BEE

THE bee, from its singular instincts, its active industry, and the useful products resulting from its labours, has, from the remotest times, attracted general attention and interest. No nation upon earth has had so many historians as this remarkable class of insects. The patience and sagacity of the naturalist have had an ample field for exercise in the study of the structure, physiology, and domestic economy of bees; their preservation and increase have been objects of assiduous care to the agriculturist; and their reputed perfection of policy and government have long been the theme of admiration, and have supplied copious materials for argument and allusion to the poet and the moralist in every age. It is a subject that has been celebrated by the muse of Virgil, and illustrated by the philosophic genius of Aristotle. Cicero and Pliny record that Aristomachus devoted sixty years to the study of these insects; and Philiscus is said to have retired into a remote wood, that he might pursue his observations on them without interruption. A very great number of authors have written express treatises on bees; periodical works have been published relating exclusively to their management and economy; and learned societies have been established for the sole purpose of conducting researches on this subject.

In so complicated a branch of natural history, correct observation and induction require laborious and long-continued efforts. But, on the subject of bees, the inquirer after truth had, besides, many obstacles to encounter from the very general diffusion of errors, which had been transmitted without due examination from one author to another. The history of the opinions of successive writers sufficiently proves how gradual and slow has been the growth of an accurate knowledge of these insects,—what is now known being the result of the persevering labours of ages. The accumulation of curious and interesting facts, indeed, which has accrued from the researches of Swammerdam, Maraldi, Reaumur, Schirach, Huber, Dzierzon, and Von Siebold, constitutes almost a new science. It will therefore be proper, in this place, to give a connected and systematic account of the natural history of the bee; and the principal features of internal conformation will be described along with the particular functions. Our descriptions will apply, more especially, to the common and best-known species, the *Apis mellifica*, which is the one particularly prized on account of the rich products it affords.

We shall begin with a brief account of the different sorts of bees inhabiting the hive, and of the respective offices of each; we shall then proceed to consider their comparative physiology, including the leading particulars relating to the functions of their various organs, sensitive powers, instincts, secretions, and diseases. We shall also explain the theory of parthenogenesis and the impregnation of queens, and shall follow the bees in their different labours, from the period when the swarm has settled in a new habitation,—detailing the complex structure of their combs, their curious processes of architecture, and the pains they bestow on rearing their progeny, and in sending forth new swarms; and, in the last place, we shall notice the best systems of modern bee-keeping, and give some account of hives and apiarian implements.

The leading feature in the natural history of bees, and one which distinguishes them from almost all other insects, is their singular distribution into three different kinds, constituting to all appearance so many different modifications of sex. The drone (fig. 1), which is characterized by a thicker body, a round head, a more flattened shape, and more obtusely terminated abdomen, within which are contained the male organs of generation, is undoubtedly the male of the species. It is distinguished also by the absence of a sting, and by the humming noise that accompanies its flight. The queen-bee (fig. 2), which is unequivocally recognized as the female, is larger than any of the others, has the abdomen of greater length, and is provided with a sting and two ovaria of considerable size. The worker bees (fig. 3) compose the third class, and are distinguished by the smallness of their size, their lengthened proboscis, the peculiar structure of their legs and thighs, which are adapted to the collection of certain materials obtained from vegetables, and by the apparent absence of every trace of generative organs,—we say *apparent*, because, as will be shown, rudiments of ovaria do exist, which, however, are not perceptible without a very minute and careful dissection. Till recently the worker bees were regarded as devoid of sex, and were accordingly termed *neuters*. It is their function to perform all the laborious offices for the community, to construct the interior of their habitation, to explore the country in search of nourishment and other materials, to collect and bring them to the hive, and apply them to different purposes, to attend upon the queen, and supply all her wants, to defend the hive from the attacks of depredators, and to carry on hostilities against the various enemies of the tribe. The life of the queen is chiefly engrossed with the duties of laying eggs. The drones producing neither wax nor honey, and depending on the rest for their subsistence, are idle spectators of the others' labours. They appear to be formed only for the momentary but important duty of impregnation, since they perish when this purpose is accomplished. There is commonly only one perfect queen existing at a time within each hive, and she usually appears to be treated by all the other bees with every mark of affection and of deference. The number of workers is very different in different hives; sometimes there are only a few thousands; at other times from twenty to forty, or even fifty thousand. The drones, even in the spring, seldom compose more than one-thirtieth or one-fortieth of the whole; and, at other seasons, there are none to be found in the hive when a fertile queen is present. In order to form some estimate of the number of bees which can occupy a certain space, Hunter counted what number of drowned bees could be contained in an alehouse pint, and found it to be 2160; so that if a swarm were to fill two quarts, their numbers would be nearly 9000. Reaumur, with the same view of ascertaining their numbers, employed the more accurate method of weighing them; he found that a collection, weighing one ounce, consisted of 336 bees, and, therefore, that 16 ounces, or one pound, would consist of 5376 bees.

Fig. 1.—Drone.

Fig. 2.—Queen-Bee.

Fig. 3.—Worker Bee.

Notwithstanding the difference in conformation, instincts, and offices between the queen-bee and the workers, it is now established on the most incontrovertible evidence that they both originally proceed from the same kind of egg or larva, which is capable of being converted, according to

circumstances, either into a worker or a queen. It has been proved that the former, although exhibiting no appearance of sexual organs on a superficial examination, are in reality females, and have the rudiments of these organs, which, however, not being developed, are incapable of exercising their proper functions, although it sometimes happens that they become sufficiently so to enable a worker to lay unfecundated eggs. It may be remarked that the idea of the worker bees being radically females had been suggested long ago by Dr Warder in his *Monarchy of Bees*, in which he terms them "True Amazons;" but no attention had been paid to his opinion. The real merit of this great discovery, which affords a key to a multitude of hitherto inexplicable facts, unquestionably belongs to Schirach. When first announced to the world it was received with suspicion by the greater number of naturalists, and with complete incredulity by others. It was, indeed, at variance with the whole tenor of the observations of Swammerdam, Maraldi, and Reaumur. Wilhelmi, the brother-in-law of Schirach, though an eye-witness of the experiments from which this theory had been deduced, for a long time refused to admit the doctrine, but at length became one of its most strenuous supporters. It is noticed in a vein of sarcastic ridicule by John Hunter in his otherwise excellent paper on bees in the *Philosophical Transactions*. Needham wrote a *Memoir* for the Imperial Academy of Brussels in 1777 for the express purpose of refuting it, and he then inveighs in strong language against those naturalists who had deigned to give it the least countenance. Bonnet, after exercising a laudable scepticism, and making a diligent inquiry, in which he displays a genuine spirit of philosophy, yielded a reluctant assent. But the truth of the doctrine has since been placed beyond the reach of controversy by a multiplied series of observations and experiments in different parts of Europe and America.

In considering the physiology of the bee, the first function that claims our notice is that of nutrition. The food of bees is principally of two kinds, namely, the fluid secretions of vegetables contained in the nectaries of the flowers, and the dust of the anthers, which has been termed by botanists the pollen, but which, when collected by the bees, has received a variety of appellations, such as farina, bee-bread, &c. Occasionally, however, we find bees feeding upon other saccharine substances besides honey such as honey-dew, syrup, &c.

Organs for collecting food

The organs by which they collect food are extremely complex, comprising instruments adapted to the reception of liquid aliment as well as those fitted for the division of solid materials. Reaumur has given a most elaborate description of these organs, and corrects some errors into which Swammerdam had fallen. For the purpose of taking up fluids, bees are provided, in common with all hymenopterous insects, with a long and flexible proboscis or trunk, which may be considered as a lengthened tongue, though, strictly speaking, it is formed by a prolongation of the under lip. It is not tubular, as Swammerdam had supposed, but solid throughout; and the minute depression at its extremity is not the aperture of any canal through which liquids can be absorbed. The trunk of the bee performs strictly the office of a tongue, and not that of a tube for suction; for when it takes up honey or any other fluid aliment, the under or the upper surfaces are more immediately applied to it, and rolled from side to side, and the bee thus licks up what adheres to it, while the extremity of the trunk is frequently not applied at all to the substance taken up. The trunk is supported on a pedicle, which admits of being bent back or propelled forwards, and thus can retract or stretch out the trunk to a considerable extent. Protection is given to it by a double sheath; the external part consisting of two scales furnished by the expansion of one of the portions of the labial palpi, and the internal formed by the prolongation of the two external portions of the jaw. The whole member thus consists of five principal parts, on which account Fabricius termed it *lingua quinquefida*.

Proboscis.

For the purpose of mechanically dividing solid materials, the mouth is furnished with two strong mandibles and four palpi; they are but little employed in eating, but are of great use in enabling the insect to seize and break down hard substances for other purposes. In the worker bee all these parts are of larger dimensions than in the other kinds. The teeth are two in number, and have the form of concave scales with sharp edges; they are fixed to the ends of the jaws, and play horizontally as in other insects. Reaumur describes and delineates a large aperture above the root of the proboscis, which is so surrounded with fleshy parts as not to be readily seen unless the proboscis be extended and bent downwards. This he considers as the mouth or orifice of the gullet; on the upper side of which, and of course opposite to the root of the proboscis, a small fleshy and pointed organ is seen, which he regards as the tongue, assisting in the deglutition of the food. Through this orifice, it is presumed, all the aliment, whether liquid or solid, passes; the former being conveyed to it by the trunk, which, by its contractile power, presses forward the fluids it has collected between itself and the inner sheath, and the latter being received directly after its comminution by the teeth, behind which it is situated. Latreille, however, whose authority is great on a point of this nature, thinks that Reaumur has deceived himself with regard to such an aperture, and disbelieves its existence. He conceives that the food simply passes on by the sides of the tongue, finding its way from thence into the œsophagus and so on to the stomach.

The bee has two stomachs. The first is a large transparent membranous bag, pointed in front and swelling out into two pouches behind. It performs an office in some respects analogous to that of the crop in birds; for it receives and retains for a time the fluid of the nectaries, which does not appear to differ in any respect from honey. Hunter observes that whatever time the contents of this reservoir may be retained he never found them altered so as to give the idea of digestion having taken place. The coats of this reservoir are muscular, by which means it is capable of throwing up the honey into the mouth, so that it is regurgitated into the honey cells or imparted to other bees. None of it ever passes out from the extremity of the trunk as Swammerdam had believed. For the purpose of digestion a second stomach is provided, which takes its origin from the middle of the two posterior lobes of the former, and is of a lengthened cylindrical shape. Its communication with the intestine is not direct, but takes place by a projecting or inverted pylorus, thickest at its most prominent part, with a very small opening in the centre, of a peculiar construction. This inward projecting part is easily seen through the coats of the reservoir, especially if full of honey. A similar kind of structure takes place at the communication of the first with the second stomach, and having the properties of a valve, must effectually prevent all regurgitation from the latter into the former.

The pollen, or fertilising dust of flowers, is collected by the bees for the purpose of feeding the young. It is stored in the cells until required, and then partly digested by the nurses with honey, and a kind of chyle formed of it. When natural pollen cannot be obtained the bees will eagerly take farina, either of rye, chestnuts, or pease, as a substitute, which appears to answer the same purpose. The bees, by means of the pencil of hair which grows on the tarsi, first collect a certain quantity of pollen, and then

knead it together into a ball, and place it in the space situated at the middle joint or tibia of the hinder leg, which has been termed the basket. This portion of the leg is smooth and concave, somewhat like the bowl of a spoon, with stout hairs of moderate length rising from its left edge and nearly straight. Other hairs on the right side are much longer and are curved, rising up with a high arch and crossing more than half the width of the hollow, making a large basket-like enclosure for a load of pollen. In order to gather large quantities at once, the bees are sometimes observed to roll their bodies on the flower, and then brushing off the pollen which adheres to them with the feet, form it into two masses, which they dispose of as before mentioned; and it is said that in moist weather, when the particles of pollen cannot be readily made to adhere, they return to their hive dusted all over with pollen, which they then brush off with their feet. The part in Nature's economy thus unconsciously performed by the bee in common with other insects is most important. By this means the pollen is carried from flower to flower, or from the stamens to the pistils, and plants are made fertile which without such aid would often remain barren.

Wax. It was long the received opinion that wax was but a modification of pollen, which required for this conversion only a slight pressure and a kind of kneading by the feet of the bees. But it has been completely proved, by the researches of Duchet, Hunter, and Huber, that wax is a secretion from the abdomen of the bee, and that it depends not at all on the pollen which the insect may consume (indeed, it is doubtful if it consumes any), but on the quantity of honey or other saccharine substance which it receives into its stomach. The first light thrown on this subject was in a letter of Wilhelmi to Bonnet in 1768, in which he says that wax, instead of being ejected by the mouth, exudes from the rings which enclose the posterior part of the body. Of this we may satisfy ourselves by drawing out the bee from the cell in which it is working with wax, by means of the point of a fine needle; and we may perceive, in proportion as the body is elongated, that the wax will make its appearance under the rings in the form of small scales. Duchet, in his *Culture des Abeilles*, gives a full statement of the principal circumstances attending the production of wax, which he very justly ascribes to the conversion of honey into this substance in the body of the bee. These facts appear to have been entirely overlooked till the subject was again brought forward by Hunter, in his paper in the *Philosophical Transactions* for 1792. Huber was engaged in prosecuting his inquiries on this subject at the same period with Hunter, and discovered, in 1793, the existence of regular receptacles or pouches, from the coats of which the wax is secreted, and within which it accumulates till its edges raise the scales, and become apparent externally. These plates of wax are withdrawn by the bee itself, or some of its fellow-labourers, and are applied in a manner hereafter to be described.

Huber has shown, by a series of well-conducted experiments, that, in a natural state, the quantity of wax secreted is in proportion to the consumption of honey, but that an equal or even greater quantity will be formed if the bee be fed on a solution of sugar in water. Warmth and rest promote this process of secretion; for the bees, after feeding plentifully on saccharine food, hang together in a cluster without moving, for several hours, at the end of which time large plates of wax are found under the abdominal rings. This happened when bees were confined and restricted from any other sort of nourishment, whilst those that were fed on pollen and fruits alone did not produce any wax. In the second volume of Huber's *Nouvelles Observations sur les Abeilles*, he describes minutely the anatomy of the pouches or receptacles for the wax, which are parts peculiar to the working bees, being totally absent in the males and queens. The cavities are lined with a membrane, which presents a number of folds, forming an hexagonal net-work, not unlike the appearance in the second stomach of ruminant quadrupeds, and evidently destined to perform the office of secretion.

Among the secretions peculiar to the bee, the poison which is poured into the wounds made by the sting deserves to be noticed. It is said to owe its mischievous efficacy to certain pungent salts. If a bee is provoked to strike its sting against a plate of glass, a drop of poison will be discharged; and if this is placed under a microscope, the salts may be seen to concrete, as the liquor dries, into clear, oblong, pointed crystals. The sting consists of a finely-pointed tubular instrument, open along the whole length of its upper surface, this opening being closed by two slender horny barbs each having about ten serrations on its outer edge. These barbs are not projected in advance of the sting as usually described, neither are they within the sting, but complete its outer tubular surface, down the centre of which the poison is injected from a little bag at the root of the sting. The serrations prevent the worker bee from withdrawing its sting from an enemy; and, consequently, it is torn from the body, with a portion of the intestines, causing the death of the bee.

Respiration is effected by means totally different from those which are usual in the higher classes of the Animal Kingdom. As the blood, or fluid corresponding to the blood, cannot be presented to the air in any separate organ, the air must be conducted to the blood wherever such a fluid is met with. For this purpose tracheæ, or air-tubes, having several external openings or spiracles, are made to ramify like arteries, and are distributed in an infinite number of branches to every part of the body. The condition of a hive of bees in which many thousand individuals, full of animation and activity, are crowded together in a confined space, having no communication with the external air but by means of a very small aperture in the lowest part, which aperture is frequently obstructed by a throng of bees passing in and out during sultry weather, would without some precautions be of all possible conditions the one least favourable to life. Bees cannot exist in an impure atmosphere any more than creatures of a larger growth. And on examining the air of a populous hive it is found scarcely to differ in purity from the surrounding atmosphere. Ventilation of the hive. The means by which this is effected observation has shown is by the rapid vibration of the bees' wings, a certain number being told off to imitate the action of flying, for which purpose they fasten themselves with their feet to the floor of the hive, so that the whole effect of that impulse which, were they at liberty, would carry them forwards with considerable velocity is exerted on the air, which is therefore driven backwards in a powerful current. Some bees occasionally perform these ventilating motions on the outside of the hive, near the entrance, but a still greater number are employed in this office within doors. Sometimes twenty are thus occupied at once, and each bee continues its motions for a certain time, occasionally for nearly half an hour, and is then relieved by another, which takes its place. So rapid a motion of the wings is thus produced that they cannot be seen except at the two extremities of the arc of vibration, which is at least one of 90°. This is the occasion of that humming sound which is constantly heard from the interior of the hive when the bees are in a state of activity. The immediate cause of these actions is probably some impression made on their organs by the presence of vitiated air, for a bee may be made to ventilate itself by placing near it substances which have to it an unpleasant odour.

The connection between an active respiration and a high temperature is remarkably exemplified in bees, among which, in consequence of their collecting together in large numbers, the heat is not readily dissipated, and admits also of being easily ascertained by the thermometer. Hunter found it to vary from 73° to 84° Fahr.; and Huber observed it on some occasions to rise suddenly from about 92° to above 104°.

The physiology or the external senses in a class of animals of a nature so remote from our own species must necessarily be very imperfectly understood by us. The infinite diversity of character presented by the different tribes of insects, as well as of other animals, naturally suggests the idea that external objects produce on their sentient organs impressions widely different from those which they communicate to ourselves. The notions we form of their senses must not only be liable to great inaccuracy, but may often be totally inadequate representations of the truth. A finer organisation and more subtile perceptions would alone suffice to extend the sphere of their ordinary senses to an inconceivable degree, as the telescope and the microscope have with us extended the powers of vision. But they possess in all probability other organs appropriated to unknown kinds of impressions, which must open to them avenues to knowledge of various kinds to which we must ever remain total strangers. Art has supplied us with many elaborate modes of bringing within our cognizance some of the properties of matter which nature has not immediately furnished us with the means of detecting. But who will compare our thermometers, spectroscopes, or hygrometers, however elaborately constructed, with those refined instruments with which the lower orders of animals, and particularly insects, are so liberally provided?

Functions of the antennæ. The antennæ, which are so universally met with in this class of animals, are doubtless organs of the greatest importance in conveying impressions from without. Their continual motion, the constant use which is made of them in examining objects, the total derangement in the instincts of those insects which have been deprived of them, point them out as exquisite organs of sense. To impressions of touch arising from the immediate contact of bodies they are highly sensitive, but their motions evidently show that they are affected by objects at some distance. They are, no doubt, alive to all the tremulous movement of the surrounding air, and probably communicate perceptions of some of its other qualities. Composed of a great number of articulations, they are exceedingly flexible, and can readily embrace the outline of any body that the bee wishes to examine, however small its diameter. Newport, in a paper published in the *Transactions of the Entomological Society*, says he is convinced from experiments that the antennæ are auditory organs; and that however varied may be their structure, they are appropriated to the perception and transmission of sound. The majority of modern physiologists and entomologists coincide in this view, and the weight of authority in favour of it is certainly very great, comprising as it does Sulzer, Scarpa, Schneider, Borkhausen, Bonsdorf, Carus, Straus-Durckheim, Oken, Burmeister, Kirby and Spence, Lespès, and Hicks. Nevertheless, other eminent entomologists, as, for instance, Lyonet, Küster, Robineau-Desvoidy, Vogt, and Erichson, regard these organs as the seat of smell. The question may be considered as yet undetermined, and it is possible that they are the organs of some sense of which we know nothing, and which we consequently cannot describe. It is by these instruments that the bee is enabled to execute so many works in the interior of the hive, from which the light must be totally excluded. Aided by them it builds its combs, pours honey into its magazines, feeds the larvæ, and ministers to every want which it appears to discover and judge of solely by the sense of touch. The antennæ appear also to be the principal means employed for mutual communication of impressions. The different modes of contact constitute a kind of language which seems to be susceptible of a great variety of modifications, capable of supplying every sort of information for which they have occasion.

The sense residing in the antennæ appears to be on many occasions supplementary to that of vision, which in bees, as in other insects, is less perfect than in the larger animals. During the night, therefore, they are chiefly guided in their movements by the former of these senses. In full daylight, however, they appear to enjoy the sense of vision in great perfection. A bee alights unerringly on the flowers in search of nectar or pollen, and as truly at its own hive's entrance on its arrival there. When returning from the fields to its hive it seems to ascertain the proper direction by rising with a circular flight into the air; it then darts forward with unfailing precision, passing through the air in a straight line with extreme rapidity, and never failing to alight at the entrance of its own hive, though whether its course be determined by vision alone we are unable to say.

Their perceptions of heat and cold are extremely delicate. The influence of the sun's rays excites them to vigorous action. Great cold will reduce them to a state of torpor, and inferior degrees of cold are unpleasant to them; a temperature of 40° Fahr. will so benumb a bee as to deprive it of the power of flight, and it will soon perish unless restored to a warmer atmosphere. When, however, bees are in the usual winter's cluster in the hive, they will bear a very great degree of cold without injury. In America hives often stand where the external temperature is as low as 20° below zero, and from the condensed vapour within the hive, the bees may be found in a solid lump of ice, and yet, with returning spring, they awake to life and activity. The degree of cold which bees can endure has not been ascertained, though it is no doubt considerable. They survive the winter in many cold parts of Russia, in hollow trees, without any attention being paid to them; and their hives are frequently made of the bark of trees, which does not afford a very complete protection from the effects of frost. Many bees which are thought to die of cold in winter die in reality of famine or damp. A rainy summer and cold autumn often prevent their laying in a sufficient store of provisions; and the hives should, therefore, be carefully examined in the after-part of the season, and the amount of food ascertained. Mr White judiciously observes, that bees which stand on the north side of a building whose height intercepts the sun's beams all the winter will waste less of their provisions than others which stand in the sun; for, coming forth seldom, they eat little, and yet are as forward in the spring to work and swarm as those which had twice as much honey left with them the preceding autumn. They show by their conduct that they are sensible of changes in the state of the weather for some time before we can perceive such alterations. Sometimes when working with great assiduity they will suddenly desist from their labours, none will stir out of the hive, while all the workers that are abroad hurry home in crowds, and press forward so as to obstruct the entrance of the hive. Often, when they are thus warned of the approach of bad weather, we can distinguish no alteration in the state of the atmosphere. Gathering clouds sometimes produce this effect on them; but perhaps they possess some species of hygrometrical sense unconnected with any impression of vision. Huber supposes that it is the rapid diminution of light that alarms them, for if the sky be uniformly overcast they proceed on their excursions, and even the first drops of a shower do not make them return with any great precipitancy.

Their taste is, perhaps, the most imperfect of their senses. They use scarcely any discrimination in the collection of honey from different flowers. They are not repelled by the scent or flavour of such as are extremely offensive to our organs, and scruple not to derive supplies from such as are highly poisonous. In some districts in America it is well known that honey acquires in this way very deleterious properties. The qualities of honey are observed to vary much according to the particular situation from which it is obtained. In their selection of flowers they are guided by the quantity of honey they expect to meet with, and in no respect by its quality. That gathered from ivy blossoms in England is sometimes so bitter and nauseous as to be useless for our eating, although the bees consume it readily. But their smell must be sufficiently acute to enable them to discover honey at great distances, and in concealed situations direct experiment has indeed proved this to be the case. Huber found that they proceeded immediately towards boxes which contained honey concealed from view; and such, in fact, is the situation of the fluid of the nectaries in flowers. Some odours, and especially all kinds of smoke, are highly obnoxious to them; and this is also the case with ammonia and other volatile chemical agents, upon receiving the impression of which they immediately set about ventilating themselves in the usual manner. The odour of the poison of their sting produces similar effects, exciting them to immediate rage and hostility. It has been observed that bees recognize the presence of a stranger in their hive by the smell; and in joining two stocks into one, if the bees are united without precautions, a battle will probably ensue. To obviate this bee-keepers are in the practice of strongly scenting both families by means of peppermint, tobacco smoke, or other strong-smelling agent; this overpowering the bees' natural scent, they are unable to distinguish their own party from the intruders, and peace is insured. The sense of vision does not appear to aid them, for where Ligurians are added to common black bees the effect is the same, although in colour the two varieties are very different. In the introduction of an alien queen to a stock it is also usual to imprison the new sovereign within the hive which she is to rule until she has acquired the peculiar scent of her future subjects, who will then make no objections to her, while had she been at once set at liberty she would probably have met her death.

Although it is clear that insects possess the power of smell, yet the particular organ of this sense has never been accurately ascertained, and the opinions of naturalists have been much divided on the subject. These opinions have been supported more by arguments drawn from the analogy of what happens in other classes of animals than by direct experiment on insects themselves. We know that in all animals respiring by means of lungs, the organs of smell are placed at the entrance of the air-passages; and it has often been concluded that in like manner the stigmata, or the orifices of the air-tubes, are the seat of this sense in insects. Huber's opinion was that in the bee this sense resides in the mouth itself, or in its immediate vicinity. Here, indeed, would be its proper station if this faculty be intended, as we may reasonably suppose it to be, to apprise the individual of the qualities of the food prior to its being eaten. When the mouth of a bee was plugged up with paste, which was allowed to dry before the insect was set at liberty, it remained quite insensible to the same odours to which it had before manifested the strongest repugnance.

It is generally supposed that bees possess the sense of hearing. The common practice of making a loud noise by drums and kettles in order to attract a swarm is founded on this supposition. But the evidence is by no means conclusive, for we find that they are not disturbed by a loud clap of thunder, or by the report of a gun, or by any other noise that may happen to arise round them. Sir John Lubbock, who has made a great many observations in this direction, says that he could never find them take notice of any sound he made even when it was close to them. He tried them with a violin, dog whistle, shrill pipe, and set of tuning forks, also by shouting, &c., close to their heads, but in spite of his utmost efforts the bees took no notice, not even by a twitch of the antennæ showing they heard. It is, however, certain that they are capable of emitting a variety of sounds which appear expressive of anger, fear, satisfaction, and other passions; and it would seem that they are even capable of communicating certain emotions to one another in this manner. Huber observed that the young queens not yet liberated from their cocoons sent forth a peculiar piping sound, and this is answered by the old queen, who apparently must hear the note of her aspiring rival.

A certain cry or humming noise from the queen will strike with sudden consternation all the bees in the hive, and they remain for a considerable time motionless and stupified. Hunter has noticed a number of modulations of sound emitted by bees under different circumstances, and has instituted an inquiry concerning the means employed by them in producing these sounds; for an account of this see his paper in the *Philosophical Transactions*.

Instinct

If the function of sensation in insects be involved in doubt and obscurity, the knowledge of those more interior faculties, which are the springs of voluntary action, is hid in still deeper mystery. Buffon refuses to allow bees any portion of intelligence, and contends that the actions we behold, however admirably they are directed to certain ends, are in fact merely the results of their peculiar mechanism. Other philosophers, such as Reaumur and Brougham (*Works*, vol. vi.), have gone into the opposite extreme, and have considered them as endued with extraordinary wisdom and foresight, as animated by a disinterested patriotism, and as uniting a variety of moral and intellectual qualities of a higher order. The truth, no doubt, lies between these overstrained opinions; but it is nevertheless extremely difficult to decide in what degree these respective principles operate in the production of the effects we witness. The term *instinct* should properly be regarded, not as denoting a particular and definite principle of action, whose operation we can anticipate in any new or untried combination of circumstances, but as expressive of our inability to refer the phenomena we contemplate to any previously known principle. Thus the actions which an animal performs in obedience to the calls of appetite are not properly said to be instinctive; nor can the term be applied to actions which are the consequence of acquired knowledge, and of which the object is with certainty foreseen by the agent. But when an animal acts apparently under a blind impulse, and produces effects useful to itself or to the species, which effects it could not have previously contemplated as resulting from those actions, it is then customary to say that it is under the guidance of instinct, that is, of some unknown principle of action. It will be proper, therefore, to keep this distinction in view in judging of the voluntary actions of the lower animals.

In no department of natural history is it more necessary to be aware of the proper import of the term instinct, than in studying the phenomena presented by the bee; for nowhere is it more difficult to discriminate between the regular operation of implanted motives and the result of acquired knowledge and habits. The most striking feature of their history, and the one which apparently lays the foundation for those extraordinary qualities which raise them above

the level of other insects, is the disposition to social union. It may in general, indeed, be remarked, that animals which associate together so as to form large communities, display a higher degree of sagacity than those which lead a solitary life. This is especially observable among insects. The spider and *Formica leonis* may exhibit particular talents, or practise particular stratagems in the pursuit and capture of their prey; but their history is limited to a single generation, and embraces none of those interesting relations which exist between individuals composing the gregarious tribes, such as the ant, the wasp, and the bee. Among these we trace a community of wants and desires, and a mutual intelligence and sympathy, which lead to the constant interchange of good offices, and which, by introducing a systematic division of labour, amidst a unity of design, leads to the execution of public works on a scale of astonishing magnitude. The attachment of bees to their hive, which they defend with a courage and self-devotion truly admirable, their jealousy of intruders, their ready co-operation in all the labours required for the welfare of the community, their tender care of their young, the affection and homage which they bestow on their queen, imply qualities such as we could hardly persuade ourselves could animate a mere insect, on which we are in the habit of proudly looking down as placed in one of the lowest orders of created beings.

We shall content ourselves at present with these general observations, as the instances which serve to illustrate their moral and intellectual character belong properly to the history of the different processes they follow in the construction of their combs, the hatching and rearing of their progeny, and the mode of conducting their migrations. To these subjects, therefore, we shall now proceed; and in order to present the most connected and complete account of their economy, we shall begin the history from the period when a new swarm has just occupied a hive, and when all the arrangements for their habitation, and the construction of the cells in which their eggs and provisions are to be deposited, are yet to be effected.

Preparation of the hive.

The first care of the worker bees, on their settlement in their new abode, is to clean it out thoroughly. While one set of bees is thus employed, another is distributed about the country in order to procure the proper materials for blocking up the small holes and chinks of the hive, and for laying a firm foundation for the edifice which is to be constructed within it. The substance which is principally employed in this preliminary stage is *propolis*, a species of glutinous resin, of an agreeable aromatic odour, and reddish-brown colour, in process of time becoming darker, and acquiring a firmer consistence. According to the analysis of Vauquelin (*Mém. Soc. Agricult. Departem. Seine*), it is composed chiefly of resin, with a small proportion of wax, and of acid and aromatic principles. It is soluble in alcohol, ether, and oils, both fixed and volatile, and tinges the solvent of a beautiful red colour. Cadet has since ascertained in it the presence of benzoic and gallic acids. Reaumur had not been able to discover from what plants the bees collect this substance. Riem asserts that it is chiefly from pines and other trees of the fir kind. The observations of Huber have assisted in the solution of this question. On placing branches of the wild poplar tree before the hive, he found that the bees eagerly seized upon the varnish which exudes from the buds; and examining the chemical properties of this varnish, he identified it with the propolis with which the inside of the hive is lined.

Propolis.

The propolis adheres so strongly to the legs and feet of the bee which has collected it, that it cannot be detached without the assistance of its fellow-labourers. For this purpose the bee that is loaded presents its legs to the workers in the hive, which carry off with their jaws this adhesive substance, and immediately apply it, while yet ductile, all round the interior of the hive, and particularly over all the projecting parts; hence its name, of Greek derivation, signifying *before the city*. In like manner all the foreign bodies that are introduced into the common habitation and are too heavy for removal are covered over with this resinous substance. If a snail, for instance, should happen to introduce itself into the hive, after despatching it with their stings, they encrust it over with propolis.

The next object of their labours is the construction of the combs, the future receptacles for the eggs with which the queen is pregnant and which are now to be laid. The material employed is wax; and the bees, for the purpose of secreting this, are actively employed in collecting honey. When they have filled their crops with honey they hang together in a thick cluster from the top of the hive, and thus remain in a state of inactivity for a considerable period, during which time the secretion of wax is proceeding. It may be seen collected in laminæ under the abdominal scales, whence it is removed by the hind legs of the bee, transferred to the fore legs, and from thence taken up by the jaws. In this operation they are often assisted by their companions, who even sometimes directly seize upon the wax from under the abdomen of those who are before them. When a sufficient quantity of material has thus been collected together, the process of building is commenced; but in order to understand the subsequent operations it is necessary to have a correct idea of the form of the cells which compose the combs. We shall, therefore, proceed to give some account of the structure when it has attained its perfect state.

Forms of the combs.

The combs of a bee-hive are formed in parallel vertical strata, each of which is about an inch in thickness, the distance between the surfaces of adjoining strata being about half an inch, a space which allows for the passage of the bees over both surfaces. The combs generally extend the whole breadth of the hive, and nearly the whole length from the top to the bottom. They consist of thin partitions which enclose hexagonal cells, opening on both surfaces of the comb and closed by a partition which is common to those on both sides, and occupies the middle distance between the two surfaces. This partition is not, however, a plane, but is composed of a collection of rhombs. Three and sometimes four of these rhombs incline to one another at a certain angle from the bottom of each cell, which thus has the shape of a flattened pyramid, of which the base is towards the mouth of the cell. The geometric form of each individual cell is therefore a hexagonal prism, terminated by a trihedral pyramid, the three sides of which are rhombs which meet at the apex by their obtuse angles, and, forming oblique angles with the sides of the prism, truncate a portion of these, and convert them from rectangles, which they would be in a regular prism, into trapeziums. Of the two angles of these trapeziums adjoining the base of the pyramid one must be acute and the other obtuse, the acute angle of one trapezium being next to the acute angle of the adjoining trapezium, and the obtuse angle being in like manner next to another obtuse angle of the preceding trapezium; so that in going round the base we meet with pairs of acute and of obtuse angles alternately succeeding each other. The two adjoining acute angles of the trapezium are adjoining to two of the terminal rhombs which here present their acute angles, so that at these points a solid angle of four planes is formed, all the angles being acute. Each pair of obtuse angles of the trapezia, on the other hand, are adjacent to the obtuse angle of one of the rhombs only, thus composing a solid angle of three planes of which the angles are all obtuse; and these two kinds of solid angles succeed one another