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Contributors

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THE EARTHWORM
AND
HOUSEFLY.

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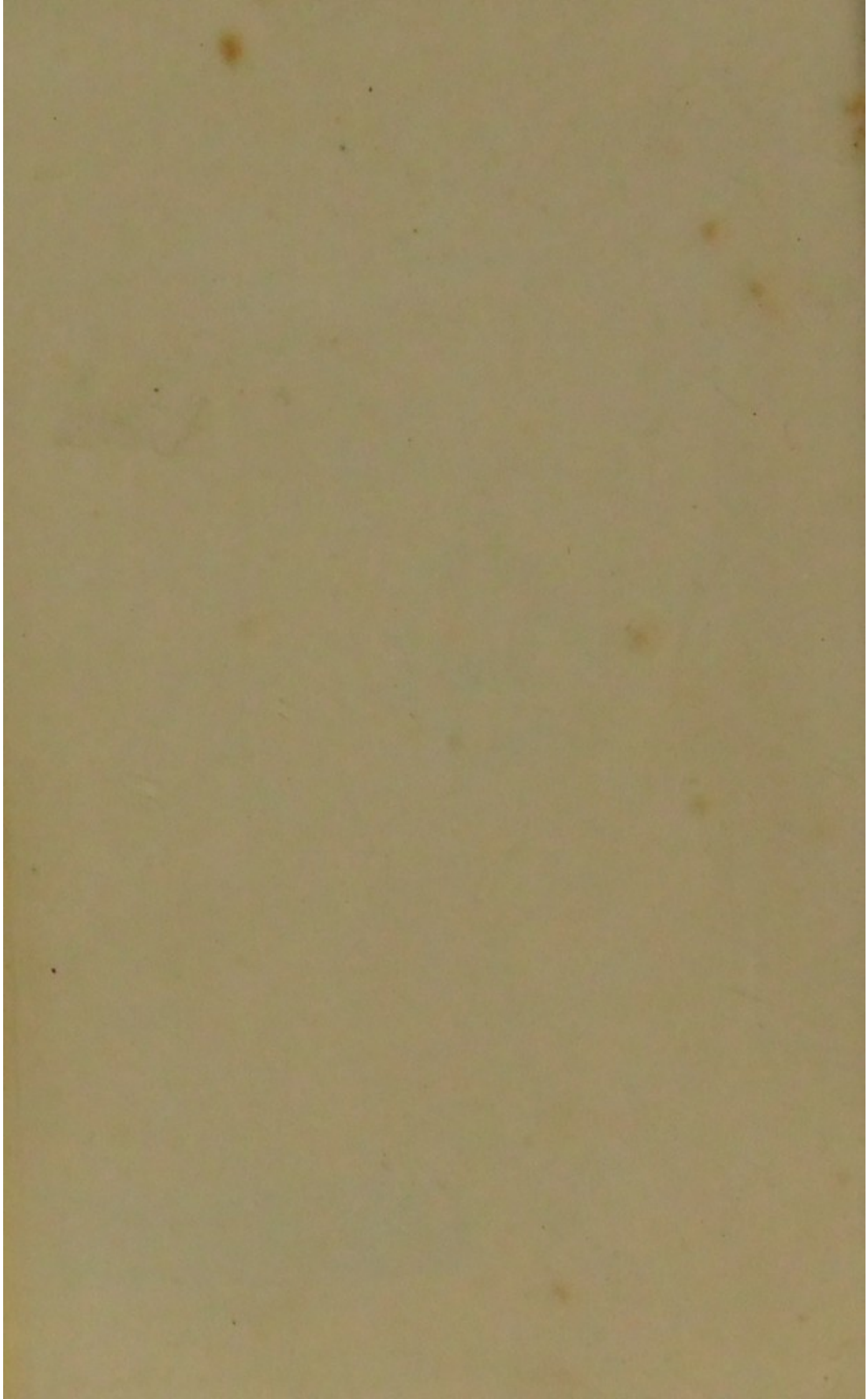


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Frontispiece

G.H. Ford

John Van Voorst, London.

HUMBLE CREATURES.

THE EARTHWORM

AND

THE COMMON HOUSEFLY.

IN EIGHT LETTERS.

BY

JAMES SAMUELSON,

ASSISTED BY

J. BRAXTON HICKS, M.D. LOND., F.L.S., &c.

WITH

MICROSCOPIC ILLUSTRATIONS

BY THE AUTHORS.

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"The bird that soars on highest wing
Builds on the ground her lowly nest;
And she that doth most sweetly sing,
Sings in the shade when all things rest:—
In lark and nightingale we see
What honour hath humility."

MONTGOMERY.

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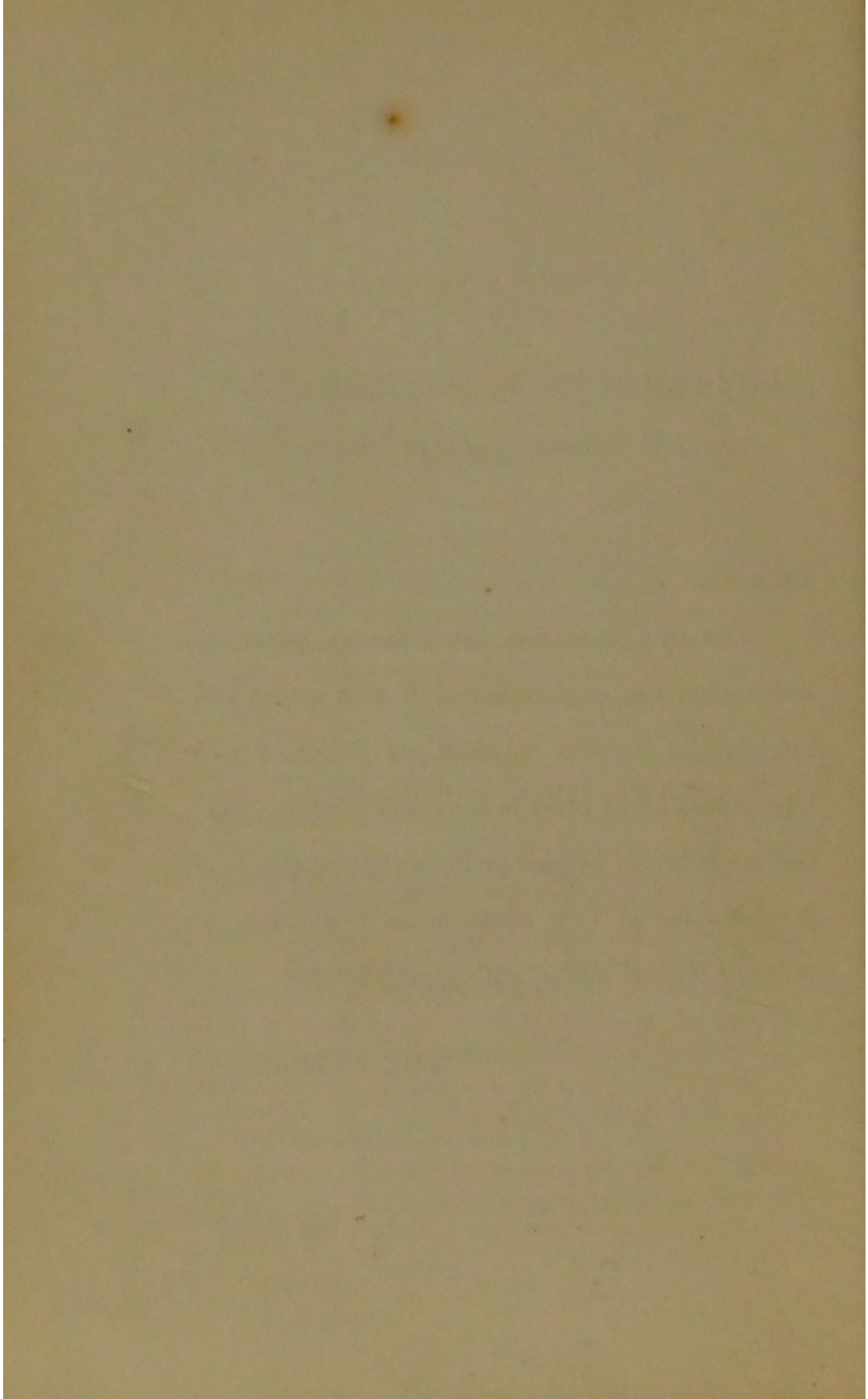
TO
WILLIAM SPENCE, Esq., F.R.S., F.L.S.,

Author of the "INTRODUCTION TO ENTOMOLOGY," &c.

DEAR SIR,

With your permission the following pages are dedicated to you, as a testimony of high esteem and respect; and in order to show you that your own labours have borne fruits in the minds of others, who, desiring to benefit by your praiseworthy example, have devoted a few of their leisure hours to the task of investing Natural History with popular interest.

THE AUTHORS.



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THE EARTHWORM

AND

THE COMMON HOUSEFLY.

LETTER I.

INTRODUCTORY.

DEAR READER,

FROM the title of this Treatise you will see that we invite you to consider with us the natural history of two creatures which are usually supposed to rank amongst the humblest in the Animal Kingdom, and which, although exceedingly familiar to us, are, comparatively speaking, less understood and appreciated than almost any other living forms. But why should this be the case? Suppose any one were to inquire of us whether we are aware upon what principle, and of what materials, a penknife, or any ordinary article in daily use is constructed, and to what purposes it is applied, we should hardly thank him for his estimate of our knowledge with regard to common things; but we should feel in no way affronted, if, instead, he asked us whether we possessed similar information

respecting the worm or the fly, as to how they are formed, for what useful ends they have been created, and what place they occupy in the realms of Nature ;—as though the works of man were entitled to a prior place in our thoughts to those of our Creator !

Not only, however, do these humble creatures merit our attention on the ground that they rank amongst the valuable works of Nature, but also as affording useful lessons in the education of our minds ; for unless we carefully examine and endeavour to comprehend the character and attributes of the lower animals, we remain children in the knowledge of Nature.

The rich coat of the leopard, the beautiful and variegated plumage of the bird of paradise, the sweet note of the nightingale, and the graceful form and movements of the gazelle, all delight the senses, but tend little towards the elevation of the intellect. These afford gratification alike to the savage, the child, and the educated man—perhaps in a less degree to the last than to either of the former ; but when we come to examine those creatures that offer no such attractions to the superficial observer, we find them to be so wisely constituted, and to possess such interesting appliances by which they perform their natural functions, that we begin to wonder how it is we should have remained so long in ignorance of their remarkable properties. We find ourselves in a new world, and the objects contained therein, at the same time that they impart sensations quite as plea-

surable as those which were wont to excite our childish imaginations when first we beheld the more beautiful of the higher animals, communicate new ideas; a fresh capacity to imitate and design; and, what is of far greater importance, they instil into our minds careful habits of observation, and enable us to form a more correct estimate of our own humble capacities, and of the boundless power and wisdom of our Creator.

But whilst we regard this study as an element in the education of our intellect, let us not omit to mention, that the pleasurable sensations to which we have alluded, as arising from the investigation of those objects of which it treats; objects that are within the reach of every one; also render it a delightful recreation,—aye, we can unhesitatingly say, the most effective mode of relaxation for those whose days are passed, and whose minds are occupied, in the oppressive cares of business.

The formal pages of this book, with its imperfect illustrations, will enable you to form but a faint idea of the attractions which are presented by such a pursuit; but you have only to inquire of some zealous entomologist, microscopist, or other natural student, to hear how many delightful hours he has spent in the green fields, or in country-lanes searching for objects, and how many agreeable evenings have been passed in their investigation. *He* will not fail to convince you that there is considerable enjoyment connected with the study.

Or, if you are not satisfied with the *ipse dixit* of

another, who may appear to you an imaginative enthusiast, let us ask you to try the experiment yourself, and form your own opinion on the subject.

The next time you go out on your morning or evening ramble, if you chance to see a worm in your path, do not kick it aside, nor step over it; but take it from the ground, and lay it on the palm of your hand; and as it tries to crawl away, you will experience a slight sensation of roughness on your skin. If you take a pocket-lens, and examine carefully the under side of the worm's body, you will perceive several rows of fine sharp hooks, extending from one end to the other, each annulated division (for the worm's body is, as you doubtless know, composed of rings) being furnished with four pairs of these hooks, which are situated upon small protuberances on the creature's skin. These minute hooks cause the rough sensation alluded to; and that portion of the body on which they are placed corresponds to the abdomen of the higher animals, the hooks themselves being nothing more nor less than rudimentary feet to aid the worm in its progress (Pl. II. fig. 2).

It has perhaps never occurred to you to inquire how it is, when you endeavour to draw a worm forth from the earth, that it can offer such resistance to your efforts, as almost to necessitate your tearing it in two before you can extract it, and why, as soon as you relax your hold, it disappears with such rapidity under the soil. These hooks are the cause; they are retractile at the will of the animal, and operate so as

not to impede its onward progress ; but when a portion of its body is once extended, and has penetrated into the soil, they keep it firmly fixed, whilst the remaining part is drawn after it by muscular contraction.

Now, is not this a simple but interesting feature in the anatomy of the worm, that should be known to every one?—yet how few, even of the best-educated, are aware of its existence ! How many anglers, do you think, are there, who handle their poor victim as frequently as we do our pen, and are yet unacquainted with this fact !

And as regards the Fly : you need not even quit your study or parlour to have an opportunity of witnessing a strange, and, to the masses, inexplicable phenomenon connected with the insect, namely the mode in which it walks upon the ceiling with its feet upwards, or progresses upon the smooth vertical pane of glass in your parlour window, setting at defiance a well-known law of gravitation. If you are not able to solve this mystery, ask some friend who possesses a microscope to show you the foot of a fly under the instrument, and you will find, that at its extremity it is furnished with a pair of membranous discs, on which there are disposed countless minute suckers, that operate upon the inverted ceiling, or smooth glazed surface over which the fly is marching, in the same manner as did the leather sucker with which, as a schoolboy, you were wont to amuse yourself in lifting heavy stones : this is the simple, but effective apparatus which enables the little creature to main-

tain its hold with security in any position (Pl. VII. figs. 1 & 1 a).

Nay, you may even, whilst lounging lazily upon your sofa, watch some little fly that has settled upon your coat, and is busily engaged in removing the dust from its wings: you will notice with what facility it crosses its hinder legs over the wings, or raises the latter gently from beneath; and after having effected this cleansing operation, then rubs one leg against the other, to remove any particles of dust from these members also. But are you aware that for this purpose its diminutive limbs are covered with numberless hairs, by means of which the insect is enabled as efficiently to remove the dust from its wings or body, as you are from your treasured volumes or pictures with your artificial brush of similar materials?

These are two of the numerous evidences revealed to us when we examine the Fly's structure, of the care with which the insect has been endowed with organs that conform perfectly to its mode of existence; showing, that however useless and unimportant it may appear to us, and although we may regard it as a plague in our dwellings, yet every provision has been made for its comfort and safety.

Let us adduce one still more remarkable and interesting example:—

Whilst we possess only two eyes, beautiful and perfect, no doubt, in their construction, the humble Fly is furnished with about 4000 simple, but perfect, organs of vision; and even this number falls far short

of that in other insects. Many have been the conjectures why the insect races are thus liberally, indeed to all appearance lavishly, supplied with visual organs. We shall detail their nature and probable operation further on; but may here observe, that, so far as we are able to judge, they are the best adapted to the habits of the insect; and that the end required, namely the conveyance to the brain of a distinct image of surrounding objects, could not have been so effectually attained by any other contrivance.

We trust that these brief allusions to a few of the most striking phenomena connected with the external structure of the worm and the fly, may have awakened in your mind some curiosity to know more of these household forms; or will at least have satisfied you that they are wonderfully constructed for wise and good purposes; and we hope that you may now be induced to pass on with us to a nearer consideration of their structure and habits.

We shall endeavour, as concisely as possible, and so far as it lies in our power, to make you acquainted with the present state of knowledge regarding their natural history; but, as a great deal that relates to their various organs has still to be elucidated, we shall append, in notes, the names of the various authors who have devoted their attention to the subject, and of such of their works as we have employed as reference, in order that you may, if so inclined, avail yourself of these pages merely as a guide to a more comprehensive view of the subject.

LETTER II.

THE CLASS VERMES AND ITS SUBDIVISION INTO ORDERS.—
LUMBRICUS TERRESTRIS, THE COMMON EARTHWORM.—ITS
FORM.—MEMBERS OF LOCOMOTION.—MOUTH.—ALIMENT.—
NATURE OF WORM-CASTINGS.—DIGESTIVE ORGANS.—CIRCULATING APPARATUS.—NERVOUS SYSTEM.

Few persons have a correct idea of the extent of that group of animals known as the “Vermes” or Worms.

Many, whose acquaintance with zoology is very limited, believe the use of the term to be restricted to the Earthworm, and intestinal worms, such as the Tapeworm, and the Ascarides, or small round worm of infants; others again, although aware that these creatures do not alone constitute the class, know little of the remaining forms which it contains. Let us therefore, whilst treating of this portion of the subject, endeavour to form some general idea of the whole class, and inquire what are its distinguishing characteristics.

The “Vermes,” which occupy a distinct position in the Animal Kingdom, have soft elongated bodies, possessing neither an *internal* skeleton, as we find in the vertebrated animals, nor (as a general rule)

Fig. 1.



Fig. 2.

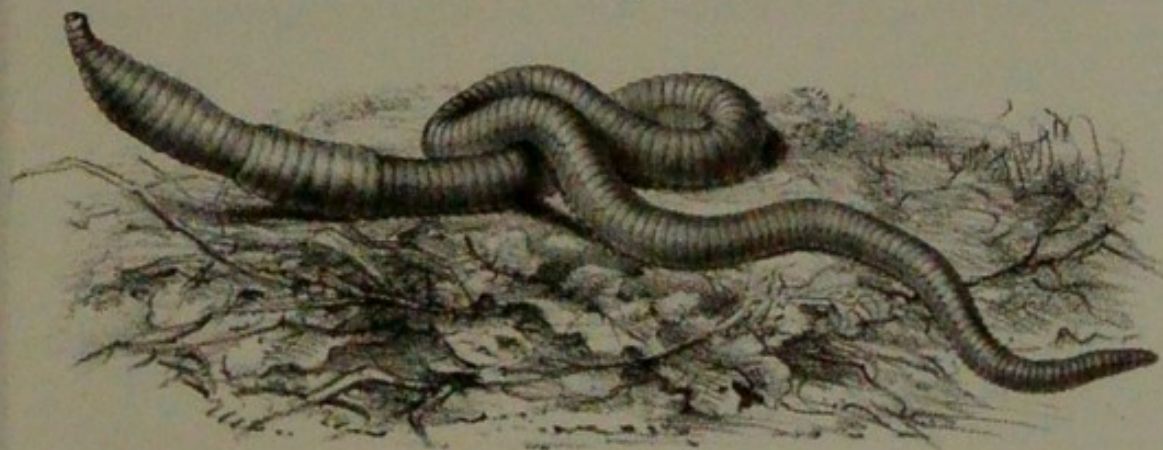


Fig. 3.

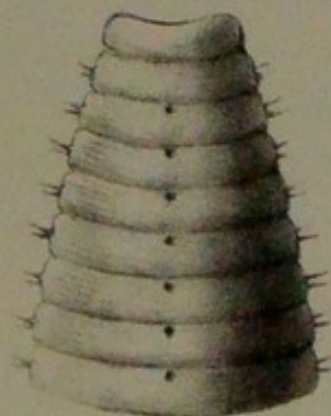
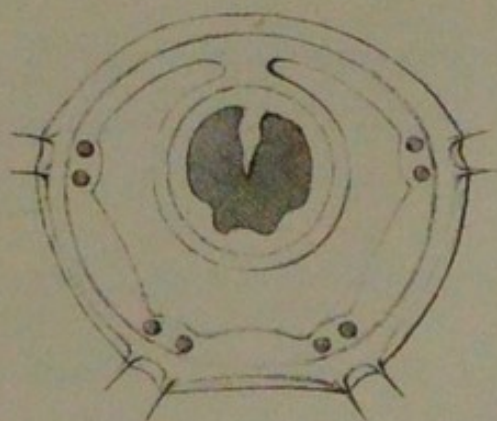
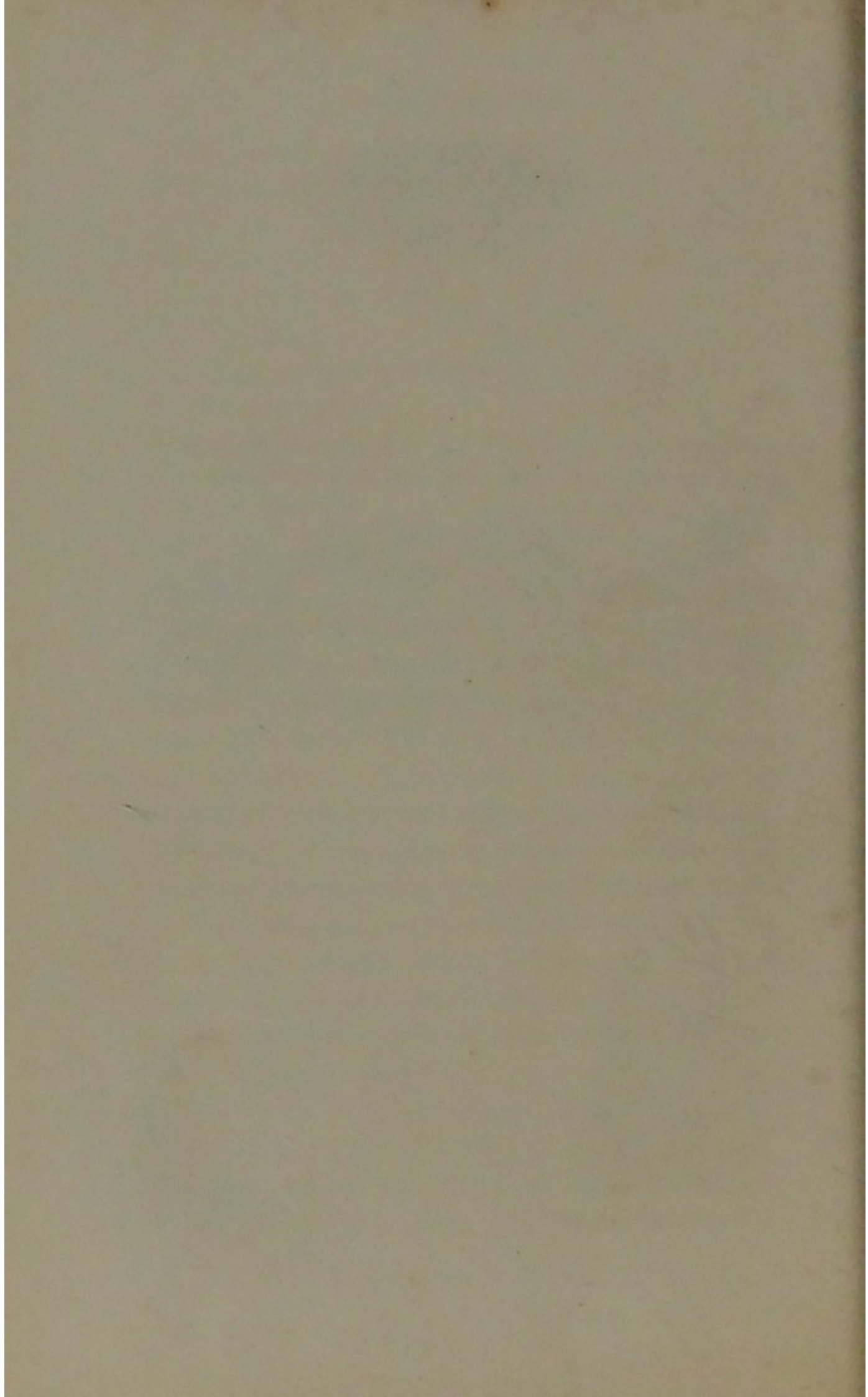


Fig. 4.





external hardened cases, as in the beetle and other insect tribes; nor yet a calcareous shell, as in the univalve or bivalve mollusks, such as the snail and oyster. With few exceptions, their bodies are unprotected by any kind of hardened envelope, and they possess no articulated members of locomotion. They are usually enclosed in a tough skin, and their bodies are composed of a series of segments, all of which, with the exception of the first, which represents the head, resemble each other in almost every respect.

Some of the most recent and accurate writers on zoology have divided the whole class into four orders, possessing distinct and well-marked peculiarities*.

1. The lowest of these is that of the *Nematoid* or round worms, whose bodies are not annulated, nor divided into distinct sections, but present an almost unbroken cylindrical form. These are for the most part intestinal worms; and the *Ascaris* and *Strongylus*, the former inhabiting the intestines of man, the latter an enormous, usually fatal worm found in the kidney of the pig, may serve as examples of the order.

2. The next division, that of the *Platyelmia*, or flat worms, is more numerous than the last. In some cases, as in the *Cestoid* worms (*e. g.* the *Tænia*, or

* Vogt, Zoologische Briefe. Frankfort, 1851.—Carpenter, The Microscope. London, 1856.—See also Burmeister's Zoological Atlas. Berlin, 1843.—Achille Richard's *Eléments d'Histoire naturelle*. Paris, 1849.

common Tapeworm), the body is divided into a great number of segments, all similarly formed and organized ; in others, as in the *Planarian* worms, inhabiting the water, it consists of one flattened, undivided disc. These are two of the great variety of groups and families which comprise the order.

3. The third order is wholly microscopic. They are termed the *Rotifera*, or wheel-bearing worms, are found in incalculable numbers in fresh and salt water, and present almost every conceivable form. They are distinguished, as their name denotes, by the so-called "wheels," wreaths of minute hair-like processes termed "cilia," situated on the head. These cilia are kept in a state of constant vibration, and perform the functions of locomotion as well as of nutrition. Many of the *Rotifera*, minute though they be, have their bodies protected by beautiful transparent cases.

4. The last and highest group is that of the *Annelida*, or annulose worms, in which is included the subject of our remarks, the Earthworm. Also the various groups of worms represented by the *Leech* ; the *Serpula* and *Terebella*, which are found on the sea-shore, and construct for themselves tubular dwellings ; the *Nais* or Mud-worm ; and the "*Errantia*" or "*Natantia*" (*errant*, or *swimming worms*), which represent the intermediate type between the Worms and the higher articulate groups, and strongly resemble the well-known *Centipedes* in appearance ; the chief distinction being, that whilst the latter are formed for a terres-

trial existence, the locomotive members and other portions of the swimming-worms are constructed in conformity with their marine life*.

The *Annelida*, or annulose worms, then, the highest and most perfect of the four orders, contain amongst their number the Earthworm (*Lumbricus terrestris*), which, in common with its congeners, possesses, as you well know, a soft elongated body. This, in the full-grown animal, is usually divided into from 120 to 150 rings or segments, which decrease in circumference as they approach either end, causing the body to terminate in what may be called two pointed extremities, the head and the tail. To the hooks, situated upon each ring of the body, we have already alluded in our Introduction, and these are the only appendages that the worm possesses (see section of Worm's body, Pl. II. fig. 4). But you will perhaps be somewhat surprised to hear us speak of the "head" of a worm, for you are accustomed to connect with that idea a mouth, eyes, nose, and ears, none of which are perceptible in the worm; and the first, that is the mouth only, being actually present. Although, however, the senses of vision, smell, and hearing are, so far as we have been able to ascertain, denied to this humble Annelide, yet we cannot but grant to its anterior final ring the title of a head; for if you examine it with a pocket-lens, whilst the creature raises that part of its body, you will perceive upon it a

* See note, page 27, Letter IV.

well-formed protruding upper lip, to which a smaller or lower lip is placed in juxtaposition.

These two lips form an imperfect ring, and constitute the oral aperture or mouth, which is however not provided with teeth, nor organs of any other description. This being the case, and as the worm possesses no prehensile members with which to lay hold of its food, you will naturally be curious to know upon what it subsists, and how it obtains its nourishment.

You have doubtless heard of the chameleon, which, wonder-loving sages tell us, feeds upon the air*. At least you will say, this diet cannot be very indigestible; but we fear you will smile incredulously when informed that the Earthworm not only inhabits the earth, but also feeds upon the element in which it exists; and although some naturalists have declared that it derives its nutriment from the roots of plants, yet this statement, according to the most reliable authorities, is now pronounced to be a pure fable. The soil is, as you will probably be aware, impregnated with decaying organic substances of various kinds, and in order to secure these for its sustenance, the worm gorges itself with earth; the nutritive constituents are extracted in its stomach by the digestive process, and the indigestible portion ejected in little

* The chameleon subsists upon small insects, which it is enabled to seize by darting forth its wonderfully constructed tongue with great rapidity. See Carpenter's 'Zoology.' London, 1857.

worm-shaped masses, well known to gardeners and others as "worm-castings." Of these more hereafter.

The *digestive apparatus* is of the simplest kind, consisting of a straight alimentary canal which runs from one end of the body to the other, commencing at the mouth and terminating in the final posterior ring. This tubular stomach is slightly constricted at each ring, and is covered externally along its whole length with a granular envelope, composed of numerous glands, which secrete a fluid that aids in the digestion of the alimentary substances and their elaboration into the blood (Pl. II. fig. 4, section of Worm's body, showing the form of alimentary canal).

If you examine the living worm, you will notice a fine crimson streak shining through its semitransparent covering; this is the main trunk or artery which extends along the whole body, in the same manner as the alimentary canal, and serves as the receptacle of the blood. To observe the circulation of the latter, you need but remove a worm from the ground, and keep it a little while, until it has voided the earth which it contained, and thus rendered its body more transparent; you will then be able to distinguish the crimson current as it courses along the creature's *back*, flowing from the tail to the head confined within the central artery; and on turning it upon its back you will perceive the return current flowing in the opposite direction, through another blood-vessel, situated near the abdominal surface. The dorsal vessel must be regarded as the heart, and partakes to some

extent of the nature of that organ in the higher animals, inasmuch as its wall, or limitary membrane, is elastic, and by its contractions propels the blood onwards. Whilst thus passing along the main artery it is brought into communication with the atmospheric air, to be renewed by the absorption of oxygen, in a manner which we shall presently describe; and then returns, as already explained, along the second (abdominal) canal, which is united to the former by a number of smaller veins into which the blood also penetrates, so that it may yield its regenerating constituents to every portion of the body.

The aëration of the blood takes place as follows:—On closely examining the dorsal surface of the worm with a pocket-lens, a minute circular aperture is distinguishable between each ring and the adjoining one (Pl. II. fig. 3). By these the air is admitted into the body, and being conducted by special canals to the dorsal circulating organ, there gives off its oxygen to the contained fluid.

So far, then, we find that the *nutritive* organs of the worm resemble in principle those of the higher animals; for although it possesses no central organs, such as the stomach and heart, yet, in the alimentary system, the intestine or canal, with its glands, perform the functions of the former, whilst the place of the heart is supplied in the circulating system by the contractile dorsal vessel. As, however, these organs are more highly developed in the Fly, the physiology of which we shall consider in a subsequent letter, we

have made but brief allusion to them here, and will now conclude this letter with a few words in regard to the nervous system of the Earthworm.

This is framed in conformity with the general shape of its body, and is as simple as the organs already described. It consists, first, of a minute roundish mass of nervous substance, termed the "cephalic ganglion," which corresponds to our brain, and is composed of two smaller masses, of equal size, fused together. The "cephalic ganglion" is situated in the head, just above the throat (if the commencement of the long alimentary canal may be so termed), and from each of its hemispheres there proceeds a nervous chord, one of which passes downwards and backwards on either side of the throat, and the two again amalgamate under the alimentary canal. Hence they are continued, as a single nervous stem, along the whole ventral portion of the body, close to the external surface, giving out in each ring a number of branches of remarkable delicacy, which encircle the body, passing round to the creature's back, and imparting sensibility to every portion of its frame. (See ! what excruciating pain the angler inflicts upon the poor worm when he impales it upon his barbed hook, which he passes from one end of its body to the other !)

Even in this apparently uninteresting part of the animal's structure a noteworthy trait presents itself, namely, that whilst in our bodies, and those of the vertebrate animals generally, the spinal chord passes along the *back*; in the worm, and, let us add, in all

the articulate races—worms, millipedes, crustaceans, arachnidæ, and insects,—the central nervous stem traverses the opposite, that is, the *ventral* side, almost immediately in contact with the outer surface.

There now remain to be considered, in connexion with the natural history of the Earthworm, its organs and mode of reproduction, and also its habits of life, and obvious uses.

LETTER III.

MODE OF REPRODUCTION IN THE EARTHWORM.—ITS HABITS.
—DWELLING.—USES IN THE FORMATION OF THE SURFACE-
SOIL.—CONCLUSION.

IN our last letter we reviewed cursorily the chief portions of the Worm's anatomy, and must now devote a short space to the consideration of its organs and mode of reproduction.

The worm, in common with many others of the humbler animals, is remarkably endowed in this respect, each creature possessing within itself both the male and female organs of reproduction. These strongly resemble each other in appearance, for both consist of a series of what physiologists term "tubuli," or little tubes, one set of which serves for maturing the female ova, and the other for the development of the male spermatozoa, little motile fructifying bodies visible only under the microscope.

At certain seasons of the year, when the ova are ripe, and ready for fecundation, a number of the rings, usually from four to eight (Pl. II. fig. 2), situated at about the anterior third of the body, become enlarged, and this swelling, which you will

doubtless often have noticed, strongly resembles a healing wound, for which it is usually mistaken by the uninitiated. From this portion of the body a glutinous substance, secreted by special glands, exudes; and although, as just observed, the worm is hermaphrodite, yet contact with another of its species being necessary for fecundation, the creature leaves its underground haunts at night, and, coming to the surface, adheres by its swelled and glutinous rings to the same rings upon the body of another worm. Through this act, the ova and spermatozoa are liberated in each worm from the respective tubuli in which they were contained, and pass into the general cavity of the body; they there encounter each other, and fructification of the ova is the result. A great deal, however, remains unexplained concerning the reproductive process in the Earthworm, as well as in regard to the development of its young.

Respecting the latter, we know that the young worm is usually developed whilst still in the ovum within the parent's body; and, what is somewhat strange, it is sometimes born naked, whilst at others it is enveloped in a hard covering, which subsequently bursts, and allows the young worm to escape (Pl. II. fig. 1). This difference in the stages of development when the worm leaves its parent, "depends," we are told, "on the nature of the soil which the worms are inhabiting: in a light and loose soil, the young quit the parent prepared to act for themselves; but in a tough clayey soil, they continue in the pupal form for

some time, so as to arrive at a still higher degree of development before commencing to maintain an independent existence*.”

Although, however, the young worm is born in the fully-developed shape of its parent, yet, as it increases in size, the number of its rings is augmented by the *subdivision* of those which it possessed at its birth,—a circumstance that denotes its humble position in the animal scale ; for the lower we descend, the more frequently we find living forms endowed with the power to reproduce, by a vegetative process, similarly organized portions of their frame after they have left the body of the parent. Notwithstanding, however, that the worm occupies so humble a position, you will have seen, from the preceding outline of its anatomy, that no essential parts of its structure are wanting, and that, like all other created beings, it is perfect, so far as regards adaptation to its mode of existence. It is not indeed furnished (according to our present knowledge) with any of those more delicate organs of sense that characterize the higher animals ; but then, of what service would eyes and ears be to a creature which we know spends the greater portion of its existence underground ? Its dwelling consists of one or more burrows, of the same shape as its body, which it constructs beneath the surface, and lines with a kind of slime, so as to render the walls consistent, and thus prevent the soil from falling in and closing up the cavity. These burrows it quits when

* Carpenter's ‘Comparative Physiology,’ p. 593.

compelled to do so by the spade of the labourer—(and the worm is said to be very sensitive to any disturbance of the soil in its vicinity),—when it wishes to visit the surface in search of a mate, or in order to discharge from its body the earth from which it has extracted the decaying organized matter by the digestive process. In this last operation it performs an act of great utility to the agriculturist, inasmuch as it enriches the surface-soil by the deposition of those little heaps of earth which we alluded to in a former letter under the designation of “worm-castings.” We shall narrate briefly how this interesting circumstance was first discovered, showing at the same time how important a part the worm plays in the construction and fertilization of the soil.

About twenty years since, an eminent naturalist*, whilst visiting a friend in the country, was surprised to hear from his host, that on some *pasture*-land which he possessed, an unaccountable change had taken place in the character of the soil, which in various fields had, without apparent cause, materially increased in depth during the previous years, and that cinders and other substances, which had originally been thrown upon the surface, had apparently sunk to a considerable depth in the soil. Curiosity induced him to try a few experiments in order to ascertain the cause of this strange phenomenon, and with this view he dug several holes in different fields ;

* Mr. Darwin. See ‘Transactions of the Geological Society,’ 2 ser. vol. v. p. 505 ; his paper “On the Formation of Mould.”

in these he found similar indications of a gradually increasing thickness in the surface-soil, and beneath, an accumulation of pebbles, cinders and lime, which had originally been deposited on the surface. In one field, for instance, the cinders which had been thrown on the surface three years previously, were buried to the depth of an inch; in another they were buried three inches deep, and formed a layer an inch in thickness. But let us give the narrative in his own words :—

“The appearance in all the above cases was as if (in the language of farmers who are acquainted with these facts) the fragments had ‘worked themselves down.’ It is, however, scarcely possible that cinders or pebbles, and still less powdered quicklime, could sink through compact earth and a layer of matted roots of vegetables, to a depth of some inches. The explanation of these facts which occurred to Mr. Wedgewood” (his host), “though it may appear trivial at first, I have no doubt is the correct one, namely that the whole operation is due to the digestive process in the common Earthworm. On carefully examining between the blades of grass in the fields above described, I found scarcely a space of two inches square without a little heap of cylindrical castings of worms. It is well known that worms in their excavations swallow earthy matter, and that, having separated the portion which serves for their nutriment, they eject at the mouth of their burrows the remainder in little intestine-shaped heaps. These partly retain

their form until the rain and thaws of winter spread the matter uniformly over the surface. The worm is unable to swallow coarse particles, and as it would naturally avoid pure or caustic lime, the finer earth lying beneath the cinders, burnt marl or lime, would be removed by a slow process to the surface. This supposition is not imaginary, for in the field in which the cinders had been spread out only half a year before, I actually saw the castings of the worms heaped on the smaller fragments. Nor, I repeat, is the agency so trivial as at first it might be thought, the great number of earthworms, as every one must be aware who has ever dug in a grass-field, making up for the insignificant quantity of the work which each performs.

“On the idea of the superficial mould having been thus prepared, the advantage of old pasture-land, which, it is well known, farmers in England are particularly averse to break up, is explained, for the length of time required to form a thick stratum must be considerable. In the peaty field, in the course of fifteen years, about $3\frac{1}{2}$ inches had been well prepared; but it is probable that the process is continued, though at a very slow rate, to a much greater depth. Every time a worm is driven, by dry weather or any other cause, to descend deep, it must bring to the surface, when it empties the contents of its body, a few particles of fresh earth. Thus the manures added by man, as well as the constituent parts of the soil, become thoroughly mingled, and a nearly homo-

geneous character is given to the soil. Although the conclusion may appear at first startling, it will be difficult to deny the probability, that every particle of earth, forming the bed from which the turf in old pasture-land springs, has passed through the intestines of worms, and hence the term 'animal mould' would in some respects be more appropriate than that of 'vegetable mould.'” He concludes by remarking, “that the agriculturist, in ploughing the ground, follows a method strictly natural; he only imitates in a rude manner, without being able either to bury the pebbles, or to sift the fine from the coarse earth, the work which Nature is daily performing by the agency of the Earthworm.”

With regard to the latter portion of these remarks, exemplifying, as they do, in a forcible manner the principle to which we have more than once alluded in the course of this short history, namely that Nature has not bestowed all these pains on the formation of the worm without some useful end, we would now also add a few words in concluding this section of our treatise.

Those who know what astonishing results are produced by the labours of the minute and (compared with the worm) still more humble Madrepora polyp, commonly known as the Coral insect; how in the course of ages it builds up continents in the midst of the ocean; will not for an instant be inclined to doubt that the worm aids in the deposition of the surface-soil, simply on the score of its apparent insignifi-

cance ; and although the traces of the Annelide in the geological formations of past ages are but slight, yet it is believed by reflecting observers that the little creature has (as in the case of the polyp just referred to) pursued its labours from a very early period in the earth's history.

But be that as it may ; suppose its operations have only been confined to the deposition of a portion of the existing mould, a circumstance which we believe to be placed beyond a doubt ; still our assertion holds good, that its history affords a striking exemplification of the divine truth, that no creature has been formed without its special ends, and that the humblest are frequently selected to carry out the most gigantic natural operations. And again, what can be more obvious, than that the Earthworm, by aiding in the accumulation and fertilization of the surface-soil on pasture-lands, is the indirect means of supplying us with many of our most valuable comforts and luxuries ; that the verdant meadows which clothe the surface of the earth in a robe of evergreen, and afford nourishment to the herds of cattle that have been bestowed upon man as his birthright, are rendered still more verdant and fruitful by its untiring labours ? There it toils away, unconscious of its great mission, again and again penetrating the earth, and each time, when it returns to the surface, bringing up with it a small portion from below to aid in the restoration of the exhausted soil, and multiply the comforts of the human race.

At length, if it be not hunted by some angler, and prematurely tortured to death, to assist him in his sport as a requital for the services it has rendered to his race, it concludes the chapter of its usefulness by serving as wholesome nourishment for one of the winged inhabitants of the air.

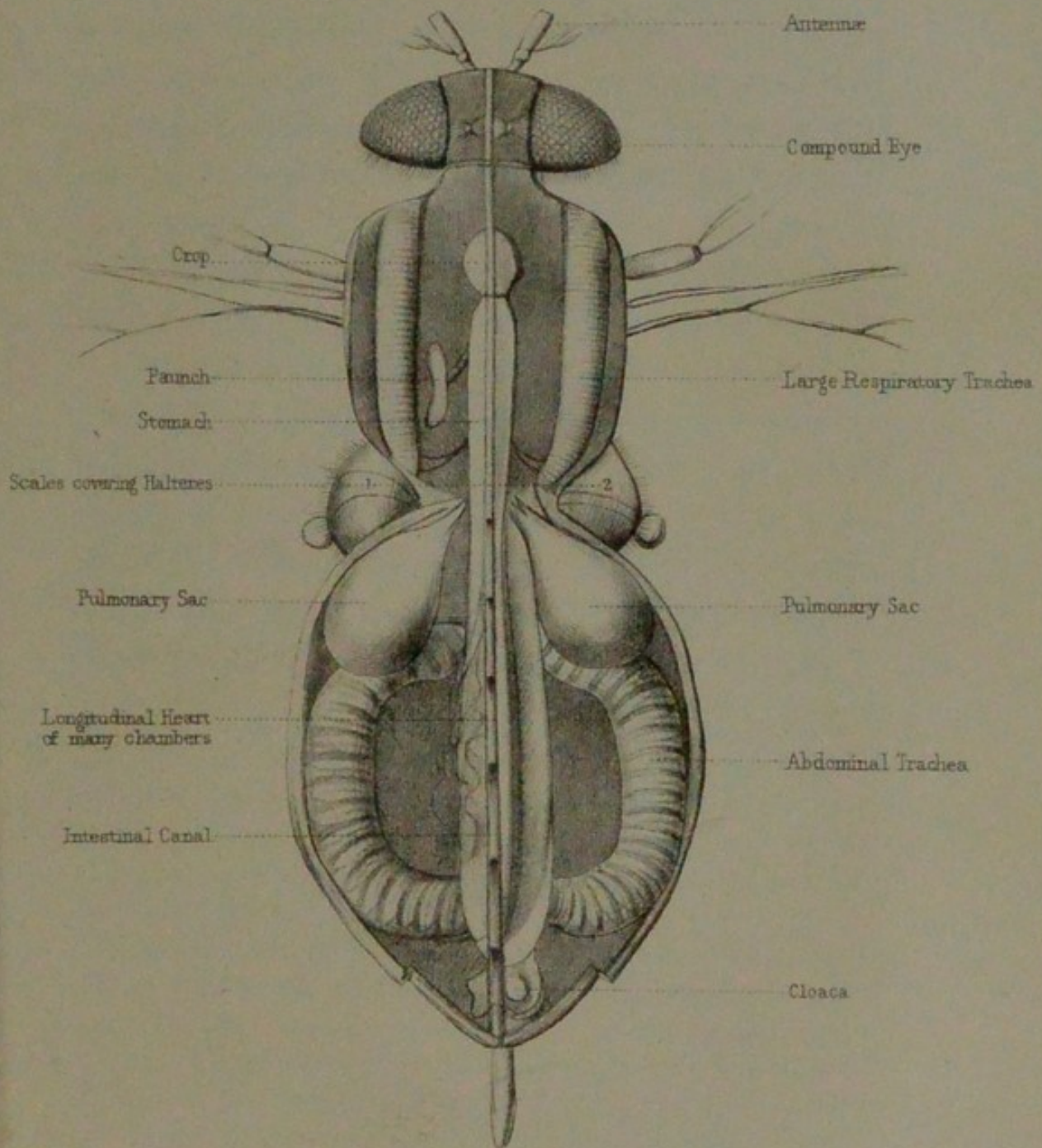
Reader ! this is the story of the Worm's life.

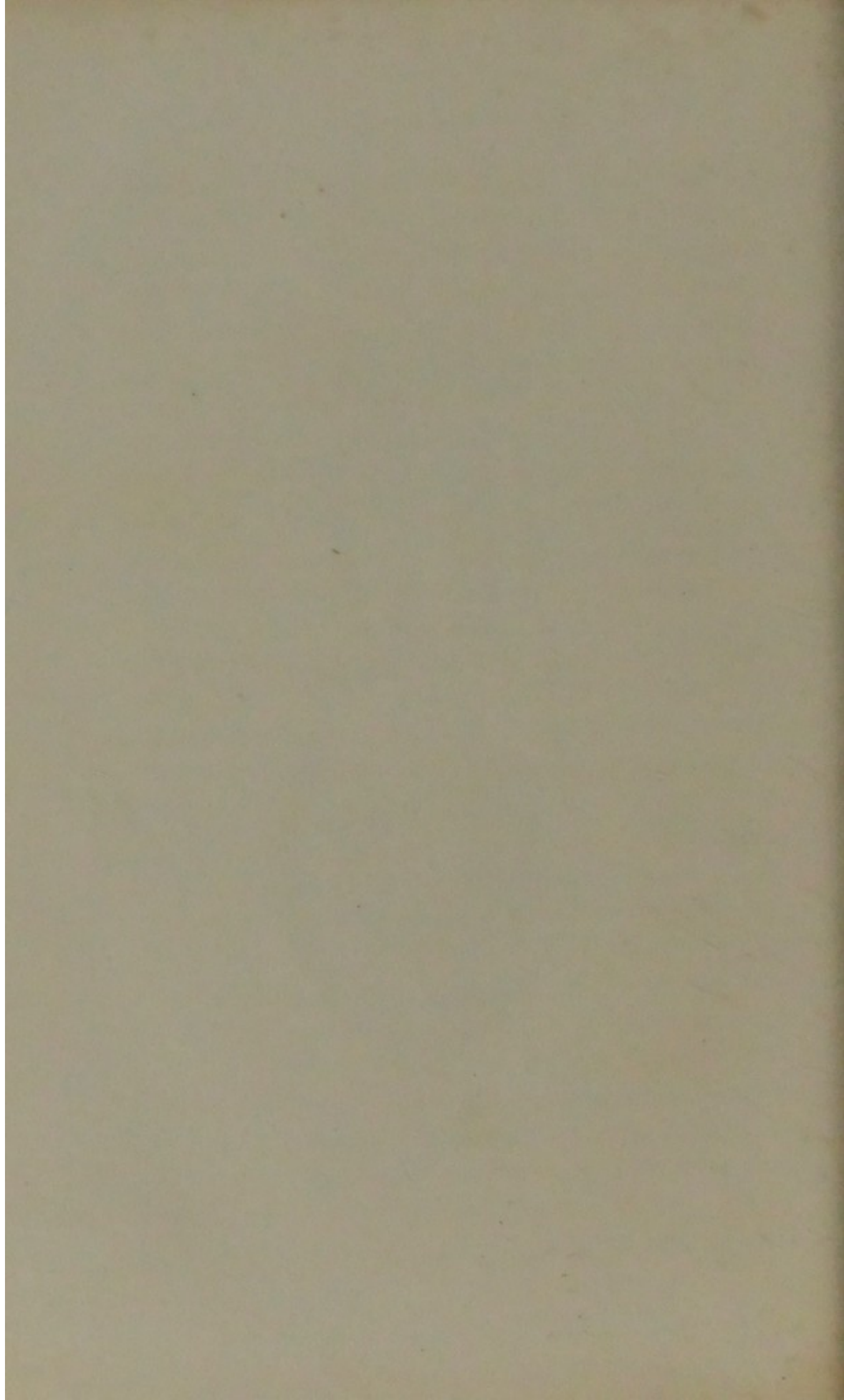
LETTER IV.

CUVIER'S CLASSIFICATION OF ANNELIDES AND INSECTS.—
GUIDES TO A SYSTEMATIC ARRANGEMENT OF ANIMALS.—
AFFINITIES BETWEEN THE WORM AND FLY.—CLASSIFICATION
OF INSECTA, AND THE POSITION OF THE HOUSE-FLY (*MUSCA
DOMESTICA*) IN THE CLASS.—GENERAL CONSIDERATION OF
THE FLY'S FORM AND STRUCTURE.

ON referring to Cuvier's classification of animals, you will find that, according to the views of that great zoologist, the Annelides should be included amongst the Articulata (articulate races), and that he regards them as the lowest, and the Insecta, or Insects, as the highest class in that section of the Animal Kingdom. Now, although in treating of the Earthworm, which you of course know to be one of the Annelida, we place that group at the head of the Class Vermes, in conformity with the arrangement of the most recent and accurate zoologists, yet it is necessary to add, that the line of demarcation between the Annulose worms and some of the family of Articulata is so faint and ill-defined, that many naturalists still continue to follow the classification of Cuvier, and consider the former as the lowest of the Articulate types.

It would be advisable, for the better comprehension





of our subject, that we should inquire what principle has of late guided zoologists in their systematic arrangement of these forms; and it will then also become obvious what reason has induced us to couple together in this little treatise two such apparently opposite creatures as the Worm and the House-Fly, employing the first as an introduction to the more complicated structure of the second*.

Those who have acquired at all a scientific knowledge of zoology are well aware that each great division of the Animal Kingdom exhibits a progressive development in the organization of the various groups that it contains; and also, that in following the life-history of a single individual in that section, a remarkable analogy is apparent between the various stages of development through which it passes, and those to which we have just referred as existing in

* In glancing over a Synopsis of the Hunterian Lectures on the anatomy and classification of the Invertebrate animals, delivered last year by Professor George Busk, F.R.S., at the Royal College of Surgeons, we find the relation between the Worm and the Fly denoted in a striking manner by the classification which that physiologist has adopted.

Under the title of "Annulosa," or annulated animals, he includes every creature possessing a body composed of rings or segments, and amongst the subdivisions of that great class we find that he unites the *Annelides* (of which the Earthworm is the typical representative) to the Insecta, whereof the Fly is one of the characteristic forms, by the Myriapoda (Centipedes), which partake of the nature of both groups.

We have seen no classification that confirms so clearly as this, the idea which induced us to couple the Worm and the Fly in one treatise.—(See page 10, Letter II. "*Natantia*.")

the whole class. So striking is this comparative progress in the organization of classes and individuals, that the *lowest* creatures in any particular section strongly resemble, when in their perfect form, the early or embryonic stage of the *higher* animals in the same section, the latter undergoing various changes of form and structure before they assume their characteristic type.

Let us take, for example, the two groups of which we are here treating, namely the Annelides and Insects; the first as having been placed by Cuvier and others at the base, the second as the head of the Articulate division of the Animal Kingdom; and let us also select at the same time, the Worm as the typical representative of the former, and the Fly as that of the latter group.

The Annelides have a long, soft, cylindrical body, divided into rings, and furnished with no external members except the rows of hooks that serve to aid them in locomotion; but as we rise in the scale of Articulate animals, their bodies become shorter, and are divided into distinct segments irrespective of the rings, which decrease in number. The members of locomotion are more prominent: first, legs appear, which enable the creatures to crawl or leap; and then we arrive at the perfect insect, whose wings, super-added to the legs of the lower races, impart to it also the power of flight.

And now as regards the individual. The larva of the Fly, or the form in which it leaves the egg, closely

resembles a worm, not only in its external shape, but also in its internal physiology; it possesses locomotive hooks similar to those of the Worm, but not so numerous, and more perfectly developed, and its elongated cylindrical body is divided into rings only. (The points of *difference* between the two creatures will be noticed hereafter.) When it has passed a certain length of time in this stage, it assumes the *pupa* form, being enclosed in a hard fusiform case, perfectly motionless, and to all appearance inanimate. Whilst in this state, the remarkable change from one of the lowest to one of the highest examples of the Articulate type is going on; *first the legs and then the wings* becoming developed; and when the metamorphosis is complete, the insect bursts its prison-house and issues forth in its perfect or '*imago*' form, furnished with legs and wings, and all those wonderful appliances, which we shall presently describe in detail.

The foregoing comparison will show you, that not only the outward forms of animals, but also their life-history, and the metamorphoses to which they are subject, are all duly considered by scientific zoologists, in their systematic classification. But the knowledge of this fact is all that need be deemed essential for our purpose; for we are not dealing with groups, nor even genera, but only with *species*; and it matters very little to us whether zoologists have placed the Earthworm at the head of one group, of which it is a perfect representative, or at the base of

another, to which it is allied by less powerful links. In treating of it *per se*, we placed it in the former position, denoted by its most important properties. And here we draw your attention to its affinities to that higher type which we are now about to consider.

The Class Insecta, to which the House-fly belongs, is one of the most extensive in the Animal Kingdom, and is divided into several Orders, distinguished from each other by well-defined characteristics. The chief typical feature of the whole class is the *invariable* possession of six legs by the fully developed insect (*imago*), although in the larval stage the number of these members is arbitrary, varying in the different groups; and even in some cases they are entirely absent. Another, although not so constant an attribute as the former, is the presence of wings,—members that are found in no other group of the invertebrate animals; and lastly, we may name, as a special but not invariable distinction, the division of the body into three sections (hence the term ‘insect’),—head, thorax or chest, and abdomen.

Vogt, whose classification we adopted in our brief notice of the Class Vermes, divides the Insecta into three great subclasses, characterized by the various degrees of metamorphosis that they undergo before arriving at the perfect state. The forms contained in the lowest of these subclasses (*Ametabola*) are subject to no important change in their outward appearance, excepting so far as their growth is concerned, from the time of quitting the egg to the attainment of

maturity. Of this group, which is but limited, the Louse (*Pediculus*) is a well-known, but not very agreeable example, and, in common with the other genera that constitute this subclass, the Louse is *apterous*, or wingless.

The second group (*Hemi-metabola*) undergoes one metamorphosis, namely from the larval to the imago, or perfect form; their appearance, however, in the first of these stages varies but little from that of the full-grown insect, the principal distinction being, that the wings are wanting in the larva, and only make their appearance at a later period of the insect's existence. This group is far more numerous than the last; and as familiar examples, we may quote the Earwig (*Forficula*), the Locust (*Acridium*), the Dragon-fly (*Libellula*), and that terror of all good housewives, the Bug (*Cimex*).

Lastly, we have an extensive race of insects that undergo a complete transformation (*Holometabola*), or, more correctly speaking, two changes; the first from *larva* to *pupa*, the second from *pupa* to *imago*. These three stages of growth are so familiar to all who have any knowledge of natural history, that we need but allude to the metamorphosis of the Butterfly, first from the caterpillar to the chrysalis, and from the latter to the winged insect, by way of passing illustration. The Bee (*Apis*), the Wasp (*Vespa*), the Butterfly (*Papilio*), the Beetle tribes (Coleoptera), and, amongst many other similar forms, the common House-fly (*Musca domestica*), are all members of this extensive group.

Our little Fly, then, belongs to the highest of the three subclasses of insects, inasmuch as it undergoes a perfect transformation ; and, not to weary you with any lengthened reference to orders and genera, we will simply add, that on account of its possessing *two* wings it is included in the Order *Diptera*, in contradistinction to those tribes which are wingless (*Aptera*), and other Orders characterized by the varied nature of their organs of flight.

Having thus cursorily surveyed this province of the Animal Kingdom in order to ascertain what rank and position are held by the Fly, let us now direct your attention to the details of its structure ; and in introducing this portion of the subject we will first observe, that, simple and unassuming as its form may appear to the superficial observer, it has been deemed worthy of a large share of the zoologist's notice ; for its external members, as well as its internal organization, have been almost as carefully scrutinized and accurately described as those of man.

If you examine the body of a Fly, you will find it to be composed of the three sections already referred to : the head ; the thorax or chest, joined to the head by a thin neck ; and the abdomen. See Frontispiece and Plate III.

Let us examine each division *seriatim*.

1. The *head* bears externally the organs of sense and nutrition, that is to say, the antennæ or feelers, the wonderful eyes (compound and simple), and the proboscis ; within, it encloses the cerebral ganglion

or brain, and the nerves of sense proceeding therefrom to the organs just named.

2. The *thorax*, or chest, is again subdivided into three parts;—imperfect rings, the anterior of which is termed the *prothorax*, the middle the *mesothorax*, and the posterior the *metathorax*. On these three rings the members of locomotion are distributed as follows: viz. on the *prothorax* is found the first pair of legs only; on the middle or *mesothorax*, which in the Fly is largely developed, the second pair of legs and the pair of wings (for, as before remarked, the Fly possesses but *one* pair); and on the *metathorax* the last pair of legs, and two organs, termed the *halteres* or *poisers*;—the last-named will be fully described hereafter. Within the *thorax* is situated the continuation of the nervous system (which here consists of the nervous chord, the thoracic ganglion and nerves branching from it to the members; see Pl. I. fig. 1); also the stomach and part of the circulating and respiratory apparatus.

3. The abdomen, which bears no external members, is also composed of several rings, and contains the intestinal canal, with its appendages; two pulmonary sacs, with other portions of the respiratory apparatus; the many-chambered heart, and the reproductive organs.

Having thus glanced in a cursory manner at the form and structure of the Fly, we shall in our next enter into a more particular account of its various organs.

LETTER V.

THE ANTENNÆ OR FEELERS OF THE FLY; THEIR STRUCTURE,
AND VARIOUS THEORIES REGARDING THEIR FUNCTIONS.—
THE EYES, COMPOUND AND SIMPLE; THEIR STRUCTURE AND
USES.

THERE is perhaps not a more interesting object in the animal creation than the head of a common House-fly. If you take a lens, and examine it carefully, you will find in front of the forehead a pair of short antennæ or feelers (Pl. IV. fig. 1, *a a*), organs which, in some of the insect races, impart those wonderful instinctive properties that have in this respect raised their possessors to a level with the so-called higher animals, and have rendered them a complete mystery to the naturalist.

The antennæ of a fly are well worthy of a particular description; they are composed apparently of three, but really of six joints, the third of which (Pl. VI. fig. 2) is dilated and much larger than the rest; whilst the sixth is furnished with an arborescent tuft of bristles, and is termed a plumose joint.

When the fly is at rest, the first three joints lie in a depression of the insect's head (Pl. IV. fig. 1, *a a*), whilst the plumose joint is seen to protrude: the

Fig 1.

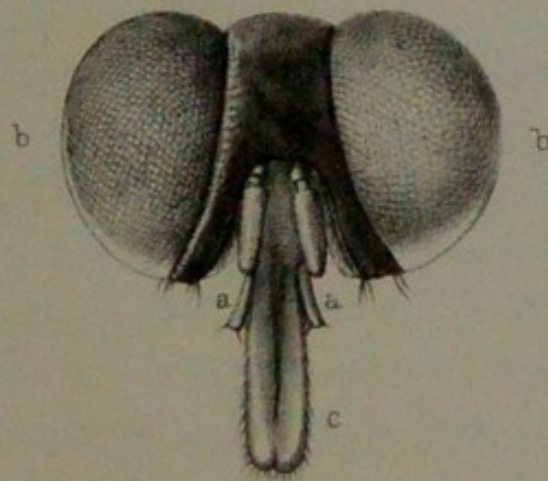


Fig 2.

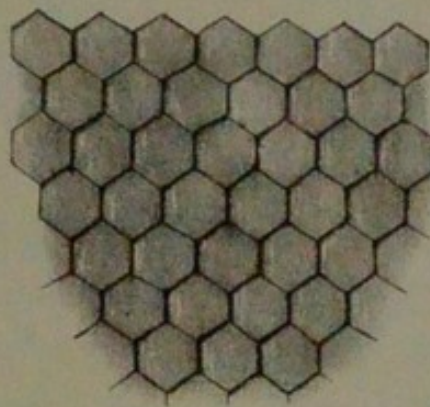
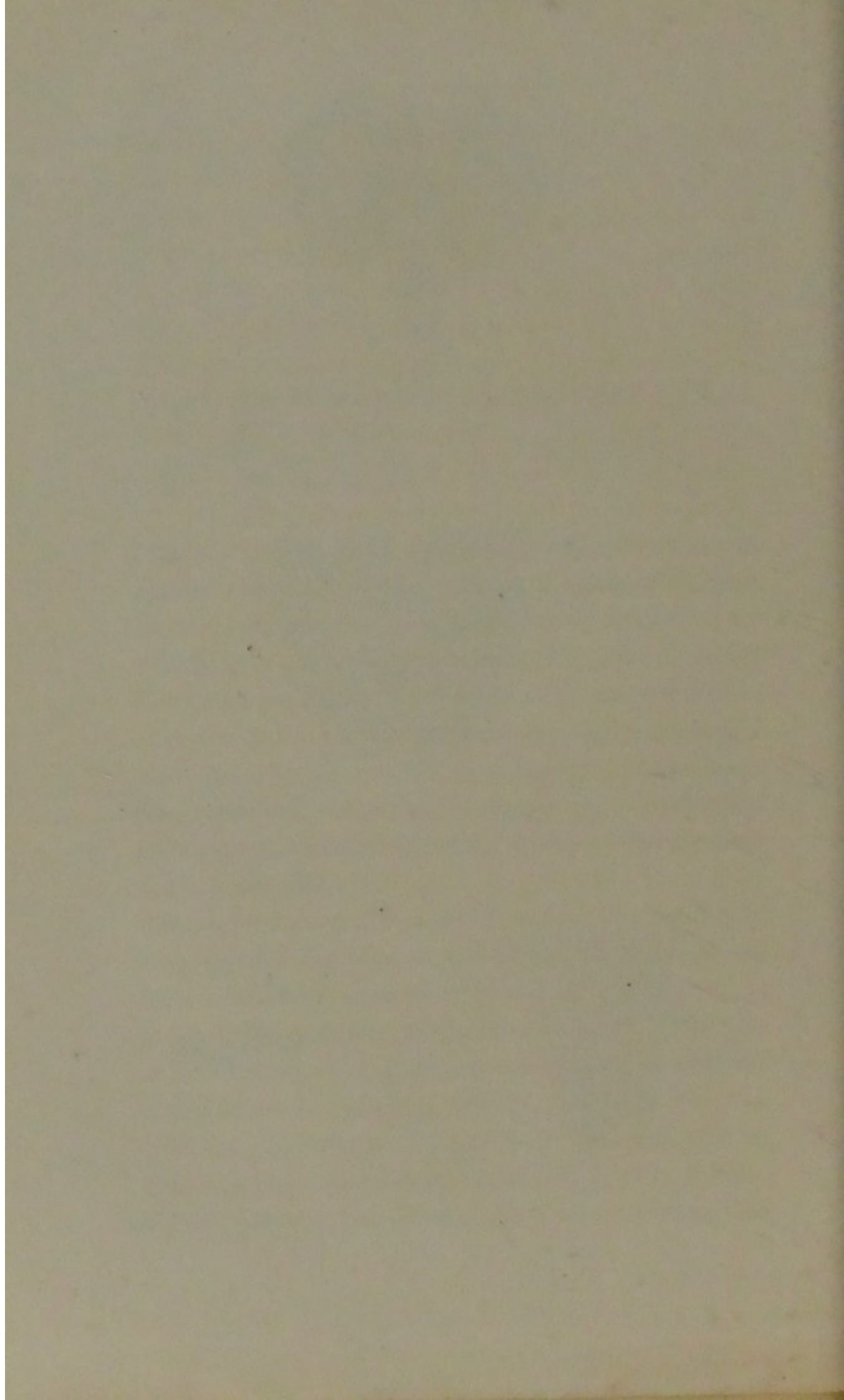


Fig 3



Fig 4





object of this is probably that the third joint, which we shall find to be the most important and delicately organized, should thus be protected from dust and other causes of injury. The principal feature of interest in the antennæ is, that the third joint, when magnified, is found to be perforated all over with minute punctures; these are in reality (as a high magnifying power reveals, after the antenna has been bleached with chlorine) a series of microscopic sacculi (little sacs) extending inwards, and closed in from the air by a very thin membrane, and between these sacculi there are interspersed on the surface a great number of fine short hairs (Pl. VI. fig. 2, *a*). Near the base of the joint are three or four larger apertures leading into chambered cavities, protected at the bottom by microscopic hairs, and to each of these cavities a nerve has been traced from the brain, showing that they perform some sensory function.

What, then, you will ask, can be the nature of organs so intricate in their construction as these antennæ? That is a question which naturalists have in vain essayed to answer, and the true function of the feelers is a problem still to be solved. Some zoologists attribute to them the sense of hearing, others of smell, and others again have superadded to the latter sense that of touch.

These conclusions have been arrived at by comparing the structure of the antennæ in various tribes of insects with their respective habits of life. They have been considered organs of sound chiefly on ac-

count of their anatomical structure ; but Mr. Newport, a very careful observer, has also adduced, as an instance where the feelers exhibit a sensibility to *sound*, the fact of a beetle, which retracts its antennæ on a sudden noise, and falling down counterfeits death. On the other hand, we have various circumstances in evidence of their tactile and olfactory functions ; amongst these may be quoted the Ichneumon-fly (one of the Class Hymenoptera, to which the Bee belongs), which lays its eggs by means of a sharp ovipositor in the larvæ of various insects ; on the bodies of these, the larvæ of the Ichneumon subsist as soon as they are hatched. If we observe this insect seeking for larvæ or caterpillars that inhabit wood, old posts, &c., we shall notice that it pushes its antennæ before it into every irregularity of surface until it has met with a caterpillar, which it then pierces with its ovipositor, and injects one or more eggs. Other insects employ the antennæ for the same purpose ; and it has been proved beyond a doubt that the sense of smell guides them in depositing their eggs ; for some insects, whose larvæ derive their nourishment from decaying meat, have been known to commit the singular mistake of placing them upon plants that possess a similar odour, but were totally unsuitable as food for the larvæ, in consequence of which they died of hunger almost as soon as they were hatched. The Bee, again, employs its antennæ, or organs of smell, in searching for honey : the Ants use these organs to point out to each other the locality in which

they have discovered food; and to suppose that they do this by means of *signs* caused by sound, would be attributing to them a power of imparting information that could hardly be regarded as the result of instinct. The discovery by one of the authors* of this little treatise, of the existence of sacs behind the delicate membrane covering the pores, and also of the larger apertures already alluded to at the base of the third joint, may probably throw fresh light upon the nature of the antennæ. Meanwhile, however, we must continue to regard the question of their function as still unsettled, and content ourselves with observing that they possess some sensory function besides that of touch; either smell, hearing, or both †.

If the antennæ of the Fly have proved a mystery to naturalists, equally so have its wonderful *eyes* been the subjects of speculative inquiry. These are five in number, two being compound, and of comparatively enormous proportions; for they monopolize the greater part of the head, from each side of which they protrude in a semi-globular form (Pl. IV. fig. 1, *b b*).

* Dr. J. B. Hicks: see Transactions of the Linnean Society, vol. xxii. p. 147, in which he describes the bleaching process, and similar organs to those named, in other insects.

† The sense of hearing has been assigned to them by Burmeister, Carus, Strauss-Durkheim, Oken, Robineau, Desvoidy, and Newport; that of smell, or smell and touch, by Reaumur, Lyonnais, and several French anatomists, Küster, Erichson, and Vogt.

It appears to us, that if insects, whose sensibility to external influences is known to be acute, were *confined* and *watched*, fresh light would be thrown upon the nature of their antennæ.

The remaining three are small, simple in their structure, and disposed in a triangle on the top of the head, between the two compound eyes. We shall direct your attention chiefly to the last-named, the compound organs. At the first glance, these resemble two small hemispheres, covered with a bright brown varnish; when you examine them more closely with a lens, the convex surface appears to be marked with a species of network (Pl. IV. fig. 1), and, when placed under the microscope, this network is found to consist of a vast number of convex lenses, disposed in regular rows upon the projecting surface. These lenses, each of which forms the external surface of a simple, but perfect organ of vision, have been carefully counted, and their number amounts to 4000; in other insects they are far more numerous.

If we make a vertical section of one of these compound eyes, dividing it by an incision across the middle of its circumference, and examine it under the microscope (Pl. IV. figs. 2, 3, 4), we shall find it to be constructed as follows:—Each simple lens or facet is double convex and hexagonal in form; and behind this is a six-sided, transparent pyramid, so attached to the facet, that the latter forms, as it were, the base of the pyramid directed outwards*. Each pyramid is imbedded in a dark pigment; so that the light which enters one facet may not be dispersed, nor

* Rymer Jones calls the pyramid "an hexaedral prism, whose office may be compared to that of the vitreous humour of the human eye."

penetrate into the neighbouring one, and thus cause a confusion of rays; from each facet, or rather from the apex of each pyramid, a distinct nerve passes into the substance of the eye, and all these nerves meeting in one common centre, form a large nervous trunk, which conveys the image of surrounding objects to the brain. You will therefore see that a perfect image of external objects is admitted into each facet, which, together with its pyramid, partake of the character of a telescopic tube; and that these images most probably centre in one point, from which the various nervous fibres depart.

Until recently it was a question much discussed amongst naturalists, whether these remarkable eyes convey to the brain of the Fly, *one* or *many* images of the surrounding objects; and the existence of the three simple eyes already referred to, as being placed on the back of the head, by no means tended to the solution of this problem.

Many were of opinion that each facet of the compound eyes, as also of the simple ones (the former are termed *stemmata*, the latter *oculi*), conveyed a distinct image of external objects to the brain, just for instance as we see a series of images on looking through a toy multiplying-glass, which is a prism of many facets. It has, however, of late been shown that such is not necessarily the case; for, although it can be clearly demonstrated that each facet receives a distinct image of surrounding objects, yet, from the position of these facets, which do not all embrace the same view of the

external field, there can be little doubt that the various images meet at a common centre, and are conveyed to the brain as a single picture of the surrounding field. We have only to consider the operation of our own eyes, to find a perfect illustration of this principle; for, although we look at one object with both eyes, and consequently a distinct image is reflected upon the retina of each, we do not *see* two objects, but only one distinct image is apparent to our sense. A still more remarkable example of the fusion of images is, however, found in the action of the stereoscope, where we actually have *two objects*, or pictures, the images of which first pass through *two* distinct lenses, and into our two eyes, and still only *one* clear and prominent figure is carried to the brain.

You will perhaps inquire why such pains have been taken to provide the Fly and other insects with so many hundreds of eyes, whilst we and the higher animals are furnished only with two of these organs. Many explanatory replies have been given to this question, few, however, being at all satisfactory; and experiments have of late been tried in connexion with the function of the simple and compound eyes (the former of which are composed of similar parts to the single facets of the latter), whereby we should be led to the belief that the two sets of eyes do not operate alike; namely, that the one set reflects distant objects, whilst the other enables the creature to examine those in its immediate vicinity. Further

experiments will, however, be necessary before we can regard this as an established fact*.

Probably the existence of the compound eyes may be attributed to the circumstance that insects seek their food in the deep tubes, or dim hollows of flowers, and have frequent occasion to enter crevices into which the light but partially penetrates. A single image reflected in such localities would be faint and imperfect; whereas a series, collected, as we know those of insects to be, in one common centre, and thence conducted to the brain, would form one clear and distinct picture. If, on the other hand, the same mechanism were employed in the minute eyes of insects, as concentrates the external rays in our own organs of vision, we mean the contractile iris, the disposable surface would be almost entirely absorbed, and little room left for the admission of rays; whilst it appears much more natural and in accordance with the general structure of insects (which affords numerous examples of a repetition of similar parts), that they should possess a number of simple lenses, than that the visual organs should be furnished with the mechanical contrivances attached to those of the higher animals. If this be so, we may say with Lyonnet, the great French naturalist, that if it pleases

* The means employed in this experiment were to besmear, with an opaque substance, first one set of eyes in one insect, and watch its movements; and then to exclude the light in a similar manner from the other set of eyes in another insect, and observe the result. The comparison of the movements in the two cases led to the above conclusion.

the Creator to construct for the Bee or the Fly 10,000 eyes, in order the more effectually to meet the creature's wants, it is as easy for Him to do so as to construct a single lens*.

* The Fly is furnished with . . .	4,000 facets.
The Mordella (a kind of beetle) .	25,000 facets.
The Dragon-fly	12,544 facets.
The Butterfly	17,355 facets.
The Sphinx Moth	1,300 facets.
The Ant	50 facets.

(*Burmeister.*)



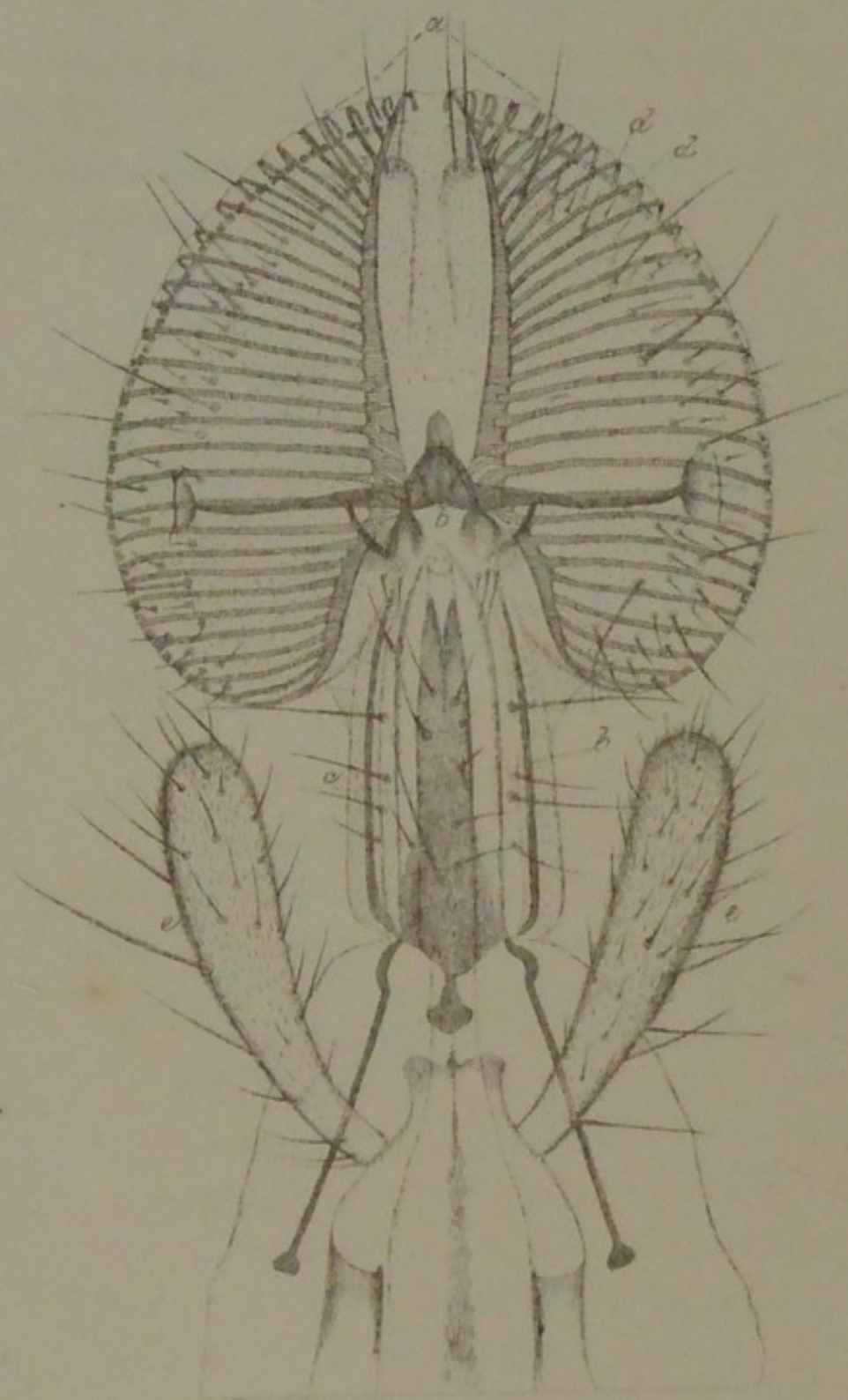


Fig. 1.

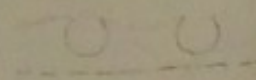


Fig. 3.

Fig. 2.

Proboscis
of
House Fly

LETTER VI.

THE MOUTH OF INSECTS.—THE PROBOSCIS OF THE FLY.—THE MEMBERS OF LOCOMOTION.—WINGS; THEIR STRUCTURE.—WONDERFUL RAPIDITY OF FLIGHT—HALTERES OR POISERS; THEIR ANATOMY AND SUPPOSED FUNCTION.—THE LEGS.—REMARKABLE ORGANIZATION OF THE FLY'S FOOT.—REPE- TITION OF SIMILAR PARTS IN THE ORGANS DESCRIBED.

BEFORE passing from the consideration of the Fly's head, we have still to examine another organ, namely that of nutrition, which is termed the *proboscis*; this is situated in front, towards the under surface of the head, and when not in use, lies folded up in a depression, out of the way of injury.

In order more clearly to explain the character of this organ, we must briefly describe the *typical* structure of the mouth of insects generally. Those that masticate their food are usually furnished with the following parts:—1. an upper lip (*labrum*), and a lower lip (*labium*), which work together in a similar manner to our own, and when closed conceal the remaining parts. Between these lips there is, 2. a pair of jaws (*mandibulæ*), and, 3. a smaller pair (*maxillæ*), which operate laterally and masticate the food; and, 4. we find two pairs of feelers; the first (*maxil-*

lary palpi) attached to the maxillæ, and the second (*palpi labiales*) connected with the lower lip. These feelers enable the insect to test the nature of its food. Now, when an insect does not reduce its food by mastication, but, as in the case of the Fly and others, obtains it by suction, all the organs just enumerated appear to be wanting, and a *proboscis* or suction-pump is substituted, as being better adapted to the changed character of the food on which the insect subsists. On examining it more closely, however, we find that the proboscis is, after all, but a transformation of the maxillary organs just referred to as existing in the generality of insects. Let us take that of the House-fly for example. The proboscis of the Fly (Pl. IV. fig. 1, *c*, and Pl. V. fig. 1) consists of a tubular bag, formed of thin transparent membrane, which arises from the front of the head, and is dilated at its extremity, forming at this part a large sucking disc. This bag is the converted portion of the lower lip (*labium*), known as the '*ligula*,' or tongue, a term that is often applied to the proboscis itself, and is furnished inside with a very complicated apparatus, to enable it to perform its functions. The terminal sucking disc (Pl. V. fig. 1, *a*) is so constructed as to gather the fluids and attract them towards an aperture at *b*, which leads to the throat or gullet (to be described hereafter); and in a groove on the under-side of this tubular portion are two sharp bristles or lancets, *c*, and beneath these, one more lancet, less pointed, but still sharp (*b*). The apex of the latter is

pierced by an opening, as above mentioned, that passes up its centre and conducts to the gullet, which runs through the base of the tubular bag. These lancets are the representatives of the 'maxillæ' and 'mandibles,' and are employed to puncture the objects from which the Fly sucks the juices. On the under surface of the disc are a number of lines running from the circumference to the centre, as in Pl. V. fig. 1, *dd*; and when these are highly magnified, they are found to be a number of ribs, forming about three-fourths of a tube, the open portion of which faces downwards, so as to admit the liquid food; when the fluid has entered it passes along, probably by capillary attraction, to the centre, close around which all the tubes open. Here it enters the aperture in the single lancet, finally to reach the gullet. These ribbed tubes are connected together by very delicate lines, springing from the points of the ribs, as represented in Pl. V. fig. 2. Besides the piercers, the proboscis is furnished with a pair of well-defined maxillary palpi (Pl. V. fig. 1, *e*), which enable it to test the character of its nutriment; and the entire apparatus is covered with a great number of fine hairs, and permeated by respiratory tubes (*tracheæ*), the nature of which we shall consider hereafter.

You may, perhaps, not have been aware that the harmless little Fly possesses such weapons as the aforesaid lancets; but if you have ever been stung by one about the time when they are dying out, and have seen the drop of blood arising from the wound, you

would feel satisfied that such an effect can only be produced by a sharp instrument. The eye, antennæ, and proboscis of the Fly are all objects of great interest to the microscopist, and may be found, prepared in slides, in the cabinet of almost every collector. They are obtainable at a trifling cost*; a low power, and consequently an inexpensive instrument†, suffices to show their structure; and if you desire to become acquainted with the physiology of the insect, or even to employ a leisure hour agreeably, you will find them well worthy of a careful inspection.

Having made ourselves tolerably well acquainted with the various organs of sense and nutrition situated upon the head of the House-fly, let us now take a cursory glance at the members of locomotion, all of which we shall find appended to the second division of the body, the thorax or chest. In our fourth letter we enumerated the three parts into which this section of the Fly's body is divided, and mentioned that the little creature possesses three pairs of legs, one pair of wings, and a pair of organs termed halteres or poisers; the first pair of legs being situated upon the prothorax, or anterior ring; the second pair and the wings upon the mesothorax, or central ring; and

* One shilling and sixpence each. The objects which have served to illustrate this treatise were prepared by Mr. Purkiss of Tottenham.

† A microscope may be purchased for 10s. 6d. of sufficiently high power for this purpose.

the last pair of legs and halteres upon the metathorax, or last subdivision of the chest.

The most important of these members, looking at the habitat of the Fly, are undoubtedly the wings. They consist, as you are well aware, of a pair of membranous expansions; each wing is composed of an upper and lower transparent membrane, and between these two layers the blood-vessels and respiratory tubes (*tracheæ*) ramify, so as to form a beautiful network for the support of the extended membranes.

You will perhaps be somewhat surprised to hear that the wings of our little Fly, to whose structure you may never have devoted a single moment's thought during your lifetime, have been so carefully investigated, and received so much of the anatomist's attention, that not only has each branch or 'nervure,' as these ramifications (Pl. VI. fig. 1, *a*) are termed, but also each intervening portion of the transparent membrane has been deemed worthy of receiving a distinct designation. To enumerate these would be to trespass beyond the limits and intention of this little treatise; but we mention the fact, in order to show how much there is to be learnt in creatures of even the most humble character.

We may here also observe, that near the root of the wings, where these are joined to the body, there have been discovered a great number of small vesicles, the nature of which is still a mystery; but as we shall have occasion to describe them more fully when treating of the halteres, where they are also found,

we shall here simply allude to their presence in the members now under consideration. But although we pass thus rapidly over the anatomy of the wings, as being of too scientific a character for this treatise, we must not omit to refer to the remarkable effects that they produce, and will dwell for a moment upon their wonderful operation.

The rapidity of their vibrations is something incredible, and the number of these within a given space of time has been approximately ascertained by the following experiment. When a spring is caused to vibrate a certain number of times, it emits a particular tone, and, as the number of its vibrations is increased or diminished, this note rises or falls in pitch. Now, this vibration being analogous to that of the wing of an insect, which *also* emits a musical sound, an apparatus has been constructed wherein a multiplying-wheel, with a given number of cogs, against which a spring strikes, is made to revolve rapidly. A note being thus produced, varying in pitch according to the rapidity of the revolutions, the velocity is accelerated or retarded until this note is the same as that proceeding from the wings of the insect, and by an easy calculating process the number of vibrations may be thus ascertained.

Messrs. Kirby and Spence inform us that "an anonymous writer in Nicholson's Journal calculates that in its ordinary flight the common House-fly (*M. domestica*) makes with its wings about 600 strokes, which carry it 5 feet, every second; but if alarmed,"

he states, "their velocity can be increased six- or seven-fold, or to 30 or 35 feet per second. In this space of time a race-horse would clear only 90 feet, which is at the rate of more than a mile per minute. Our little Fly, in her swiftest flight, will in the same space of time go more than the third of a mile. Now, compare the infinite difference of the size of the two animals (ten millions of the Fly would hardly counterpoise one racer), and how wonderful will the velocity of the minute creature appear ! Did the Fly equal the race-horse in size, and retain its present powers in the ratio of its magnitude, it would traverse the globe with the rapidity of lightning !"

Every observer must have remarked with what ease the fly plays around the head of a horse in rapid motion ; and Vogt says the Gad-fly flies with a speed equal to that of a railway-train. Though this may appear exaggerated, the calculation will not seem so far from the truth when we notice that, whilst the moving body proceeds in straight lines, the insect performs numerous gyrations at the same time, thereby considerably increasing the distance. Some allowance must be made for the assistance the insect derives from the stratum of air put in motion by the progression of the object, as also by the momentum gained by occasionally touching the object with which it is travelling. The common Gnat (*Culex pipiens*) has a much higher rate of vibrations, which are computed at many thousands per second.

In such insects as possess two pairs of wings, *e. g.*

the Butterfly, Beetle, Dragon-fly, &c., the second pair is situated upon the metathorax, the third ring ; but in the Fly, which is only furnished with one pair, the place of the second is supplied by two little members termed halteres, or poisers. These appear to be rudimentary wings, are protected by a pair of horny scales, and, seen with the naked eye, they resemble two globules, which are kept in a state of constant vibration whilst the insect is on the wing. On being detached, however, and examined under the microscope, they present a clubshaped appearance (Pl. VI. fig. 3), and their base is found to be studded all over with microscopic vesicles disposed in regular rows upon the surface. Between these vesicles, as in the case of the antennæ, numerous hairs are interspersed with great regularity. It has been found that two large nerves proceed from one of the principal nervous centres in the insect (the thoracic ganglion) into the halteres ; and from these, minute branches have been traced *to all the vesicles* upon the surface : from this it must be inferred that these vesicles (as well as those in the wings, with which nerve-fibres also communicate) are organs of sense, and it is believed by the observers who discovered them* that *they* are the organs of smell. Should this prove to be the case, there will be less difficulty in determining the true character of the antennæ, in which the vesicles are *depressed*, as stated

* Mr. Purkiss and Dr. J. B. Hicks : see papers by latter in the Journal of the Linnean Society, vol. i. No. 3 ; and Linnean Society Transactions, vol. xxii. p. 144.



PLATE VI

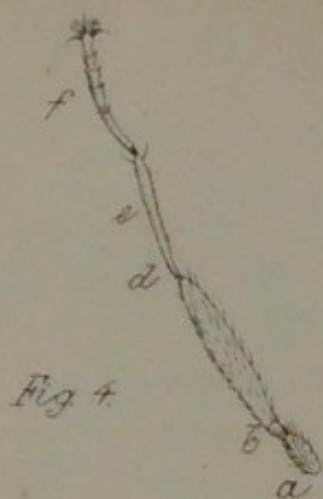


Fig. 4.



Fig. 5.

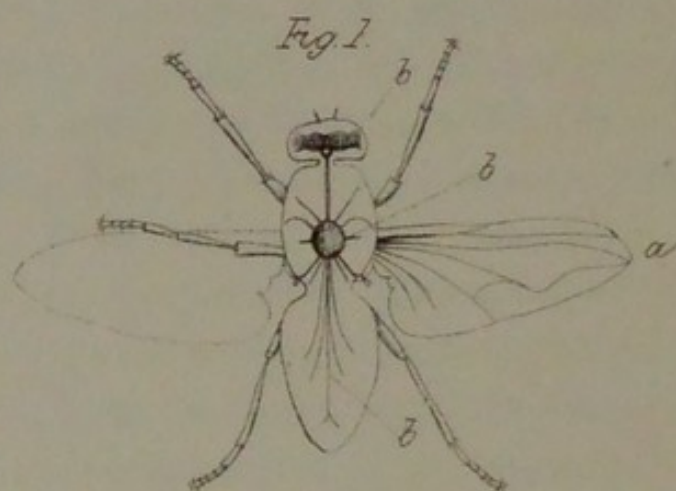


Fig. 1.

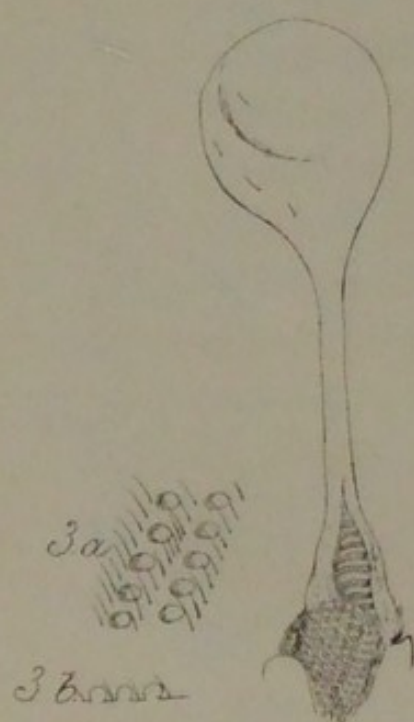


Fig. 3

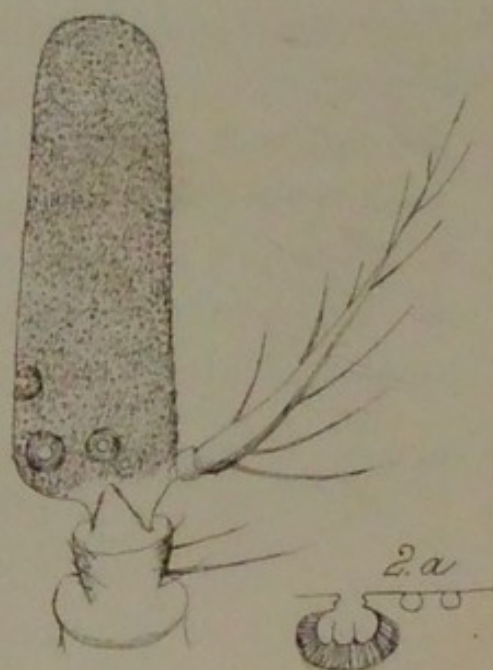


Fig. 2.

in a former letter ; whilst those in the *halteres* and wings project from the surface (Pl. VI. fig. 3, *a* and *b*), nerves having been traced to both sets of organs.

The last, but by no means the least interesting of the Fly's members, to which we shall draw your attention, is its leg, and more especially the final or "tarsal" joint. The leg of the Fly (and indeed of insects in general) is divided into five distinct limbs or joints : the first of these is the "coxa," or hip, by which the leg articulates upon the body (Pl. VI. fig. 4, *a*) ; then the "trochanter," a short round joint (Pl. VI. fig. 4, *b*) ; next the "femur," or thigh, the largest of the five joints (4, *c*) ; the "tibia," a somewhat thinner member (4, *d*) ; and lastly, the "tarsus," or foot (4, *f*). None of these are distinguished by any feature of peculiar interest, excepting the last-named ; but that one we shall find quite deserving of a closer examination.

The "tarsus" or foot of the Fly is subdivided into five joints, the final one being furnished with that remarkable apparatus which enables the insect to walk upon what appear to us perfectly smooth or polished surfaces, and also to progress in a position opposed to the laws of gravity.

This apparatus consists of two moveable claws (Pl. VII. fig. 1), resembling a cow's horns in shape, which the insect can affix to any little eminences or depressions that present themselves in its course ; and further, of a pair of membranous expansions, termed "pulvilli," or, familiarly, pads, which, when magnified

(same figure), resemble the broad termination of a child's battledore formed of parchment. Until recently, these pulvilli, which are furnished with innumerable hairs, were supposed to operate as suckers; but the higher powers of the microscope have revealed, at the termination of each of the numerous hairs that cover the surface, a minute expansion, which is kept moist by a fluid exuding from the extremity*; and the belief now prevails that, whilst each single hairlet (Pl. VII. fig. 1, *a*) serves as a sucking disc, the two pulvilli themselves act as cushions for the preservation of the larger hooks (which would otherwise become abraded), in a similar manner to the soft cushions that protect the sole of a cat's foot, and enable it to tread so lightly.

This view is strengthened by the examination of the foot of *Dytiscus marginalis*, one of the large Water-beetles, in which these small suckers are developed in a remarkable degree; and also to some extent by the ambulacral suckers that serve as members of locomotion in the Star-fishes and other Echinoderms, and the terminal cushions upon the toes of the Climbing-frog (*Hyla arborea*), in all of which a power is imparted similar to that possessed by the House-fly.

With this description of the Fly's foot, we shall conclude our cursory review of its external parts; and, before quitting this portion of the subject, let us

* For this discovery we are indebted to Mr. Hepworth: see his paper in the Quarterly Journal of Microscopical Science, 1854, vol. ii. p. 158.

again draw your attention for an instant to a remarkable peculiarity in its most important organs, one to which we have already made passing allusions, namely, to the repetition of similar component parts in the structure of these organs. The eyes with their facets, the antennæ, wings, and halteres with their numerous vesicles, and lastly, the pulvilli with the appended suckers, all present examples of that peculiarity of structure which has proved such a difficult problem to naturalists; and although bundles of nerves have been traced to the three sensory organs, yet neither the searching powers of the microscope nor a comparison of their structure in the various races of insects, have enabled anatomists fully to understand and estimate their true properties. A closer examination of their habits, however, combined with what is already ascertained in regard to their anatomy, will doubtless soon clear up the mystery; and should you be inclined to enter the ranks of observers, you will find the field to be one of unbounded study and interest.

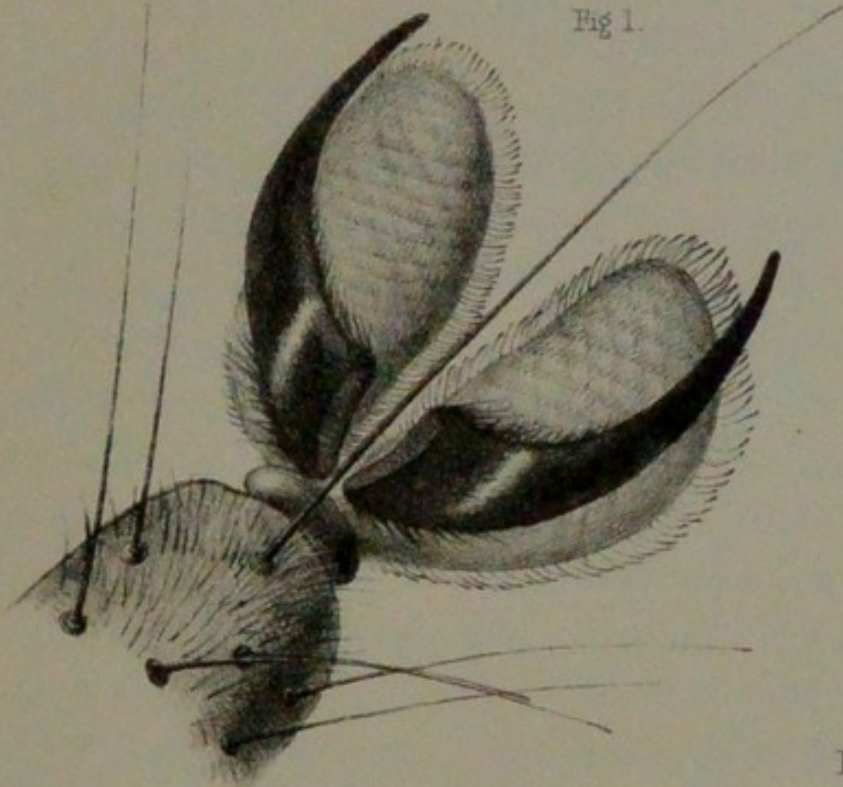
LETTER VII.

THE ANATOMY OF THE FLY.—ITS ORGANS OF DIGESTION; OF CIRCULATION; OF RESPIRATION.—WONDERFUL STRUCTURE OF THE SPIRACLES OR BREATHING-HOLES, AND TRACHEÆ OR RESPIRATORY TUBES.—NERVOUS SYSTEM.—CONSIDERATIONS UPON THE NERVOUS SYSTEM OF THE HOUSE-FLY AS COMPARED WITH THAT OF ITS LARVA AND OF THE WORM.

FROM the foregoing description of the external members of the House-fly, you will have perceived how well adapted they are to its aërial existence; and if we now investigate its internal structure, we shall see that the vital organs are so disposed and constructed as also to facilitate its movements in the atmosphere. Let us take each function *seriatim*. First, as regards that of *nutrition*. We have fully considered the proboscis, by which the food is procured; thence it passes into the throat, which is muscular, and forms the entrance into a species of crop (Pl. III.) situated at the left side of this throat, and opening into it is a long-necked food-reservoir, not inaptly termed the paunch, and which is adapted, by its conformation, to facilitate the ruminating process*.

* Léon Dufour, Anatomie Générale des Diptères, Ann. des Sci. Nat. i. p. 244; Vogt, Zoologische Briefe, vol. i. p. 598.

Fig 1.



1a.

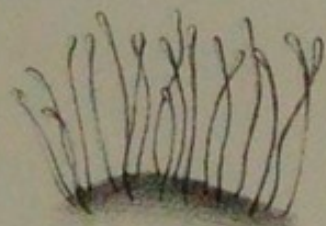
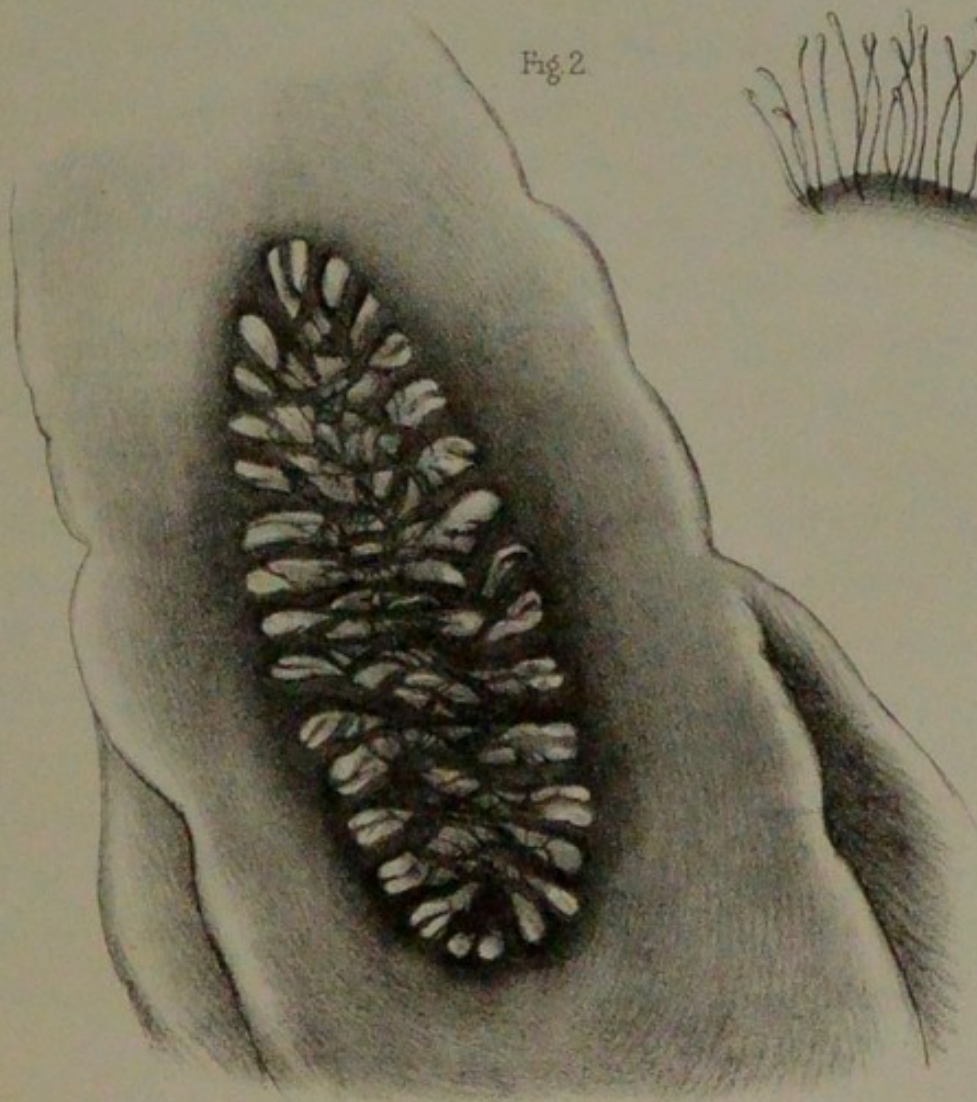
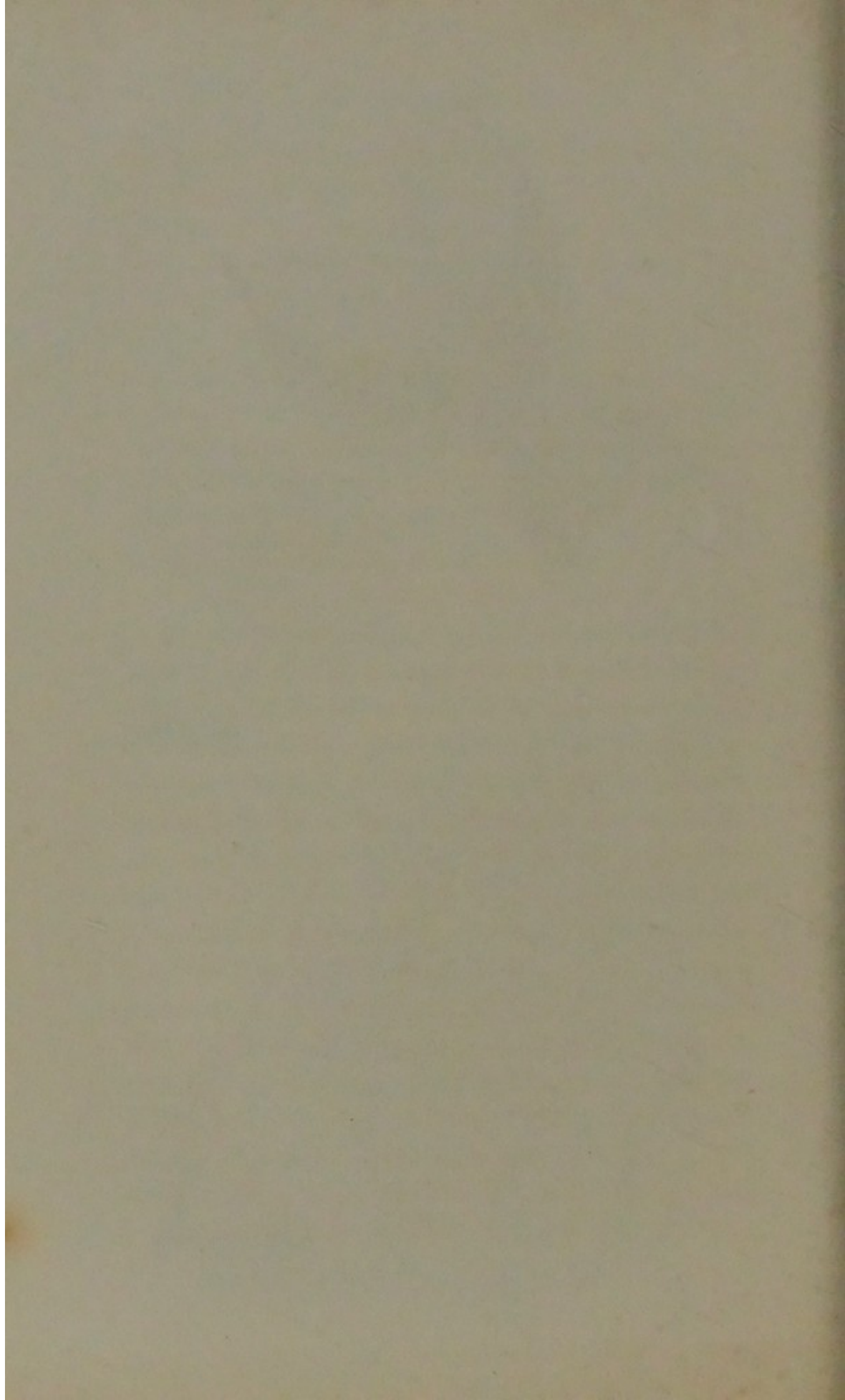


Fig 2.





From this crop the food passes into an extended stomach, and thence into a long convoluted bowel, to which are attached numerous biliary tubes, and which terminates in an expansion called the cloaca. This complicated digestive apparatus extends throughout the whole body, the throat commencing in the head, and terminating in the thorax, in which is also situated the stomach and its appendages; whilst the long winding intestine is found, along with the other viscera, in the last or abdominal section of the body. Instead, therefore, of a simple alimentary canal, passing in a straight line from end to end of the body, as we found in the Worm, the lowest of the articulate series, we have here four distinct divisions in the digestive apparatus,—a progressive step in the development, with which we shall find the other vital organs in perfect accordance. In regard to the circulation of the blood, for instance, you will recollect that the Worm possessed one undivided contractile tube, which extended along the back, and, performing the functions of the heart, propelled the vital fluid along the whole body, after which it was again collected in another canal running along the ventral portion of the animal. Now in the Fly, although the *principle* of operation is precisely the same, the organs that perform the function are far more highly developed. The *dorsal* vessel (heart) extends along the whole body, just within its external covering, and differs from that of the Worm inasmuch as that portion of it which is situated in the third or *abdominal section* of

the body, is not only contractile, but at the same time divided into a series of chambers (Pl. III.) opening into one another by means of valves ; the portion of the dorsal vessel, however, which passes through the *thorax*, is a simple contractile tube resembling that found in the Worm. The blood is forced, by the contractility of the dorsal vessel, from the tail towards the head, first passing from chamber to chamber in the abdominal segment ; for the valves which connect these are so constructed as to admit of its flowing forward, but not allowing it to return. From the abdominal chambers it enters that portion of the dorsal vessel situated in the thorax, and is thence projected forward into the head. A ventral tube is also present, which, as in the Worm, conveys the blood from the head backwards in the direction opposed to that which it pursues in the dorsal heart ; but, in consequence of the opaque covering of the Fly (and other insects), anatomists have not been able fully to trace the circulation. A surprising circumstance is, however, known with regard to this function ; and that is, that in some portions of the body the blood circulates in cavities, *unconfined by any vessels whatever*, and bathes the different viscera. It then collects in the vicinity of the dorsal vessel, the chambers of which are furnished with valves at each side (as well as those which connect one chamber with another) ; and this second set of valves is also so constructed that they admit the blood from without, but prevent its egress. It is also ascertained

that the central trunk gives out numerous branches, which convey the blood to the different members of the body.

Intimately connected with the circulating system is that of *respiration*; and when you consider that the Fly is formed to be a denizen of the atmosphere, and that its specific gravity is necessarily one of the most important features in connexion with its existence, you will not be surprised to hear that the apparatus by which the air is admitted and allowed to circulate through the body, is very beautiful, and displays marked evidences of a designing hand. If you examine the under surface of the Fly with a pocket-lens, you will find extending along the middle of the abdomen a membranous band that divides the horny rings of which the covering is composed into two parts, and at each side of this membranous division (but on the rings themselves) you will perceive a row of minute punctures which penetrate the so-called chitine integument of the body. These little apertures, a pair of which is situated upon each abdominal ring, and two pairs upon the thorax, in contiguity with the members, have been variously denominated *spiracles*, *stigmata*, or breathing-holes, and through them the air is admitted into the body; the respiratory operation is effected in a somewhat similar manner to the same process in the higher animals, namely by muscular dilatation and contraction, in this case of the abdominal region.

Through the spiracles, which we shall find to be

beautifully constructed organs, the air passes into fine tubes called *tracheæ*, whence it is conducted into other receptacles varying in form and size. Two of these are capacious sacs, occupying a considerable portion of the abdomen (Pl. III.) ; whilst one main tracheal or tubular vessel extends along each side of the abdomen and thorax ; and from these, minute branches ramify in such a manner as to convey the needful supply of air to every part of the insect's body. Let us first examine the *spiracles* or *stigmata*, that admit the air into the body. If these had been simple incisions or apertures in the outer integument, they would have admitted along with the atmosphere minute particles of dust, and the tracheal tubes would soon become so choked up as to prevent the free circulation of the air. To obviate this difficulty, therefore, nature has protected the entrance by a species of sieve or screen, which is as beautiful as it is effective, and is formed in the following manner :— From every part of the circumference of the aperture there proceed towards the centre a great number of short arborescent trunks (Pl. VII. fig. 2), whose innumerable minute ramifications become so interlaced as to form a complete network across the entrance, and beyond which every particle of foreign matter is effectually prevented from passing. But when the air has entered the *tracheæ* or circulating tubes, another difficulty presents itself ; for these tubes are necessarily very compressible, and the rapid movements of the insect must often cause them to collapse

in various parts, where of course the circulation of the air is then arrested; and unless some means were employed to re-open the tube, its lining membrane would be very liable to adhere, and cause it to remain permanently closed. Nothing can be more delicate and simple than the contrivance by which this obstacle is overcome,—a contrivance, that we find constantly imitated in our every-day life. When one of the larger tracheæ is magnified about 400 diameters, it is found to consist of a double integument, between which a close continuous coil of hairlike fibre is situated, which supports the tubes in a similar manner to the coil of wire in gas- or speaking-tubes. This coil (Pl. VI. fig. 5) adds considerably to the elasticity of the air-vessels; and when these collapse through the movements of the insect, it prevents the opposed sides from adhering permanently, and causes them to resume their tubular form as soon as the pressure is removed.

In the distribution of the tracheæ we find the same wise arrangement that characterizes every other portion of the internal economy of the Fly. The *abdomen*, being the heaviest section of the body, on account of the mass of viscera that it contains, has its specific gravity considerably diminished by being furnished with two large air-bladders (Pl. III.), as well as two tracheal tubes of considerable size, that pass along either side of the body; whilst the *thorax*, on which the wings are situated (and which of themselves add to the buoyancy of the insect), is only pro-

vided internally with a pair of lateral tubes; in both cases the main tracheæ give out innumerable minor branches, as already noticed, around which the blood flows, becoming by that means thoroughly oxygenized.

But if the nutritive and circulating systems of the House-fly afford, through their advanced organization, a remarkable contrast with those of the Worm, still more striking shall we find the indications of a comparatively high degree of development presented by the *nervous system* of the insect. This portion of its anatomical structure (Pl. VI. fig. 1, *bb*) consists—1, of the *brain*, otherwise termed the *cephalic* or *supra-æsoophageal ganglion*, which is composed of two small masses of nervous matter situated (as the foregoing expressions denote) in the head, “above the *æsophagus*” or throat. From the sides of this ganglion there proceed two large nerves to the eyes, and in front a nerve to each antenna, and some smaller ones to the parts of the proboscis. 2. From the lower portion of the brain a small nervous chord passes downward on each side: these surround the gullet and form *below* it, 3, the *sub-æsoophageal* ganglion; from which again, 4, the two nervous chords, united into one, pass to the centre of the thorax, where we find, 5, a large mass of grey matter, called (from its position) the *thoracic* ganglion.

From this large nervous centre nerves are given off in pairs (see Pl. VI. fig. 1, *bb*) in all directions, viz.

a pair to the anterior legs, another to the wings, a third pair to the second legs, a large pair (the largest of all) to the halteres, and two nerves to the posterior legs. Besides these, the thoracic ganglion also gives out a bundle of nerves (arranged bilaterally) into the abdomen; a single one, however, passing through the centre of that section of the body, at the termination of which it is forked, and the two extremities proceed to the reproductive organs on each side. Thus you will perceive that every portion of the Fly's body, every organ and member, is provided with its special nerve; and if we now compare this portion of its physiology with the nervous system of the Worm (Letter III.), and of the Fly itself in its larval stage, we shall find the comparison of their structure to be interesting and instructive. The brain of the Worm resembles that of the Fly, and also gives off two chords, which unite and pass along the ventral surface of the body. In each ring we found bilateral branches proceeding from the central chord; and these branches being often repeated, and of a uniform size, afford evidence, upon the principle already referred to*, of the humble organization of the Worm.

If we next take the larva, or grub of the House-fly, the body of which also consists of soft rings, as in the Worm, we shall find in each ring, and situated

* In treating of the eye of the Fly, we explained that a repetition of similar parts was an evidence of its low organization, as compared with the higher animals.

upon the central chord, a nervous ganglion, from which bilateral branches proceed in a similar manner to those in the Worm, showing a *somewhat* superior, but still low stage of development. But now, if we compare these structures with the nervous system of the Fly, we shall find a marked progress, indicated by a *concentration* of the chief nervous centres, and by a great *disproportion* in the size of the various bilateral branches. The only two important centres are the cephalic ganglion (brain) and that in the thorax, the latter being produced by a fusion of all the *larval* ganglia, except the brain and subœsophageal ganglion. The nerves, too, differ considerably in their proportions, owing to the unequal development of the organs and members to which they proceed. The optic, which has already been described, is enormously developed, to supply the numerous facets of the compound eye. Next in size is that which proceeds to the halteres, then that to the wings, whereby the importance of these organs is sufficiently indicated; and the remaining nerves are of comparatively small dimensions.

We have thus dwelt upon the nervous system of the Fly, not only for the purpose of showing its analogy with that of the Worm, and the points of difference between them, but also because the consideration of this part of their anatomy, along with that of the larva of the Fly, in reality comprises a review of the nervous system of the whole series of Articulated animals, all of which more or less nearly

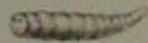
resemble that of one or other of these three forms ; and we shall now conclude our account of the House-fly with a description of its wonderful powers of reproduction and some details of interest connected with its life-history.

LETTER VIII.

LIFE-HISTORY OF THE FLY.—ORGANS OF REPRODUCTION.—
MODE OF DEPOSITING ITS EGGS.—TABLE SHOWING ITS RE-
MARKABLE REPRODUCTIVE POWERS.—THE LARVA; THE
PUPA. — TRANSFORMATIONS. — THE PERFECT FLY; ITS
HABITS.—STRANGE FATAL DISEASE TO WHICH IT IS SUB-
JECT.—ITS USES AS A SANATORY AGENT, ETC.—TRANS-
FORMATION OF MATTER IN THE ANIMAL CREATION.—RE-
FLECTIONS UPON GEOLOGICAL FACTS IN CONNEXION WITH
THE FLY.—CONCLUSION.

HOWEVER cursory the foregoing review of the wonderful structure and varied functions of the Fly may have been, still we think you will experience some difficulty in realizing the idea that we have been describing that familiar insect whose swarms invade our parlours and store-rooms as the summer months approach, and become so formidable that we are obliged to resort to various expedients in order to rid ourselves of their presence. Although this is the most unfavourable aspect under which the Fly presents itself to our notice, yet the very multitudes that force themselves into our dwellings, and cause us so much annoyance, suggest to the reflecting observer considerations which are far from uninteresting.

Fig 1.



1a.



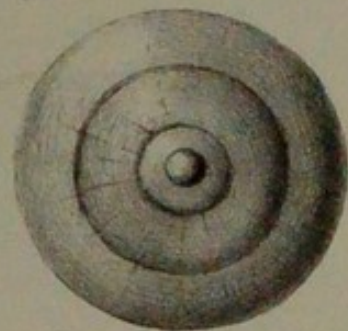
Fig 3.

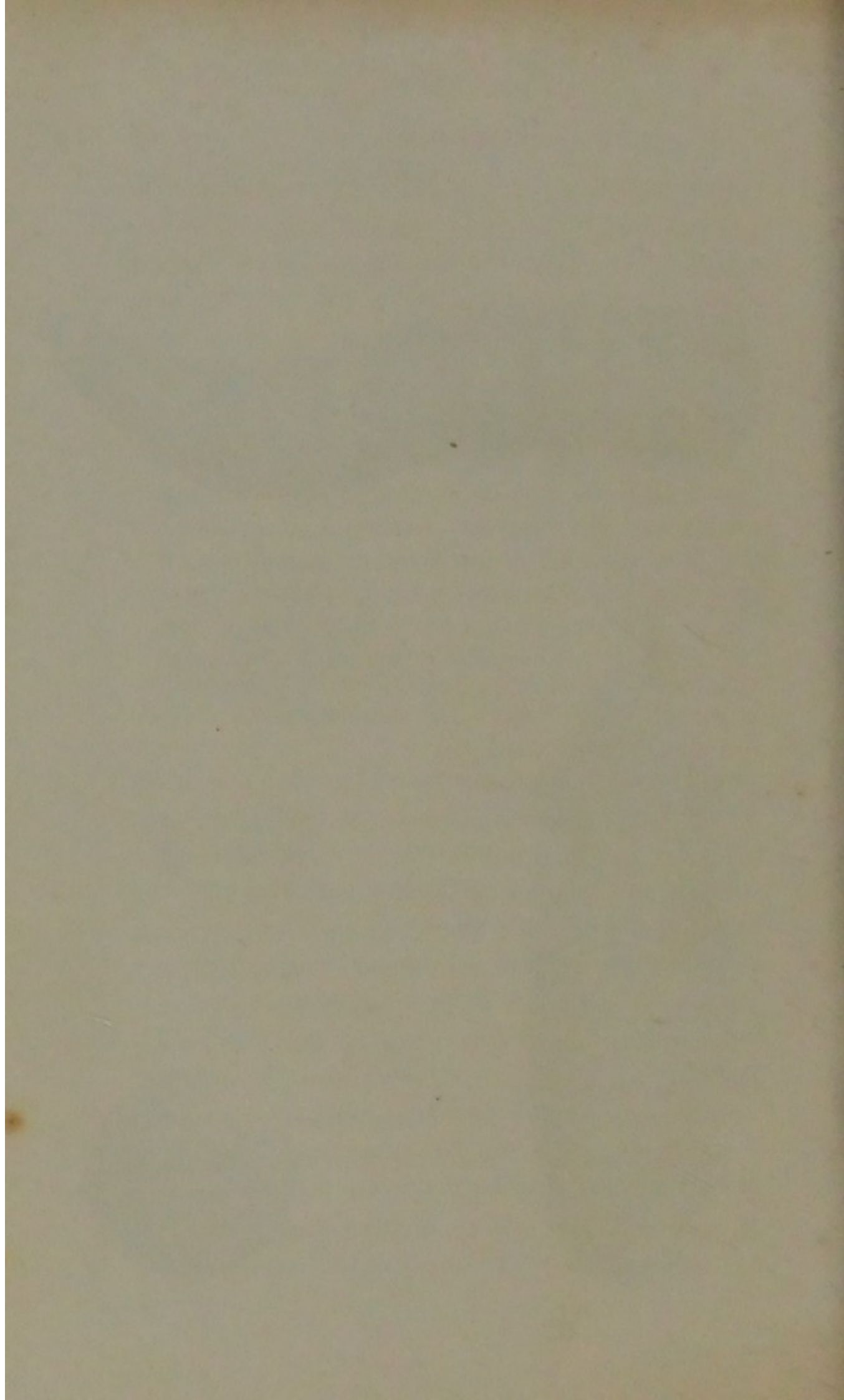


Fig 2.



Fig 4.





The questions that you will naturally put to yourself when you enter your breakfast-room, and find that the little intruders have already taken possession of your choicest viands, are: "Whence come these myriads of insects, of which, a few days since, scarcely a single one was visible? and what has been their previous career?" We shall endeavour briefly to answer these queries, and to detail a few of the best-known facts in regard to the life-history of the Fly.

"Few persons are aware," (to quote the words of an old German writer* on the subject) "that these insects, which swarm around their heads, had previously crept under their feet;" but that such is the case, we have already mentioned in treating of the metamorphoses which the Fly undergoes, and of the analogies that exist between *its* larva and the fully-developed Worm (Letter IV.); and a reference to this portion of the subject leads us first to consider the mode of reproduction in the Fly, and of the extraordinary powers that it possesses to multiply its species.

As we have glanced at the general anatomy of the Fly, we may here mention, with reference to its organs of reproduction, that they are never united in the same creature, as we found to be the case in the Worm; but in this insect the sexes are perfectly distinct, the female being recognizable by the pre-

* Keller, 'Geschichte der gemeinen Stubenfliege' (trans. "History of the Common House-fly." A copy may be found in the British Museum).

sence of a little tube (*ovipositor*), situated at the end of the abdomen. This organ is formed of three or four rings, which the Fly can protrude or retract, after the manner of a telescope, and employs for the purpose of depositing her eggs. Internally, the organs of the female consist of a pair of branching tubes, in which the ova are developed, whilst the male is furnished with tubes and glands necessary for the development of the fructifying elements, these organs in both sexes being situated in the abdominal section of the body. Beyond this there is nothing of interest to the general reader in this portion of the Fly's anatomy.

Keller, the naturalist, to whom we have just referred, and who studied the history of the Fly with considerable attention, tells us that the female deposits her eggs six or eight days after impregnation. This she usually does in such decaying substances as her instinct denotes to be suitable for the nourishment of her larvæ, as, for example, the heaps of vegetables and other substances that are found in the neighbourhood of our dwellings.

“If,” says Keller, “the Fly be enabled to choose the place which suits her best for the deposition of her eggs (as for instance, in my sugar-basin, in which I placed a quantity of decaying wheat), she takes a correct survey of every part, and selects that in which she believes her ova will be the best preserved, and her young ones well cared for. If there were too much moisture, the maggots would be drowned ; if too

little, the first drought would cause eggs and larvæ to become desiccated. Having chosen a suitable locality, one neither too wet nor too dry, she protrudes her little ovipositor, and therewith lays her eggs, by the side of, and upon one another, with the same precision as the cleverest hands would arrange larger objects; she then sits perfectly still, without moving a single member of her body excepting her ovipositor; indeed it would appear as though she were not quite conscious whilst this operation is being performed, for so long as she is not absolutely touched, one may approach her as nearly as one likes, without causing her to exhibit the least symptom of alarm. During this operation, which lasts half a quarter of an hour (a few minutes more or less), she lays 70, 80, or 90 eggs." Generally speaking, the greater number of insects die as soon as they have deposited their eggs; but Keller's observations led him to believe that this is not the case with the Fly, for he retained several alive in a glass for some days after oviposition was completed, and he, as well as other naturalists, believe that the insect deposits her eggs three or four times during her life, the duration of which is a few weeks or months.

Assuming that the Fly deposits 80 ova at a sitting, and that she performs this operation four times during her life, Keller has drawn up the following curious table, from which it would appear that a single female might in one season be the progenitrix of upwards of two million flies:—

"The parent Fly lays her eggs four times during the summer, and each time she deposits 80 eggs, making 320 flies.

Now, it must be assumed that half of these are females, so that at each of the four depositions 40 females are born:—

- | | | |
|--|---------|---|
| (1) The first eighth, or the 40 females resulting from the first deposition, lay again four times during the season, making together | 12,800 | „ |
| Again the first eighth of these, or 1600 females, deposit three times, making . | 384,000 | „ |
| The second eighth, or 1600 females, deposit twice, making | 256,000 | „ |
| The third and fourth eighths, or 3200, deposit once, making | 256,000 | „ |
| (2) The second eighth, or 40 females of the first deposition, lay three times more, making | 9,600 | „ |
| One-sixth of these, or 1600 females, deposit again three times, making . . | 384,000 | „ |
| The second one-sixth, or 1600 females, deposit again twice, making . . . | 256,000 | „ |
| The third one-sixth, or 1600 females, deposit again once, making | 128,000 | „ |
| (3) The third eighth of the first laying, or 40 females, lay twice, making . . . | 6,400 | „ |
| Of these, one-fourth, or 1600 females, deposit twice, making | 256,000 | „ |
| (4) The fourth one-eighth of the first deposition, say 40 females, deposit once more, making | 3,200 | „ |
| Whereof one-half, say 1600 females, deposit at least once, making | 128,000 | „ |

*Total . . . 2,080,320 flies."

* Keller makes the addition 2,208,420, which appears erroneous; but for our purpose it is immaterial. Another naturalist

Although the foregoing calculation is quite sufficient to account for the immense swarms of Flies that make their appearance during the summer and autumn months, *yet these would be considerably increased* were it not that, from various causes (such as drought, flood, &c., and the rapacity of birds and other animals that prey upon them), a considerable number of the eggs thus deposited are never hatched; or if hatched, the larvæ are, from similar causes, destroyed in that stage, and do not attain the imago form. The eggs are hatched a few days after they are deposited; and if you wish to obtain a tolerably accurate idea of the appearance of the larva that proceeds from them, you have but to examine with a pocket-lens one of the well-known long white maggots, commonly termed "jumpers," which are found in decaying cheese, and afterwards become converted into a small black Fly (*Piophilæ*) belonging to a kindred group; or one of the ordinary maggots found in ham when in a state of decay.

The body of the larva is divided into thirteen rings, the anterior one, or head, being furnished with a pair of hooked jaws and rudimentary eyes. These are the only external organs, and *otherwise* the creature is perfectly smooth and devoid of members (Pl. VIII. fig. 1 & 1, *a*). Whilst in this state, it is constantly devouring the substances in which it was hatched, and increasing rapidly in size; it is, however, *asexual*, computes the number of ova deposited to be above 2,000,000,000, and Schwammerdam counted 140 eggs in the body of one Fly.

i. e. incapable of reproduction, and in a few days assumes the *pupa* form. This change is effected by the hardening of the outer skin, which becomes brown and tough, inclosing the larva in a little barrel-shaped case ; or, to speak more correctly, causing it to resemble a grain of rice in the husk.

Whilst the insect is in this its second or pupal condition, that remarkable metamorphosis is taking place in its internal as well as external structure, which raises it from the type of a Worm to that of a highly-organized insect, a change to which we have more than once referred in the course of this treatise.

The simple jaws of the larva are replaced by the complicated proboscis that is so necessary for the sustenance of the Fly ; the compound eyes by which we have found the insect races to be characterized now make their appearance, as also the delicately-constructed feet and wings, and the mysterious antennæ (Pl. VIII. fig. 3). Simultaneously with the division, or rather the *concentration*, of the cylindrical body into head, thorax, and abdomen, a change also takes place in the *internal* anatomy ; for whilst this, in the larva, resembled that of the Worm (see Letter II.), it now becomes changed to the more perfect structure of the Fly, as detailed in the preceding letters. In a few days, when all these transformations are complete, the insect forces its way out of its prison-house in the following manner :—After it has, by a series of muscular efforts, detached itself from the pupal covering, it strikes its head forcibly

against one end of the case time after time, until it bursts open, as it were, upon a hinge, like the lid of a cylindrical snuff-box (Pl. VIII. fig. 4).

When the Fly first makes its escape, it presents anything but a graceful appearance; for, whilst it was in the pupa-case, its members were folded against the body more with a view to economy of space, than to display their elegance; and the wings are necessarily crumpled and insignificant in appearance. As mentioned in the previous letter (VII.), these members are supplied internally with a great number of tracheæ, or air-tubes; and one of the first operations of the insect is to inflate these by a trembling motion, and by the expansions and contractions of the abdomen: in thus dilating the tracheæ, the insect gives to the wings their necessary expansion and support.

We have now followed the Fly from its first appearance upon a dunghill, until it enters the habitations of man, and feeds at the tables of monarchs and peasants. Of its habits in this, the last phase of its history, we can tell you but little that you do not already know. Its brief existence presents but few facts that are of interest to the naturalist; for the Fly neither constructs dwellings like the bee, nor does it display any peculiar instinctive intelligence in its natural operations.

In its perfect form it appears to be as great an epicure as it was a gourmand in its larval stage, and indulges in all the delicacies of our table whenever they come within its reach. It delights to bask in

the sunshine, but at the first approach of winter retreats into the warm nooks and crannies of our dwellings, and secretes itself in curtains and drapery; and when the cold sets in, its swarms vanish as rapidly as they first made their appearance in spring.

But even its brief and apparently gay and tranquil existence is not unattended with danger. That it is massacred and poisoned wholesale by man, falling a victim to its keen appreciation of the *sweets* of life; that it is devoured by birds, cats and other quadrupeds, spiders, &c.; tortured and crushed to death by children, and dissected by microscopists, you are doubtless well aware. But there is another peril to which it is subject, and of this you are perhaps not cognizant; this is a curious disease, to which vast numbers fall victims towards the close of the autumn, and, although highly interesting to the naturalist and microscopist, it must be a fearful infliction to the poor little Fly. As this disease has been very graphically described in a recent number of the 'Microscopic Journal,' we cannot do better than transcribe a short extract* :—

“The subject of this paper is the well-known curious disease which prevails among common House-flies at the period when the departing warmth of autumn induces them to seek shelter within doors.

“At this time innumerable dead bodies of flies may

* “*Empusa Muscæ*; the Disease of the Common House-fly. By Dr. F. Cohn.” Breslau, 1855.—‘Microscopic Journal,’ April, 1857.

be seen adhering to the windows, walls, shutters, &c., in all parts of the room: the dead insect, although dry, and so friable as to crumble into dust upon the slightest touch, retains so far the attitude of life, that it is difficult, without touching, to believe that it is not a living fly on the point of taking flight. Insects in dying usually draw up the legs, and cross them beneath the body; but in the case of the disease now under consideration, the dead body is supported upon the outstretched legs, whose feet retain their adhesive property, and by the protruded proboscis, with which the Fly would seem to be sucking; and by which, even when the feet may happen to be detached, the body is still retained *in situ*. The dead flies in this condition are always surrounded with a halo, about an inch in diameter, composed of a whitish dust, which upon examination is found to consist of the spores [seeds] of a *fungus*. The abdomen is much distended, and the rings composing it are separated from each other, the intervals being occupied by white prominent zones, constituted of a fungoid growth proceeding from the interior of the body. Further examination will show *that the whole of the contents of the body of the Fly* have been consumed by the parasitic growth, and that nothing remains but an empty shell, lined with a thin felt-like layer, composed of the slender mycelia of the innumerable fungi.

“This disease appears to have been long noticed, though of course, in the absence of sufficient microscopic assistance, its true nature was not at first

known. First noticed it would seem by De Geer, in 1782, it did not escape the minute eye of the illustrious Goethe, who gives an accurate description of the phenomena attending it, and especially of the appearance of the white dust between the rings of the body and its dispersion in a wide area around the dead insect. Accurate microscopic observations were made upon it by Nees v. Esenbeck in 1827, though he did not arrive at any very definite conclusions as to the nature of what he observed. But in 1835 Mons. Duméril declared the fine white dust to be a *true mould*, which had probably caused the death of the animal, in the same way that plants are killed by the different species of *Exysiphe*: he compares it to the 'muscardine' of the silkworm."

With this extract we shall close the life-history of the Fly, and shall now consider for a moment the uses for which it was created, and the lessons we may learn from its existence.

If you asked a sceptic, who doubted that *every* species of animal is created for an end, and has its place and object assigned by the Creator, to name some of those that he regarded as useless, it is not at all improbable that he would select the Worm and the Fly. Of the Worm's value as a fertilizing agent we have already spoken (Letter III.), and shall now find that the humble Fly, in its lowest stage, performs an office of still greater importance,—nay, that it is indispensable to the existence of some, and to the health and comfort of the whole human race.

Reader! this is no exaggeration: go into the fields or lanes, and seek the body of some recently-killed animal; or, if you reside near the sea, look at the carcase of one of the many creatures that are cast up by the waves; and if your olfactory organs be not too easily offended, turn the body over, and examine it for yourself. See what myriads of maggots are writhing throughout its frame! A few hundreds of these may be the larvæ of the Carrion Beetle, or of the Devil's Coachman (*Staphylinidæ*); but thousands upon thousands are the maggots of flies, and, if you return a few days after your first inspection, you will find that they have devoured the whole carcase, save a little skin, and the indigestible bones. The elements of the tissues, instead of decomposing into poisonous and ill-savoured compounds, and filling the air with miasma pregnant with pestilential disease and death, at once spring phoenix-like into life again, and in a few days there appears the animated form of the Fly, which only an Omnipotent hand could have moulded with such rapidity and accurate design. That which was left of the carcase, the bones, form one of the most valuable manures that we possess; and whilst the elements of the flesh and tissues *rise*, to form a living creature of the air, the bones *descend* into the earth, and there enter into the constitution of plants, and provide nourishment for other animated beings. The Fly in its turn falls a victim to birds, frogs, or rapacious insects, and these in like manner become the prey of man and the lower animals, or

are converted into the constituents of the soil ; and thus it is that the current of life flows on in constant and ever-varying circles.

The history of the Fly also leads our thoughts back into the obscure past, even to the earliest periods of Creation, and here again it testifies to the wisdom and omnipotence of the Creator. That the insect and its congeners were formed long before man, is evident from the circumstance that traces of its fragile remains have been discovered far down in the geological formations. Then, as now, each mechanical portion of its structure was suited to the element upon which it operated, or that entered the body of which it was to become a constituent part. Then, too, its wings propelled it rapidly through the limpid atmosphere, and its spiracles sifted the self-same atmosphere before admitting it into the circulating tubes.

The insects that formerly existed were chiefly such as were suited to a life in the vast woods and forests, and their larvæ were developed in the earth itself* ; but when man received possession of the earth, and, in accordance with his Maker's will, beautified and laid it out in gardens, then the Creator altered the nature even of the humble Fly, and brought into existence new races, adapted in their structure and habits to the changed surface, or produced in greater abundance the requisite forms, that had before been but sparingly distributed†. These revelled amongst

* The *Nemocera*, or long-horned Diptera.

† The *Brachycera*, or short-horned Diptera.

sweet-scented flowers and herbs, and their young were reared upon decaying vegetation. Even in the past history of the insignificant Fly, therefore, and in the links that have connected it with creation, do we read of steadfast unity of purpose, eternal wisdom in design, and boundless power in execution.

And now, dear Reader, we must draw these observations to a close, and shall claim your attention whilst we address a few concluding remarks to you concerning the task that we have accomplished.

If you were previously unacquainted with the nature of the Worm and Fly, we hope that our description and history will have revealed to you such novel facts as are calculated to elevate your conception of these two animals, and invest them with fresh interest. We have endeavoured, without burdening your mind with scientific details and phraseology, to lay before you the principal circumstances that have been ascertained in regard to their structure and history, up to the present time; to communicate the enjoyment afforded to ourselves by the investigation of the various organs, and thereby induce you to take a deeper interest in the subject, and occupy yourself with inquiries into those functions that you will have found to be imperfectly understood. It is difficult, either by a description, or plates, to impart an adequate idea of the various beauties that present themselves in an investigation of the different parts of the Fly's structure, with the aid of the microscope; and if these pages lead you to examine for yourself

the curious mechanisms by which the creature performs its vital functions, we have little doubt that the pleasure you will experience will be to you, as it has already been to many others, the magnet that will attract you to a more earnest search after scientific knowledge.

If you are a scientific student, and have already devoted some time to the pursuit, we trust that our remarks will have opened new avenues of thought, and been suggestive of fresh ideas or subjects for investigation. At least, we may confidently hope that we have succeeded in accomplishing the object we had in view in undertaking this task, and to which we referred in our Introduction, namely, to display those remarkable characteristics in two of the humblest of animal forms, which render them interesting to the naturalist, and to show that the mechanical contrivances with which they are supplied are far more deserving of our attention than the instruments constructed by the hand of man after their model.

If we have been so far successful, and have rendered popularly interesting these two creatures, which from their very familiarity were considered unworthy of notice, we shall be well satisfied, and amply repaid for our efforts to compile and lay before you this brief account of the anatomy and natural history of the Earthworm and common House-fly.

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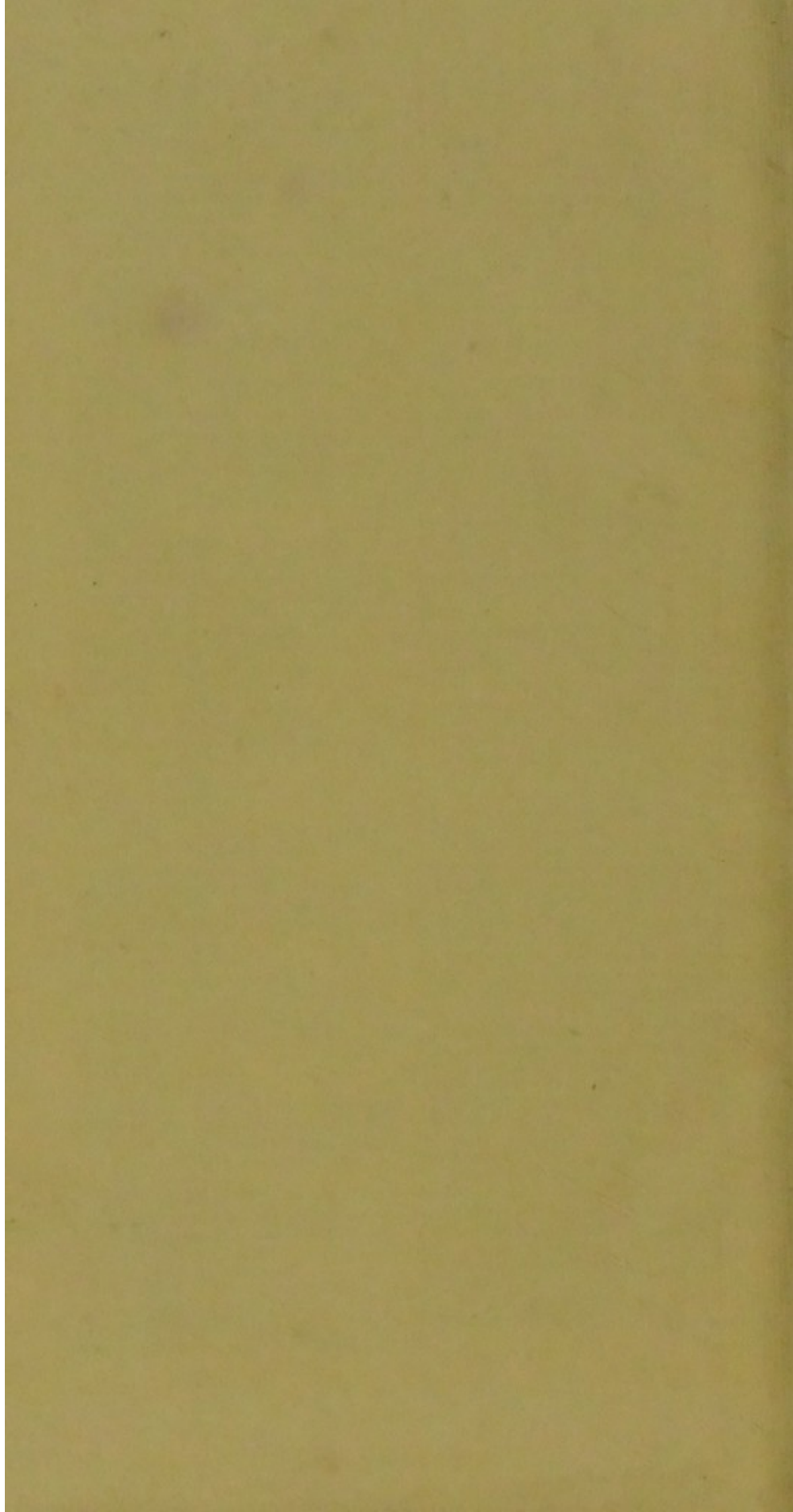
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Two books from Mr. Darwin in the course of a year are a gift to be grateful for. A year ago he gave us the strange results of a long series of observations on the movements of plants, and now he has even stranger things to tell us as to the work of worms on our earth. It must not, however, be thought that Mr. Darwin's new work is the product of a single year; it really embodies the results of something like half-a-century's observations and experiments. No better example could be adduced of the truth of Carlyle's definition of genius—an infinite capacity for taking trouble; and nearly every page abounds with instances of the importance in scientific investigation of what most people would consider trifles. Mr. Darwin's method of work may well be regarded as modelled on that method of nature herself with which his name is so intimately associated. Beginning with a nucleus of fact, he develops it by innumerable little additions from all sides, modifies his growing scheme in accordance with whatever new conditions may arise, and only asks us to behold his work when all its parts have been so fitly framed together and raised upon so solid and wide a foundation of facts as to compel our admiration and approval. Mr. Darwin has shed new and true light over great regions of nature, and the total result of his labours has been to revolutionize the methods of science in many of its departments, and to readjust the standpoint from which we look at nature's multifarious handiwork. He has led us to suspect that probably nothing exists in the universe without a meaning and a service; that many creatures and parts of creatures that seem useless and cumbersome are really ingenious adaptations to the performance of the most essential functions; that nature is never wasteful and accomplishes the most stupendous ends by means that would seem to the untrained observer contemptible and hopelessly inadequate for the purpose. Mr. Darwin has given us reason to believe that probably nothing walks this earth "with aimless feet"; that even "unintelligent" plants have something astoundingly analogous to a brain, and that their tiniest movements are all directed to a well-defined end. And now in the volume before us he has taught us to be cautious in calling anything common or unclean. If in his work on "The Descent of Man" he "put down the mighty from their seats," in that just published he has certainly "exalted them of low degree."

No subject for investigation could, at first sight, seem more unsavoury than worms. For centuries and centuries they have furnished moralists, poets, and ascetics with similes for all that is abject and grovelling and useless; humility itself cannot exult in a lower epithet than "worm of the dust." We all know what Cowper meant when he declared that he would not count him among the list of his friends "who wilfully would tread on a worm"; the results of Mr. Darwin's investigations have put an entirely new meaning into the lines. In the mouth of a farmer, after reading Mr. Darwin's book, they would have a significance undreamed of before. For, although doubtless worms may do some little damage to seeds and roots the benefits they annually confer upon humanity infinitely outweigh it. "It may be doubted," Mr. Darwin concludes, "whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures." Indeed, Mr. Darwin declares that these despised creatures are among the greatest benefactors of humanity. They are nature's ploughmen; and had it not been for the work they have done through long ages, in many parts of the world, there would have been nothing for the plough to work upon. Mr. Darwin, as usual, wastes no words. He tells us at once what he means to do, and is never for one sentence diverted from his purpose. "The share," he tells us in the first sentence of his book, "which worms have taken in the formation of the layer of vegetable mould which covers the whole surface of the land in every moderately humid country is the subject of the present volume." The first paper which Mr. Darwin wrote on the subject was read so long ago as 1837. It contained the results of several years' observations, and these have been continued ever since. Not only has he himself, aided by his sons, carried on a long series of observations and experiments, but he has obtained information bearing on his inquiries from observers in all parts of the world. Other inquirers have been working at the same subject in recent years, and

since. Not only has he himself, aided by his sons, carried on a long series of observations and experiments, but he has obtained information bearing on his inquiries from observers in all parts of the world. Other inquirers have been working at the same subject in recent years, and some of them have published their observations. Mr. Darwin utilizes the results of other inquirers, and gives them all credit; but he waits patiently till his own work is complete before he gives it to the world. He gives us first of all a clear account of the structure of the worm, which is much more elaborate and beautiful than it seems. It has no eyes and no ears, but has a digestive system of some little complexity, including something very like a gizzard. Everyone knows the difficulty of pulling a worm out of its hole; it will rather break than yield, and this is owing to a multitude of tiny bristles that fix themselves against the sides of the hole. Worms may have a sense of smell, and certainly have one of taste, as is proved over and over again by their preference for certain kinds of food. Where they can get them, their staple food seems to be leaves, though they are specially partial to onions. These leaves they drag down into their holes, not only for food, but to line the mouths of their holes with, probably for the sake of keeping their bodies from the cold earth. And in the methods followed by the worms in dragging leaves thus down through their narrow holes, Mr. Darwin discovers clear traces of intelligence, of a faculty for adapting means to an end. The holes themselves exhibit workmanship of some elaboration, they are carefully lined often with a thin layer of fine, dark-coloured earth, which, when carefully smoothed, makes the holes fit easily, but perfectly, to the body of the worm. Often their holes are covered with a tiny heap of small stones, and sometimes they are plugged up by the stalks of leaves that have apparently been on purpose placed in proper position. But these and many other details as to the structure of worms and their habits are all preliminary to the great purpose of the work, which is to show that what is generally called "vegetable" mould is almost solely the work of these worms, and is, therefore, more animal than vegetable. They are constantly swallowing earth and tiny stones, and passing them through their bodies to the surface in a finely triturated and fertilized condition; in fact, they may be said to manure the earth inside their own bodies. By means of this process the entire earthy surface of a country is constantly in a state of change. The whole earth underneath our feet all over the world is swarming with worms; probably all over there are in every acre of land from 35,000 to 50,000 worms. Everyone is familiar with the casts of worms, which themselves look like worms of earth. With so many worms at work, then, it is not difficult to imagine what will be the effect of a constant accumulation of such casts. In some cases, if spread over the ground, they would measure one-fifth of an inch in depth per year, equal to one inch of earth brought up from below, passed through the bodies of worms, and deposited on the surface in five years. In one instance given by Mr. Darwin 12oz. of castings were thrown up in a year on a square foot, or 676lb. on the square yard, equal to 14½ tons of so-called fertile "vegetable" mould over an acre in one year. Leaves and stones and lime and other substance spread over a field, and left untouched, have been found in a very few years several inches below the surface in a uniform layer. This, there can be no doubt, from the multitude of data supplied by Mr. Darwin, is all the work of worms. The millions of leaves and other vegetable matter dragged by the persevering creatures underneath the soil, whether passed through their bodies or not, form a splendid natural manure. Not only so, but "the bones of dead animals, the harder parts of insects, the shells of land molluscs are before long all buried beneath the accumulated castings of worms, and are thus brought in a more or less decayed state within reach of the roots of plants." The worm burrows generally do not go beyond a few inches beneath the surface, though not unfrequently they have been found at the depth of several feet, and thus, it is supposed, materially aid the drainage and allow the air to penetrate deeply into the ground. They are even a powerful factor

in geology, performing a great part in the disintegration of rocks, not simply by direct action on the softer kinds, but by the indirect action of the acids which get mingled in their bodies with whatever they swallow, and which will have a slow, but ultimately powerful effect on even hard rocks. Not only the farmer, but the archaeologist ought to be grateful to the worm for the work it has done. Mr. Darwin shows that large stones, and even paved walks, when left undisturbed, have in the course of a few years been completely buried beneath the casts of worms. To this cause we owe the preservation of part of the floor of Beaulieu Abbey, and the recumbent huge stones of Stonehenge have sunk partly underground owing to similar action. Not only so, but Mr. Darwin shows that there is the greatest probability that whole towns, like the old Roman towns of Silchester and Uriconium, owe their preservation for the inspection of modern archaeologists to a large extent to the ceaseless work of generations of these lowly creatures, showing the stupendous effects of a continually recurring cause, even when it seems almost infinitesimally small. No one can rise from the study of Mr. Darwin's new work, which is one of the most interesting he has written, without thenceforth feeling something like tenderness and respect for the hitherto loathed worm, even if he hesitates to credit it with all the stupendous feats which its advocate attributes to it. Mr. Darwin has elevated the creature from a cumberer of the ground to the rank of a benefactor of our race, and has by his researches thrown another fresh flood of light upon the workings of nature. As usual, there is little theorizing in his book; it consists mainly of an accumulation of authenticated instances, from which the reader may draw his own conclusions; and, as usual also, Mr. Darwin points out any weaknesses in the line of his argument, and suggests objections as candidly as if he were on the other side. But the weight of the multitude of facts he brings forward is too powerful to be resisted.

*"The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits." By Charles Darwin, LL.D., F.R.S. With Illustrations. London: Murray. 1881.

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