
Part I.—The Anatomy of the Fly.

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With Plates 22—26.

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I. INTRODUCTION.

This paper is intended to be the first of a series of three dealing with the anatomy, development and bionomics of the House-fly, *Musca domestica*, L. The second part will
include an account of the anatomy of the larva, its development and the breeding habits of the fly; the series will be concluded with an account of the bionomics of the fly with special reference to its relations with man.

The term "House-fly" to the zoologist refers only to one insect—Musca domestica of Linnaeus, but to the popular mind it includes insects, not different species only, but different families of Diptera. The Root Maggot fly (Pl. 22, fig. 2), Anthomyia radicum, L., sometimes occurs commonly in houses. Homalomyia canicularis, L. (fig. 3), often called the Small House-fly, is a very common inhabitant of houses. The latter species is smaller than M. domestica, and on this account they are frequently supposed to be young specimens of the latter species by persons who are ignorant of the fact that growth takes place during the larval stage and not after the exclusion of the imago. Stomoxys calcitrans, L. (fig. 4), is found in houses, especially in the autumn. It is frequently mistaken for M. domestica, and as it is one of the blood-sucking species (See Austen, 1906), the pernicious habit is attributed to the harmless M. domestica either on account of the supposed ill-nature of the latter or the influence of some change in the weather.¹

In addition to these, other species of flies occur in houses but these will be considered in a later part. Reference has been made here to the various species inhabiting houses to show that the term "House-fly" as ordinarily used is rather an inclusive one.

The House-fly has received some attention from naturalists in all ages. Reaumur (1738), De Geer (1752-78) and Bouche (1834) have all included a short account of this insect in their classical memoirs. They do not contribute much to our knowledge of the anatomy and development of the fly.

¹ Stomoxys calcitrans can be readily distinguished from M. domestica by the awl-like proboscis which projects forwards from beneath the head. It has a more robust general appearance, a dark spotted abdomen, and its flight is more steady.
most complete of these early accounts is that of Keller (1790) which is illustrated by several striking plates. He gives an interesting account of the development and breeding habits, but in attempting to describe the anatomy he was not so successful as exemplified by his mistaking the brown testes for kidneys. In 1874 Packard wrote what is up to the present time the most complete account of the development of this species, and in 1880 Taschenburg, in his 'Praktische Insektenkunde' gave a good popular account of the insect. Howard has more recently (1898 and 1902) contributed to our knowledge of the developmental history.

No complete account of the anatomy of this insect has yet been published. A short popular account by Samuelson and Hicks (1860) though interesting is very superficial, and contains much that is inaccurate. Macloskie (1880) has published an account of the proboscis of M. domestica, and the foot has been made an object of study by several workers, chief of whom are Hepworth (1854), and Merlin (1895 and 1905), who correctly described the glandular hairs of the pulvilli. Wesche has recently (1906) described the genitalia of both sexes, but his description and figures are inaccurate. An interesting account of the copulation of the fly has been published by Belese (1902), in which he briefly describes the reproductive organs, his work will be referred to later. Lowne's monograph (1895) on the Blow-fly (Calliphora erythrocephala), which is an elaboration of his previous memoir (1870) is the only complete account which has been published on Muscid anatomy. The result of my study of the anatomy of M. domestica, which was begun in 1905, and is being continued in the Zoological Laboratories of the Manchester University, has been to make it apparent that much of Lowne's work needs confirmation.

Musca domestica was first described by Linnaeus (1758), his description is as follows:—

"Antennis plumatis pilosa nigra, thorace lineis 5 obsoletis abdomine nitidulo tessellato: minor. Habitat in Europae
domibus, etiam Americæ. Larvæ in simo equinæ. Pupæ parallele cubantes."

Later Fabricius described it more fully in his 'Genera Insectorum.' The House-fly, together with the Blowfly, and the blood-sucking flies Stomoxys and Glossina belongs to the family Muscidae, which is characterised by having the terminal joint of the antenna—the arista always combed or plumed and by the absence of large bristles or macrochaetae on the abdomen. The Muscidae, together with the Anthomyidae and Tachinidae constitute the group Muscidae calyptratae are characterised by the possession of squamae, small lobes at the bases of the wings which cover the halteres. In the acalyptrate muscids the squamae are absent or rudimentary. These two groups belong to the suborder Cyclorrhapha, one of the two primary divisions of the Diptera. The Cyclorrhapha have coarctate pupæ, the pupal case being formed by the hardening of the last larval skin, and the flies escaping through a circular orifice formed by the fly pushing off the end of the pupa by means of an inflated sac-like organ—the ptilinium which is afterwards withdrawn into the head, its presence being marked by a frontal crescentic opening the lunule. The other sub-order the Orthorrhapha have obtect pupæ.

The most complete specific description of Musca domestica has been given by Schiner (1864), of which the following is a free translation:

"Frons of male occupying a fourth part of the breadth of the head. Frontal stripe of female narrow in front, so broad behind that it entirely fills up the width of the frons. The dorsal region of the thorax dusty grey in colour with four equally broad longitudinal stripes. Scutellum grey, with black sides. The light regions of the abdomen yellowish, transparent, the darkest parts at least at the base of the ventral side yellow. The last segment and a dorsal line blackish brown. Seen from behind and against the light the whole abdomen shimmering yellow, and only on each side of the dorsal line on each segment a dull transverse band. The
lower part of the face silky yellow, shot with blackish brown. Median stripe velvety black. Antennae brown. Palpi black. Legs blackish brown. Wings tinged with pale grey with yellowish base. The female has a broad velvety black, often reddishly shimmering frontal stripe, which is not broader at the anterior end than the bases of the antennae, but becomes so very much broader above that the light dustiness of the sides is entirely obliterated. The abdomen gradually becoming darker. The shimmering areas on the separate segments generally brownish. All the other parts are the same as in the male.

The mature insects measure from 6–7 mm. in length and 13–15 mm. across the wings. Flies which have been starved during the larval stage or subjected to adverse conditions are generally smaller in size.

II. Methods.

All the details of the anatomy which are about to be described have been studied by means of dissections. The dissections were made on both fresh and preserved material under a Ziess' binocular dissecting microscope with magnifications varying from 25–65 diameters. Serial sections have been made to confirm the dissections and to study the histological details.

Perfect series of sections of the whole fly were hard to obtain on account of the somewhat brittle nature of the internal chitinous structures. These internal chitinous skeletal elements caused the greatest trouble as they were apt to damage the internal anatomy. Celloidin sections were not a great improvement on those cut in paraffin. The best results were obtained by fixing the flies from 12–24 hours in Henning's solution, which is—Nitric acid 16 parts, chromic acid (5 per cent.) 16 parts, corrosive sublimate saturated in 60 per cent. alcohol 24 parts, picric acid saturated in water 12 parts, and absolute alcohol 42 parts, washing out with iodine alcohol. This not only fixes, but to a certain extent, though not completely, softens the chitin. They should not
be imbedded too long or the chitin becomes brittle again. Serial sections made of recently emerged imagines before the chitin has hardened give good results. Other fixing agents used were Perenyi, Rabl's Chromoformic, Picro-formal (Boum's solution), Glacial acetic acid, and absolute alcohol. Of the various stains which were used the most satisfactory were Heidenhain's Iron-hæmatoxylin, Brazilin,¹ and Delafield's Hæmatoxylin. With the last stain perfect results were obtained by overstaining and differentiating with acido-alcohol.

The structure of the thoracic ganglion was studied by means of reconstructions. The method employed was as follows:—The sections were drawn by means of the camera lucida on Bristol board of a thickness proportional to the magnification. They were afterwards cut out and seccotined together. The resulting model was trimmed and soaked in melted paraffin, taken out and dipped several times till a thin coating of paraffin covered the model. This was then trimmed down to the original size, all the interstices having been filled by the paraffin. After a coating of graphite it was electrotyped with copper. In this way a permanent model was obtained.

III. EXTERNAL STRUCTURE.

1. THE HEAD CAPSULE.

The head capsule of M. domestica presents great modifications when compared with the typical insect head. Considerable difficulty is experienced in explaining its structure in the morphological terms employed in the simpler orders of insects. Lowne did not lessen the difficulty in describing the head of the blowfly by the invention of new terms of little morphological value. The head of the fly is strongly convex in front (Pl. 23, fig. 1), the posterior surface being almost flat and slightly conical. For the sake of clearness the

composition of the head capsule will be described from behind forwards. The occipital foramen occupies a median slightly ventral position on the posterior surface. It is surrounded by the occipital ring, the inner margin of which projects into the cavity of the head. From the sides of the inner margin of the occipital ring two short chitinous bars bend inwards and approach each other internally, forming a support—the jugum for the tentorial membrane. On each side of the occipital ring below the jugum a small cavity occurs into which a corresponding process from the prothorax fits, forming a support for the head.

The occipital ring is surrounded by the four plates, which make up the sides and back of the head capsule. On the ventral side, between the occipital ring and the aperture from which the proboscis depends, a median basal plate, the gulo-mental plate, represents the fused gula and basal portions of the greatly modified second maxillae. The occipital segment is bounded laterally by the gense (Lowne’s paracephala) and dorsally by the epicranium. These parts have been divided by systematists into so many regions that a somewhat detailed description will be necessary to make their boundaries clear.

The gense bear the large compound eyes which occupy almost the whole of the antero-lateral regions of the head. On the posterior flattened surface of the head the gense are flat, and extend from the gulo-mental plate to the epicranial plate, the sutures of the latter being vertical. On the dorsal side each sends a narrow strip between the inner margin of the eye and the epicranium; this strip surrounds the eye and meets the ventral portion of the gena; it is of a silver to golden metallic lustre. On the ventral side below the eye each gena bounds the proboscis aperture laterally; a number of stout bristles arise from this margin and also from its antero-lateral region, which is often spoken of as the “jowl.” In the anterior region, where the gense are in contact with the clypeus, there are two prominent ridges bearing strong setae; these are usually known as the “facialia.”
The epicranium (epicephalon of Lowne) on the posterior surface of the head is flat. On the anterior surface it is convex, and divided into a number of regions. On the top of the head between the eyes it is called the vertex. This contains the three ocelli situated on a slightly raised ocellar triangle, which is surrounded by a second triangle, the vertical triangle. The median region in front of and below the vertex is the frons. In the middle of this there is a black frontal stripe. In the male the eyes are only narrowly separated by the frontal stripe. In the female the frontal stripe widens out on the vertex. This character provides a ready means of distinguishing the male from the female, as the result of it is that in the male the eyes are close together on the dorsal side being separated by about one fifth of the width of the head, whereas in the female the space between the eyes is about one third the width of the head. The edges of the genæ bordering on the frons bear each a row of stout setæ—the fronto-orbital bristles. The antennæ arise from the lower edge of the frons. Each antennæ consists of three joints and the arista. The two proximal joints are short and compose the "scape." The third joint, the flagellum, is longer, somewhat cylindrically prismatic in shape, and hangs vertically in front of the clypens. It is covered with sensory setæ, and contains two pits of sensory function (olfactory, I believe). From the upper side the plumose arista arises. This probably represents the terminal three joints of the antenna. The lower edge of the frons represents the anterior margin of the epicranium.

The rest of the facial region is composed of the clypeus or, as it is usually called, the face—a convenient term, but one which hides its true morphology. The face is depressed, and is covered by the flagellæ of the antennæ. Between the upper and lateral edges of the face and the lower edge of the epicranium a crescentic opening, the lunule, marks the invagination of the ptilinium. The epistomium is a narrow strip below the face bounding the anterior edge of the proboscis aperture.
The Skeleton of the Proboscis.—The proboscis of *M. domestica* is very similar to that of the blowfly, which has been described by Kraepelin (1880) and Lowne (1895), though the results of these authors differ in many details. My study of *M. domestica* confirms Kraepelin's results, and as Lowne's is the only complete account of the muscid head a full description of its internal and external anatomy will be given in this paper.

Lowne regards the greater part of the proboscis as being developed from the first maxillae and not from the labium or fused second maxillae, which is the usually accepted view and one which I support on morphological grounds. On account of his exceptional conclusion he refuted the commonly accepted terms for the various parts and invented new ones. It will be necessary for the sake of descriptive clearness to refrain from constant reference to these or any discussion as to their value.

The proboscis consists of two parts, a proximal membranous conical portion—the rostrum and a distal half the proboscis proper which bears the oral lobes. The term haustellum is also used for this distal half (minus the oral lobes), and as a name it is probably more convenient, as the term proboscis is used for the whole structure—rostrum, haustellum, and oral lobes.

The rostrum (fig. 13, Ros.) is attached to the edges of the proboscis aperture, that is to the epistomium, genae, and the gulo-mental plate. It has the shape of a truncated cone, and bears on the anterior side a pair of palps, which bear sensory setae of two sizes.

The haustellum (fig. 13, H.), or proboscis proper, is attached to the distal end of the rostrum. The posterior side is formed by a convex, somewhat heart-shaped sclerite—the theca (figs. 1 and 3, th.) which probably represents a portion of the labium. The lower angle of the theca is incised by a semicircular sinus. By means of this the theca rests on a triradiate chitinous sclerite—the furca, which consists of a median, slightly convex rod (fig. 1, f.), from the
anterior end of which two arms diverge and form the chief skeletal structures of the oral lobes. The lower end of the theca rides on this structure, the bottom of the sinus resting on the median rod, and the two-pointed lateral terminations of the theca rest on the arms. In this manner these processes, in a state of repose, keep the arms of the furca closely approximated. The result of this will be seen later in studying the musculature of the proboscis.

The sides of the haustellum are membranous. On its anterior face, in a groove formed by the overlapping membranous sides, lie the labrum-epipharynx and labium-hypopharynx. The labrum-epipharynx (figs. 1 and 3, l.ep.) is attached at its proximal end to the membranous rostrum, but is incapable of a labral-like movement on account of its close connection with the labium-hypopharynx. Two slightly-curved, hammer-shaped apodemes (fig. 1, ap.) are attached to the proximal end of the labium-epipharynx. They assist in folding the proboscis during retraction, as will be shown later. The labium-epipharynx is shaped like a blunt arrow-head; the external surface is somewhat flattened. It is composed of two pairs of sclerites, an outer pair enclosing an inner pair, which form the pharyngeal channel. The edges of the inner tube are connected by a groove with the hypopharyngeal portion of the labium-hypopharynx, as shown in fig. 3. The labium-hypopharynx (fig. 3) represents the fusion of the hypopharynx with the greatly modified and fused second maxillae or labium. It consists of a sclerite, curved in section, having the chitinous hypopharyngeal tube (fig. 3, hp.) fused to it along the upper half of its length. The edges of the hypopharyngeal tube engage with those of the inner pair of sclerites of the labium-epipharynx, as mentioned before. Distally the hypopharyngeal tube becomes free from the labium, as shown in fig. 3, and ends in a point where the lingual salivary duct opens.

Down each side of the labium-hypopharyngeal sclerite a rod-like thickening runs. Distally these thickened margins (paraphyses of Lowne) articulate with the discal sclerites.
The discal sclerites (fig. 1, ds.) are united at the posterior end to form, when the oral lobes are expanded, a U-shaped structure, with the limbs constricted in the middle where the ends of the thickened margins of the labium-hypopharynx articulate. They are sunk in deeply between the two oral lobes at the base of the oral pit with the free ends of the U anterior, these being spatulate and curved anteriorly.

The two oral lobes are normally connected by a bead and groove attachment along their anterior edges, but under pressure the connection is severed, and the oral disc presents a heart-shaped instead of the normal oval appearance. The oral lobes are covered on their upper aboral surfaces by sensory setae, the large marginal setae being different in structure from the rest. On the lower or oral surface a large number of channels, the pseudotracheæ (fig. 1, ps.) run from the internal margins of the oral lobes to the external borders. The channels of the pseudotracheæ are kept open when the lobes are extended by means of small incomplete chitinous rings, which give the channels a tracheal appearance, hence their name. Each of these incomplete rings has one end bifid, and as the bifid ends alternate the opening into the channel has a zigzag appearance. The number of pseudotracheæ on each lobe is generally thirty-six, and they are grouped in three sets. The anterior set of twelve all run into a single large pseudotracheal channel running along the anterior inner margin of the lobe, and a posterior set of twenty-one all run into a channel running along the posterior inner margin; between these two sets three pseudotracheæ run direct into the oral aperture. The oral aperture lies at the base of the small oral pit, which is a space kept open between the oral lobes by means of the discal sclerites. The pseudotracheæ do not extend as far as the discal sclerites, but on entering the oral pit the rings cease and the sides of the channels are covered by overlapping teeth, which extend back to the discal sclerites. Between the pseudotracheæ the membranous surface of each oral lobe is thrown into two longitudinal sinuous ridges, and projecting up from the
bottom of the furrows are several papillae, generally four or five to each interpseudotracheal area, of a gustatory nature—the gustatory papillae (figs. 1 and 18, pp.).

The Fulcrum.—This chitinous portion of the pharynx (fig. 1, F.) lies on the lower part of the head and in the rostrum. Kraepelin describes it as being shaped like a Spanish stirrup iron. Its structure will be best understood by referring to the figures. It consists of an outer portion, which is U-shaped in section; the basal portion, which is posterior and forms the floor of the pharynx (which Lowne, unfortunately, terms the hypopharynx) is vertical when the proboscis is extended. This basal portion is evenly rounded at both ends, and at the sides of the upper end there is a pair of processes—the posterior cornua (fig. 1, pc.) which serve for the attachment of muscles. The sides of the fulcrum are somewhat triangular in shape; their upper anterior portions are produced to form the anterior cornua (a.c.); here the sides bend inwards at right angles, and meet below the epistomium, upon which the fulcrum is hinged. The fulcrum is therefore quadrilateral in section at the upper proximal end, and trilateral at the lower distal end. The basal portion (fig. 2, b.p.) forms the floor of the pharynx; the roof of the pharynx is formed by another chitinous piece (r.p.) with a median thickened raphe. This roof lies parallel with the basal piece, and is fused with the sides of the fulcrum. On the membranous wall of the pharynx, between the labium-hypopharynx and the fulcrum, a small chitinous sclerite (fig. 1, k.) is developed, which Lowne terms the hyoid sclerite. It is U-shaped in section, and serves to keep the lumen of the pharynx in this region distended.

2. The Thorax.

As in all Diptera the possession of a single pair of wings has resulted in the great development of the mesothorax at the expense of the other thoracic segments, consequently the thorax is chiefly made up of the sclerites composing the
mesothorax. The prothorax and metathorax compose very small portions on the anterior and posterior faces respectively. Seen from above the thorax is oviform with the blunt end anterior and slightly flattened. Three transverse sutures on the dorsal side mark the limits of the prescutum, scutum, and scutellum of the mesothoracic segment; the mesothoracic scutellum forms the pointed posterior end, and slightly overhangs the anterior end of the abdomen.

The Prothorax.—The prothoracic segment has been reduced to such an extent that it is hopeless to attempt to homologise all the separate sclerites with those of a typical thoracic segment. To obtain a complete view of the prothorax it is necessary to examine it from the anterior end after the removal of the head. The following sclerites can then be recognised. The prosternum is a median ventral plate, quadrilateral in shape having the anterior end rounded and broader than the posterior end. It does not occupy the whole of the prosternal area, but is bounded by the prosternal membrane. Internally a ridge runs to the posterior end of the prosternum and bifurcates, each ridge running to the posterior corners, to which two strong processes (the hypotremata of Lowne) are attached. In front of the prosternum there is a small saddle-shaped sclerite which, on account of its position, may be called the interclavicle (the sella of Lowne). Two lobes at its anterior end are covered with small processes, probably sensory in function. A pair of small sclerites is situated in front of these lobes; these sclerites with the interclavicle no doubt belong to the prosternum. The interclavicle is ventral to the cephalothoracic foramen. The jugulares (3me jugulaires of Kunckel d'Herculais) are two prominent pocket-shaped sclerites lying one on each side of the cephalothoracic foramen, and having their convex faces external. Lying immediately below each of the jugulares is a small rod-like sclerite—the clavicle. The dorsal region of the prothorax the pronotum (fig. 6 pr.n.) is formed by two sclerites united in the median line, their dorsal sides being curved. From the ventral side of the pronotum a pair of
chitinuous apodemes project into the thoracic cavity. The lateral regions of the pronotum are in contact with the humeri and the prothoracic episterna. The humeri (hu.) are a pair of strongly convex sclerites situated in the antero-lateral region of the thorax. They are bounded above by the prescutum of the mesothorax, internally and below by the episterna of the prothorax, and externally by the lateral plate of the mesosternum and the anterior thoracic spiracle. Its inner concave surface serves for the attachment of the muscle of the prothoracic coxa. The episterna (eps.)(epitrochlear sclerites of Lowne) are comparatively large sclerites forming the lateral regions of the prothorax. They overhang the attachments of the prothoracic limbs. The internal skeleton of the prothorax consists of the two stout hollow apodemes—the hypotremata mentioned previously. They arise from the postero-lateral edges of the prosternum, and run obliquely across the ventral edge of the anterior thoracic spiracle where the hypotreme divides, the posterior branch runs up the posterior margin of the spiracle, between the lateral plate of the mesosternum and the peritreme (the chitinuous ring surrounding the spiracle), the anterior branch fuses with the prothoracic episternum.

The Mesothorax.—The notum of the mesothorax occupies the whole of the dorsal side of the thorax. It is composed of the four sclerites to which Audouin (1824) gave the name of prescutum, scutum, scutellum, and postscutellum. The prescutum (prs.) forms the anterior part of the dorsal region of the thorax. Its anterior portion bends down almost vertically to unite with the pronotum. The anterior edge of the prescutum is inflected after the pronotal suture, and is produced in the median line into a small bifurcating process. The prescutum is bounded laterally by the humerus and a membranous strip—the dorso-pleural membrane. The scutum (se.) is the largest of the mesonotal plates. It occupies the whole of the median dorsal region of the thorax. Anteriorly it is bounded by the prescutum, laterally by the alar membrane and the lateral plate of the postscutellum, and posteriorly by
the scutellum. From the lateral region of the scutum a process projects forwards and downwards, and articulates with the posterior portion of the wing-base (the metapterygium). The scutellum (scut.) is a triangular pocket-shaped sclerite which overhangs the postscutellum and the base of the abdomen. The posterior surface of the thorax is chiefly composed of the large postscutellum. This is made up of three pieces, a median escutcheon-shaped plate (mpsc.) strongly convex to the exterior, and two convex lateral plates (lp.sc.). The lateral plates are bounded below by the metasternum and spiracles, and anteriorly by the pleural region of the mesothorax.

The mesosternum is a sclerite of considerable size and forms the keel of the thorax. It consists of a median ventral portion (ms.) which is produced laterally to form two large lateral plates (lp.). The median portion is bounded in front by the prosternum and the foramina of the anterior coxae, and behind by the median coxal foramina. A short distance behind the anterior end a depression in the mid-ventral line extending to the posterior edge indicates a median inflection forming the entothorax. The lateral regions of the posterior margins of the mesosternum are inflected on each side to form the entopleura. The lateral plates of the mesosternum form the whole of the anterior portion of the pleural region; each is bounded in front by the humerus, spiracle, and prothoracic episternum, and above by the dorso-pleural membrane, and behind by the mesopleural membrane. The ventral side of the lateral plate is continuous in front with the median plate of the mesosternum, and behind is united by means of a suture. The remaining portion of the mesopleural region is made up of the episternum, epimeron, and two small sclerites connected with the wing-base—the parapteron and costa. The episternum (eps.) is situated behind the mesopleural membrane and below the alar membrane, below and behind it is bounded by the epimeron. Its surface is marked by two convexities, the ampullæ, the upper of the two corresponding to Lowne's great ampulla of the blowfly. The dorsal side of
the episternum is intimately connected with the sclerites of the anterior portion of the wing-base.

The epimeron (ep.) is a triangular sclerite, and is bounded below by the mesosternum and metasternum, behind by the lateral plate of the postscutellum, and above by the episternum and alar membrane. The parapteron (pt.) is a sclerite situated at the top of the mesopleural membrane. The greater portion of it is internal, only a small triangular portion can be seen externally. Internally this is continued as a cruri-form sclerite to which are attached important muscles controlling the wings. The costa (ca.) is a small sclerite situated on the dorsal margin of the epimeron. The internal skeleton of the mesothorax consists of the entothorax, entopleura, mesophragma, and the inflected edges of the episterna and epimera. The entothorax is composed of a median vertical plate subtriangular in shape, on the top of which a median plate produced laterally into wing-like processes rests. On this structure the thoracic nerve-centre lies. The entopleura and the inflected edges of the epistera and epimera all serve for the attachment of wing muscles. The mesophragma (mph.) is a convex sclerite fused with the lower edge of the postscutellum. Its posterior edge is incised in the middle and forms the dorsal arch of the thoraco-abdominal foramen.

The Metathorax.—The largest sclerite of the greatly reduced metathorax is the metasternum (mts.). It is a wing-shaped sclerite with the narrow transverse portion situated between the coxal foramina of the median and posterior pairs of legs; the expanded lateral portions form the wall of the thorax above the insertions of these legs. The edges of the narrow transverse strip are inflected, and unite the lateral portions of the metasternum. A trough-shaped longitudinal fold—the metafurca rests on the narrow transverse portion of

1 In this account the individual sclerites which compose the wing base will not be described. Lowe has described them at great length for the blowfly, and although the wing-base sclerites of M. domestica differ slightly in shape from those of Calliphora, Lowe's description of their relations holds good for the former insect.
the metasternum. The posterior end of the metafurca bends downwards and articulates with the posterior coxae on each side. The metafurca serves for the attachment of the thoraco-abdominal muscles. The pleural region of the metathorax is a narrow triangular space situated behind the lateral portion of the metasternum and the posterior coxae. It is composed of a narrow triangular episternum and epimeron. The former (eps.) is bounded in front by the metasternum, the posterior thoracic spiracle and the base of the haltere, below by the posterior coxal foramen, and behind by the epimeron. The epimeron (ep.) is also bounded below by the coxal foramen and behind by the narrow dorsal arch of the metathorax and the first abdominal segment, its apex comes in contact with the base of the haltere. The dorsal region of the metathorax has practically disappeared, all that can be recognised as metanotum is a narrow chitinous strip (mn.) on each side between the apex of the metapleural area and the dorsal edge of the first abdominal area.

Wings.—The wings are situated at the sides of the scutum on the alar membrane, to which are attached the sclerites of the wing base. They are covered with very fine hairs.

In describing the neuration of the wings the nomenclature proposed by Comstock and Needham (1898) for the wings of the whole group of insects will be employed.

The nervures of the wing are ocreaceous. The anterior edge of the wing (fig. 16) is formed by a stout nervure, the costa (C1.), which is very setose. The second longitudinal nervure, the subcostal (Sc1.), joins the costal about half way along its length. A small transverse nervure, the humeral (h.), divides the costal cell into costal (C.) and first costal (1 C.) cells. The next main nervure—the radial—divides into a number of branches (in the typical insect five); some of these have coalesced in the fly. A nervure joining the costal just past the middle is the first radial (R1.) cutting off the subcostal cell. The next nervure, which joins the costal on the apical curve, represents the fused second and third radial nervures
This cuts off the first radial cell ($1R$.). The last nervure, which joins the costal almost at the apex of the wing, represents the fused fourth and fifth radial nervures ($R. 4 + 5$), and so cuts off the third radial cell ($3R$.). The fourth main longitudinal nervure is the median, which, in the typical insect, divides into three, but in the fly the nervures have undergone coalescence, as will be shown. The first and second median nervures have coalesced ($M. 1 + 2$), and do not run direct to the margin of the wing, but bend forwards and almost meet $R. 4 + 5$ on the costa. About half way across the wing a transverse nervure, the radio-medial ($rm.$) unites $R. 4 + 5$ and $M. 1 + 2$, and cuts off the fifth radial cell ($5R.$) from the radial ($R.$). The next longitudinal nervure represents the coalesced third medial and cubital nervures ($M. 3 + Cu. 1$). It runs to the posterior margin of the wing about half way along the length of the latter. The nervures $M. 1 + 2$ and $M. 3 + Cu. 1$ are united by two transverse nervures. The proximal nervure—the medio-cubital ($m.cu.$) cuts off the small triangular medial cell ($M.$); the distal transverse nervure ($m.$) cuts off the first second medial cell ($2 M.$) from the second second medial cell ($2 M.$). The last longitudinal nervure—the anal ($A.$)—is undivided, and does not reach the margin of the wing, thus incompletely separating the first cubital ($1 Cu.$) and anal ($A.$) cells. A small transverse nervure, the cubito-anal ($cu.a.$), slightly more proximal than the medio-cubital, cuts off the small triangular cubital cell ($Cu.$) from the first cubital cell ($1 Cu.$). Running parallel with, and posterior to, the anal longitudinal nervure, there is apparently another nervure. This, however, is not a true nervure, but is merely a chitinised furrow giving additional strength to the posterior angle of the wing. The posterior edge of the base of the wing is divided into a number of lobes. These are the anal lobe, and, as Sharp (1895) proposed, the alula, antisquama, and squama. The squama is thicker than the rest, and is attached posteriorly to the wing root between the mesoscutum and the lateral plates of the
postscutellum. It covers the haltere, as in all "calyptrate" Muscidae.

The Halteres.—The halteres or balances (fig. 6, hal.) are generally considered to represent the rudimentary metathoracic wings. They are covered by the squamae, and are situated on the sides of the thorax above the posterior thoracic spiracles. Each consists of a conical base on which are a number of chordonotal sense-organs, and on this base is mounted a slender rod, at the end of which a small spherical knob is attached. The wall of the distal half of this sphere is thinner than the proximal half, and in preserved specimens is generally indented. Experiments show that the

1 The nomenclature of Comstock and Needham has not yet been adopted by dipterologists in general; but, on account of its great morphological value, it will no doubt in course of time replace the present confused system. It may therefore be useful if the nomenclature employed in the foregoing description be compared with those most usually employed.


Transverse nerves.—h. Humeral, 1st transverse; basal cross vein (Verrall). rm. Discal, 2nd transverse; middle cross vein (Verrall); medial transverse; anterior transverse (Austen). m-cu. Anterior basal transverse (Austen); lower cross vein (Verrall); postical transverse (Lowne). m. Posterior transverse (Austen); postical cross vein (Verrall); discal transverse (Lowne). cu-a. Posterior basal transverse (Austen); anal cross vein (Verrall); anal transverse (Lowne).

Cells.—C. Costal. 1 C. Second costal. Sc. Third costal (Lowne correctly calls this "sub-costal"). 1R. Marginal. 3R. Sub-marginal; cubital (Lowne). 5 R. First posterior cell (Austen); sub-apical (Lowne and Verrall). 2 M'. Second posterior cell (Austen); apical. 1 Cu. Third posterior cell (Austen and Verrall); patagial (Lowne). 2 M'. Discal (this term is used also in Lepidoptera, Trichoptera, and Pscoptera, and in each family refers to a different cell!). R. Anterior basal cell (Austen); upper or 1st basal or radical (Verrall); prepatagial (Lowne). M. Posterior basal cell (Austen); middle or 2nd basal or radical (Verrall); anterior basal (Lowne). Cu. Anal cell (Austen); lower or 3rd basal or radical (Verrall); posterior basal (Lowne).
halteres are organs of a static function. They are not balancing organs in the sense that they are equivalent to the balancing pole of a rope-walker. They also have probably an auditory function. They are innervated by the largest pair of nerves in the thorax.

The Legs.—The three pairs of legs are composed of the typical number of segments. Each consists of coxa, trochanter, femur, tibia, and tarsus. The coxae are the only segments which show any considerable difference in the three pairs of legs. The anterior coxae are comparatively large and boat shaped, the intermediate coxae are smaller and their separate sclerites more marked; the coxal plates of the intermediate coxae are shown in fig. 6 (cp.). The coxal joints of the posterior pair of legs are almost similar to those of the intermediate pair. The anterior femora are shorter and stouter in the middle than those of the intermediate posterior pairs of legs. The anterior tibiae are also shorter than those of the succeeding legs. The anterior tibiae are covered on their inner sides with closely-set, orange-coloured setae which serve as a comb by means of which the fly removes particles of dirt adhering to the setae which clothe its body; the first tarsal joints of the posterior legs are also similarly provided. The tarsi consist of five joints, the terminal joints bearing the "feet." These organs about which so much has been written consist of a pair of curved lateral claws or "ungues" which subtend a pair of membranous pyriform pads—the pulvilli. The pulvilli are covered on their ventral sides with innumerable, closely-set, secreting hairs by means of which the fly is able to walk in any position on highly polished surfaces. A small sclerite lies between the bases of the pulvilli. The tarsal joints and the other segments of the legs are covered with a large number of setae.

3. The Abdomen.

The abdomen is oviform with the broad end basal. The total number of segments which compose the abdomen is eight in the male and nine in the female. The visible portion con-
sists of apparently four segments in the male and female, in reality there are five as the first segment has become very much reduced, and has fused with the second abdominal segment forming the anterior face of the base of the abdomen (see fig. 8). The segments succeeding the fifth are greatly reduced in the male, and in the female they form the tubular ovipositor which, in repose, is telescoped within the abdomen. The second, third, fourth, and fifth abdominal segments are well developed, and consist of a large tergal plate, which extends laterally to the ventral side. The sternal plates are much reduced, and form a series of narrow plates lying on the ventral membrane along the mid-ventral line. The spiracles are situated on the lateral margins of the tergal plates. The sclerites of the abdomen which are exposed are strongly setose, especially the fourth and fifth dorsal plates, but they do not bear macrochaebæ.

IV. INTERNAL STRUCTURE.

1. The Muscular System.

The muscular system of the fly is similar to that of Volucella, described by Kunckel d'Herculais (1881), and of the Blow-fly, described by Lowne and Hammond, and consequently they will be but briefly described. The muscles may be divided into the following groups: 1. Cephalic, 2. Thoracic, 3. Segmental, 4. Those controlling the thoracic appendages, and 5. Special muscles.

1. The cephalic muscles will be considered in the detailed description of the head.

2. The thoracic muscles are enormously developed and almost fill the thoracic cavity. They are arranged in two series. The dorsales (figs. 13 and 15, do.) are six pairs of muscle-bands on each side the median line, attached posteriorly to the postscutellum and mesophragma, and anteriorly to the prescutum and anterior region of the scutum. The sternodorsales (st.do.) are vertical and external to the dorsales and are arranged in three bundles on each side. The first
two pairs have their upper ends attached to the prescutum and scutum, and their lower ends inserted on the mesosternum, the third pair is attached dorsally to the scutum and ventrally to the lateral plate of the postscutellum above the spiracle. As Hammond has shown in the blowfly (1881) all these muscles are mesothoracic. The dorsales by contraction loosen the alar membrane and so depress the wing, the sternodorsales have the opposite effect.

3. The segmental muscles. These muscles, which are so prominent in the larva, have almost disappeared in the imago. They are represented by the cervical muscles, certain small thoracic muscles, the thoraco-abdominal muscles, and the segmentally-arranged abdominal muscles together with the muscles controlling the ovipositor and male gonapophyses.

4. The muscles controlling the thoracic appendages, the wings, legs, and halteres. There is an elaborate series of muscles controlling the roots of the wing, but in order to avoid too much detail they will not be described here. The flexor muscles of the anterior coxae have their origin on the inner surfaces of the humeri, a fact supporting the pro-thoracic nature of these sclerites; the flexors of the middle pair of legs have their origin on the sides of the posterior region of the prescutum. The internal muscles of the leg are similar to those of the blowfly and Volucella.

5. Special muscles. These are the muscles controlling the spiracular valves, the penis, and other small muscles.

2. The Nervous System.

The central nervous system (fig. 11) consists of (1) the brain or supracesophageal ganglia which are closely united with the subcesophageal ganglia, the whole forming a compact mass which I propose to call the cephalic ganglion (fig. 1, C.G.), perforated by a small foramen for the passage of the narrow cesophagus, and (2) the thoracic compound ganglion which is composed of the fused thoracic ganglia with the abdominal ganglia. The two compound nerve-centres are
united by a single median ventral cord running from the suboesophageal ganglia to the anterior end of the thoracic nerve-centre.

The cephalic ganglion consists of the supraoesophageal ganglion and the suboesophageal ganglia so closely united that the commissural character of the circumoesophageal connectives is quite lost. Externally, on the dorsal side of the brain three longitudinal fissures can be seen, a median fissure and two lateral fissures marking the origin of the optic lobes.

The supraoesophageal ganglia. The characters of the ganglia composing the brain are hidden by the sheath of cortical cells which fills up the spaces between the ganglia, the characters of these can be ascertained by the serial sections. The median mass the procerebrum is formed by the fusion of the procerebral lobes. These are united before and behind, and enclose a central ganglionic mass—the central body. Behind the procerebrum two pairs of fungiform bodies arise. On the anterior face of the procerebrum the antennal or olfactory lobes which represent the deutocerebrum are situated laterally. Each sends a nerve (figs. 1 and 11, an.n.) to the antenna. Above these and on the dorsal side are a pair of lobes—the frontal lobes contiguous with each other in the median line—these belong morphologically to the tritocerebrum. Posterior to these in the median dorsal line of the cerebrum a single median nerve, the ocellar nerve (figs. 1 and 11, oc.n.), arises; this runs vertically to the ocelli. A pair of lobes which correspond to Lowne’s thalami of the blowfly are situated external to and between the frontal and antennal lobes. The peduncles of the optic lobes have their origins from the sides of the procerebrum. Each optic peduncle (fig. 11, O.P.) contains three ganglionic masses which Hickson (1885) has termed from the brain peripherally the opticon, epiopticon, and periopticon (fig. 1, P.O.) respectively.

The suboesophageal ganglia (fig. 1, S.O.). The commissures uniting the supraoesophageal ganglia to the oesophageal mass cannot be recognised as such, owing to the extreme state of cephalisation of the cephalic ganglia. They are
represented by the regions lateral to the oesophageal foramen, and from the anterior side of each of them arises a pharyngeal nerve (figs. 1 and 11, ph.n.). From the ventral side of the suboesophageal ganglia a pair of nerves—the labial nerves (fig. 1, lb.n.)—arise and run down the proboscis, innervating the muscles of that organ; on reaching the oral lobes they bifurcate and branch freely, supplying the numerous sense organs in those structures. The cortical cells (Leydig’s “Punktsubstanz”), which fill up the spaces between the ganglia and form an investing sheath round the whole ganglionic mass, are of two kinds. The smaller cells are rounded, their nuclei are large in proportion to the protoplasm, and their protoplasmic fibres anastomose with each other. Among these smaller cortical cells, and also occasionally in the ganglionic substance, larger ganglionic cells occur, their protoplasm taking the stain very readily. Unipolar, bipolar, and tripolar ganglion cells are found.

The eyes. Each eye contains about 4000 facets. They are similar in all respects to the eyes of the blowfly, which have been fully described by Hickson (loc. cit.), whose results my study confirms; consequently, a description of their structure will not be given. It should be noted that, in spite of the fact that Hickson corrected many mistaken views held by Lowne in his memoir (1884), these are repeated in his monograph of the Blowfly.

The cephalo-thoracic nerve cord (fig. 11, c.n.) unites the cephalic and thoracic ganglia. Near its junction with the thoracic ganglion a pair of cervical nerves (cer.n.) arise, innervating the muscles of the neck.

The thoracic ganglion (figs. 12 and 14) is pyriform, with the broad end anterior, and rests on the entothoracic skeleton of the mesothorax. As in the cephalic ganglion, the component ganglia are ensheathed in a cortical layer, which is of the same nature. The nerves of the three pairs of legs (pr.cr., ms.cr., mt.cr.) arise from three large ganglia, which are the prothoracic (Pr.G.), mesothoracic (Ms.G.), and metathoracic (Mt.G.) ganglia. These are united by a median
longitudinal band of nerve tissue, which runs dorsal to them, and behind the metathoracic ganglia swells out into a ganglionic mass (A.G.), which represents the abdominal ganglia. In this median dorsal band there is a median dorsal fissure stretching posteriorly from above the middle of the mesothoracic ganglia. The dorsal regions of the mesothoracic and metathoracic ganglia show ganglionic swellings. From the antero-dorsal sides of the prothoracic ganglia a pair of prothoracic dorsal nerves (pr.d.) arise and supply the muscles of that region, including those of the anterior thoracic spiracle. The nerves supplying the mesothoracic legs (ms.cr.) arise from the postero-ventral sides of the mesothoracic ganglia. Between the mesothoracic ganglia there is a median ganglionic mass, situated slightly dorsal, from the middle region of which the nerve-fibres of the large pair of dorsal mesothoracic nerves (m.s.d.) arise; Lowne, in the blowfly, calls these prothoracic. The roots of these nerves are broad dorsoventrally. These nerves innervate the sterno-dorsales muscles of the middle region. In this median mesothoracic nerve centre, posterior to the origin of the dorsal mesothoracic nerves, the fibres of a pair of nerves, the accessory dorsal mesothoracic nerves (ac.ms.), have their origin; these appear externally to arise dorsal to the roots of the mesothoracic crural nerves. The dorsal metathoracic nerves (mt.d.), which innervate the halteres, and are the largest pair of thoracic nerves, have their origin from the median dorsal band in front of the metathoracic ganglia, so that they appear to be almost mesothoracic in origin. The metathoracic crural nerves (mt.cr.) arise from the posterior-ventral sides of the metathoracic ganglia. Posterior to these a pair of slender nerves, the accessory dorsal metathoracic nerves, have their origin, and innervate the muscles at the posterior end of the thorax.

The dorsal band becomes much thinner posterior to the abdominal ganglion, and runs into the abdomen as a median abdominal nerve (ab.n.). In the thorax two pairs of abdominal nerves arise. In the abdomen the abdominal nerves
arise alternately and irregularly from the median abdominal nerve. The median abdominal nerve finally terminates in the genitalia.

3. The Alimentary System.

The alimentary canal of the house-fly is shorter than that of the blowfly, and also than that of Glossina described by Minchin (1905), and slightly longer than the alimentary tract of Stomoxys described by Tulloch (1906). It serves as a good example of the Muscid digestive canal. It is of a suctorial character, and consists of pharynx, oesophagus, crop, proventriculus, ventriculus or chyle stomach, proximal and distal intestine and rectum.

The pharynx has already been described, and will be further referred to in the detailed description of the head. At the proximal end of the fulcrum, where the oesophagus arises, there is usually a small mass of cells, which Kraepelin has described as glandular, but which I believe to be simply fat-cells.

The oesophagus (figs. 1, 17, 20, oes.) commences at the proximal end of the pharynx, and describes a curve before passing through the oesophageal foramen in the cephalic ganglion, where it narrows slightly. It then passes through the cervical region into the thorax in the anterior region, of which it opens into the proventriculus (figs. 17, 20, Pv.), continuous with, and in the same line as the oesophagus, the duct leading to the crop (fig. 20, d.cr.) passes along the thorax dorsal to the thoracic nerve-centre, and entering the abdomen it leads into the crop, which lies on the ventral side of the abdomen. The oesophagus has a muscular wall, enclosing a layer of flat epithelial cells, and is lined by a cuticular intima, which is thrown into several folds at the anterior end.

The crop (fig. 17, Cr.) is a large bilobed sac, capable of considerable distension, and, when filled with the liquid food, it loses its bilobed shape, and occupies a large portion of the
antero-ventral region of the abdomen. Its walls exhibit muscular (unstriped) fibres; the flat epithelial cells have a very thin cuticle.

The proventriculus (Po.) is circular and flattened dorso-ventrally. Its structure will be understood by reference to fig. 20. In the middle of the ventral side it opens into the oesophagus, and on the dorsal side the outer wall is continued as the wall of the ventriculus (Ven.). The interior is almost filled up by a thick circular plug (Pv.p.), the cells of which have a fibrillar structure, and it is pierced through the centre by the oesophagus. The neck of the plug is surrounded by a ring of elongate cells, external to which the wall of the proventriculus begins, and, enclosing the plug at the sides and above, it merges into the wall of the ventriculus. I do not agree with Lowne in regarding the proventriculus as "a gizzard and nothing more," but its structure suggests a pumping function and also that of a valve. On the dorsal side of the oesophagus, at its junction with the proventriculus, a small ganglion, the proventricular ganglion (Pv.g.), lies, communicating by a fine nerve with the cephalic ganglion.

The ventriculus, or chyle stomach (figs. 17, 20, Ven.), represents the anterior region of the mesenteron, the posterior region of the latter being formed by the proximal intestine. It is narrow in front, and widest in the posterior region of the thorax, where it again narrows in passing through the thoraco-abdominal foramen into the abdomen to become the proximal intestine. Except in the anterior and posterior regions, where columnar cells compose the digestive epithelium, the walls of the ventriculus are thrown into a number of transverse folds, which are again subdivided longitudinally, the result being the formation of small crypts or sacculi, which are lined by large cells. These sacculi correspond to the digestive coeca of other insects.

The proximal intestine (figs. 17, 21, p.int.) is the longest region of the gut. It varies in length considerably. In the normal-sized condition its course is as follows:—Beginning at the anterior end of the abdomen it runs dor-
sally beneath the heart to the posterior region, where it curves downwards, turns to the left, and runs forward for a short distance, curving to the right, where it doubles back transversely to the left. Here it doubles sharply back to the right, from whence it runs forward for a little way, and crosses over to the left. Curving, it runs posteriorly to become the distal intestine. Its walls are lined by an epithelium of large columnar cells.

The distal intestine (d.int.). The junction of this with the proximal intestine is marked by the entrance of the ducts of the malphigian tubes. It runs posteriorly, and curves dorsally and forwards to become the rectum, from which it is separated by a cone-shaped valve—the rectal valve, the position of which is marked externally (fig. 21, X.). The epithelium of the distal intestine consists of small cubical cells, which project into the lumen, and are covered by a fairly thick chitinous intima. The epithelial wall of the distal intestine is thrown into usually about six longitudinal folds.

The rectum (rect.) is composed of three parts, an anterior region, an intermediate region which is swollen to form the rectal cavity, and a shorter region posterior to this which opens externally by the anus. The anterior region is lined by cubical cells, whose internal faces project into the lumen of the rectum, and give the chitinous intima a tuberculated structure. The intermediate region which forms the rectal cavity contains the four rectal glands (rect.gl.). Its walls are lined by a thin cuticle supported by a flattened epithelium. The posterior portion of the rectum is short, and has thick muscular walls. The cuticular intima is continuous with that of the external skeleton.

Salivary Glands.—There are two sets of salivary glands—a pair of labial and a pair of lingual glands. The structure of the labial glands will be described in the account of the anatomy of the head.

The lingual glands (fig. 17, sl.g.), though considerably longer than the total length of the body, are of the simplest
tubular type. They are of uniform width throughout their whole length, except the slightly swollen blind termination. These blind ends lie one on each side of the ventral and posterior region of the abdomen, generally embedded in the fat-body. They take a sinuous course forwards through the abdomen into the thorax, where they run alongside the ventriculus. At the sides of the proventriculus they are thrown into several folds, which appear to be quite constant in character. They pass forwards at the sides of the oesophagus and on entering the cervical region the ducts lose their glandular character, and assume a spiral thickening; before leaving the cervical region the two ducts unite below the oesophagus, and the single median duct enters the head ventral to the cephalothoracic nerve cord, and runs direct to the proximal end of the hypopharynx, at the end of which it opens. A short distance before entering the hypopharynx the salivary duct (fig. 1, sal.d.) is provided with a small valve controlled by a pair of fine muscles (s.m.), which serves to regulate the flow of the salivary secretion. The glands are composed of glandular cells (fig. 22), which are convex externally, and have a fibrillar appearance in section. No vacuoles have been found in the cells.

The Malpighian Tubes.—A pair of malpighian tubes (fig. 21, malp.) arises at the point of junction of the proximal and distal intestines, that is, where the mesenteron joins the proctodaeum. Each malpighian tube shortly divides at an angle of 180° into two malpighian tubules. The malpighian tubules are very long and convoluted, and intimately bound up with the diffuse fat-body, so that it is a matter of considerable difficulty to dissect them out entire. They have a moniliform appearance and are of uniform width throughout; never more than two cells can be seen in section. They are generally yellowish in colour. As in most insects they are undoubtedly of an excretory nature, as the contents of the cells and tubules show. Lowne's view that, in the blowfly, they are of the nature of a hepato-pancreas is untenable morphologically and physiologically.
The Rectal Glands.—The four rectal glands (rect.gl.) are arranged in two pairs, two on each side of the rectal cavity. Each rectal gland (fig. 25) has a conical or pyriform apex with a swollen circular base. It is composed of a single layer of large columnar cells (r.gl.), the papilla being hollow, with the cavity in communication with the general body cavity. It is covered externally by a perforate chitinous sheath (sh.), which is continuous with the intima of the rectum. A number of tracheae (tr.) enter the cavity of each gland, and fine tracheae may be seen penetrating the wall. The cavity of the gland is filled with a loose tissue of branching cells. As the gland is capable of pulsation there is no doubt a constant interchange of blood between the cavity of the gland and the body cavity (which is a haemocel). By this means waste products may be extracted from the blood by the large gland cells and excreted into the rectum through the pores on the external sheath of the gland. The rich supply of tracheae probably assists the cells in the process of excretion, as we find the tracheae very numerous, and intimately connected with the malpighian tubules.

4. The Respiratory System.

The respiratory or tracheal system is developed to a very great extent in the fly and occupies more space than any other anatomical structure. Only by dissection of the freshly-killed insect can one obtain a true conception of its importance. It consists of tracheal sacs of varying size having extremely thin walls and tracheae which may arise from the sacs, or, in the case of the abdominal tracheae, independently from the spiracles.

The Anterior Thoracic Spiracles (figs. 6 and 13, a.th.).—Each is a large vertical opening behind the humeral sclerite and above the anterior legs. It is surrounded by a chitinous ring, the peritreme and the opening is guarded by a number of dendritic processes which prevent the entrance of dust and other foreign bodies. It leads into a shallow chamber or
vestibule which communicates with the rest of the spiracular system through a valvular aperture.

The anterior thoracic spiracles supply the whole of the head, the anterior and median regions of the thorax, the three pairs of legs, and by means of the abdominal air-sacs a large part of the viscera.

Internal to the valve the tracheal system divides. The tracheal sacs springing from the posterior side are as follows: Ventrally a rather narrow tracheal duct leads into a sac—the anterior ventral thoracic sac (fig. 13, a.v.s.) situated at the side of the thoracic ganglion which it supplies. Above the origin of this another tracheal duct leads to a vertical sac supplying the anterior sterno-dorsales muscles. Dorsally the ducts of two sacs take their origin; the smaller and more dorsal is a flat sac closely apposed to the anterior ends of the dorsales muscles (d.o.) which it supplies; the more ventral of the two is one of the two most important branches of the anterior thoracic spiracle (the other being the branch supplying the head). In the thorax it takes the form of an elongated sac lying below the dorsales muscles, and by side of the alimentary canal. From the dorsal side of this the longitudinal thoracic sac (l.tr.s.) a number of branches arise which supply the lower dorsales muscles. It is constricted about the middle of its length and anterior to the constriction; a branch is given off which supplies the ventral portion of the median sterno-dorsales muscles. In the posterior region of the thorax another ventral branch is given off from which branches arise, one supplying the ventral portions of the posterior sterno-dorsales muscles, the other opening into the posterior ventral thoracic sac (p.v.s), which supplies the intermediate and posterior legs. The longitudinal thoracic sac then narrows, and passes through the thoraco-abdominal opening into the abdomen. In the adomen it immediately dilates to form one of the large abdominal air-sacs (a.b.s.). The pair of abdominal air sacs in some cases occupy about half the total space of the abdomen. When the fat-body is not greatly developed they occupy almost the whole of the
basal portion of the abdomen. They give off internally a large number of tracheae which ramify among the viscera and provide a large portion of the contents of the abdomen with air.

From the anterior side of the anterior thoracic spiracle a flattened sac arises. On its ventral side this gives off a branch which supplies the muscles of the neck and the anterior leg. The sac then narrows into a rather thick-walled cervical tracheal duct (c.tr.), which passes through the neck alongside the cephalo-thoracic nerve-cord and enters the head.

Tracheal Sacs of the Head.—The tracheal sacs of the head occupy the greater portion of the head capsule. They entirely fill up all the space which would otherwise be haemocoel. These tracheal sacs are supplied by the cervical tracheal ducts which, on entering the head capsule, curve dorsally behind the cephalic ganglion. Before curving upwards each gives off a large ventral duct (fig. 4), which spreads out beneath the cephalic ganglion forming a structure of a tentorial nature upon which the ganglion rests. The dorsal cephalic ducts unite behind the cephalic ganglion above the esophagus. From the point of junction three ducts arise, two lateral ducts and a median dorsal duct. The median dorsal duct (m.d.) opens into a large bilobed dorso-cephalic sac lying on top of the ganglion, and occupying the dorsal region of the head capsule. It gives off branching tracheal twigs supplying the antero-dorsal portion of the optic ganglion (peri optic). Each of the lateral ducts (fig. 4, l.d.) supplies the posterior cephalic sacs. It first communicates with a sac (fig. 13, p.c.s.) lying behind the dorsal portion of the optic ganglion to which it gives off a large number of tracheal twigs. This sac opens into an elongate vertical sac which occupies the ventro-posterior region of the head capsule. The remaining tracheal sacs of the head are supplied by the tentorial tracheal ducts (tr.d.), which spread out beneath the cerebrum in a fan-shaped manner, and are bilaterally distributed. Each half, in addition to giving off internally tracheal twigs to the optic
ganglia, communicates with two tracheal sacs. An internal duct leads into a large spherical sac, the anterior cephalic sac (a.c.s.) situated in the anterior region of the head dorsal to the fulcrum. From the dorsal side of this sac a branch is given off which supplies the antenna of its side; the ventral side is continued down the fulcrum as a narrow tracheal sac. The lateral portion of the tentorial tracheal duct opens into the ventro-lateral cephalic sac (v.c.s.) situated posterior to the optic ganglion. The lower end of this sac gradually narrows as it enters the rostrum which it traverses, giving off half-way along its length a trachea which supplies the palp of that side. On reaching the haustellum it takes the form of a trachea proper, having annular thickenings. Shortly after entering the haustellum it gives off two branches to the muscles of this region. The main trachea is continued into the oral lobe of its side where it divides into anterior and posterior branches, and these again divide into numerous small tracheae running to the edges of the oral lobes. Lowne, in his description of the tracheal system of the blowfly, describes and figures the tracheal supply of the proboscis as being of the nature of tracheal sacs and capable of distension; he also describes a trefoil-shaped tracheal sac at the base of the oral lobes giving off very regular branches, the dilation of which causes the inflation and tension of the oral lobes. The mechanism of the proboscis will be discussed later (p. 439), but it may be noticed here that in M. domestica there is no trace of a trefoil-shaped sac at the base of the oral lobes, and that all the tracheal structures of this the haustellum region are definite annular tracheae, and therefore incapable of distension.

The posterior thoracic spiracle (figs. 6 and 15, p.th.) is triangular in shape and guarded by dendritic processes. It possesses a vestibule which leads into a distributing tracheal sac. The tracheal sacs of this system (fig. 15) have not the extended range of those supplied by the anterior thoracic spiracle, but are confined to the thorax, chiefly in the median and posterior regions which are not aerated to any great
extent by those of the other system. They supply chiefly the large muscles of the thorax. Laterally a series of sacs (l.th.s.) extends antero-dorsally in an oblique direction, external to the sterno-dorsales muscles to the humeral region. From the first of these sacs a large number of tracheal twigs arise and supply the muscles of the wing and the anterior sterno-dorsales muscles. Ventral to this sac a large sac (m.v.s.) penetrates internally between the anterior and median sterno-dorsales muscles and supplies the lower dorsales muscles. From the dorsal side of the distributing sac a number of sacs arise, some of which penetrate between the sterno-dorsales muscles and supply the upper dorsales muscles. A more posterior set supplies the posterior regions of the dorsales muscles, ramifying between them in a very extensive manner, some ultimately terminating in the tracheal sacs beneath the scutum and the scutellar sac (sc.s.).

The abdominal spiracles differ in number in the two sexes. In the male there are seven pairs of abdominal spiracles; in the female I have only been able to find five pairs. In both sexes each of the large tergal plates which cover the abdomen has near its lateral margin a small circular spiracle. The first abdominal segment which has fused with the second has a pair of small spiracles (see fig. 8) slightly anterior to those of the second (apparent first) abdominal segment. In addition to these the male possesses two pairs of spiracles in the membrane at the lateral extremities of the rudimentary sixth and seventh abdominal segments (see fig. 5). In the female I have been unable to find any additional spiracles. Each of the abdominal spiracles is provided with a vestibule and atrium which are separated by a valve controlled by a minute chitinous lever. All the spiracles of the abdomen communicate with tracheæ which ramify among the viscera and fat-body; there are no tracheal sacs in connection with these spiracles.
5. The Vascular System and Body-cavity.

By the great development of the tracheal sacs in the head, the muscles in the thorax, and the fat-body and air sacs in the abdomen, the haemocoelic space in the fly is greatly reduced. The blood is colourless, and is crowded with corpuscles, mostly containing substances of a fatty nature.

The fat-body varies greatly in the extent of its development. In some cases it may almost fill the body-cavity, pushing the intestine back into a postero-dorsal position: this is generally the case in flies before hibernating; in other cases it may be only moderately developed. The fat-body receives a very rich tracheal supply, and stores the products of digestion which are conveyed to it by the blood with which it is bathed. It consists chiefly of very large cells, both uninucleate and multinucleate; the fat-cells of the head are not so large.

The dorsal vessel or heart lies in the pericardial chamber, immediately beneath the dorsal surface. It extends from the posterior end to the anterior end of the abdomen, and four large chambers, corresponding to the four visible segments, and a small anterior chamber can be recognised; the last represents the chamber of the first abdominal segment. The chambers are not separated by septa, but each has a pair of dorso-lateral ostia situated at its posterior end where the alar muscles of the pericardium arise. The walls of the heart are composed of large cells. The pericardium contains fat-cells and tracheæ, and its floor is composed of large cells of a special nature. The alar muscles run laterally in the floor of the pericardium to the sides of the dorsal plates where they are inserted. The anterior end of the heart is continued as a narrow tube (fig. 20, d.a.) along the dorsal side of the ventriculus, where it terminates in a mass of cells (l.g.), which are usually considered to be of a lymphatic nature.
6. The Reproductive System.

The two sexes are slightly different in size, the females being larger than the males; the sexual dimorphism of the width of the frontal region of the head has already been noticed (p. 402). There does not appear to be any great disparity in the numerical proportions of the sexes; near breeding places there is naturally a preponderance of females.

The Female Reproductive Organs.—The generative organs of the female consist of ovaries, spermathecae or vesiculae seminales, accessory glands and their ducts.

The ovaries, when containing mature ova, occupy the greater part of the abdominal cavity (fig. 23, ov.). They lie ventral to the gut, occupying the whole of the ventral and lateral regions, the gut resting on the V-shaped hollow between them. Each ovary contains about seventy ovarioles, in each of which ova in various stages of development can be seen. The two short thin-walled oviducts (ov.d.) unite on the ventral side of the abdomen to form the common oviduct (c.o.d.). The walls of the common oviduct are muscular, and when the ovipositor is in a state of rest, retracted into the abdominal cavity, the oviduct curves forwards and dorsally to enter the ovipositor (ov.p.) ventral to the rectum (rect.). Here it swells slightly to form a sacculus (fig. 26, sac.) which leads into the muscular vagina (vag.). The vagina opens into the ventral side of the ovipositor immediately behind the sub-anal plate.

The spermathecae (sp.) or vesiculae seminales are three in number, two on the left side, and a single one on the right. Each consists of a small, black, oviform, chitinous capsule, the lower half of which is surrounded by a follicular investment continuous with the cellular wall of the duct, the whole having the appearance of an acorn with a long stalk. The ducts of the spermathecae are lined by a thin chitinous intima continuous with the chitinous capsule, and they open at the posterior end of the sacculus on the dorsal side.
There is a single pair of accessory glands (ac.g.), which are fairly long, and on nearing the vagina they become narrower to form a slender duct, which opens on the dorsal side of the vagina immediately behind the ducts of the spermathecae. The accessory glands are closely united with the fat-body. They probably secrete the adhesive fluid which covers the eggs when they are laid, and causes them to adhere to each other and to the material upon which they are deposited. Behind the accessory glands there is a pair of thin-walled transparent vesicles (tasche dell' ovidotto of Berlese), which I propose to name the accessory copulatory vesicles (a.c.v.) on account of the part they take in ensuring firm coitus with the male during copulation, during which process they expand to a much greater extent.

The ovipositor (fig. 8). The terminal abdominal segments of the female are much reduced to form a tubular ovipositor, the chitinous sclerites being reduced to form slender chitinous rods. When extended it equals the abdomen in length. It is composed of segments vi, vii, viii, and ix, each being separated from the adjacent segments by an extensible intersegmental membrane, which is covered with fine spines. When the ovipositor is retracted (fig. 23, ovp.) it lies in the interior of the posterior end of the abdomen, the segments being telescoped the one within the other, so that only the terminal tubercles are visible from the exterior. The dorsal arch of the sixth abdominal segment is reduced to a \( \Lambda \)-shaped sclerite (vi, d.), lying on the dorsal side of the segment. The ventral arch of this segment is reduced to a slender chitinous rod (vi, v.) in the mid-ventral line. The dorsal arch of the seventh segment is represented by two slightly-curved sclerites (vii, d.), with their concave faces opposite; the ventral arch (vii, v.) is similar to that of the sixth segment. At the junction of the posterior ends of the sixth and seventh segments with the inter-segmental membranes succeeding them there are several setose tubercles arranged more or less in pairs, but they vary in development in different individuals. The dorsal arch of the eighth
segment consists of two parallel and slender sclerites (viii, d.),
not so narrow as those of the two preceding segments. A
pair of slender sclerites (viii, v.) also represents the ventral
arch. The terminal anal segment, which I consider repre-
sents the reduced ninth segment, has a dorsal chitinous
sclerite, the sub-anal plate (s.p.), which is triangular in
shape, and a ventral sub-anal plate of the same shape. The
female genital aperture is situated at the anterior end of the
latter plate, between the eighth and anal (ninth) segments.
A pair of terminal setose tubercles is situated laterally at the
apex of the anal segment.

The Male Reproductive Organs.—The male repro-
ductive organs (fig. 24) are situated ventral to the alimentary
canal, and lie within the fifth abdominal segment. They
consist of a pair of testes, vasa deferentia, ejaculatory duct
and sac, and the terminal penis. There are no accessory
genital glands in the male.

The testes (te.) are a pair of brown pyriform bodies, with
their long axes placed transversely, and their pointed ends
facing. In young males they have a bright red appearance.
They are covered with a follicular investment of cells, which
varies in thickness apparently according to age. The thin
brown chitinous capsules contain the developing spermat-
zoa. The pointed end of each testis is continued as a fine
vas deferens (v.d.), which meets that of the other testis in the
median line, where they open into the common ejaculatory
duct (d.e.). This runs forwards for a short distance, and then
bends to the left ventrally, and, after several convolutions on
the left ventral side of the abdomen, the duct narrows con-
siderably, forming a narrow ejaculatory duct. This crosses
over the dorsal side of the rectum to the right side, where it
runs forwards for a short distance and then curves back in
the median ventral line, opening into a pyriform ejaculatory
sac (e.s.). The walls of this ejaculatory sac are muscular,
longitudinal muscles, giving the walls a striated appearance.
It contains a phylliform, chitinous sclerite—the ejaculatory
apodeme (e.a.), which has a short handle at the broad end.
This sclerite is, no doubt, of great assistance in propelling the seminal fluid along the ejaculatory duct during copulation. A short distance behind the ejaculatory sac the duct opens into the penis.

The Male Gonapophyses.—The extremity of the abdomen in the male (fig. 10) has undergone considerable modification in the formation of the external genitalia. The visible portion of the abdomen, as seen from above, consists of the first five abdominal segments; the remaining three segments are slightly withdrawn into the fifth segment, and, on looking at the abdomen from the posterior end, only the terminal segment, the eighth, surrounding the anus, can be seen. The sixth and seventh segments have been greatly reduced. The sternal portion of the fifth segment consists of a cordiform sclerite (V.v.), the apex of which is directed forwards, and each of the lateral margins of the base is produced to form a short process, swollen at the tip—these lateral processes form the primary forceps (p.f.), and lie at each side of the aperture of the male genital atrium (g.a.), of which the posterior edge of the sclerite forms the lower or anterior lip. The dorsal plates of the sixth and seventh segments lie on the membrane, which is tucked underneath the posterior edge of the fourth abdominal segment. The dorsal plate of the sixth segment (vi, d.) is a narrow, transverse sclerite; its lateral edges, which do not extend down the sides, are slightly produced anteriorly. The ventral plate of the sixth segment (vi, v.) is asymmetrical, and, with the dorsal plate of the seventh segment, produces a pronounced asymmetry of the posterior end of the male abdomen. It consists of a spatulate plate on the left side, the anterior or ventral side of which is produced into a narrow bar extending across the ventral side of the aperture of the genital atrium, its distal extremity bifurcating. The dorsal plate of the seventh segment (vii, d.) is asymmetrical. It consists of a narrow sclerite, which, on the dorsal side, is similar to the sixth dorsal plate, but the left side (see fig. 5) extends down the side, and broadens out into a somewhat
triangular-shaped area; the anterior edge of this is incised, and receives the seventh spiracle (vii, a.sp.); the ventral edge is internal to the spatulate portion of the sixth ventral plate. The ventral arch of the seventh sclerite has been completely withdrawn into the abdomen, and consists of a pair of curved sclerites (fig. 9, vii, v.), somewhat rhomboidal in shape, lying dorsal to the fifth ventral arch and ventral to the penis (P.); they form the secondary forceps. Their lateral edges, which are thickened articulate with the alar processes of the body of the penis (c.pe.), and with the dorsal arch of the eighth abdominal segment (viii, d.). Their inner edges are curved, and almost meet in the mid-ventral line. The dorsal arch of the eighth and last abdominal segment (viii, d.) forms the apex of the abdomen. It consists of a strongly convex sclerite, deeply incised on the ventral side; in this incision the vertical slit-like anus (fig. 10, anu.) lies. The ventral portion of the segment is completed by a pair of convex sclerites (viii, v.), which are united in the mid-ventral line, forming the ventral border of the anal membrane and the dorsal side of the entrance to the genital atrium.

All the sclerites of the posterior segments except the sixth and seventh are setose.

Berlese (1902) in his account of the copulation of the House-fly describes the genitalia. From his account of the male genitalia he appears to have missed the narrow dorsal arch of the sixth segment, or, what is very probable, he may have mistaken it for the fifth dorsal arch, as he terms the seventh dorsal arch the sixth, and describes what I have called the ventral arch of the seventh as the dorsal arch of that segment. This mistake in nomenclature has probably arisen from the fact that he considered the visible portion of the abdomen as consisting of four segments instead of five, in which case the narrow dorsal arch of the sixth segment would naturally be taken for that of the fifth.¹

¹ Berlese describes a sinistral asymmetry of the posterior segments, but his figures show a dextral asymmetry, a mistake probably in the reproduction of his figures which has escaped the author's notice.
The penis (figs. 7 and 9) lies internally on the ventral side of the abdomen, dorsal to the ventral arches of the fifth and seventh segments. It is composed of several sclerites. A median sclerite (c.pe.), the anterior and ventral edge of which is roughly semicircular in outline, forms the body of the penis. This is produced laterally to form two alar processes; at the bases of these processes the lateral extremities of the dorsal arch of the eighth segment articulate with the body of the penis; the extremities of the processes are attached to the lateral extremities of the ventral sclerites of the seventh segment, the secondary forceps. The penis proper consists of a hollow cylindrical tube, the theca, which receives the ejaculatory duct. The theca articulates with the body of the penis by means of a pair of small chitinous nodules ("cornetti" of Berlese); posterior to the attachment the theca is constricted slightly. Below the aperture for the entrance of the ejaculatory duct, the theca is produced into a ventrally directed curved process, the inferior apophysis (i.ap.); above the aperture a short cylindrical process, the superior apophysis (s.ap.), arises. The anterior end of the theca is continued as a slightly inflated hyaline structure, the glans (p.gl.), at the curved extremity of which the ejaculatory duct opens.

V. THE INTERNAL STRUCTURE OF THE HEAD.

The skeletal framework and tracheal system of the head have already been described. It remains, therefore, to give an account of the musculature of the head and pharynx, and also an account of the oral lobes.

The posterior region of the head (fig. 1) not occupied by tracheal sacs is usually filled up with small multinucleate fat-cells (f.c.), which are also occasionally found in the proboscis. The frontal sac or ptilinium (Pt.) fills up the anterior portion of the head not occupied by air-sacs. Its crescentic opening, the lunule, has already been described. It is attached to the
wall of the cephalic capsule by muscles which vary considerably in the extent of their development. In recently emerged flies the muscle-supply of the ptilinium is considerable, as they have served to retract the sac after it has been inflated to assist the exclusion of the imago, but in older specimens it becomes less. The walls of the ptilinium are muscular and lined by a chitinous intima covered with small broad spines.

The Musculature of the Proboscis.—The chief muscles controlling the movements of the pharynx and proboscis are these:

The Dilators of the Pharynx (figs. 1 and 2, d.ph.)—This pair of muscles occupies the interior of the fulcrum. Each muscle is attached to the antero-lateral regions of the fulcrum and inserted into the dorsal plate of the pharynx (r.p.). These muscles are the chief agents in pumping the liquid food into the oesophagus, and in drawing it up through the pharyngeal tube.

The Retractors of the Fulcrum (fig. 1, r.f.).—These muscles are attached to the internal anterior edges of the genae, and are inserted into the posterior cornua (p.c.) of the fulcrum. Their contraction causes the rotation of the fulcrum on the epistome as a hinge in the retraction of the proboscis.

The Retractors of the Haustellum (r.h.).—These muscles have their origin on the dorso-lateral regions of the occiput. They are long and narrow, and running on each side of the common salivary duct are inserted into the dorsal margin of the theca.

The Retractors of the Rostrum (r.r.).—This pair of muscles has its origin at the sides of the occipital foramen, and is inserted into the posterior side of the membranous rostrum about half-way down its length. In the retraction of the proboscis these muscles draw in the rostrum.

The last two pairs of muscles acting together assist in the retraction of the whole proboscis.

The Flexors of the Haustellum (f.h.) have their origin close to that of the retractors of the rostrum at the
sides of the occipital foramen. They are inserted into the base of the labral apodeme (ap.), and serve to flex the haustellum on to the anterior face of the rostrum.

The Extensors of the Haustellum (ex.h.).—Each of these muscles arises from the distal cornu of the fulcrum, and is inserted into the head of the labral apodeme.

The Accessory Flexors of the Haustellum (a.f.h.) are attached to the lower (distal) anterior margin of the fulcrum, and inserted with the extensors into the head of the labral apodeme.

The Flexors of the Labium-epipharynx (f.l.).—These muscles have their origin on the anterior and upper edge of the fulcrum, and are inserted into the proximal end of the labium-epipharynx. The first pair of the last three sets of muscles serve to extend the haustellum in the extension of the proboscis, and the remaining two pairs assist in the retraction of the proboscis by flexing the haustellum on to the rostrum.

A pair of very fine muscles (s.m.) have their origin at the base of and internal to the posterior cornua of the fulcrum. They are inserted into the dorsal side of a small valve (s.v.) on the common salivary duct which regulates the flow of the secretion of the lingual salivary glands.

The muscles of the haustellum are—

The Retractors of the Furca (r.fu.).—A pair of muscles having their origin on the upper part of the theca. Each is inserted along the upper proximal half of the lateral process of the furca. When the muscles contract the lateral processes of the furca, which, in a state of repose are brought together by the elasticity of the ventral cornua of the theca, are diverged, and thus cause the divergence and opening of the oral lobes.

The Retractors of the Discal Sclerites (r.d.s.).—These muscles have their origin on the lateral edges of the upper part of the theca, and are inserted upon the sides of the discal sclerites. They work together with the retractors.
of the furca, their contraction causing the divergence of the
discal sclerites, and the consequent opening of the oral pit.

The Dilators of the Labium-hypopharynx (di.l.).
—These fan-shaped muscles arise in the middle region of
the theca on either side the median line, and diverging
are inserted in the lateral edges of the labium-hypopharyngeal
sclerite. By their contraction they will widen the channel of
the labium-hypopharynx.

The Dilators of the Labium-epipharynx (di.l.)—
These form a series of short muscles attached to the anterior
and posterior walls of the labium-epipharynx. The size of
the pharyngeal channel will be regulated by these muscles.

The Oral Lobes.—The external structure of the oral lobes
has already been described. Their internal structure and
histology will be given here, as it seemed preferable to do so
rather than postpone it to a future communication.

The setigerous cuticle and the pseudo-tracheae lie on a
hypodermis of cubical cells (fig. 18, hy.). Beneath the hypo-
dermis of the aboral surface is another layer of cells contain-
ing a large amount of dark pigment. Each of the large
marginal sensory bristles (g.s.) of the aboral surface has a fine
channel running down the whole length of the seta. This
channel communicates with the cavity of a pyriform mass of
nerve-end cells (s.p.), consisting of five or six cells. These
masses of cells occupy a large part of the interior of the oral
lobes. As these gustatory bristles are exposed and directed
ventrally when the proboscis is retracted, they may assist the
fly in testing the nature of its food before extending its pro-
bscis. On the oral side of the oral lobes the nipple-like gus-
tatory papillae (figs 1 and 18, gp.) have already been described.
The aperture at the end of the papilla leads into a fine duct,
which ends in a pyriform sensory bulb (s.g.p.). The tracheae
(tr.) can be seen running through the cells, some of which con-
tain several nuclei, and from their appearance are probably
derived from the fat-body. No tracheal sacs could be found
either in the oral lobes or at their bases, but the annular
tracheae are continuous with those of the proboscis. The
hæmocœl of the oral lobes is well developed. This supports the view set forth by Kraepelin, and with which I agree that the inflation of the oral lobes is due to the blood. I consider that the extension of the proboscis is due to the inflation of the tracheal sacs of the head. The proboscis having been protruded the oral lobes are then diverged by the contraction of the retractor muscles of the furca and discal sclerites, and distended by the inrush of blood which keeps them turgid, and causes the openings into the pseudo-tracheal channels to remain open.

The Labial Salivary Glands (figs. 19 and 1, lb.sl.).—These salivary glands lie in the haustellum at the base of the oral lobes. The glands, which are spherical in shape, are composed of a large number of gland cells somewhat triangular in shape. Each gland cell is 40 μ in size, and possesses a large nucleus (12 μ), and internal to this a permanent circular vacuole (vac.), which is 16 μ in size, and is lined by a thin chitinous intima. The duct of each gland cell opens into the side of the vacuole (od.). The ducts (ic.d.) are intracellular, and run from the centre of the gland, some of them uniting, to form a number of fine ducts on the ventral sides of the discal sclerites, which unite and open into the oral pits by a median pair of pores. Kraepelin, in his description of the proboscis of the blowfly, described the labial glands and their ducts (but not their histology) of that insect, his description being similar to the condition I find in M. domestica. Lowne, however, states that in the blowfly he traced the ducts of the gland cells through the oral lobes to the apertures of the gustatory papille, which he regarded therefore as the apertures of the labial salivary glands.

The secretion of the labial salivary gland serves to keep the surface of the oral lobes moist.

VI. SUMMARY.

1. The exoskeleton of the head capsule and of the pharynx is described in detail; the relations of the parts in the terms
generally employed by dipterologists to the morphological divisions of the insect head capsule are shown. On morphological grounds, the view that the distal portion of the proboscis represents the modified second maxillae or labium is adopted, as opposed to that of a first maxillar derivation put forward by Lowne for the blowfly.

2. After a detailed description of the external and internal skeletal structures of the thorax, the neuration of the wings is described in the terms proposed by Comstock and Needham in their valuable memoir; and to facilitate their more general adoption for the wings of the Muscidae and other Diptera, a comparison is made between their nomenclature and the several systems employed in describing the muscid wing.

3. The abdomen is shown to consist of eight segments in the male and nine in the female, in both cases the first five segments form the visible portion of the abdomen; the external genitalia of the two sexes are described under another section.

4. As the muscular system does not differ from that of Volucella described by Kunckel d'Herculais and the blowfly described by Hammond and Lowne, it is briefly described. The cephalic muscles, however, are fully described in the detailed description of the head (V).

5. The nervous system, which is of the normal muscid type, is described, but for the sake of clearness a very detailed description of the composition of the cephalic ganglion is not given. The structure of the optic tract is similar to that of the blowfly as described by Hickson. The structure of the thoracic nerve-centre is found to differ slightly from that of the blowfly as described by Lowne.

6. The alimentary canal is similar in its structure to those of Stomoxys and Glossina, only differing in a few details. The mesenteric region, which is represented by the ventriculus or chyle, stomach, and proximal intestine, is well developed. The lingual salivary glands, rectal glands, and
Malpighian tubes are described; the function of the rectal glands is believed to be of an excretory nature.

7. As the tracheal systems of the Diptera have not received much attention a detailed account of the tracheal system is given. There are two thoracic spiracles, the first of which supplies the whole of the head, the anterior and median regions of the thorax and the three pairs of legs, and by means of a pair of large abdominal air-sacs a large part of the viscera. The posterior thoracic spiracle supplies the muscles of the median and posterior region of the thorax, especially the large dorsales muscles. There are seven pairs of abdominal spiracles in the male and five pairs in the female all of which are connected with tracheae only.

8. The dorsal vessel or heart is found to consist of five incomplete chambers, each with a pair of ostia. The anterior end is continued forwards along the dorsal side of the ventriculus, and terminates in a glandular mass in the anterior margin of the proventriculus.

9. The reproductive organs of the male are simple, consisting of a pair of testes, vasa deferentia, and common ejaculatory duct; there are no accessory glands such as are found in many other Diptera. The terminal abdominal segments of the male exhibit a sinistral asymmetry.

The ovaries of the female, when mature, occupy the greater portion of the abdominal cavity. There are a pair of accessory glands (probably of a "gum" or "glue" nature), three spermathecae, and a pair of vesicles used during copulation. The ovipositor is about as long as the abdomen, and is composed of segments six to nine.

10. The musculature of the head is described in detail, and it is found that the House-fly agrees with the blowfly in the number and relations of its cephalic muscles, though in a few cases the attachments are slightly different. In the haustellum and oral lobes of the House-fly no tracheal sacs similar to those described and figured by Lowne for the blowfly occur, but only annulated tracheae are found, and, as these are incapable of distension, the view that the oral lobes are
distended by the action of inflated air cannot be held. The extension of the proboscis I believe is due to the inflation of the tracheal sacs of the head and rostrum, and I agree with Kraepelin that the distension of the oral lobes is effected by blood-pressure.

Two kinds of gustatory sense-organs are found on the margin of the aboral and on the oral surfaces respectively. The latter were described in the blowfly by Lowue as the openings of the ducts of the labial salivary glands, but Kraepelin's correct description of their structure in the blowfly is confirmed by this study of the House-fly. The labial salivary glands are described in detail. They consist of large cells containing permanent vacuoles, which communicated with intracellular ducts. These open by a pair of pores into the oral pits, the secretions of the glands serving to keep the surface of the oral lobes moist.

VII. Literature.

The following is not intended to be a full list of the literature relating to M. domestica. Further references will be given in the succeeding parts.


1898.—CoMSTOCK, J. H., and NeEDHAm, J. G.—"The Wings of Insects," "Amer. Nat.," vol. xxxii, p. 43, etc., and through the vol. into vol. xxxiii.


STRUCTURE, DEVELOPMENT, AND BIONOMICS OF HOUSE-FLY. 443


1870. Lowne, B. T.—'The Anatomy and Physiology of the Blowfly (Musca vomitoria),' 121 pp., 10 pis., London.


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EXPLANATION OF PLATES 22—26,
Illustrating Mr. C. Gordon Hewitt's paper on "The Structure, Development, and Bionomics of the House-fly (Musca domestica, Linn.). Part I. Anatomy of the Fly."

PLATE 22.

Fig. 1.—Musca domestica. Female.
Fig. 2.—Anthomyia radicum. Female.
Fig. 3.—Homalomyia canicularis. Male.
Fig. 4.—Stomoxys calcitrans. Female. The halteres of this species have been drawn too far back, and in this and the other species the nervures of the wings have been made thicker than they naturally are.

These figures are not drawn to the same scale.

PLATE 23.

Fig 1.—Interior of the head of M. domestica. In this figure the left side of the head capsule and of the proboscis have been removed and the compound eye of the same side, leaving the optic ganglion (periopticon). All the tracheal structures have been omitted.


\textbf{Fig. 2.}—Transverse section through the lower portion of the head-capsule, showing the muscles and tracheal sacs in this region and the fulcrum in section. (Camera lucida drawing.)

bp. Floor of pharynx.  \textit{r.p.} Roof of pharynx.  \textit{tr.s.} Tracheal sac. Other lettering as in Fig. 1.

\textbf{Fig. 3.}—Transverse section through the lower half of the haustellum, where the hypopharynx (\textit{hp.}) has become free from the labium. (Camera lucida drawing.)

di.l. Dilator muscles of the labium-epipharynx.  \textit{tr.} Trachea. Other lettering as in Fig. 1.

\textbf{Fig. 4.}—Posterior view of the tracheal ducts which supply the cephalic sacs and tracheae.

cotr. Cervical tracheae which fuse above the oesophagus on the posterior side of the cephalic ganglion.  \textit{l.d.} Lateral duct.  \textit{m.d.} Median dorsal duct.  \textit{t.n.d.} Tentorial tracheal ducts which spread out beneath the cephalic ganglion.

\textbf{Fig. 5.}—Lateral view of the terminal segments of the abdomen of the male after their removal from the fifth segment.

vi, \textit{a.sp.} and vii, \textit{a.sp.} Sixth and seventh abdominal spiracles. Lettering as in Fig. 10.

\textbf{Fig. 6.}—The thorax seen from the left side. The insertions of the larger setae are shown; for the sake of clearness the sclerites of the wing-base are omitted.


\textbf{Fig. 7.}—Penis seen from the right side after it has been removed from within the terminal abdominal segments.

\textit{i.ap.} Inferior apophysis.  \textit{th.p.} Theca of penis.  \textit{p.gl.} Glans.  \textit{s.ap.} Superior apophysis. Other lettering as in Fig. 9, etc.

\textbf{Fig. 8.}—Abdomen of female showing the extended ovipositor.

\textit{V, d.} to ix, \textit{d.} Fifth to ninth dorsal arches or plates of the abdomen.  \textit{V, v.}
to viii, v. Fifth to eighth ventral plates or arches. su.p. The suranal plate (ninth dorsal arch).

The anus is situated between the two lateral terminal tubercles.

Fig. 9.—Dorsal view of the penis and the ventral half of the terminal abdominal segments. The median portion of the eighth dorsal arch has been removed, leaving the lateral portions attached to the body of the penis (c.pe.) and the ventral arch of the seventh segment (vii, v.).

Lettering as in Fig. 10.

Fig. 10.—The posterior end of the abdomen of the male seen from behind, showing the pronounced sinistral asymmetry.

v, d. to viii, d. Fifth to eighth dorsal plates or arches. v, v. to viii, v. Fifth to eighth ventral plates or arches. an. Anus. g.a. Aperture of genital atrium. p.f. Primary forceps.

PLATE 24.

Fig. 11.—Nervous system. The very fine nerve which runs along the dorsal side of the oesophagus to the proventricular ganglion (P.g., Fig. 20) has been purposely omitted.


Fig. 12.—Thoracic compound ganglia. Left aspect. Lettering as in Figs. 11 and 14.

Fig. 13.—The tracheal sacs supplied by the anterior thoracic spiracle (a.th.). In this figure the tracheal sacs supplied by the posterior thoracic spiracle and the sternodorsal muscles of the left side have been removed. The left side of the head and proboscis have also been removed. The first abdominal segment has been removed to show the large abdominal air sacs (ab.s.) and an abdominal trachea which is supplied by the second abdominal spiracle (a.sp.).


Fig. 14.—Thoracic compound ganglion after the removal of the cortex. Seen from the ventral side. This and Fig. 12 were drawn from models reconstructed from sections.

Pr.G., Ms.G., Mt.G. Pro-, meso-, and meta-thoracic ganglia. A.G. Abdominal ganglion. Other lettering as in Fig. 11.

Fig. 15.—The tracheal sacs supplied by the posterior thoracic spiracle.
In this figure the left side of the thorax has been removed, together with the wing muscles and the posterior sterno-dorsales. It must be imagined that this figure is superimposed on Fig. 13.


Fig. 16.—Wing. The nervures are drawn slightly thicker than they naturally are.


PLATE 25.

Fig. 17.—The alimentary canal as it is seen on dissection from the dorsal side. The malpighian tubes have been omitted, and also the distal portion of the lingual salivary gland (s.lg.) of the right side. The duct of the crop (Cr.) is shown by the dotted line beneath the proventriculus (Pe.) and ventriculus (Ven.).


Fig. 18.—Portion of a transverse section of the oral lobes, showing the two types of gustatory sense organ, etc.

g.s. Gustatory seta. g.p. Gustatory papilla. hy. Hypodermis under which lies a pigmented layer. p.s. Pseudo-trachea in section. s.g.p. Sensory bulb of gustatory papilla. sp. Sensory bulb of gustatory seta. tr. Trachea.

Fig. 19.—Transverse section of labial salivary gland, to show the structure of the gland cells (g.c.). (Camera lucida drawing.)


Fig. 20.—Section through the proventriculus and the anterior end of the ventriculus, to show the structure of the proventricular plug (Pv.p.) and the ducts of the esophagus (as.) and crop (d.cr.). (Camera lucida drawing.)

Fig. 21.—The posterior region of the alimentary canal, to show the rectal glands (rect.gl.) with their tracheal supply, the origin of the malpighian tubes (malp.), and the position of the rectal valve indicated at x.

Fig. 22.—Transverse section of the lingual salivary gland, showing the fibrillar character of the gland cells. x 220. (Camera lucida drawing.)
PLATE 26.

Fig. 23.—Female reproductive organs in situ; the left ovary and the viscera have been removed. The ovipositor (ovp.) is shown retracted, in which state the common oviduct (c.o.d.) is doubled back.


Fig. 24.—The male reproductive organs. They have been slightly spread out, and the rectum (rect.) has been turned over to the right side.


Fig. 25.—Vertical section of one of the rectal glands, to show its structure. × 56. (Camera lucida drawing.)


Fig. 26.—Terminal region of the female reproductive organs, showing the accessory glands, etc.

sac. Sacculus. vag. The muscular vagina which evaginates during copulation; a pair of retractor muscles are shown. Other lettering as in Fig. 23.
MUSCA DOMESTICA.
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