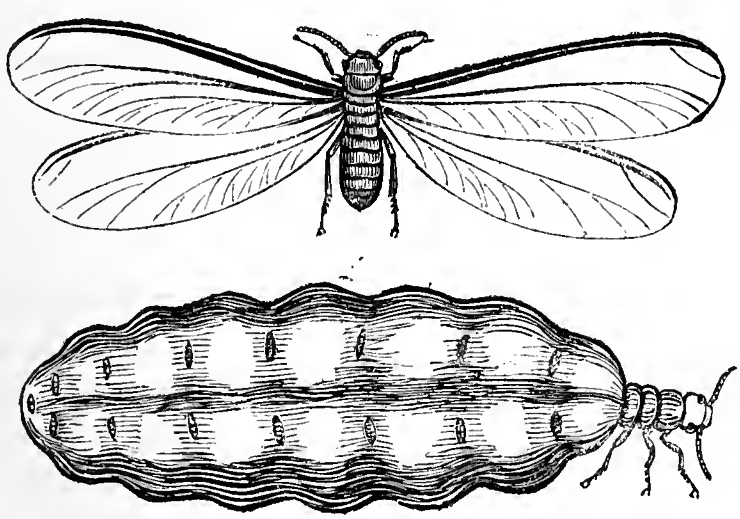


A, the Dragon-fly making its escape from the pupa—B, the same, drying its wings.

pellicle in which they had been previously enveloped. In some the pupa state is inactive, and inclosed in a cocoon formed by the larvæ, as in *Hemerobius, Myrmeleon,* &c. The *Termitidæ*, or white ants, offer as curious an instance of departure from the type of the order as do some of the *Apidæ* in the order *Hymenoptera*, there being three kinds of individuals exclusive of the active larvæ and pupæ. The transformations of *Panorpa* are unknown. In the imago state the duration of life is variable, some species, as many of the *Ephemeridæ*, being but the creatures of a day, or even of a still less period. There is also very considerable diversity in the size of these



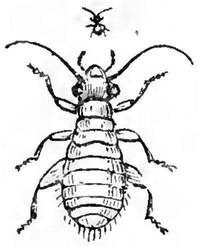
White Ants : 1, Worker—2, Soldier.


3

4

3, Queen in the first or winged state— , ditto, filled with eggs.

insects; some of the *Libellulidæ* being amongst the largest of our insects, whilst some of the *Hemerobiidæ* or *Psocidæ* are very minute, but not so minute as the smallest *Hymenoptera* or *Coleoptera*. The smallest insect in the order is the *Atropos pulsatorius,* belonging to the last-named family, and which is ordinarily found amongst books and papers.



Atropos pulsatorius.

From the considerable variation, both in structure and transformations of these insects, there has been a considerable diversity of opinion relative to the extent of the order, the *Libellulæ* and *Ephemeræ,* having an aquatic pupa, being regarded by some authors as the types of distinct orders. The same has also been maintained respecting the *Termitidæ,* or white ants, and the caddice flies (*Phryganeæ*), which last have been formed by Mr. Kirby into the order *Trichoptera,* whilst, by Latreille, the order is maintained in its Linnæan extent. I have adopted the views of modern English authors, separating only the *Phryganeæ.* The order is therefore divisible into sections, which exhibit the following succession of natural relations, founded upon the habits and transformations of the groups:—1. Carnivorous insects, having aquatic larvæ and active pupæ, bearing a certain resemblance to the imago; 2. Carnivorous insects, having terrestrial or aquatic larvæ and incomplete pupæ; 3. Carnivorous or omnivorous insects, terrestrial in all their states, and having active pupæ differing from the imago only in wanting wings. Latreille, by introducing the *Phryganeæ* into the order (and which correspond with the *Ephemeræ* in the aquatic habits of the larvæ and the rudimental structure of the mouth of the imago, and forming together Dumeril's family *Agnatha* or *Buccelles*), adds a fourth group of herbivorous insects, with aquatic case- or caddice-forming larvæ, and inactive, incomplete pupæ; terminating the order with those species of *Phryganeæ* which have the wings very slightly reticulated, resembling, in many respects, some of the least perfectly organized *Lepidoptera.* This last relationship is admitted by most recent authors, so that the neuropterous insects may be arranged with the *Trichoptera* on one side, leading to the *Lepidoptera,* whilst, on the other side, they are allied to the *Orthoptera,* as above noticed: the *Trichoptera,* again, are allied to the *Tenthredinidæ* in the order *Hymenoptera,* which renders it impossible to place these orders in a continuous series in regard to their affinities.

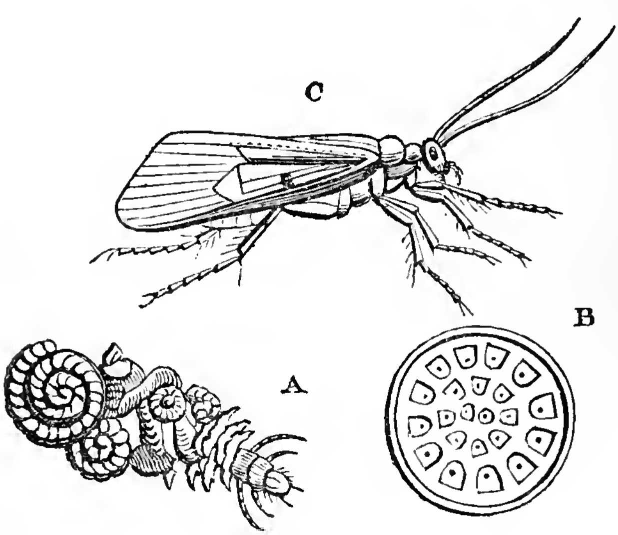
The order *Neuroptera* is divisible into the following sections and families.

1. *Subulicornes* (Latreille). Having the antennæ minute and setiform, with not more than seven joints; eyes large; ocelli two or three; larvæ aquatic; pupa resembling the larva; imago aerial.
   - A. *Odonata* (Fabricius). Wings of equal size; mandibles very large; respiration of the larva anal. Genus *Libellula* (Linnæus).
   - B. *Anisoptera* (Leach). Posterior wings small; mandibles rudimental; respiration of the larvæ by means of lateral pseudo-tracheæ. Genus, *Ephemera* (Linneus).
2. *Filicornes* (Latreille, *Planipennes,* Règne Animal). Antennæ long, filiform, setaceous, or clavate, much longer than the head, multi-articulate; eyes moderate; ocelli sometimes wanting; larvæ generally terrestrial.
   - A. Tarsi five-jointed. Linnæan genera, *Panorpa, Myrmeleon, Hemerobius.*
   - B. Tarsi four-jointed. Linnæan genera, *Raphidia, Termes.*
   - C. Tarsi two- or three-jointed. *Termes, Psocus* (Latreille).
   - D. Tarsi three-jointed. Genus, *Perla* (Geoffroy)—

each of which genera constitutes the type of a modern natural family.

ORDER VII.—TRICHOPTERA (Kirby).

This order comprises the Linnean genus *Phryganeæ,* having the mouth of an obsolete character, the mandibles being either entirely wanting or minute and membranous, as are also the under jaws and lip; the palpi are, however, present, which of course proves the presence of the organs of which they are appendages; the posterior wings are generally larger than the superior, and folded longitudinally when at rest, at which time the organs of flight are laterally deflexed, the anterior pair being more or less pilose, and the nervures are for the most part longitudinal, and branching with very few transverse connecting nerves: the eyes are prominent and globular; the ocelli two in number; the abdomen soft, and not furnished with terminal setæ; and the legs are long and slender, the coxæ elongate, and the tibiæ generally furnished with one or more pair of spurs; the tarsi are five-jointed. These insects are found in the neighbourhood of water, and are called caddice-flies or water-moths, and their larvæ caddice-worms, in which latter state they reside in the water in cases of sand, shells, &c. (fig. A). Both in their larva and perfect state they are excellent baits for fishing. The pupa is inclosed within the case formed by the larva; it is of that species termed incomplete, having all the limbs distinct, but folded upon the breast, the head being, moreover, furnished with a pair of curved mandibles, which appear to be applied to no other use than that of making a passage through an open-work grating of silk (fig. B), which the larva had formed at the opening of its

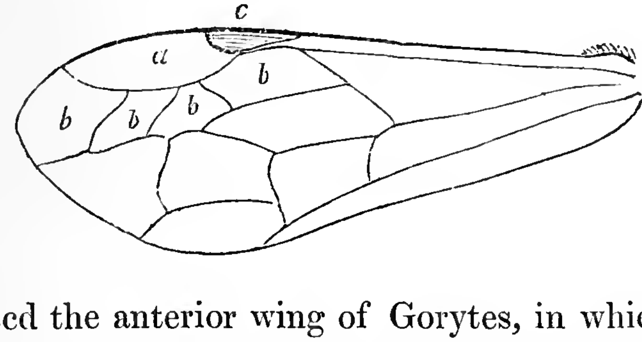


case previous to assuming the pupa state. This grating hardens in the water, and becomes indissoluble; strong threads crossing each other forming a small thickish circular plate of brown silk, which becomes as hard as gum, and fits exactly into the opening. De Geer has described and figured several of these eases thus grated at one end; and Reaumur has ascertained that the holes left in the grating were for the purpose of breathing, by admitting a current of fresh water, effected evidently by the spiraeles of the pupa; and he actually saw the grate-work in alternate motion, from convex to concave, as the water passed out and in. When, therefore, the time arrives for the insect to quit its watery abode, and assume the winged state, it is endowed with powers of motion far greater than are possessed by any other incomplete pupa, so that it is enabled not only, in the first place, to cut through the grating of silk, but afterwards to creep out of its case, and ascend into the air, where it throws off its outer skin, and appears as a eaddice-fly (fig. c). The species are found flying, chiefly after sunset, about streams, ponds, &e. They are of a small or moderate size, and generally of obscure pale brownish colours. They greatly resemble each other in general appearance, although sufficient characters are to be found in the nerves of the wings, the form of these organs, colours, &c. The admirable work of M. Pietet upon these insects has made us acquainted with the eharacters and habits of very numerous species.

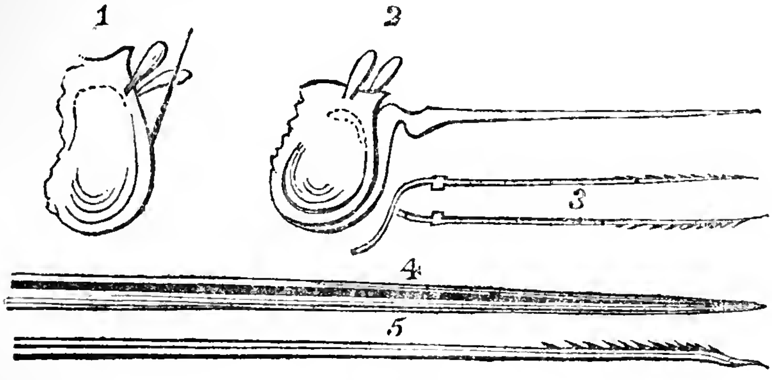
ORDER VIII.—HYMENOPTERA.

This order is distinguished by having four membranous wings, furnished with various veins, forming cells, but not assuming the appearance of net-work, the posterior pair being smaller than the anterior; the mouth eomposed of a pair of upper and lower jaws, and two lips, the lower of whieh is elongated, and forms, together with the lower jaws, a kind of tongue or sueker, eapable of being extended to a eonsiderable length, and employed in eolleeting honey from flowers; the females are furnished with a horny apparatus at the extremity of the body, which in some species is transformed into a pair of saws, adapted for making slits in twigs of plants, for the reception of the eggs, and in the others eonsisting of a powerful sting, the strueture of whieh is already deseribed in page 375. In others, again, it is elongated into an ovipositor, adapted for depositing the eggs in the bodies of eaterpillars, &e. The head is furnished, moreover, with a pair of antennæ, which, in the typical division, eonsist of thirteen joints in the males, and twelve in the females: in the rest the number of the joints varies in the greatest degree, in some eonsisting of only five or six, and in others of sixty or seventy artieulations. In the form of these organs we also find great variation, the sexes differing in this respect, in some being long and slender, in others short and elubbed; in some furnished with hairs, in others branched or forked, and in the majority elbowed at the extremity of the basal joint, whieh is ordinarily long. The eyes are large, and oeeupy the sides of the head; they are alike in both sexes, except in a very few instances, in which they are united in the males on the erown of the head, as in some of the Diptera: they are generally round or oval, whilst in some, as the wasps, they are kidney-shaped. They are asserted to be obsolete in a few speeies of ants. In addition to these eomposite eyes, the majority of the inseets of this order are furnished with three minute simple eyelets (oeelli), on the erown of the head; the lower jaw and lip are furnished with palpi, whieh vary in the number of their joints from six to one.

The thoracic segments are united into an oval mass, in the front of which is to be observed an arehed piece, termed the collar; and at the sides are attached the two pairs of wings, the anterior pair having a scale (squamula) at the base. The front margin of the anterior wings is furnished, a little beyond the centre, with a callous point, termed the stigma, *c*, from which is emitted a vein or nerve, which runs to the tip of the wing, the space between it and the front margin of the wings forming one or two cells, which are termed the marginal or radial cells, *a*. Behind this nerve, and running somewhat parallel with it, is another nerve connected with the former by various short transverse nerves, the space between which forms the submarginal or cubital cells, *b b b b*, varying in number from one to four: there are other nerves forming basal and discoidal cells, but the former are of the greatest importance, being employed as affording constant characters in the discrimination of genera. There is, perhaps, nothing more strikingly calculated to prove the beautiful order and certainty existing throughout nature than is exhibited by these slender and apparently trivial nerves, which maintain their position in every individual of a given species, although in the adjacent species the situation of some one or other of them may be altered. Of such importance, indeed, is the consideration of these nerves, that in the latest work upon the Hymenoptera, (St. Fargeau, Hist. Nat. des Hymenopt., Paris, 1836) we find upwards of five-and-twenty pages devoted to their illustration. We have here

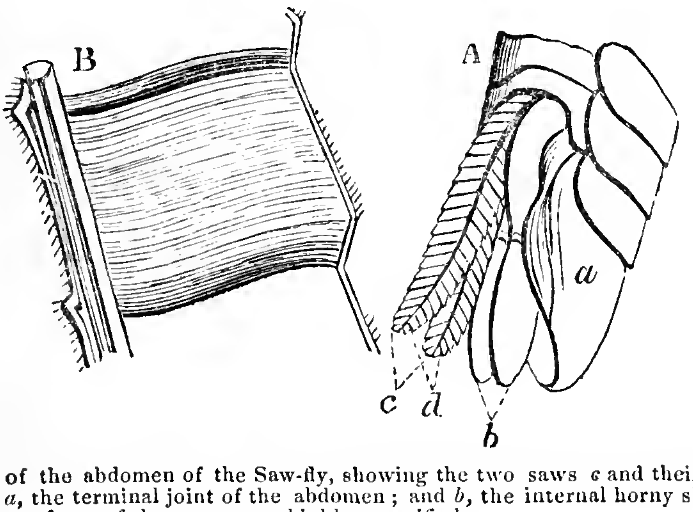


represented the anterior wing of Gorytes, in which we have a number of cells; but in some groups the number of the nerves is greatly diminished, and in a few, as the Chalcididæ and Proctotrupidæ, the nerves are almost, and even absolutely and entirely, obliterated. In many of these insects a remarkable apparatus exists, whereby the two wings on each side are kept steady together in flight, consisting of a series of very minute hooks or crotchets, discoverable under a good magnifier on the anterior margin of the posterior wings. They have been noticed by no other authors than De Geer and Kirby, the latter of whom observes, that they are much more conspicuous in the bees than in the winged ants. The legs, which are six in number, are inserted on the lower side of the thorax, and consist of various pieces, which contribute to their movements. These pieces are the coxa, a short piece connecting the leg with the thorax; trochanter, another short piece articulated between the coxa and the following piece, and which, in the Ichneumonidæ, is divided into two parts; the femur, or thigh, which is long and robust; the tibia, or shank, which is more slender, and terminated by one or two spurs; and the articulated tarsus, which constantly consists of five joints, the fifth being of a conical form, the extremity being the thickest part, and furnished with two strong but small claws, between which the pulvilli, or cushions, are often to be observed. These legs, which are, in fact, the chief organs whereby the insects are enabled to carry on their varied economy and habits, are necessarily very varied in their form, and in the appendages with which they are furnished. The abdomen, which is also of a very varied form, is attached to the posterior part of the thorax, either by its entire width, in which case it is said to be sessile, or by means of a slender peduncle, or foot-stalk, which in some groups is also as long as the abdomen itself. At the extremity of this abdomen, on its lower surface, is attached the ovipositor, saw, or sting above mentioned, each of which, although varied in form, so as to suit its intended uses, is but a modification of the same instrument. From the centre of the under-side of the abdomen, near its extremity, arise two plates, each consisting of two joints, sometimes valvular, and together forming a scabbard, sometimes more slender, and resembling palpi, and sometimes



Bee's Sting.

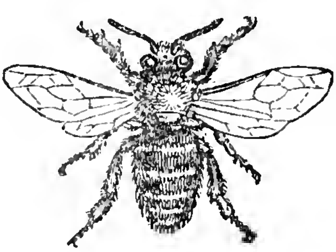
very long; between these plates (fig. 1 and 2, as they exist in the bee, under the form of two flattened plates, with a pair of small terminal lobes) arise two other pieces, which are very slender, serrated at the tip in the bees (fig. 3 and 5), but much broader in the saw-flies, and transversely striated, forming the saws with which these insects are provided: moreover, these two pieces are received, in the bees, into a canal (fig. 2 and 4), but in the saw-flies this gutter is broad,



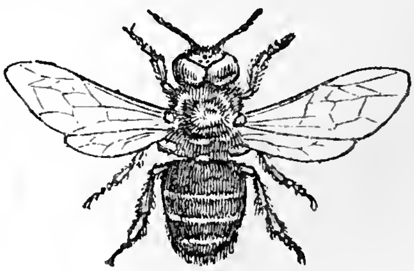
A, extremity of the abdomen of the Saw-fly, showing the two saws c and their supports d, extended; a, the terminal joint of the abdomen; and b, the internal horny sheath. B, a small portion of one of the saws, very highly magnified.

flattened, and divided into two separated parts, forming the backs of the two saws. In the ichneumons, these various parts are so slender, that at first sight they appear to consist but of a single piece: on more minutely examining the instrument, however, it will be found that it consists of a scabbard, composed of two pieces, inclosing a fine hair-like bristle, which is, in fact, the exact analogue of the stinging part of the bee's sting, consisting of three pieces.

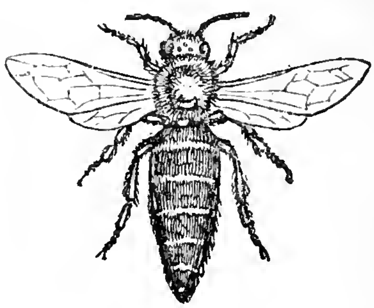
These insects, which constitute the fifth Linnean order, are unquestionably the most interesting of the insect tribes, comprising as they do the bee, wasp, ant, sand-wasp, cuckoo-flies, and saw-flies; the economy of which is so remarkable, that it has attracted the curiosity of the most uninquisitive persons. Their colours are seldom brilliant; brown, yellow, black, or grey, being their prevailing tints; neither do they often acquire a large size, the majority being under an inch



Neuter Bee.

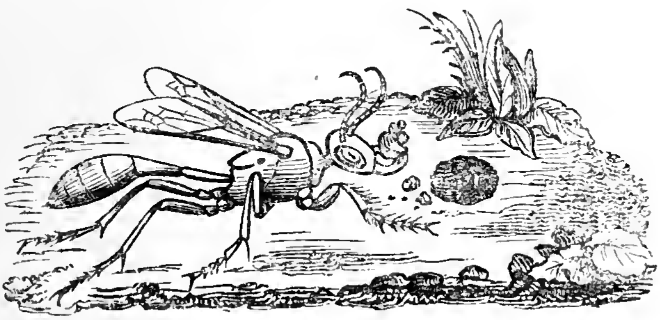


Drone Bee.



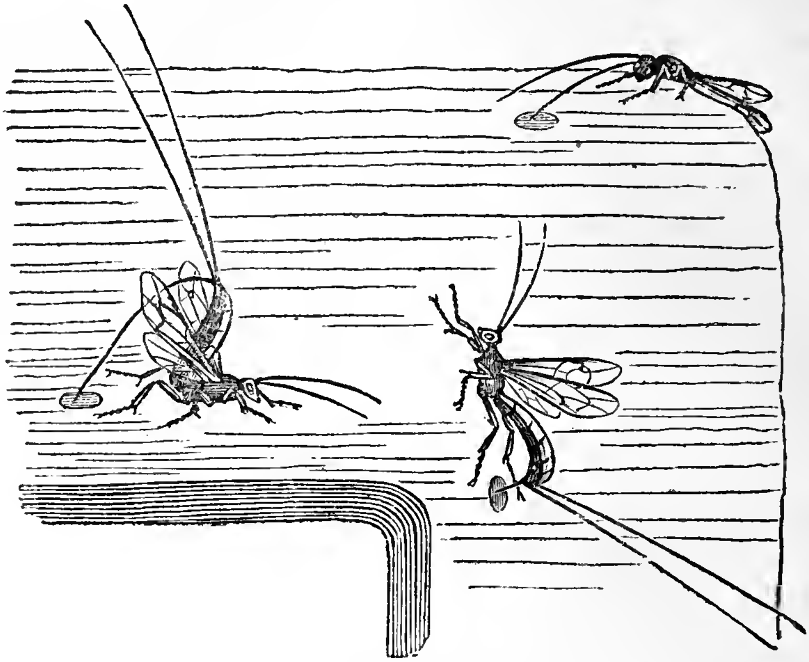
Queen Bee.

in length, and some being so exceedingly minute as to be invisible to the naked eye, except when seen creeping against the light upon a window. Many of the species live in societies more or less numerous, as the bees, ants, and wasps; these assemblages consisting of males and females, and neuters, the latter being abortive females, and destined to perform the more laborious duties of the community. Others, as the sand-wasps, &c., are solitary in their habits, but their economy is not less interesting than that of the former; since, although not exhibiting such a variety of remarkable physiological traits, the construction



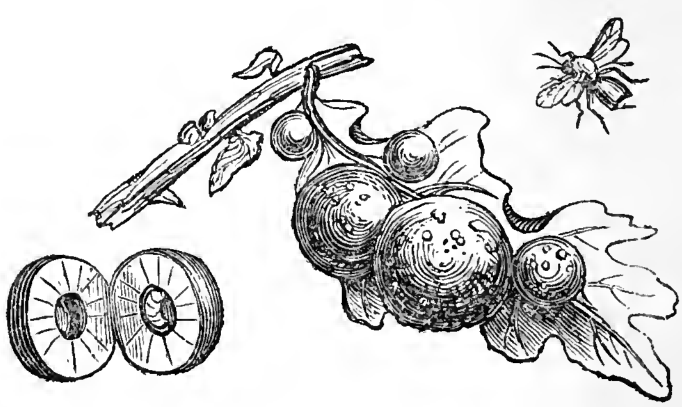
Ammophila sabulosa making its nest.

of a nest, and the provisioning it with a supply of food for the young when hatched, by a single insect, is sufficient to prove that the instincts of that insect are not less developed than in cases where a particular duty devolves upon a particular set of individuals. The food laid up in store by one class of these insects, consists of honey collected from flowers; whilst in another class it consists of insects deposited in cells by the parent fly. Another class have the instinct to deposit their eggs in the already provisioned cells of the working classes, the young of which latter are starved to death by the previous exclusion of the parasitic grub, which devours the supply provided for the former. Another class is parasitic in a different sense of the word, depositing their eggs upon or within the bodies of other insects, chiefly in the larva state, the intestines of which are preyed upon by the grubs when hatched. Others deposit their eggs in the leaves or stems of various plants,



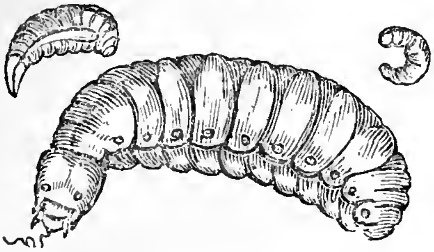
Pimpla manifestator depositing its eggs in wood larvæ.

together with an irritating matter, which causes the production of galls or warts, often of a large size, upon the substance of which the larvæ, when hatched, continue to

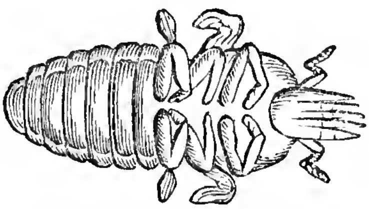


Oak-apple and Cynips quercusfolii.

feed until they assume the perfect state; and the remainder place their eggs in slits in the stems of plants, upon the leaves of which the young feed. From the nature of their food, and their abode in the midst of it, it will be at once evident that they have little need of locomotive organs serving for its discovery. We accordingly find that the majority of the hymenopterous larvæ are footless grubs of



Bee grubs, natural size and magnified.



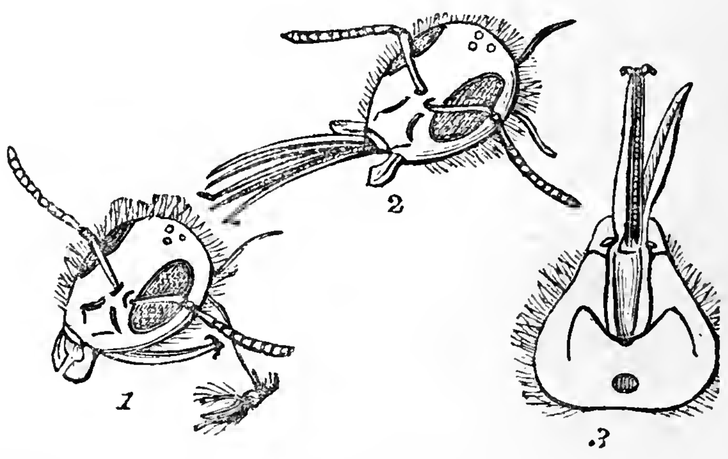
Grub stripped of skin.

a white colour, and of a fleshy substance, having the parts of the mouth small, and but slightly developed, although in the perfect insect the same organs attain a maximum degree of developement. In those larvæ, however, which are external feeders, we find the necessity for locomotion causing the addition of locomotive organs; the legs in the larvæ of the saw-flies varying in number from six to twenty-two. The pupæ of these insects are inactive, having the various limbs of the perfect insect developed, but inclosed in separate cases, and lying along the breast. In this respect, therefore, they resemble the Coleoptera, and like them they are in this state either inclosed in cocoons formed by the grubs previous to their transformation, or are naked.

Bee pupa.

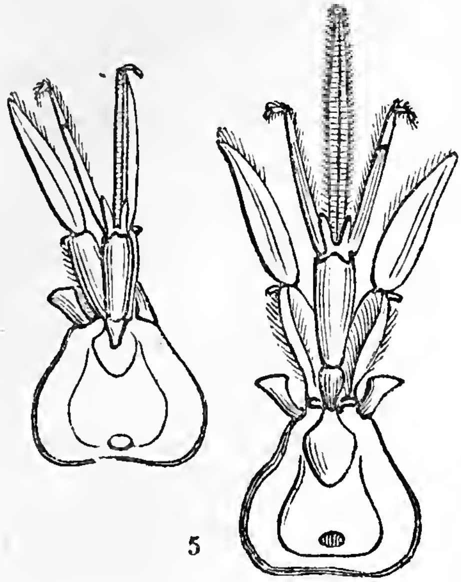
The species of this order are extremely numerous. They are annual insects; the majority of them pass the winter season in the form of grubs or pupæ, whilst others pass this period in the perfect state. These, however, are but few in number, and consist of females which have been impregnated during the preceding autumn, and are destined to become the foundresses of fresh colonies, upon the arrival of spring. In their perfect state, they feed almost exclusively upon the honey of flowers. Some, indeed, have been said to feed upon other insects, but these observations have been made upon a casual occurrence, or upon insects which were in the act of securing the supply of food for their progeny. In the tropical countries, the species attain the largest size; there, too, they appear to be the most abundant.

The situation of this order in the classification of insects is especially interesting. The possession of a pair of robust mandibles necessarily places it amongst the Mandibulata or masticating insects, whilst the elongated structure of the lower parts of the mouth, forming a proboscis for sucking up



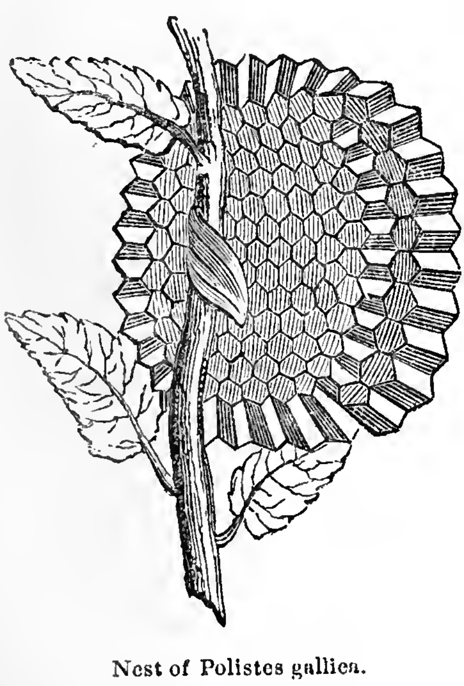
Head of the bee, with tongue at rest, in fig. 1, and with the various parts of which it is composed partially extended, in fig. 2 and 3.

the honey of flowers, seems to unite it with the haustellated or sucking insects. Latreille has accordingly placed it between the mandibulated *Neuroptera* and the suctorial *Lepidoptera*. The structure of the parts of the mouth, as appearing to indicate the essential habits, might be regarded as of primary importance in determining the classification of the insects; but it is essential to bear in mind the following circumstances, which may have the effect of proving that too great a weight ought not to be allowed to these considerations. We have already said that the *Hymenoptera* in general feed upon the honey of flowers —hence, unlike the *Coleoptera* (in which some are predaceous, others lignivorous, others herbivorous, and others necrophagous), an uniformity in the mode of nourishment exists; the only variation consisting in the employment of the sap exuding from the wounds of plants, or the juices of fruits. If, indeed, certain of the *Tenthredinidæ* (such as *Tenthredo scrophulariæ*) attack other insects, they form but an exception to a general rule, which they and some other species infringe but rarely, and, as it would seem, only when the excessive heat has dried up the supply of honey. The ants and wasps also appear to offer exceptions to the rule, but it is not real, since, as they are often found upon flowers, of which they will suck up the honey, it is presumable that this is their ordinary food, and that if they destroy other insects, it is only for the purpose of getting at the honey with which the latter are gorged. Moreover, in the nests of certain social wasps, and even in



5

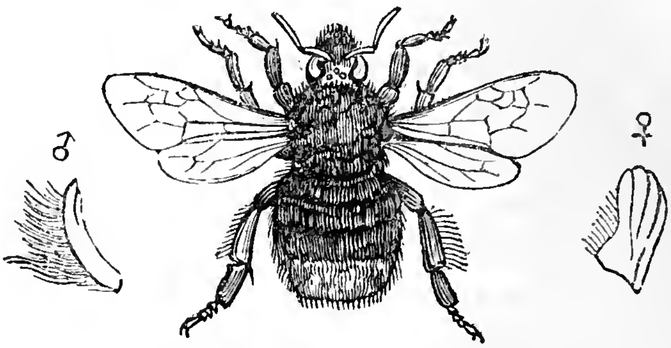
Head of the bee, with the tongue more fully extended, in fig. 4; and with all the parts displayed, in fig. 5.



Nest of Polistes gallica.

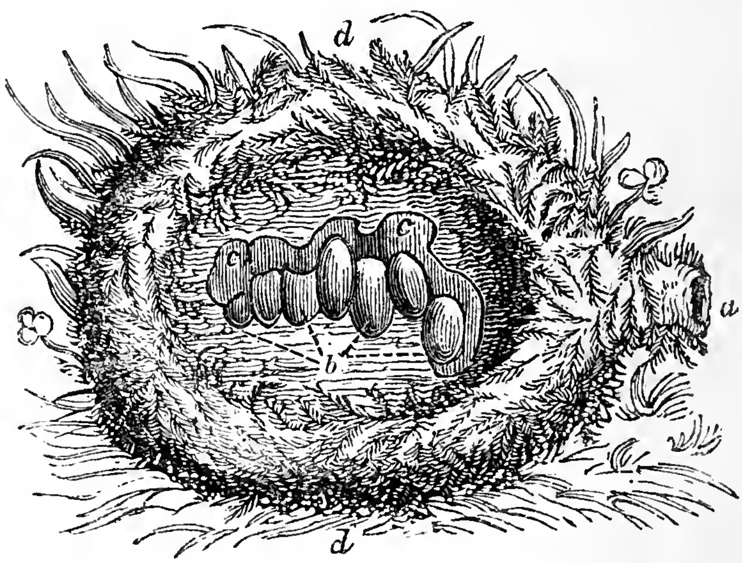
that of the *Polistes licheguana* of Brazil, as observed by M. Auguste de St. Hilaire, a quantity of cells, full of honey, have been found, of which this distinguished traveller ate a considerable quantity without experiencing any inconvenience; and the same has been observed in respect to the honey found in the nests of *Polistes gallica*. The larger species of wasps will occasionally attack raw meat in the butchers' shops; but this is of rare occurrence, and can only be attributed to an occasional diminution of their ordinary food; indeed, many nests are too far distant from the habitations of man, for the wasps which inhabit them to have recourse to such a kind of food. In the same manner may be explained the interesting instance of supposed instinct exhibited by a wasp, recorded in some of the popular works on Natural History, which had captured a fly which it was unable to fly away with, owing to the wind acting upon the wings of the latter, whereupon it clipped off these wings and also the legs, and then flew off with it to devour it at leisure. Here it was evident that the wasp had been prevented from obtaining its usual supply of food, and that its instinct had been sharpened by hunger. I was witness, some time ago, of another equally interesting instance of instinct exhibited by the same insect, which had discovered some flies, upon which it wished to make a meal, revelling upon excrement, which it was anxious not to touch with its feet or wings in seizing its prey. It approached, therefore, as near to one of the flies as it could, and then with a swoop, which reminded me of the flight of the hawk, darted upon the fly, and carried it off without soiling itself. The ants, in like manner, although some of them have the instinct to secure in their nests entire colonies of aphides, do not devour them, but merely lap up with their tongues the saccharine fluid which they emit, and which is, in fact, merely vegetable liquid slightly modified during its passage through the body of the aphis. All other species of hymenopterous insects observed killing, wounding, or dragging along other insects, caterpillars, or spiders, have been ascertained to be employed, not in providing for their own support, but for that of their offspring. The elongation of the parts of the mouth of the *Coleoptera* has been regarded as a character indicating carnivorous appetites; and hence the same idea has been applied to those Hymenoptera which have the trophi, especially the jaws, elongated; but observation has proved that these species are destined to carry heavier burthens than the others; their prey destined for their progeny is more weighty; and they consequently need more powerful tools for its transport. Now the *Coleoptera* have no work of this kind to perform, and consequently the analogy cannot be supported: and this observation, as it appears to me, offers an interesting clue to the solution of the oft-debated question, why it should be requisite to employ characters derived from so many distinct organs in the natural classification of any extensive group of animals, instead of deriving them throughout the group from a single organ.

In one order of insects, for instance, we find the primary divisions founded upon variations in the construction of the tarsi, whilst in other orders the structure of these parts is uniform. Thus it is only by acquiring a perfect knowledge, not only of the structure, but of the habits of animals, that we can ever hope to be made acquainted with the relative value of this or that character, so as to be able to affirm, with any thing like precision, that the one or the other is of the greater importance; and this happens to be a question of considerable moment in respect to the order at present under consideration, in which some authors have distributed the families according to their general structure, whilst others, and more especially the Count de St. Fargeau, in the work above mentioned, have regarded the various instincts of the insects, as exhibited in their social, solitary, or parasitic qualities, as of the highest value, although these qualities may have but a very slight influence upon the general structure of the insect; thus between the humble bee and the parasitic humble bee (*Psithyrus*), there is so little general variation of structure, that Mr. Curtis even doubts the propriety of their generic separation, whilst St.



Humble bee (*Bombus Lapidarius*) with jaws of the male and female.

Fargeau, looking at their different instincts, places them in totally distinct sections, regarding the slight modification of



Nest of the Humble-bee recently commenced; *a*, covered entrance; *b*, waxen cells in which are placed the eggs; *c*, waxen envelope commenced; *d*, mossy dome commenced.

form in the legs (dependent, it is true, upon the pollinigerous or parasitic habits of the different insects), of far higher importance than that entire variation of structure which separates such families as the working bees and wasps, which are united together by the common tie of sociality. As regards the order of inseets in question, this mode of viewing their elassifieation has hitherto been too mueh negleeted to enable us to follow it out in a work like the present, whieh ought to eonvey faets rather than theories; I have, nevertheless, thought it proper to notice the subjeet, whieh is in faet one whieh materially influenees every zoologieal group. In the meantime, it may be more eondueive to our present purpose to notiee the variation of several of the more important organs, and the eauses upon whieh sueh variations are dependent. Although the nature of the nourishment of all hymenopterous inseets be alike, it does not follow that the mouth of all should be of an uniform strueture; neither, although eonsisting of the same parts and number of pieees, is it requisite that they should be formed upon the same model. The eonstruetion of the nest and the preparation and transporting of the materials employed therein, as well as the form of the flowers from which the different speeies eolleet their honey, are eonsiderations whieh modify, in a greater or less degree, the strueture of the organs of the mouth; thus, in those speeies whieh eolleet honey from flowers for their own support alone, as the *Tenthredinidæ*, *Ichneumonidæ*, &c., the lower lip or tongue, and the lower jaws, are short and narrow; but when the inseet has to colleet a supply of food, not only for its own support, but also for that of its progeny, these parts are mueh more developed, as is also the ease when the honey is placed at the bottom of tubular flowers, sueh as the *Labiatæ*, &e., which are mueh frequented by some of the long-tongued bees: the same parts are short and broad in the ants, wasps, &e., beeause they frequent flowers eomposing the heads of the *Umbelliferæ*, from the almost flat surfaee of whieh they eollect the honey, as well as the sap flowing from the wounds of trees, &e., without trouble; moreover, this organ is thus modified to serve as a trowel for the smoothening of the inner surface of the cells in which the future progeny are to be produced. Again, in those species which have to search with much diligence for the prey destined for the nourishment of their progeny, the palpi (which appear to be organs of touch) are elongated; whereas, in those whose larvæ are nourished with honey, they are short, the flowers being discoverable without difficulty by the sight, or by the antennæ. Again, the mandibles vary in their form, size, thickness, and toothing; thus, in the females of some genera, they are more robust than in the male, (see figures in p. 384), the former sex being the sole architect of the nest, and having to perform more laborious work than her partner; so in those females which have to cut the materials for their nests, they are thicker, whilst in those which have heavy burthens to carry, they are longer; but the most extraordinary instance of this kind of variation in the last-named organs, occurs in the neuters of some species of ants. Many observers have remarked in the same nest, neuters with large, and others with small jaws, the former being employed in collecting food, and the latter remaining in the nest, out of which they only make their appearance to attack any enemy that may menace their community. M. Carcel was witness of this fact (first observed by the celebrated Huber), the former of whom was witness of the destruction of a scorpion by these minute, but extraordinarily developed workers. M. Le Prieur has also observed that the nests of the South American visiting ants (*Atta*, Latreille), the neuters of which have short jaws, are defended by other workers with exceedingly long mandibles; which organs are employed in stopping those individuals which quit the ranks and might thus be lost, showing them the right way. Latreille, not being aware of this remarkable fact, has formed these long-jawed individuals into a distinct genus under the name of *Eciton*.

Many other equally interesting instances might be given of the variations and causes of variations to which not only these but other essential organs, as the ovipositor, legs, &c., are subject: but I have advanced sufficient to prove that this branch of the subject, which may, without hesitation, be laid before the reader almost as an unopened field of inquiry, possesses a very great degree of interest, sufficient to repay the labour devoted to its elucidation.

The following is the classification of this order given to us by Latreille, to whom, indeed, we are greatly indebted for our knowledge of these insects, which were especial favourites with this celebrated author.

Section I. TEREBRANTIA: abdomen of the females furnished with a saw, or borer.

Sub-sec. 1. *Securifera;* abdomen sessile, furnished with a saw; larvæ with feet. Families, *Tenthredinidæ* (saw-flies), *Siricidæ.*

Sub-sec. 2. *Pupivora;* abdomen pedunculated, furnished with a borer; larvæ without feet. Families, *Evaniidæ, Ichneumonidæ, Cynipidæ, Chalcididæ, Proctotrupidæ, Chrysididæ.*

Section II. ACULEATA; abdomen of the females (and neuters) armed with a sting.

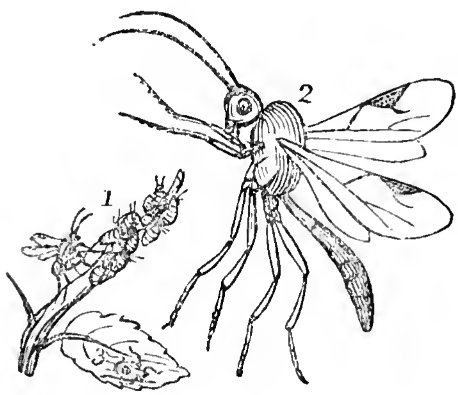
Sub-sec. 1. *Heterogyna;* females or neuters wingless. Families, *Formicidæ* (social) *Mutillidæ* (solitary).

Sub-sec. 2. *Fossores;* females winged, wings not folded, basal joint of posterior tarsi simple. Families, *Scoliidæ, Sapygidæ, Sphegidæ, Bembecidæ, Larridæ, Nyssonidæ, Crabronidæ.*

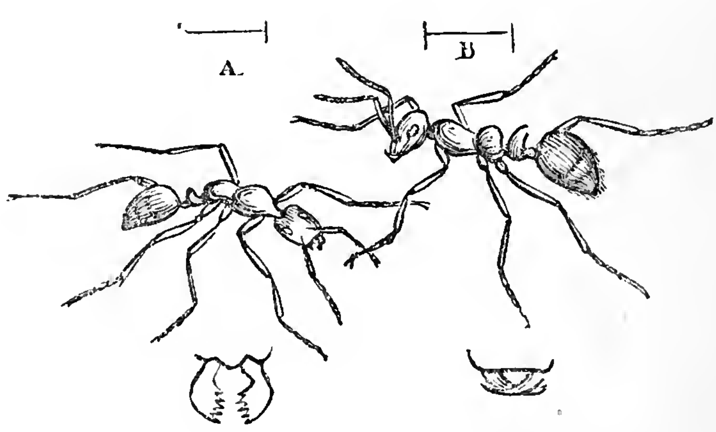
Sub-sec. 3. *Diploptera;* females (and neuters) winged, wings folded. Families, *Masaridæ, Vespidæ.*

Sub-sec. 4. *Mellifera;* females (and neuters) winged, wings not folded, posterior tarsi with the basal joint large, and compressed into a pollinigerous organ. Families, *Andrenidæ, Apidæ.*

The family *Tenthredinidæ* are termed saw-flies, from the peculiar saw-like construction of their ovipositor, above described; they are vegetable feeders. The *Pupivora*, on the contrary, are parasites, the cuckoo-flies (*Ichneumonidæ*) being eminently serviceable in checking the too great increase of caterpillars and other plant-feeding insects. The *Cynipidæ*, however, or gall-flies, are vegetable feeders, the females forming galls upon various plants, as above noticed. The family *Formicidæ* comprises the numerous tribes of ants, of which the *Atta cephalotes*, or visiting ant, already figured above, the *Formica fusca*, or brown ant, here figured with *Polyergus rufescens*, a remarkable species which lives in small colonies, making captives and slaves of the *Formica fusca*, may be mentioned as examples. This



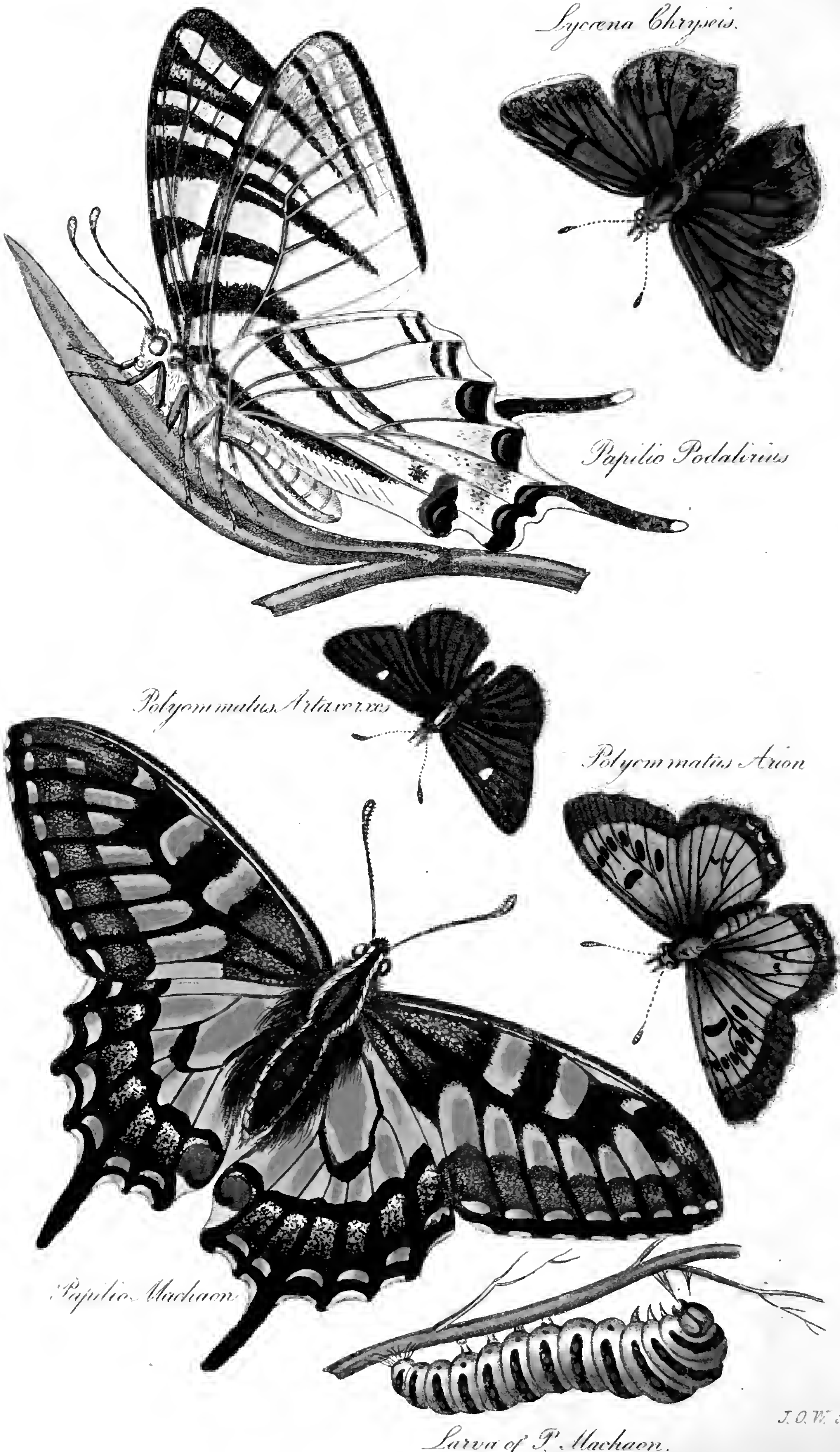
Aphidius Rosæ depositing its eggs in the plant lice, 1, natural size, and 2, magnified.



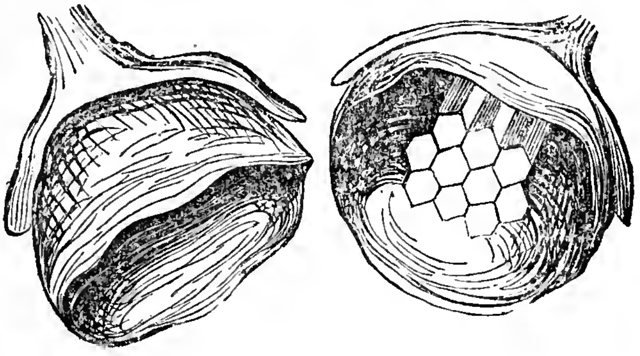
A, Polyergus rufescens——B, Formica fusca.

family, like all the other tribes of insects living in society, through their different states consists of three kinds of individuals,—males, females, and neuters.

PLATE 4

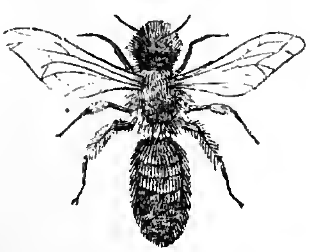

Lycæna Chryseis.
Papilio Podalirius
Polyommatus Artaxerxes
Polyommatus Arion
Papilio Machaon
J. O. W. del.
Larva of P. Machaon.

The fossorial *Hymenoptera* either burrow solitarily into sand, wood, &c., provisioning their nests with other insects, or are parasitic upon other Fossores. Some of the *Vespidæ* are also similarly fossorial, but the true wasps live in societies, consisting of males, females, and neuters, and constructing



Nest of Tree-wasp just commenced.

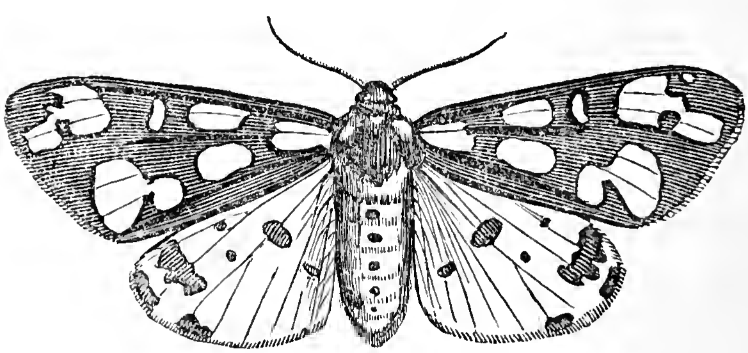
nests of various sizes and forms. The *Mellifera* consist of the various species of bees, the *Andrenidæ*, and many of the *Apidæ* being either fossorial (but provisioning their nests with pollen-paste), or are parasitic upon other bees; whilst some of the species, as the humble-bees and hive-bees, are social, living in large communities.



Andrena negro-anea.

ORDER IX.—LEPIDOPTERA.

This is a very extensive and beautiful order of four-winged insects, known by the English names butterflies and moths, and distinguished by having the wings composed of a double transparent membrane, clothed on the upper and under sides with minute coloured scales, resembling dust or farina. The eyes are large and lateral, the antennæ generally long and multi-articulate, and very variable in form; the mouth is composed apparently of a long and spirally coiled organ, which, when examined, is found to consist of two pieces, representing the maxillæ, sometimes being provided with a small jointed appendage or palpus at its base. This very slender and delicate proboscis (or spiritrompe, as it is called by Latreille, or antlia, by Kirby and Spence), is employed by the insect in sipping the sweets from the flowers, upon which alone it subsists, and which, by its peculiar construction, is admirably adapted for penetrating the narrowest blossoms. When at rest it is rolled up in a coil, and defended by two large and compressed palpi, composed of three joints, inserted upon a lip fixed to the front of the head. A more minute examination of the head, however, proves that the rudiments of the other parts of the mouth, namely, an upper lip and a pair of mandibles, also exist, but in a very minute state, and, as it would seem, unfitted for any service in feeding—a peculiarity the more remarkable, because in the preparatory state of the larva the mandibles are very robust and horny, and constantly employed in biting the leaves which at that time serve for the support of the insect. The mesothorax is furnished at the sides with a pair of large scales called pterygodes (*Paraptera* or *tegulæ*), affixed at the base of the anterior wings on the upper side,



Cream-spot tiger-moth.

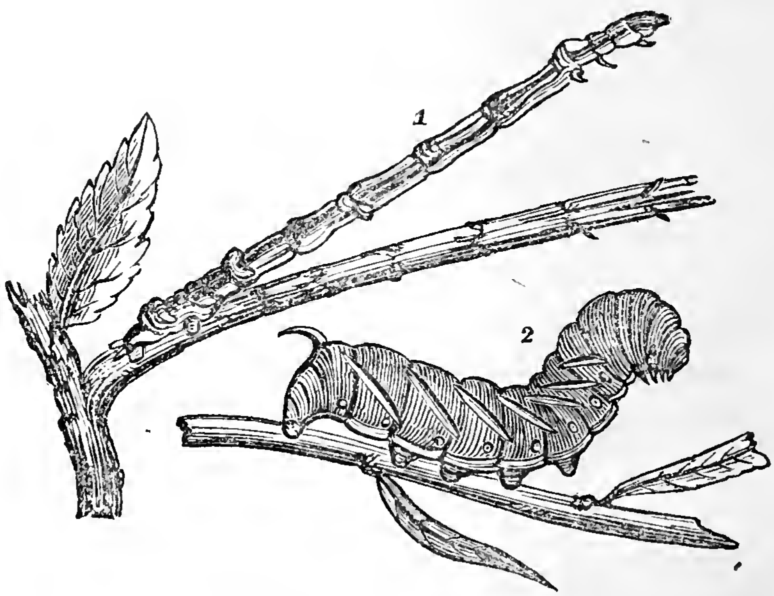
represented of a white colour in the accompanying figure of the Cream-spot tiger-moth (*Arctia villica*). The abdomen is destitute of any sting, although Dr. Burmeister has recently noticed an exotic species contained in the Royal Collection at Berlin, which appeared to be provided with an instrument of this kind, but which I should be inclined rather to regard as the acute extremity of the ovipositor, which, in many of the species whose larvæ are subterraneous or subcortical in their habits, is long and acute. The body of these insects is very pilose; it is also very variable in respect to its size; those species which are pre-eminently distinguished for their powers of flight having the body, and especially the thorax, very robust; whilst in the *Erycinidæ*, *Geometridæ*, and many others whose flight is weak, it is slender; indeed the last-mentioned family has, from this circumstance, obtained the name of slender-bodies amongst the English collectors. The form of the pterygodes also is very variable, giving to the thorax a diversity of appearance; thus in the genus *Cucullia* (moths belonging to the family *Noctuidæ*) the pterygodes are very large, and the thorax is pushed forwards, forming a sort of hood over the heads, whilst in *Xylina* they are more elongated, so as to give the sides of the thorax an elevated appearance, with the centre depressed. The colour of the thorax is generally similar to that of the anterior wings in the majority of the moths, as well as in the butterflies, in which it is clothed with fine hairs; but the prothorax often presents peculiarities of character: thus, in the larger typical butterflies, *Papilionidæ*, it is marked with two or more red or yellow spots, sometimes uniting to form a kind of collar. The wings are attached to the lateral and superior part of the thorax, and are always present, except in a few species of which the females are apterous, or have the wings reduced to small and useless appendages: the fine layers of membrane of which the wings are composed, like the upper and lower surface of a leaf, are kept expanded by a number of longitudinal corneous veins or nerves, as they have been called, but which Dr. Leach termed *Pterygostia* or wing-bones. These nerves here, as in the *Diptera* and *Hymenoptera*, according to their number and position, offer very important characters for generic distribution, but which have been too much neglected by authors. M. Boisduval, however, in his just published *Spécies Général des Lepidoptères*, Paris, 1836, has performed good service in this branch of the science by describing and delineating the nerves of the wings of many of the species of Lepidoptera: although it is proper to observe, in justice to our own countryman, Jones, that he long ago published a valuable memoir in the second volume of the Linnæan Transactions, in which the same subject was well treated. The structure of the scales, which give to the wings of these insects all their beauty, has been already described. The slight manner by which they are attached to the wing causes them to scale off on the least touch, so that by laying a butterfly in a reversed position on a piece of gummed paper, an exact impression of its markings will be obtained; the scales, however, being reversed, the broad extremity of each series of scales which was laid (roof-like) upon the succeeding row, being hidden, and the pointed base exposed. In some species the representation will not resemble the markings of the butterfly, evidently owing to these species having a double layer of scales on both sides of the wing, the under layer usually consisting of white scales. On denuding a wing of its scales, the points in which they were inserted are clearly to be perceived in the form of minute dots. Of the number of these scales it would be difficult to give a correct idea in the various species. Leuwenhoeck, however, states that there are more than 400,000 on the wings of the moth of the silk-worm. In some species of Lepidoptera, however, the wings are more or less vitreous, and consequently denuded of scales, or have but a few of them; and in others, certain portions of the wing exhibit small transparent patches similarly denuded, as in the great atlas moth. In many species, scales exhibit metallic tints, which, indeed, in some exotic butterflies, are so exceedingly resplendent, that in the bright light of the sun it is almost impossible to look upon them. In like manner, several of our fritillary butterflies, and especially *Lathonia*, or the queen of Spain, has the under surface of the lower wings adorned with beautiful silvery spots. "How this remarkable effect of metallic lustre is produced, seems not to have engaged the attention of entomologists. M. Audebert is of opinion that the similar lustre of the plumes of the humming birds (*Trochilus*) is owing to their density, to the polish of their surface, and to the great number of little minute concave mirrors which are observable on their little beards. (*Nouv. Dict. d'Hist. Nat.*, viii. 257.) But these observations will not apply to the scales of the wings of the butterflies, which are always very thin, and very flat; in some instances, as in *Morpho Menelaus*, there appears more than one very slight channel upon a scale, but this takes place also in others that reflect no lustre. Their metallic hues must, therefore, principally be occasioned by the high polish of their surface and the richness of their tints. It is the purity of the white, in conjunction with their shining surface, contrasted with the dull opaque colour of the under side of the secondary wings, that causes the spots that decorate those of the fritillaries to emulate the lustre of silver." (*Introd. to Ent.*, vol. iii. p. 652.) The curious apparatus, consisting of a loop and a strong bristle, whereby the two wings on each side are retained together, is found in many of these insects, and indeed is not met with in any other order. The loop is formed either by an elevated portion of the membrane of the strong central nerve of the upper wing, or by a little tuft of raised hairs. M. Poey has observed that it is simple in the males, but multiplied in the females, so that it furnishes a good character to distinguish the sexes. From general observations upon the distribution of colours in insects, it is evident that it is in the day-flying species that we are to expect the greatest variety of tints; and hence it is amongst the butterflies especially, as every one knows, that the most splendid hues and the most beautiful markings exist. Moreover, it is to be observed that here, as in some tribes of plants, certain tints prevail in particular groups; thus the *Pontiæ* and *Pierides* are generally white; *Colias* and its allies yellow; *Polyommatus* blue; *Argynnis* and *Melitæa* yellow or buff, spotted with black, &c.: in like manner peculiar markings prevail in certain groups, so that in many cases it is easy, by merely examining a fragment of one of their wings, to ascertain the tribe of which the insect to which it belonged formed part. Thus in *Doritis*, the centre of the wings has large eyes, with red and black circles. In *Colias* the centre of the posterior wings on the inferior surface has a silvery eyelet; the species of *Danais, Idæa,* and *Euplæa,* have the breast and head spotted with white, and in *Acræa* the base of the wing is more or less spotted with black.

The form of the wings is very much varied, preserving, however, in the species of the various groups, a certain resemblance in form; but this, however, must not be alone regarded, for amongst the strange freaks of nature, we find many groups widely apart, and belonging in fact to different primary sections in the order, exhibiting so great a resemblance together, not only in appearance, but even its habitats and habits, that an unaccustomed eye would be tempted to assert that the individuals formed but a single species. Thus *Geometra dealbata* flies about the footpaths in woods, with *Pontia napi*. In the woods of Brazil, *Acræa Thalia* (a butterfly) and *Castnia acræoides* (a moth) fly together; and in the thick forests of Guiana *Castnia linus* and *Heliconia psidii* are confounded together whilst on the wing. In like manner, *Castnia cronis* of Surinam was actually described by Cramer as the female of *Papilio cronis*. Analogies equally strong exist amongst the species contained in the separate sections; thus *Euterpe teria*, belonging to the *Pierides*, was actually placed, by Latreille and Godart, in the genus *Papilio*, to some of which, in its black wings and red spots, it bears so great a resemblance. Another, and still more remote, species of analogy exists between some Lepidoptera and the insects belonging to other orders; thus the species of *Sesia* and *Ægeria* so much resemble some bees and wasps, that they have obtained the names of wasp, hornet, and bee-sphinxes; and indeed we find such an author as Professor Bradley so far deficient upon this subject as to admit into his work a quotation to the following effect:—"There are gradual alterations from a perfect moth to the bee kind; and indeed, if we examine the 26th plate, we may find a just proportion from one to the other. The antennæ of all are alike, and their bodies are just different enough to be distinguished from one another"—the figures referred to representing the *Macroglossa stellatarum* (the humming-bird sphinx), *Trochilium fusiforne* (the narrow bordered bee-sphinx), *Trochilium bombyliforme* (the broad-bordered ditto), and *Bombus terrestris* (the humble bee), of which last the antennæ are blameably made like those of the preceding insect, that they may the better correspond with the text! The species of *Ægeria* have, in like manner, received a series of names, illustrating their striking analogy with many other insects of different orders; thus we have *Ægeria Tipuliformis*, *Æger. Chrysidiformis*, &c.; and the *Glaucopis coarctata*, in the coarctate form of its abdomen, exhibits a strong resemblance to an ichneumon. As to the analogies between the Lepidoptera and other more distinct tribes of animals, it will suffice to state, that the humming-bird moth, and many other sphingidæ or hawk-moths, have obtained these names from this kind of resemblance, whilst some of the larger exotic moths, and especially the gigantic Brazilian *Erebus*, which measures nearly a foot across the wings, have markings on their wings, which have induced the name of *Strix* (owl) to be applied to the last-named insect; and every school-boy knows that the name owlets or owlards is given to large pale-coloured thick-bodied moths, such as the puss-moth, which fly about in the twilight.

The legs of these insects are slender and hairy, offering, in many species, various remarkable peculiarities in the different sexes, which have not hitherto been sufficiently examined. In general, the six legs are alike, but in some butterflies, which have thence been termed *Tetrapodes*, the fore-legs are either very small, or occasionally rudimental. In the majority of these insects, the only difference between the males and females consists in the larger size of the latter, and especially of the abdominal portion of the body. The colours of the males are, however, often more brilliant, and the markings more decided, than in the other sex. In some species of moths, the wings in the females are very short, and quite unfitted for flight, and in others they are entirely obsolete. Some females, in this case, also much resemble their larvæ, such as those of *Psyche* and *Oiketicus*. Various differences also exist in the colours of the opposite sexes, as in the orange-tip butterfly, of which the males have the tip of the anterior wings orange-coloured, no trace of which is to be seen in the females; or still more strikingly in the ghost-moth (*Hepialus humuli*); or the muslin-moth (*Arctia meudicâ*), in which the colour of the wings is entirely different in the opposite sexes. Many instances have been observed, in which the same specimen has exhibited the characters both of the male and female insect, half of the body being masculine, and the other half feminine; and I have seen at Berlin a specimen of the scarce egger-moth, which was actually quartered in this manner, the front part of the body and front wings being half male and half female, and the hind part and hind wings half female and half male. M. Andersegg, a Swiss entomologist, has also observed a specimen of *Setina*, which exhibited not only hermaphroditism, but also hybridism, one side being that of a male (*S. ramosa*), the other a female (*S. aurita*).

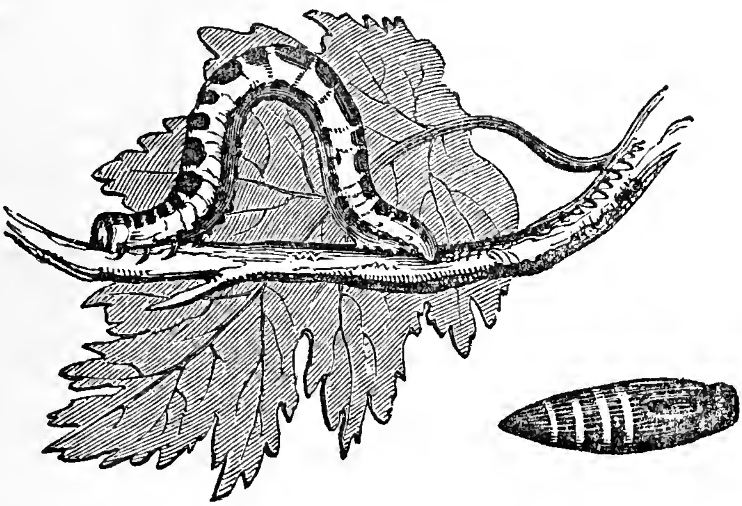
These insects undergo, in a remarkable degree, the transformations to which insects are subject, being produced from eggs, and appearing as caterpillars.

There is the greatest possible difference in the appearance of these insects in this stage of their existence, so that it is difficult to lay down any general observations upon them. They are, for the most part, of an elongated and cylindric form, and the body is fleshy, often entirely naked, but oftener clothed with hairs, spines, tubercles, or warts. They are composed of thirteen rings, of which the first represents the head: the second, third, fourth, the thorax; and the remainder the abdomen of the perfect moth or butterfly: moreover, on each side of the body, nine breathing spiracles are to be observed. The head is generally of a more scaly nature than the remainder of the body, and is furnished on each side with six minute shining tubercles, which appear to be the rudimental eyes of the future insect, as well as with two short conical antennæ, and a mouth furnished with a pair of very robust jaws, two fleshy under jaws with their two palpi, and an under lip with its two palpi. The silken matter which is spun by these insects, and which in the silk-worm (which is the caterpillar of *Bombyx mori*) constitutes one of the most valuable of insect productions, is elaborated in several long internal vessels, of which the extremities are narrowed and terminated in a tubular and conical tubercle, situated at the tip of the lower lip, which thus acts as a spinneret for the discharge of the silken threads. Caterpillars are also furnished with six short-jointed scaly legs, attached in pairs to the second, third, and fourth segments, and representing the legs of the future insect. They moreover possess from four to ten fleshy legs, armed at the extremity with a circular series of innumerable little bent hooks: the hind pair of these false legs, as they have been termed, are placed at the extremity of the body, near the anus; and it is by the assistance of these fleshy legs that the insect in general retains its hold upon the substance upon which it is placed: thus we find the fore-legs of the sphinx caterpillars seldom employed except in progression, the insect, when at rest, raising the fore part of its body into a curved position,



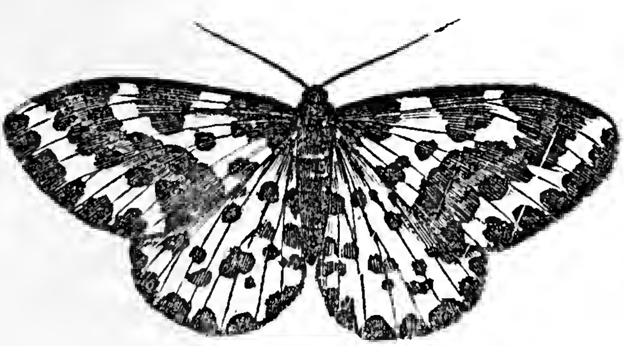
Figs. 1, Caterpillar swallow-tailed Moth (*Ourapteryx sambucaria*)—2, Caterpillar privet Hawk-moth (*Sphinx ligustri*).

whence the fanciful name of sphinx was given to this group of insects. In like manner, many of the looper caterpillars, when at rest, erect themselves into an upright position, or at different angles with the branches, on which they are observed attaching themselves firmly by means of the hind pair of false legs alone, closely resembling, in this situation, small twigs—a resemblance greatly increased by the colour and warty appearance of many of these animals. These species have only ten or twelve legs, including their six fore-legs, and have obtained their name of loopers from the curious manner of their progression: seizing hold of the twig with the fore-legs, they elevate the intermediate rings of the body until it almost assumes the appearance of a ring, by bringing the hind legs almost in contact with the fore ones,



Caterpillar and chrysalis of the Magpie Moth.

so as exactly to resemble the Greek omega, as represented in the above figure of *Abraxas grossulariata*. They then leave go with their fore-legs, and extend the body in a straight line, retaining at the same time, with their hind legs, the hold of their advanced position, so as to enable them again to effect the same manœuvre.—



Magpie Moth (*Abraxas grossulariata*).

They are enabled to effect these motions, as well as to retain their fixed and outstretched position, for a great length of time, by means of the prodigious muscular power which they possess. In fact, according to Lyonnet, in the caterpillar of the goat-moth (*Cossus ligniperda*), there are more than four thousand muscles.

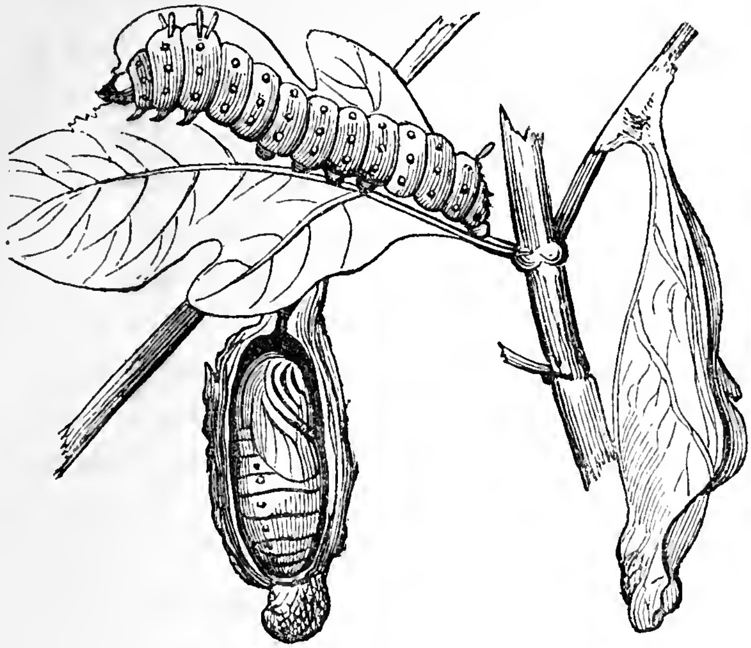
Caterpillars are, for the most part, vegetable feeders, some feeding upon leaves, often causing great destruction, as in the case of the little green Tortrix which infests the oak, sometimes stripping it entirely of leaves. The cabbage caterpillars, and those of the brown-tailed moths, may also be mentioned: others devour flowers, roots, buds, and seeds; whilst a few feed upon the ligneous particles of trees, boring (as in the case of the goat-moth, &c.) through the stems, and sometimes even completely destroying them when in a young state; others, again, feed upon cloth, furs, &c., of which the caterpillar of the clothes-moth, one of our most destructive domestic enemies, is an example; whilst a few devour lard, wax, and other fatty matters, as in the Galleriæ: some species are confined to a single plant, whilst others, as the garden-tiger moth, will thrive upon many different sorts; some species, again, are found in a state of society, as is especially the case with the small ermine moths and the processionary caterpillars: these spin a common web, which serves to protect them during inclement weather. Others, again, take a similar precaution, although solitary in their habits, as is the case with many small *Tineæ, Psyche, Fumea,* and in the large exotic *Oiketicus,* all of which form portable mantles, or cases, in which the caterpillars reside, and in which they become pupæ. Many species of the minute and gilt *Tineæ* reside within the body of different leaves, feeding upon the parenchyma, and forming slender tortuous passages. Many caterpillars feed by night: the majority, however, are day insects.

These caterpillars, for the most part, shed their skins four different times previous to becoming chrysalides: they then generally spin a silken coeoon, in whieh they inclose themselves, and in whieh they undergo their transformations. Others, however, simply fasten together the neighbouring leaves, particles of earth, or of the substances upon which they have been feeding, so as to form a rougher kind of eoeoon. The eaterpillars of butterflies, however, very rarely take any of these preeautions.

The following extraet from Mr. Peale's beautiful "Lepidoptera Amerieana" (of which the publication has recently been commeneed in Philadelphia), will, I am sure, be read with interest, presenting as it does one of the most interesting manœuvres hitherto recorded relative to the insect race. It relates to the *Bombyx Promethea* (Linn.), a very handsome

Bombyx (Saturnia) Promethea, male.

large moth, very abundant in 1833 in the vieinity of Philadelphia, at least judging from the number of eocoons seen hanging from the branches of the sassafras (*Laurus sassafras*) and spice-wood (*L. benzoin*), and which, by an ordinary observer, would readily be mistaken for withered leaves which had withstood the blasts of winter, for such they were evidently intended by the little architect to represent whilst preparing its narrow cell. After the caterpillar has attained its full size, and lost "the voracious appetite which had hitherto been its predominant character, it begins its preparations for the great transformation it is to undergo, by selecting a perfect leaf, the upper surface of which it covers with a fine light yellowish brown silk, extending this coating, with great skill and foresight, over the footstalk of the leaf, and attaching it firmly to the branch, so as to secure the leaf from being separated by any accident. This preliminary operation having been accomplished, the caterpillar next draws the edges of the leaf together, thus forming a perfect external covering or mantle, in which it spins a fine strong and durable cocoon of fine silk. In this habitation our little architect passes the winter secure from birds and other enemies. As soon as the cocoon has been completed, the caterpillar again sheds its skin, and is transformed into a pupa or nymph. At first, the leaf enveloping the cocoon remains green, but soon changes to a red or brown, when it becomes brittle, and is gradually carried away by the winds and storms of winter, until, finally, nothing remains except the cocoon itself, which is firmly suspended by the silk which once covered the footstalk of the leaf." The instinct of the caterpillar in thus providing for the permanent attachment of its future habitation, appears far to exceed that shown by any other caterpillars, if we except those of the pomegranate butterfly of the East Indies, of which I have published a memoir in the Transactions of the Entomological Society of London. The silk spun by the Prometheus moth, according to Mr. Peale, is as fine, and is produced in as great abundance, as that furnished by the *Bombyx mori*, or common silk-worm ; but it is of a darker colour, and will, it is feared, always present



Caterpillar, leaf-cocoon, and chrysalis of the Prometheus Moth.

difficulties in reeling, from the manner in which part of it is attached to the branch. I cannot conclude these observations without congratulating my readers upon that widely-extending spirit of observation into the wonders of the creation, of which Mr. Peale's work exhibits an example, trusting, at the same time, that this beautiful book will meet with that success which it so richly deserves.

Other interesting instances of the care with which the construction of these cocoons is undertaken, have already been given in preceding pages; and the general structure of Lepidopterous chrysalides is detailed in p. 207, &c.

In the earlier editions of the *Systema Naturæ*, Linnæus adopted only two genera: namely, *Papilio* for the butterflies, and *Phalæna* for the moths. In the last editions, however, he added a third genus, *Sphinx*, and subdivided these three groups in the following manner :—

1. *Papilio.*—Antennæ clavate.
   - A. *Equites.*—Posterior margin of the wing longer than the anal margin, divided into Trojans, having red spots on the breast, and Greeks, having no spots.
   - B. *Heliconii.*—Wings narrow, entire, often almost naked.
   - C. *Danai.*—Wings entire, divided into the *Candidi,* or whites, and *Festivi,* or variegated.
   - D. *Nymphales.*—Wings dentated, divided into the *Ocellati,* or those with eye-like spots, and the *Phalerati,* or those with simple spots.
   - E. *Plebeii.*—Caterpillars short, thick, divided into the *Rurales,* or those with dark spots, and the *Urbicolæ,* with transparent spots.
2. *Sphinx.*—Antennæ prismatic, thickest in the middle.
3. *Phalæna.*—Antennæ setaceous, often feathered, divided into
   - A. *Attaci.*—Wings somewhat extended, and inclined at rest.
   - B. *Bombyces.*—Wings crossed upon the body, antennæ pectinated.
   - C. *Noctuæ.*—Wings crossed upon the body, antennæ setaceous.
   - D. *Geometræ.*—Wings horizontal.
   - E. *Tortrices.*—Wings very obtuse, front margin curved.
   - F. *Pyrales.*—Wings forming with the body a furcate delta.
   - G. *Tineæ.*—Wings rolled into a cylinder.
   - H. *Alucitæ.*—Wings digitated.

Latreille adopted the Linnæan groups, to which he gave the names of—1. *Diurna* (day-fliers); 2. *Crepuscularia* (twilight-fliers); and 3. *Nocturna* (night-fliers).

The *Diurna* are divisible into the following families:—

Fam. 1. *Papilionidæ.*—Anterior legs not abbreviated, fit for walking, alike in both sexes; pupa angulated, suspended, and braced across the middle; antennæ not hooked at the tip. Here belong the genera *Papilio, Zelima, Parnassius, Thais, Pieris, Pontia, Colias.*

Fam. 2. *Nymphalidæ.*—Anterior legs abbreviated, not fitted for walking; ungues bifid; pupa angulated, and merely suspended by the tail; middle cell of the lower wings closed. Genera: *Cethosia, Argynnis, Melitæa, Vanessa, Libythea, Biblis, Nymphalis,* &c.

Fam. 3. *Heliconiidæ.*—Pupa smooth, suspended only by the tail; anterior legs imperfect; discoidal cell sometimes open. *Danais, Heliconia, Acræa,* &c.

Fam. 4. *Lycænidæ.*—Anterior legs semi-abbreviated; claws minute; pupa smooth, braced; larva onisciform. Genera: *Lycæna, Polyommatus, Thecla,* &c.

Fam. 5. *Hesperiidæ.*—Anterior legs not abbreviated; antennæ hooked at the tips; pupa smooth, braced, and folliculated. Genera: *Hesperia, Thymele,* &c.

These characters, it will be seen, are in some degree derived from the preparatory stages of the insects. Indeed, these considerations afford much more important clues to the classification of insects than they were imagined to possess by the earlier authors upon this branch of natural history. Of those who adopted a contrary opinion, Schrank may especially be noticed. He consulted metamorphosis in its various modifications, in his arrangement; and on its importance as a guide to minor subdivisions, he has the following ingenious observations, quoted by Dr. Horsfield in his Lepidoptera Javanica:—"Metamorphosis, in its larva state, may, and I think must, be taken into the characters of the genus, in the absence of other sufficiently distinctive notices. Those botanists who have derived their systems primarily from the *fruit,* have nevertheless a regard for the flower, and by this means reciprocally elucidate existing obscurities. Caterpillars are the *flowers* of the Lepidoptera. They are, indeed, not always present when the perfect insects are before the examiner; but is the case different with the botanist?" And Mr. MacLeay says to the same effect: "As the knowledge of the whole life of an insect must make us better acquainted with its nature than a mere description of one of its forms, in the same proportion ought metamorphosis to outweigh every other principle of arrangement."

Latreille's mode of primary distinction has also been adopted by Mr. Stephens, by whom, however, a distinct mode of classification of the *Nocturna*, or Linnæan *Phalænæ*, has been proposed, and by whom the following groups, considered as of equivalent rank with the *Diurna* and *Crepuscularia*, have been formed:—

1. *Lepidoptera pomeridiana*, corresponding with the Linnæan *Bombyces*, and comprising four families: *Hepialidæ*, *Bombycidæ*, *Notodontidæ*, and *Arctiidæ*.

2. *Lepidoptera nocturna*, corresponding with the Linnæan *Noctuæ*, and comprising two families: *Lithosiidæ*, and *Noctuidæ*.

3. *Lepidoptera semidiurna*, corresponding with the Linnæan *Geometræ* and *Pyrales*, and comprising the families *Geometridæ*, *Platypterícidæ*, and *Pyralidæ*.

4. *Lepidoptera vespertina*, corresponding with the Linnæan *Tortrices*, *Tineæ*, and *Alucitæ*, and comprising the families *Tortricidæ*, *Yponomeutidæ*, *Tineidæ*, and *Alucitidæ*.

There are still two other very valuable works upon the Lepidoptera, of the mode of distribution in which I would have given an account: their incomplete state, however, prevents my doing this. I allude to Dr. Horsfield's *Lepidoptera Javanica*, and the before-mentioned work of M. Boisduval; the former of which, by its philosophical introduction, and the latter by the careful description of all the species of this order, which it will contain, are especially deserving of attention. The British species, of which there are nearly 2000, have been described by Mr. Stephens in his Illustrations of British Entomology, and by the late lamented A. H. Haworth, in his rare *Lepidoptera Britannica.*

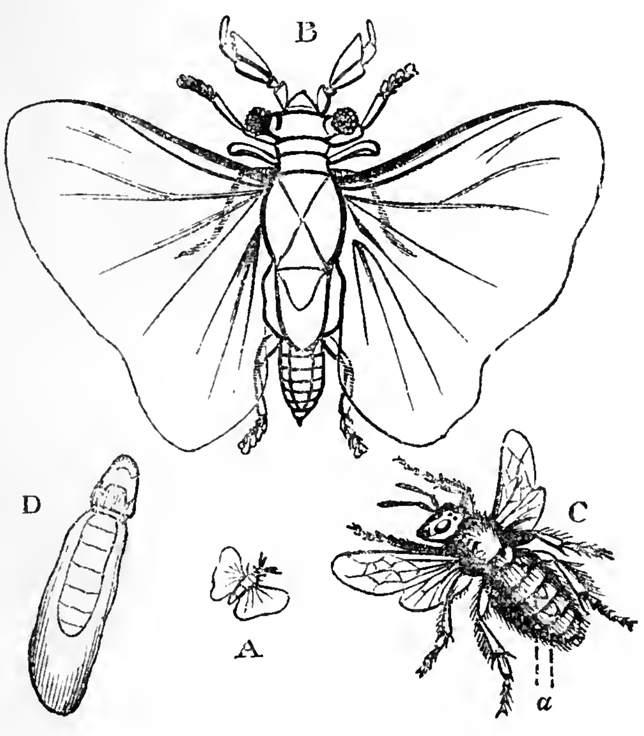
ORDER X.—STREPSIPTERA (Kirby; *Rhipiptera,* Latreille; *Rhipidoptera,* Lamarck).

This order has been established for the reception of a few insects of the most singular form and remarkable habits. The name of the order is derived from the Greek, and is in allusion to curious appendages of small size, which at first were regarded as attached to the fore-legs; and consequently, as these legs are prothoracic, and true fore-wings are mesothoracic, it was considered by Latreille that the former could not be analogous to wings, and accordingly that Mr. Kirby's name of the order was inappropriate; in lieu of which the name *Rhipiptera* was proposed, in allusion to the fan-like form of the real wings, which are very large, in shape like the quadrant of a circle, and furnished with a few longitudinal nerves, arranged like the ribs of a fan. Subsequent discoveries have, however, proved that the small twisted organs are in reality mesothoracic, and consequently as truly representations of the fore-wings of butterflies, &c., as the elytra of beetles, in some of which latter (*Atractocerus, Sitaris,* &c.) these organs are nearly as much reduced in size as the pseudelytra of the *Strepsiptera.* The head of these insects is transverse, with large exposed eyes placed on footstalks, divided into a small number of facets; the mouth is of a singular character, there being scarcely any appearance of aperture; there are also two slender and pointed organs inserted widely apart, but crossing each other, and a pair of large two-jointed palpi; the antennæ are very extraordinary in their forms, being generally furnished with an internal branch nearly as long as the antenna itself; the prothorax and mesothorax are very short, forming only two narrow rings, to each of which, on the under side, a pair of legs is attached; the mesothorax is very greatly developed, and divided by several oblique sutures; the legs are short, slender, and compressed, with the tarsi furnished with fleshy cushions, but destitute of claws; the two anterior pairs of legs are close together, and the posterior pair very far behind; the abdomen is small, and scarcely coriaceous; it is cylindric, eight or nine-jointed, and furnished with a recurved point.

These insects are of small size, and in the larva state they are parasitic in the bodies of various species of wild bees (*Andrenidæ*), and wasps (*Vespidæ*). The order was first detected by Rossi, an Italian entomologist, who discovered its habits, and formed a genus for the reception of the species which he discovered (*Xenos vesparum*, Rossi; *Xenos Rossii*, Kirby), but he regarded it as belonging to the order *Hymenoptera*. Mr. Kirby having discovered another species belonging to the same group, but to a distinct genus, in this country, and having received another species from Professor Peck of America, investigated the subject very minutely, and detailed the characters of the order and its genera in an elaborate Memoir published in the Linnæan Transactions. The following is Mr. Kirby's account of his discovery of the English species, and as it is illustrative of the habits of the insect, I shall quote it at length. Having observed upon various species of *Andrena* "something that I took to be a kind of acarus, which appeared to be immoveably fixed just at the inosculations of the dorsal segments of the abdomen, and at length finding three or four upon a specimen of *Melitta* (*Andrena*) *nigroænea*, I determined not to lose the opportunity of taking one off to examine and describe; but what was my astonishment, when, upon my attempting to disengage it with a pin, I drew forth from the body of the bee a white fleshy larva a quarter of an inch in length, the head of which I had mistaken for an acarus! After I had examined one specimen, I attempted to extract a second, and the reader may imagine how my astonishment was increased, when, after I had drawn it out but a little way, I saw its skin burst, and a head as black as ink, with large staring eyes and antennæ consisting of two branches, break forth and move itself briskly from side to side. It looked like a little imp of darkness just emerged from the infernal regions. My eagerness to set free from its confinement this extraordinary animal may be easily conjectured. Indeed, I was impatient to become better acquainted with so singular a creature. When it was completely disengaged, and I had secured it from making its escape, I set myself to examine it as accurately as possible, and I found, after careful enquiry, that I had got a nondescript, whose very class [order] seemed dubious."—*Monograph. Apum Angl.*, ii. 113.

Mr. Dale, who has been very successful in the discovery of insects of this order, communicated the following observations to Mr. Curtis, by whom they were published in the British Entomology, fol. 226, together with a beautiful illustration of *Stylops Dalii* (fig. A, natural size; B, magnified; C, the andrena with the heads of two of the larvæ exposed between the segments of the abdomen; D, larva extracted and magnified), a species named after the gentleman above mentioned, and whose remarks are as follows:—

"Every specimen of *Andrena barbilabris* I have seen this year [1828] from the 27th April to the 4th June, have contained larvæ, pupæ, or exuviæ of *Stylops*, from one to three in each. On the 5th May, I picked out one with a pin: on the 7th another rather



immature, and caught one flying in the hot sunshine over a quickset hedge in the garden; it looked milk-white on the wing, with a jet black body, and totally unlike any thing else; it flew with an undulating or vacillating motion amongst the young shoots, and I could not catch it till it settled on one, when it ran up and down, its wings in motion and making a considerable buzz or hum, nearly as loud as a *Sesia;* it twisted about its rather long tail, and turned it up like a *Staphylinus.* I put it under a glass and placed it in the sun; it became quite furious in its confinement, and never ceased running about for two hours. The elytra or processes were kept in quick vibration as well as the wings; it buzzed against the sides of the glass with its head touching it, and tumbled about on its back. By putting two bees (*Andrena labialis*) under a glass in the sun, two *Stylops* were produced; the bees seemed uneasy and went up towards them, but evidently with caution as if to fight, and moving their antennæ towards them retreated. I once thought the bee attempted to seize it; but the oddest thing was to see the *Stylops* get on the body of the bee and ride about, the latter using every effort to throw his rider. A large hole is left in the tail of the bee where the *Stylops* escapes, which closes up after a time, I have found five species of *Andrenæ* infested. When off the bee the *Stylops* kept its wings still and half erect."

The genus *Xenos* is distinguished by having both the branches of the antennæ inarticulate. It comprises two species: one found in Europe, infesting the body of the *Polistes Gallica* (one of the social wasps); and the other *Xenos Peckii,* above noticed.

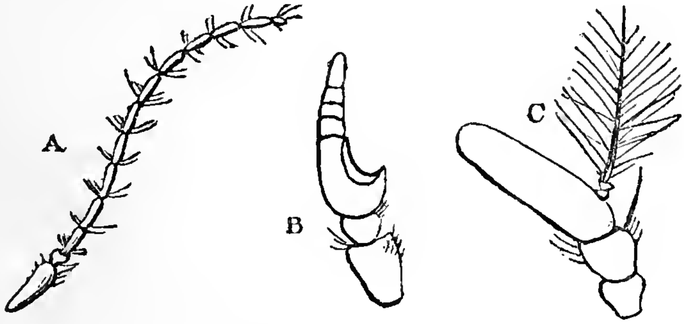
In the genus *Stylops,* the outer branch of the antennæ is flattened, and tri-articulate. This genus comprises several British species, and appears confined to the genus *Andrena.*

The genus *Elenchus* has the antennæ similarly jointed, but very long and slender, and the eyes scarcely pedunculated. Type, *Stylops tenuicornis* of Kirby. *Elenchus Templetonii,* Westw., was discovered at the Mauritius by Mr. Templeton.

The genus *Halictophagus,* so named from being *supposed* to be parasitic upon the genus of bees *Halictus,* has the antennæ internally furnished with four branches. A single individual of *H. Curtisii* was taken by Mr. Dale near Lulworth Cove, Dorsetshire, by brushing long coarse grass and thistles into a net.

ORDER XI.—DIPTERA.

This order is distinguished by the presence of only a pair of membranous extended wings affixed to the centre of the sides of the thorax, and generally furnished near their insertion with a pair of short clubbed organs, termed halteres or balancers, respecting which, as analogically representing the posterior wings of the four-winged insects, entomologists are at variance. The mouth is provided with a sucker composed of from two to six scaly lancet-like pieces, and inclosed in a canal upon the upper surface of a fleshy proboscis, or covered by one or two inarticulated plates, which serve as a sheath (*Hippobosca*). The body is composed, as in the other six-legged insects, of three principal divisions, representing the head, thorax, and abdomen. The ocelli, when present, are generally three in number. The antennæ exhibit various degrees of developement, from the exceeding length in the *Macroceræ* and *Megistoceræ* to their scarcely visible size in the *Hippoboscæ*. In the *Tipulidæ* we find these organs composed of numerous articulations. In the *Tabanidæ* and

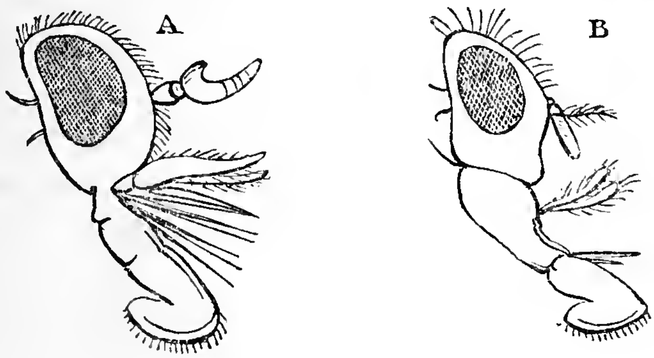


A, Antennæ of Tipula—B, of Tabanus—C, of Musca.

Beridæ they are short, and the terminal articulations become almost indistinct, so that in the *Muscidæ*, &c., where they are very short, and appear to be composed only of three joints, having a terminal bristle, it is impossible not at once to perceive that the terminal joints are, with the exception of those composing the seta, so entirely soldered together that their union is not visible. The eyes are lateral, and in many instances those of the males are much larger than in the females, uniting upon the crown of the head. In others they are so large as to occupy nearly the entire head, leaving but a small space only for the mouth.

In those species which have the mouth more perfectly developed than the rest, and which consist of the blood-thirsty gnat and gad-fly, we find a series of organs, greatly modified of course as to their form, in order to fit them for their functions, but which, as to their number, correspond with those of the mouth of the true mandibulated insects, so that it is equally impossible for us to arrive at any other conclusion than that the parts of the mouth of the fly represent, in an altered state of developement, the parts of the mouth of the beetle. We accordingly find that the mouth in *Tabanus* consists of a large fleshy organ, having a fleshy pair of lobes at its extremity, and which, being the lowest part of the mouth, corresponds with the lower lip of the beetle. At the sides of this, and rather higher in the mouth, is attached a pair of lancet-like organs, having a pair of large biarticulate palpi arising from the base: these constitute the maxillæ and the maxillary palpi. Still higher in the mouth another pair of lancets appears, which represent the mandibles, whilst a larger horny piece, channelled beneath for the reception of the others, forms the upper lip (*labrum*). Within the mouth another very fine lancet appears, analogous to the tongue of the grasshoppers,—an organ seldom developed to any extent in the Coleoptera. When we consider the habits of these insects, it is evident how necessary it is that the organization of the mouth should be fitted for a different employment from that of masticating. These habits are essentially suctorial, and the food of the insects is essentially fluid. Broad horny organs would therefore be useless; whereas a series of acute instruments for puncturing and penetrating deeper and deeper into the food, and a fleshy canal, up which, by suction, fluids easily pass, is what would exactly be looked for in the workmanship of an omniscient and all-providing Artificer.

In other groups of Dipterous insects, and more especially in those which prey upon their companions (*Asilidæ, Empidæ,* &c.), we find diminished forces in the organization of the mouth: the lancet-like mandibles have vanished, but all the remaining organs appear in full developement. In the *Syrphidæ* the maxillæ become smaller, and in *Musca* they



A, Mouth of Tabanus—B, of Musca.

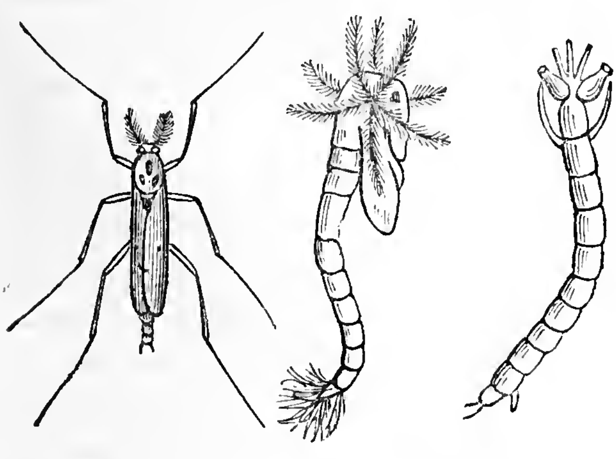
are completely lost. In the *Œstridæ* the entire mouth is sometimes completely obliterated. The legs are generally long and slender: some instances occur where they are disproportionately long, whilst in others they are more or less thickened and spined. The wings agree in their veining with the anterior pair of the *Hymenoptera* rather than with those of the *Neuroptera,* only there are fewer transverse nerves. In one group, however (*Nemestrina*), the wing is reticulated nearly as much as in the *Neuroptera.* In comparing the upper wing of a bee with the wing of a fly, no particular resemblance is to be traced between the direction and position of the veins; but if both the front and hind wings of the bee be compared together with the wing of some flies, as the *Syrphidæ,* and particularly *Aphrites,* we are enabled to trace a very great resemblance between them in this respect. M. Macquart employs this circumstance as a forcible argument in support of the opinion that the balancers of the *Diptera* do not represent the lower wings of the bee. The uses to which these balancers are applied are not yet decidedly ascertained: the insect moves them with extreme rapidity, especially when a buzzing noise is produced; and it is important to observe that they are placed close to the mouth of a pair of the breathing pores. Many species are moreover provided at the base of the wings behind with a pair of membranous doubled organs, somewhat like the valves of a shell, which are termed *alulets:* one of these is attached to the wing, and the other to the sides of the thorax. The size of these alulets is in inverse proportion to that of the *halteres.* The abdomen is generally attached to the thorax by a portion only of its basal diameter: it is composed of from five to nine visible articulations, and is generally pointed at the extremity in the females, enabling them the more readily to introduce their eggs into the situations in which they are deposited. In those species which have the abdomen composed of the fewest segments, those which appear to be wanting are transformed into a kind of ovipositor, consisting of a series of little tubes, sliding one into another like a telescope. The sexual organs of the males are external in many species, and folded beneath the abdomen. The legs are terminated by a tarsus consisting of five joints, the last of which is armed with two small claws, and very often with two or three membranous lobes or pulvilli. It is by the assistance of these terminal organs of the foot that the fly is enabled to perform the curious mechanical feat of walking with the back downwards, against gravity, upon the ceilings of rooms, highly polished glass, &c. From the experiments of Sir Everard Home, it has been generally considered that this was effected by the formation of a vacuum, by means of the close application of the margins of these soles of the feet, as we may term them, and the subsequent muscular raising up of their central parts; but the following remarks by one of our most acute modern observers, Mr. Blackwall, published by him in the Appendix of the last volume of the Linnæan Transactions (in correction of a memoir previously published by himself, in which he had adopted the vacuum system), will be read with interest, as showing what interesting sources of inquiry are opened to the student of nature, even in the commonest objects of the creation.

In experimenting upon the house-fly, he observed that individuals *frequently remained fixed* to the sides of an *exhausted* glass receiver after they had entirely lost the power of locomotion, and an evident distension of the abdomen had been occasioned by the exhaustion of the aeriform fluids it contained. To detach them from these stations, the employment of a small degree of force was found requisite.

"In prosecuting this subject, clean phials of transparent glass, containing spiders and various insects in the larva and imago states, capable of walking on their upright sides, were breathed into, till the aqueous vapour expelled from the lungs was copiously condensed on their inner surface. The result was remarkable; the moisture totally prevented those animals from obtaining any effectual hold on the glass, and the event was equally decisive if a small quantity of oil was substituted for the aqueous vapour. A similar consequence ensued, also, when the flour of wheat, or finely pulverised chalk or gypsum, was thinly strewed on the interior surface of the phials, the minute particles of those substances adhering to the tarsal brushes of the spiders, the pulvilli of the perfect insects, and the under side of the feet of the larvæ. These facts, far from corroborating the mechanical theory, appeared quite inexplicable, except on the supposition that an adhesive secretion is emitted by the instruments employed in climbing. The next point to be determined, therefore, was, whether spiders and insects in the larva and imago states, when moving in a vertical direction on clean glass, leave any visible track behind them? Careful and repeated examinations, made with lenses of moderately high magnifying powers, in a strong light, and at a favourable angle, speedily convinced me that my conjecture was well founded, as I never failed to discover unequivocal evidence of its truth, though, in the case of the spiders, considerable difficulties presented themselves in consequence of the exceedingly minute quantity of adhesive matter emitted by the brushes of those animals. On submitting this secretion to the direct rays of the sun, in the month of July, and to brisk currents of air, whose drying power was great, I ascertained that it did not suffer any perceptible diminution by evaporation under those circumstances. Now, it is reasonable to infer, from the foregoing researches, that the hair-like appendages constituting the brushes of spiders, and occurring in such profusion on the interior surface of the pulvilli of insects, are tubular."

The larvæ of the Diptera, as well as the perfect insects, have characters peculiar to themselves. In many of these larvæ the head is of a fleshy substance, without any determinate form, whilst in the majority of the larvæ of other orders the head is horny and consistent in form. The breathing pores have also a peculiar disposition; instead of being placed in pairs upon the first, fourth, and following segments of the body, as is generally the case, the anterior pair are found upon the second segment, whilst all the rest, from two to eight in number, are brought together upon the terminal segment. Those larvæ, which are constantly footless, or but rarely provided with fleshy appendages, have the mouth armed with two points formed for piercing the matters upon which they feed. In the transformations which these insects undergo in their passage to the perfect state, there is less diversity than in the organization of the perfect insect. Insects in general are oviparous, but there are of course exceptions to this rule, and two of the most remarkable are to be found in this order. The blowfly forms one of these exceptions, in which the eggs are hatched in the body of the parent, and produced in a living state. The other occurs in the forest-flies (*Hippoboscidæ*), in which group not only are the eggs hatched within the body of the female, but the larva there acquires its full growth, and assumes the pupa state, being ejected from it in the shape of an egg as large as the abdomen of the parents, and from which the perfect insect, instead of the larva, makes its escape.

The larvæ of the Diptera in general offer so great a simplicity of structure, as to cause an uniformity of appearance; nevertheless, those which reside in the water are more diversified in their characters, being furnished with organs of nutrition and respiration very unlike those of the terrestrial larvæ: this is especially the case in the common gnats (fam. *Culicidæ*), and the culiciform *Tipulidæ*, (*Chironomus*, &c.)



Larva, Pupa, and perfect Chironomus, magnified.

In passing to the pupa state, these larvæ adopt two principal modes. In the greater number there is no shedding of the skin; the skin of the larva hardens, contracts, and becomes an oval cocoon, within which the pupa is disengaged, appearing at first merely as a gelatinous mass, but afterwards exhibiting in some degree the different parts of the perfect insect, the eyes and wings being folded upon the breast. In the others the metamorphosis is effected by the larva shedding its skin, and the insect then appearing in the form of an inactive incomplete pupa, like that of the former, but not inclosed in a cocoon. In some of the latter, as in the aquatic species, the pupa retains its activity, jerking about with much agility in the water, whilst many are quite inactive.

In their perfect state, the insects of this order are scarcely less numerous, in point of *species*, than any other order of insects; but, if we look at them with respect to the number of *individuals*, we find them infinitely to exceed any other. The clouds of midges (*Chironomus*), for instance, rising at eventide over the marshes, like the incense of the Temple, equally pay homage to the Divinity, in showing forth His mighty power; whilst myriads of flies of every kind are to be found in every quarter of the globe, traversing plants and every animate object, and more particularly all that has ceased to live.

This immense profusion with which they are dispersed over the globe causes them to fulfil two very important functions in the economy of nature. First, they serve for food to a vast number of the higher animals. Charged with a Divine mission by Him "who giveth food to the young bird," the swallow and the sparrow destroy them by myriads, and the fly-catcher and the humming-bird alike find in them a constant shedding of manna; whilst, in the second place, they cease not in effecting the disappearance of all substances in a state of decomposition, both animal and vegetable. They are universal scavengers; and so great is their activity, and the rapid succession of their generations, that Linnæus might well say that three flies can consume a horse as fast as a lion. Amongst such a vast number of objects, it is not surprising that some should be found obnoxious to ourselves or our properties. Many species, accordingly, cease not to make man their prey, by sucking his blood, whilst some either attack our cattle in like manner, or deposit their eggs upon their bodies, within which the parasitic larvæ feed; others deposit their eggs, or young, upon our growing corn, and upon our prepared food of various kinds.

Many species reside in woods, in meadows, marshes, and in our habitations; others move with dancing feet upon the spray of the waves, and even upon the snows of the polar regions. Many are attached to plants, upon the flowers of which they abound, sucking the honeyed sweets, without giving the preference to any particular plant, whilst some are confined to a single species of flower; but it is upon the star-like anthemis of our meadows that the majority seem to revel with the greatest delight. During the summer and autumn the flies are attracted to our orchards, in order to destroy our fruits, whilst some species delight in the honey dew of the aphides, or the fluids which escape from the wounds of trees. The domestic fly feeds alike upon all kinds of household provisions; and other species, which so closely resemble it in size and appearance as to deceive an ordinary observer, are parasitic upon the nests of various solitary bees. Nothing, indeed, can be more amusing than to watch one of the latter following the laborious insect, the young of which she is about to supplant by her own, peering about into the mouth of the nest, and cautiously making her entrance, in order to deposit her own eggs, when the bee has, with great toil, completed her nest, and deposited her store of honey-paste for the food of her own progeny.

The order was established by Aristotle, the great father of zoology, under the name which is still retained for it; and since the days of Linnæus, by whom its distribution was attempted, various naturalists have contributed to raise it to the rank which it has now attained, although it has not been a general favourite with our amateurs. It is to Reaumur and

De Geer we are indebted for our knowledge of the transformations of many of these insects; whilst Fabricius, Latreille, Meigen, Fallen, Wiedemann, Robineau Desvoidy, and Macquart, have successively established families, tribes, genera, and species; the works of Meigen and Macquart having especially contributed to this end.

The following is the arrangement proposed by the latter in his valuable "Histoire Naturelle des Diptères," recently published, and which I have adopted, with this variation only, namely, that, with Latreille and Leach, I have considered the forest-flies as forming a primary section of the order, whereas M. Macquart has placed them merely as a family of the great group of *Muscidæ*.

SECTION I. (*Ovipara* or *Larvipara*; DIPTERA, Leach.)—Head distinct from the thorax; sucker inclosed in a labial canal; claws of the tarsi simple, or with one tooth; the transformation to the pupa state not taking place within the body of the parent.

Division 1 (NEMOCERA). Antennæ having six or more distinct joints; palpi with four or five joints.

Fam. 1 (*Culicidæ*). Sucker with six lancets.

Fam. 2 (*Tipulidæ*). Sucker with two lancets.

Division 2 (BRACHOCERA). Antennæ having three distinct joints; palpi with one or two joints.

Subdivision 1 (*Hexachæta*). Sucker with six lancets. Fam. *Tabanidæ*.

Subdivision 2 (*Tetrachæta*). Sucker with four lancets.

A. (Fam. *Cænomyidæ, Beridæ, Stratiomydæ.*)

B. (Fam. *Mydasidæ, Asilidæ, Hybotidæ, Empidæ, Henopidæ, Nemestrinidæ, Bombyliidæ, Anthracidæ*).

C. (Fam. *Therevidæ, Leptidæ, Dolichopidæ, Syrphidæ.*)

Subdivision 3 (*Dichæta*). Sucker with two lancets. This subdivision comprises an immense assemblage of species, constituting the Linnæan genera *Œstrus*, *Conops*, and *Musca*, after the removal of the *Syrphidæ;* but, owing to the numerous divisions and subdivisions necessary for its investigation having but little to interest the general reader, I shall not here detail them.

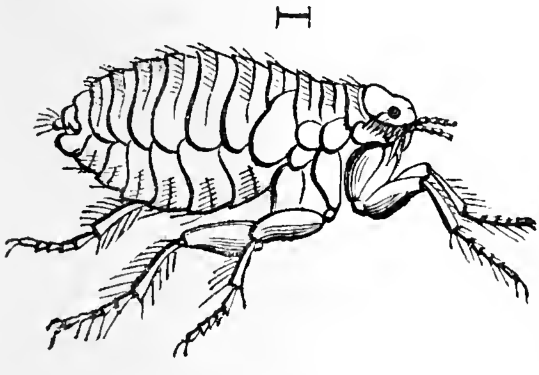
SECTION II. (*Pupipara*; HOMALOPTERA, Leach). Head immersed in the front of the thorax; sucker inclosed in two valves; claws with many teeth. The transformations to the pupa state undergone in the body of the parent fly.

Fam. 1 (*Hipposcidæ*). Head frontal.

Fam. 2 (*Nycteribiidæ*). Head dorsal.

ORDER XII.—APHANIPTERA (Kirby; *Siphonaptera*, Latreille; *Suctoria*, De Geer; *Aptera*, MacLeay).

This order consists of the various species of fleas which inhabit the bodies of man and various animals and birds, in which the body is of small size, clothed with a hard shining integument, armed with sharp bristles arranged in transverse series upon the back and legs. It is very much compressed and apterous; at least rudiments only of wings and wing-cases exist in the shape of two flattened plates, on each side of the body, near the base of the posterior legs. The mouth consists of the six ordinary parts, but is of an elongated suctorial form,



The flea (*Pulex irritans*).

provided at the base with two articulated organs, which have been regarded as antennæ, but which are the maxillary palpi; the true antennæ being lodged in a cavity behind the eyes; the legs are strong, and formed for leaping to a great distance; the tarsi are five-jointed.

The flea undergoes a series of transformations as striking as those of the bee or beetle. From the eggs are hatched long worm-like grubs, which twist about in all directions, and which, having attained their full size, form for themselves silken cocoons, in which they become incomplete pupæ, having the rudiments of all the limbs of the future insect visible.

Having arrived at the perfect state, they commence their attacks upon us or upon our animals, as well as pigeons, swallows, &c.

The Jigger (*Pulex penetrans*) also belongs to this order, differing from the common species by its habit of burrowing into the flesh of the feet in tropical climates.

ALPHABETICAL LIST OF CHIEF AUTHORS.

I WILL now, in conclusion, lay before the reader a short alphabetical list of the chief Entomological authors, with a concise notice of their chief works which are deemed of standard merit, and which no Entomological library should be destitute of. There are a great number of names which are necessarily omitted for want of space, the following being the most eminent only of the writers upon this branch of natural history.

ARISTOTLE.—The father of natural history. He lived about the year 330 B. C., and devoted considerable attention to the natural history of insects, which he separated under the name of *Entoma* from the Crustacea, which he called *Malacostraca*, and divided into three sections:—1. Those with wings, *Pterota* or *Ptilota*; 2. Those occasionally furnished with wings; and, 3. Those destitute of wings. In the first were comprised various subdivisions, admirably constructed, including the present orders *Coleoptera*, *Diptera* (which two names are still retained), and others corresponding with the *Hemiptera*, *Lepidoptera*, &c. In the second section were placed the ant and the glow-worm; and in the third, all wingless insects.

AUDOUIN (Victor).—Professor of Entomology at the Jardin des Plantes, Paris; author of numerous detached Entomological memoirs; but especially known by his invaluable researches upon the structure of the thorax.

BOISDUVAL (Mons.)—A French entomologist, especially distinguished for various works upon *Lepidoptera*; the most valuable of which is his Natural History of Lepidopterous Insects, forming part of the Suites à Buffon.

BURMEISTER (Dr. Hermann).—A young Prussian entomologist of the highest promise. His works exhibit profound erudition, an admirable ingenuity and correctness in the anatomical details, and the greatest carefulness in the elaboration of his materials. He has published various memoirs of great merit; but is best known by his Handbuch der Entomologie, or Manual of Entomology, a very useful introductory work, in which a great quantity of materials, scattered over numerous miscellaneous works, is brought together, and admirably digested. An English translation of the first volume of this work, by Mr. Shuckard, has been published. The second volume treats upon the descriptive portion of the *Hemiptera* and *Homoptera*.

Cramer.—A Dutch author, distinguished for his beautiful work, in quarto, upon exotic butterflies, in five volumes; commenced in 1779.

Curtis (John).—An English entomologist, and author of British Entomology, or Illustrations and Descriptions of the Genera of Insects found in Great Britain and Ireland; the most elegant periodical work hitherto published. Each genus is illustrated by a coloured figure of one of the species, and with the details of the mouth and antennæ. A figure of a plant is added, upon which, in many cases, the insect is found.

Cuvier (George Leopold Christian Frederick Dagobert, Baron).—The greatest zoologist of modern days; born in 1769, in Alsatia; died in Paris, in 1832. In his Traité Elémentaire, and Anatomie Comparée, he carefully investigated the comparative structures of the annulose animals, and separated the *Crustacea* as a class from insects. In his celebrated work, Le Règne Animal (The Animal Kingdom), the details of the entomological portion were executed by Latreille.

De Geer (Charles, Baron).—A Swedish naturalist; born in 1720; known by his admirable Mémoires pour servir à l'Histoire des Insectes,—a work in seven quarto volumes, with a great number of plates, in which the most ample details of the structure and metamorphoses of a vast number of species are given. MacLeay calls him the prince of entomological authors.

Dejean (M. Le Comte).—A French entomologist, and the possessor of one of the most extensive collections of *Coleoptera* ever yet made. He has published, 1. a Catalogue of his *Coleoptera*, of which several editions have appeared; 2. A description of the species of predaceous land beetles (*Cicindelidæ* and *Carabidæ*), in six octavo volumes, and (in conjunction with Messrs. Boisduval and Aubé), a description of European beetles, now in course of publication.

Dufour (Mons. Léon).—A French author, still living; distinguished for the great extent of his anatomical investigations upon insects, illustrated by figures drawn by himself. They are published in numerous foreign periodicals, especially in the Annales des Sciences Naturelles.

Esenbeck (Dr. Nees Von).—Professor of Natural History at Breslaw; author of various memoirs upon the minute parasitic

Hymenoptera; of which his recently published "Hymenopterorum Monographiæ" are the most valuable.

FABRICIUS (Johann Christian).—A German entomologist, pupil of Linnæus, and professor at Kiel in Holstein; born 1747; died, 3rd of May, 1810, aged 63*, especially distinguished as the founder of the Cibarian mode of distribution of insects (established upon the structure of the mouth); but more deservedly known and cited as a most extensive describer of species of insects. His chief works are Entomologia Systematica, in 4 vols., 8vo, commenced in 1794, and in which those species of all orders with which Fabricius had become acquainted in his numerous voyages, are described. He visited England several times, and was on terms of friendly intercourse with Sir Joseph Banks, &c. Subsequently, he published as distinct works the Systema Eleutheratorum (*Coleoptera*); Antliatorum (*Diptera*); Piezatorum (*Hymenoptera*); and Rhyngotorum (*Hemiptera, Homoptera*).

FALLEN.—A Swedish entomologist, chiefly distinguished by his works intitled Diptera Sueciæ, and Hemiptera Sueciæ, &c.; in which the species of these and some other orders found in Sweden are carefully described.

GEOFFROY.—A French author, contemporary with Linnæus; especially remembered on account of his introduction of the variations in the number of tarsal points, as affording sectional groups in the order *Coleoptera*. His chief work is intitled "Histoire abrégée des Insectes," &c. Paris, 1764, 2 vols. 4to.

GRAVENHORST (Dr. J. L. C.)—Professor of Natural History at Breslaw, author of various works upon the Brachelytra (*Staphylinidæ*), and also upon the Ichneumonidæ. Ichneumonologia Europæa, in 3 large 8vo volumes, is his most valuable work.

GUERIN (Mons. F. E.)—A French naturalist and artist, author of numerous detached Entomological Memoirs, with beautiful illustrations; but especially distinguished by his Iconographie du Règne Animal, in which types of all the leading genera of animals are figured, with an infinity of details of structure.

GYLLENHALL (Leonard).—Author of a very valuable work in 4 volumes, 8vo, intitled Insecta Sueciæ; but comprising only the beetles found in Sweden. His descriptions are admirable.

HAWORTH (Adrian Hardy).—An English entomologist, founder of the old Entomological Society, and author of Lepidoptera Britannica, a work consisting of careful descriptions of all the species of lepidopterous insects with which the author was acquainted. Died in 1834.

* There is some confusion in entomological works as to these dates. Those given above are derived from information given to me by Dr. Fabricius, of Kiel, son of the entomologist.

Huber, F.—A Swiss entomologist, distinguished for his interesting series of Observations upon the Economy of Bees.

Huber, P.—Equally distinguished with his father for his extensive series of Observations upon the Economy of the Ants. His Memoirs have been translated into English.

Hubner.—A German entomologist, author of a valuable work containing figures and descriptions of European Lepidoptera, (Der Sammlüng Europaischer Schmetterlinge), in quarto.

Jurine (Louis).—A Swiss entomologist, author of a valuable work upon the Hymenoptera, in which the structure of the veins of the wings was employed to characterize the genera, intitled Nouvelle Méthode de classer les Hyménoptères et les Diptères. Vol. 1, Hyménoptères. Geneva, 1807, quarto.

Kirby (Rev. W.)—The father of English entomologists, author of a great number of detached Memoirs, and especially distinguished by his Monograph upon the English Bees, a most invaluable work, and a model for all subsequent monographers. He likewise published, in conjunction with W. Spence, an Introduction to Entomology, in 4 vols. 8vo, a work of the greatest research. His Memoirs upon the Strepsiptera, the Genus Apion, and his Bridgewater Treatise, are also to be noticed.

Klug (Dr. Frederick).—A Prussian naturalist, conservator of the insects of the Berlin Royal Museum, particularly devoted to the Hymenoptera, and distinguished by his Memoirs upon the Tenthredinidæ (*Blattwespen*), published in the Berlin Transactions, and his Jahrbucher der Entomologie, &c.

Lamarck (Jean Baptiste de).—A French naturalist, chiefly distinguished for his works upon the invertebrated animals, of which the most valuable is the Histoire Naturelle des Animaux sans Vertèbres, presentant les Caractères généraux, &c., in 7 vols., 8vo, Paris, 1815. The class *Arachnida* was separated from the insects by this author.

Latreille (P. A.)—Professor of Entomology at the Jardin des Plantes, Paris. Born 29th of November, 1762. Died 6th of February, 1832. One of the most distinguished of modern entomologists, whose writings for nearly half a century have tended in the highest degree to improve the science which he so ardently loved. From the publication of his Précis des Caractères génériques des Insectes, published in 1796, until that of his Cours d'Entomologie, he ceased not to labour towards the accomplishment of a natural classification of insects, and to a perfect investigation of their general structure. His most valuable works are Genera Crustaceorum et Insectorum, 4 vols. 8vo, and his Histoire générale des Insectes, in 14 vols. 8vo.

Linnæus (Carl von).—A Swedish naturalist of the greatest celebrity. Born 24th of May, 1707, at Roeshult in Sweden, and distinguished as the founder of modern Zoological Classification and Nomenclature. His works appeared in succession from 1735 to 1770, each being advantageously remodelled. His Systema Naturæ, in which all the animals, plants, and minerals with which the author was acquainted, and his Fauna Sueciæ, in which the animals of Sweden were described, are most constantly cited. Of the former work twelve editions appeared in the lifetime of the author; the last of which was published in 1766, and which is considered as his most valuable work.

Lyonnet (Pierre).—Author of one of the most elaborate treatises ever published, bearing the title of "Traité de la Chenille qui ronge le Bois de Saule," in which the anatomy of the larva of the goat-moth (*Cossus ligniperda*) is described and illustrated in the most complete manner. It was published in 1760, in one volume, 4to, containing 615 pages and 18 plates. The anatomy of the pupa and imago, but in a comparatively imperfect state, have been lately published.

MacLeay (Wm. Sharp).—Author of the Horæ Entomologicæ, a most remarkable and profound treatise, in which the relations of animals are treated upon in a peculiar manner. The work also contains a classification of the Lamellicorn beetles. He has also published the first part of the Annulosa Javanica, containing a portion of the *Coleoptera* collected in Java by Dr. Horsfield, (whose Lepidoptera Javanica may be considered as a continuation of the same work), as well as the first part of the *Annulosa* of Dr. Smith's Travels.

Macquart (Mons. J.).—A French entomologist, who has confined his attention to the dipterous insects, and has published numerous Memoirs upon those found in the North of France, in the Transactions of the Natural History Society of Lille. Likewise two volumes, containing A General System of Dipterology, with plates, in the series of works termed Suites à Buffon.

Marsham (Thomas).—Author of Entomologia Britannica (London, 1802), of which only the first volume, containing the *Coleoptera* of Great Britain, was published. Being, in consequence of the difficulty of intercourse with the continent during the war, unacquainted with the labours of his contemporaries, many of the species which he described had previously received names, so that those which he proposed have been rejected.

Meigen (J. W.)—A German author, who has confined his attention to the dipterous insects of Europe, which he has carefully described in his Systematische Beschreibung der bekannten Europ. Zweiflug. Insekten. Aix-la-Chapelle, 1818, 6 vols. 8vo. During the autumn of 1836, he exhibited to me a complete series of drawings of all the species which he has described. It is greatly to be hoped that this valuable collection will be published.

Olivier (Guillaume Antoine).—Author of various Entomological Memoirs, and especially of the Entomological articles in the great French Encyclopédie Méthodique, in which great numbers of new species are described; and likewise of the Histoire Générale des Insectes, of which work, six 4to volumes, with many plates, containing the *Coleoptera* only, have appeared.

Panzer (G. W.)—A German entomologist, author of many works, but especially known by his Fauna Insectorum Germaniæ initia, a very extensive work, in which each species is figured. There were 110 numbers of this work published during the lifetime of the author, each containing 24 plates; and since his death, Ahrens and Herrick Schaffer have commenced supplements.

Paykull.—A Swedish author, published in 1800 a valuable work, in 3 vols. 8vo, upon the *Coleoptera* of Sweden, the descriptions of which are very exact. He also previously published detached Memoirs upon the *Carabidæ* and *Staphylinidæ, Curculionidæ* and *Histeridæ.*

Pictet.—A Swiss author, who has lately published a very complete work upon the Phryganeæ or caddice flies, (order *Trichoptera,* Kirby).

Ray (John).—The first true systematist, and author of The Wisdom of God in the Works of the Creation, and of a quarto volume, intitled Historia Insectorum, London, 1710, and a tract with the title Methodus Insectorum, seu Insecta in Methodum aliqualem digesta.

Reaumur (René Antoine Erchault de).—Born in 1683, at La Rochelle. He was a most astonishing genius, devoting his attention to various branches of philosophy: but the most elaborate of his works was that published under the title of Mémoires pour servir à l'Histoire des Insectes, in 6 vols. 4to, containing 3,672 pages, and 267 plates. This immortal work is so constantly cited in every work of Entomology in which the habits and manners of insects are introduced, that it would be useless to say anything in its praise. Its distinguished author died in 1757.

Redi (Francisco).—An Italian naturalist, who, by his work published at Florence, in 1668, intitled Experimenta circa generationem insectorum, completely overthrew the doctrine of spontaneous generation.

Rosel von Rosenhoff (August Johann.)—A German naturalist, author of various works upon Entomology, and particularly a beautiful work in 4 vols. 4to, with many plates, in which the habits and transformations of many interesting species of insects are recorded. It appeared in 1746, and was continued until 1761.

SAVIGNY (Julius Cæsar).—A French naturalist, distinguished by his elaborate researches into the comparative structure of the mouths of insects and other annulose animals, and author of Mémoires sur les Animaux sans Vertébres, and of the plates which illustrate the annulose portion of the magnificent French work upon Egypt, undertaken by order of Napoleon. The labours of this distinguished naturalist have cost him his eye-sight.

SAINT FARGEAU (M. le Comte Lepelletier de).—A French entomologist, who has particularly directed his attention to the Hymenoptera, and distinguished by his Monographia Tenthredinetarum, by numerous articles in the Encyclopédie méthodique, and by his work upon Hymenoptera in general, forming portion of the Suites à Buffon.

SCHONHERR (C. J.)—A Swedish entomologist, distinguished by an elaborate work in course of publication upon the Curculionidæ, in 8 vols. 8vo, and which, in fact, forms a continuation of his Synonymia Insectorum, a work in 4 volumes, 8vo, confined to the Synonymy of the Coleoptera.

STEPHENS (James Francis).—An English entomologist, author of a most laborious Systematic and Synonymical Catalogue of English Insects of all orders, and of Illustrations of British Entomology, consisting of descriptions thereof, the latter being still in progress of publication.

SWAMMERDAM (John).—One of the fathers of Entomology, chiefly distinguished by his Biblia Naturæ, a work in 2 volumes, folio, with 54 plates, in which the transformations and internal anatomy of many insects were completely exhibited.

This extraordinary work, in conjunction with that of Redi, completely established the real nature of insect metamorphoses. It has been translated into English by John Hill, whose edition appeared in 1758.

WIEDEMANN (G. R. W.)—Professor of Natural History at Kiel, and successor of Fabricius, whose attention has been chiefly confined to exotic Diptera. His chief work, Ausser Europaische Zweifl. Insekten, is in 2 vols. 8vo, and was published in 1828.

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THE END.

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