

## Glimpses of Nature.

### VII.—THE FIRST PAPER-MAKER.

BY GRANT ALLEN.



HE civilized world could hardly get on nowadays without paper; yet paper-making is, humanly speaking, a very recent invention. It dates, at furthest, back to the ancient Egyptians.

"Humanly speaking," I say, not without a set purpose: because man was anticipated as a paper-maker by many millions of years; long before a human foot trod the earth, there is reason to suppose that ancestral wasps were manufacturing paper, almost as they manufacture it for their nests to-day, among the sub-tropical vegetation of an older and warmer Europe. And the wasp is so clever and so many-sided a creature, that to consider him (or more accurately her) in every aspect of life within the space of a few pages would be practically impossible. So it is mainly as a paper-manufacturer and a consumer of paper that I propose to regard our slim-waisted friend in this present article.

It is usual in human language to admit, as the Latin Grammar ungallantly puts it, that "the masculine is worthier than the feminine, the feminine than the neuter." Among wasps, however, the opposite principle is so clearly true—the queen or female is so much more important a person in the complex community, and so much more in evidence than the drone or male—that I shall offer no apology here for setting her history before you first, and giving it precedence over that of her vastly inferior husband. *Place aux dames* is in this instance no question of mere external chivalrous courtesy; it expresses the simple truth

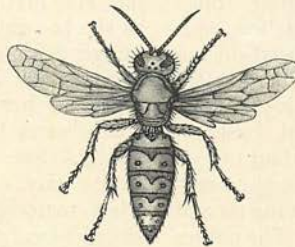
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of nature, that, in wasp life, the grey mare is the better horse, and bears acknowledged rule in her own city household. Not only so, but painful as it may sound to my men readers, and insulting to our boasted masculine superiority, the neuter in this case ranks second to the feminine; for the worker wasps, which are practically sexless, being abortive females, are far more valuable members of the community than their almost useless fathers and brothers. I call them neuter, because they are so to all intents and purposes: though for some unknown reason that seemingly harmless word acts upon most entomologists like a red rag on the proverbial bull. They will allow you to describe the abortive female as a worker only.

In No. 1, therefore, I give an illustration of a queen wasp; together with figures of her husband and of her unmarried daughter. The queen or mother wasp is much the largest of the three; and you will understand that she needs to be so, when you come to learn how much she has to do, how many eggs she has to lay; and how, unaided, this brave foundress of a family not only builds a city and peoples it with thousands of citizens, but also feeds and tends it with her own overworked mouth—I cannot honestly say her hands—till her maiden daughters are of age to help her. Women's rights women may be proud of the example thus set them. Nature nowhere presents us, indeed, with a finer specimen of feminine industry and maternal devotion to duty than in the case of these courageous and pugnacious insects.



MALE



QUEEN



WORKER

1.—FAMILY PORTRAITS OF THE WASPS.



But I will not now enlarge upon the features of these three faithful portraits, "expressed after the life," as Elizabethan writers put it, because as we proceed I shall have to call attention in greater detail to the meaning of the various parts of the body. It must suffice for the moment to direct your notice here to that very familiar portion of the wasp's anatomy, the sting, or ovipositor, possessed by the females, both perfect and imperfect—queens or workers—but not by those defenceless creatures, the males. The nature of the sting (so far as it is not already well known to most of us by pungent experience) I will enter into later; it must suffice for the present to say that it is in essence an instrument for depositing the eggs, and that it is only incidentally turned into a weapon of offence or defence, and a means of stunning or paralyzing the prey or food-insects.

The first thing to understand about a community of wasps is the way it originates. The story is a strange one. When the first frosts set in, almost all the wasps in temperate countries like England (they delude us into calling our own climate "temperate!") die off to a worker from the effects of cold. The chill winds nip them. For a few days in autumn you may often notice the last straggling survivors crawling feebly about, very uncomfortable and numb from the cold, and with their tempers somewhat soured by the consciousness of their own exceeding weakness. In this irritable condition, feeling their latter end draw nigh, they are given to using their stings with waspish virulence on the smallest provocation; they move about half-dazed on the damp ground, or lie torpid in their nests till death overtakes them. Of the whole populous city which hummed with life and business but a few weeks earlier, no more than two or three survivors at the outside struggle somehow through the winter, to carry on the race of wasps to succeeding generations. The colder the season, the fewer the stragglers who live it out; in open winters, on the contrary, a fair number doze it through, to become the foundresses of correspondingly numerous colonies.

And who are these survivors? Not the lordly and idle drones; not even the industrious neuters or workers; but the perfect females or queens, the teeming mothers to be of the coming communities. Look at the royal lady figured in No. 1. As autumn approaches, this vigorous young queen weds one of the males from her

native nest. But shortly afterward, he and all the workers of his city fall victims at once to the frosts of October. They perish like Nineveh. The queen, however, bearing all the hopes of the race, cannot afford to fling away her precious life so carelessly. That is not the way of queens. She seeks out some sheltered spot among dry moss, or in the crannies of the earth—a sandy soil preferred—where she may hibernate safely. There, if she has luck, she passes the winter, dormant, without serious mishap. Of course, snow and frost destroy not a few such solitary hermits; a heavy rain may drown her; a bird may discover her chosen retreat; a passing animal may crush her. But in favourable circumstances, a certain number of queens do manage to struggle safely through the colder months; and the wasp-supply of the next season mainly depends upon the proportion of such lucky ladies that escape in the end all winter dangers. Each queen that lives through the hard times becomes in spring the foundress of a separate colony; and it is on this account that farmers and fruit-growers often pay a small reward for every queen wasp killed early in the spring. A single mother wasp destroyed in May is equivalent to a whole nest destroyed in July or August.

As soon as warmer weather sets in, the dormant queen awakes, shakes off dull sloth, and forgets her long torpor. With a toss and a shake, she crawls out into the sunshine, which soon revives her. Then she creeps up a blade of grass, spreads her wings, and flies off. Her first care is naturally breakfast; and as she has eaten nothing for five months, her hunger is no doubt justifiable. As soon, however, as she has satisfied the most pressing wants of her own nature, maternal instinct goads her on to provide at once for her unborn family. She seeks a site for her nest, her future city. How she builds it, and of what materials, I will tell you in greater detail hereafter; for the moment, I want you to understand the magnitude of the task this female Columbus sets herself—Columbus, Cornelia, and Cæsar in one—the task not only of building a Carthage, but also of peopling it. She has no hands to speak of, but her mouth, which acts at once as mouth, and hands, and tools, and factory, stands her in good stead in her carpentering and masonry. She does everything with her mouth; and therefore, of course, she has a mouth which has grown gradually adapted for doing everything. The monkey used his thumb till he made a hand of it; the



elephant his trunk till he could pick up a needle. Use brings structure; by dint of using her mouth so much, the wasp has acquired both organs fit for her, and dexterity in employing them.

The first point she has now to consider is the placing of her nest. In this, she is guided partly by that inherited experience which we describe (somewhat foolishly) as instinct, and partly by her own individual intelligence. Different races of wasps prefer different situations: some of them burrow underground; others hang their houses in the branches of trees; others again seek some dry and hollow trunk. But personal taste has also much to do with it; thus the common English wasp sometimes builds underground, but sometimes takes advantage of the dry space under the eaves of houses. All that is needed is shelter, especially from rain; wherever the wasp finds a site that pleases her, there she founds her family.

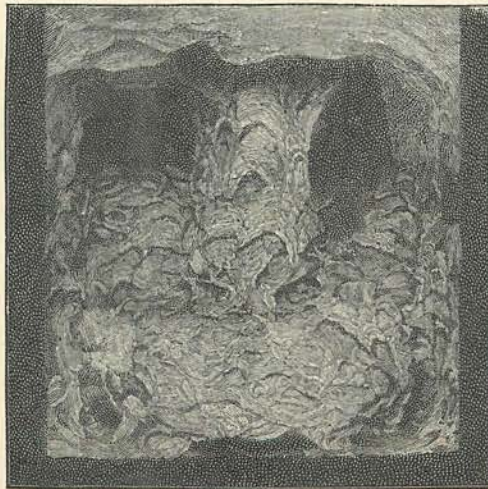
Let us imagine, then, that she has lighted on a suitable hole in the earth—a hole produced by accident, or by some dead mole or mouse or rabbit; she occupies it at once, and begins by her own labour to enlarge and adapt it to her private requirements. As soon as she has made it as big as she thinks necessary, she sets to work to collect materials for building the city. She flies abroad, and with her saw-like jaws rasps away a paling or other exposed piece of wood till she has collected a fair amount of finely-powdered fibrous matter. I will show you later on the admirable machine with which she scrapes and pulps the fragments of wood-fibre. Having gathered a sufficient quantity of this raw material to begin manufacturing, she proceeds to work it up with her various jaws and a secretion from her mouth into a sort of coarse brown paper; the stickiness of the secretion gums the tiny fragments of wood together into a thin layer. Then she lays down the floor of her nest, and proceeds to raise upon it a stout column or foot-stalk of papery matter, sufficiently strong to support the first two

or three layers of cells. She never builds on the ground, but begins her nest at the top of the supporting column. The cells are exclusively intended for the reception of eggs and the breeding of grubs, not (as is the case with bees) for the storing of honey. We must remember, however, that the original use of all cells was that of rearing the young; the more advanced bees, who are the civilized type of their kind, make more cells than they need for strictly nursery purposes, and then employ some of them as convenient honey-jars. The consequence is that bee-hives survive intact from season to season (unless killed off artificially), while the less prudent wasps die wholesale by cityfuls at the end of each summer.

Having thus supplied a foundation for her topsy-turvy city, our wasp-queen proceeds in due course to build it. At the top of the original column, or foot-stalk, she constructs her earliest cells, the nurseries for her three first-born grubs. They are not built upward, however, above the foot-stalk, but downward, with the open mouth below, hanging like a bell. Each is short and shallow, about a tenth of an inch in depth to begin with, and more like a cup, or even a saucer, than a cell at this early stage. The Natural History Museum at South Kensington possesses some admirable examples of such nests, in various degrees of growth; and my fellow-worker, Mr. Enock, has obtained the kind permission of the authorities at the Museum to photograph the cases which contain them, for the purposes of these articles. They represent the progress of the queen-wasp's work at two, five, and fifteen

days respectively (Nos. 2, 3, and 4), and thus admirably illustrate the incredible rapidity with which, alone and unaided, she builds and populates this one-mother city.

As soon as the first cells are formed, in their early shallow shape, the busy mother, sallying forth once more in search of wood or fibre, proceeds to make more paper-pulp, and construct an umbrella-shaped covering above the

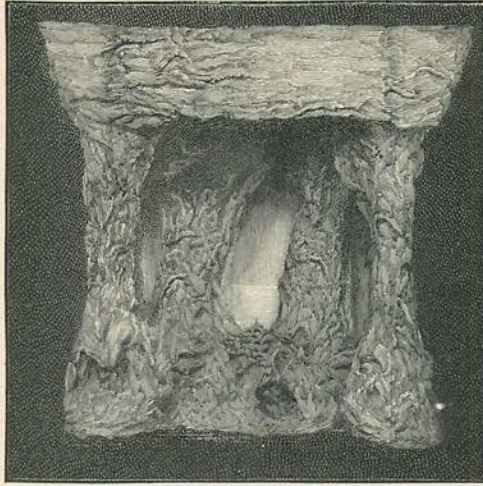


2.—THE CITY, TWO DAYS OLD.



three saucers. In each of the three she lays an egg; and then, leaving the eggs to hatch out quietly by themselves into larvæ, she goes on cutting—not bread and butter, like Charlotte in Thackeray's song—but more wood-fibre to make more cells and more coverings. These new cells she hangs up beside the original three, and lays an egg in each as soon as it is completed. But a mother's work is never finished; and surely there was never a mother so hardly tasked as the royal wasp foundress. By the time she has built and stocked a few more cells, the three eggs first laid have duly hatched out, and now she must begin to look after the little grubs or larvæ. I have not illustrated this earliest stage of wasp-life, the grubby or nursery period, because everybody knows it well in real life. Now, as the grubs hatch out, they require to be fed, and the poor, overworked mother has henceforth not only to find food for herself and paper to build more cells, but also to feed her helpless, worm-like offspring. There they lie in their cradles, head downward, crying always for provender, like the daughters of the horse-leech. Forgive her, therefore, if her temper is sometimes short, and if she resents intrusion upon the strawberry she is carting away to feed her young family by a hasty sting, administered, perhaps, with rather more asperity than a lady should display under trying circumstances. Some of my readers are mothers themselves, and can feel for her.

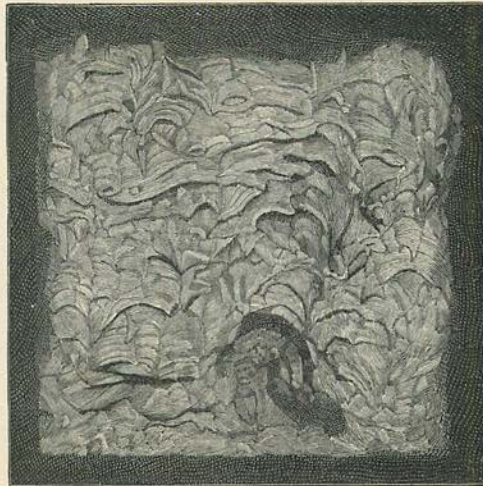
Nor is even this all. The grubs of wasps grow fast—in itself a testimonial



3.—THE CITY, FIVE DAYS OLD.

to the constant care with which a devoted mother feeds and tends them: and even as they grow, the poor queen (a queen but in name, and more like a maid-of-all-work in reality) has continually to raise the cell-wall around them. What looked at first like shallow cups, thus grow at last into deep, hollow cells, the walls being raised from time to time by the addition of papery matter, with the growth of the inmates. In this first or foundation-comb—the nucleus and original avenue of the nascent city—the walls are never carried higher than the height of the larva that inhabits them. As the grub grows, the mother adds daily a course or layer of paper, till the larva reaches its final size, a fat, full grub, ready to undergo its marvellous metamorphosis. Then at last it begins to do some work on its own account: it spins a silky, or cottony, web, with which it covers over the mouth or opening of the cell; though even here you must remember it derives the material from its own body, and therefore ultimately from food supplied it by the mother. How one wasp can ever do so much in so short a time is a marvel to all who have once watched the process.

While the baby wasps remain swaddled in their cradle cells their food consists in part of honey, which the careful mother distributes to them impartially, turn about, and in part of succulent fruits, such as the pulp of pears or peaches. The honey our housekeeper either gathers for herself or else steals from bees, for truth compels me to admit that she is as dishonest as she is industrious; but on



4.—THE CITY, FIFTEEN DAYS OLD.



the whole, she collects more than she robs, for many flowers lay themselves out especially for wasps, and are adapted only for fertilization by these special visitants. Such specialized wasp-flowers have usually small helmet-shaped blossoms, exactly fitted to the head of the wasp, as you see it in Mr. Enock's illustrations; and they are for the most part somewhat livid and dead-meaty in hue. Our common English scrophularia, or fig-wort, is a good example of a plant that thus lays itself out to encourage the visits of wasps; it has small lurid-red flowers, just the shape and size of the wasp's head, and its stamens and style are so arranged that when the wasp rifles the honey at the base of the helmet, she cannot fail to brush off the pollen from one blossom on to the sensitive surface of the next. Moreover, the scrophularia comes into bloom at the exact time of year when the baby wasps require its honey; and you can never watch a scrophularia plant for three minutes together without seeing at least two or three wasps busily engaged in gathering its nectar. Herb and insect have learnt to accommodate one another; by mutual adaptation they have fitted each part of each to each in the most marvellous detail.

It is a peculiarity of the wasps, however, that they are fairly omnivorous. Most of their cousins, like the bees, have mouths adapted to honey-sucking alone—mere tubes or suction-pumps, incapable of biting through any hard substance. But the wasp, with her hungry large family to keep, has to be less particular about the nature of her food; she cannot afford to depend upon honey only. Not only does she suck nectar; she bites holes in fruits, as we know to our cost in our gardens, to dig out the pulp; and she has a perfect genius for selecting the softest and sunniest side of an apricot or a nectarine. She is not a strict vegetarian, either; all is fish that comes to her net: she will help herself to meat or any other animal matter she can find, and will feed her uncomplaining grubs upon raw and

bleeding tissue. Nay, more, she catches flies and other insects as they flit in the sunshine, saws off their wings with her sharp jaws, and carries them off alive, but incapable of struggling, to feed her own ever-increasing household.

By-and-by the first grubs, which covered themselves in with silk in order to undergo their pupa or chrysalis stage, develop their wings under cover, and emerge from their cases as full-grown workers. These workers, whose portrait you will find on a previous page, are partially developed females, being unable to lay eggs. But in all other respects they inherit the habits or instincts of their estimable mother; and no sooner are they fairly hatched out of the pupa-case, where they underwent their rapid metamorphosis, than they set to work, like dutiful daughters, to assist mamma in the management of the city. Like the imagined world of Tennyson's *Princess*, no male can enter. If ever there was a woman-ruled republic in the world, such as Aristophanes feigned, it is a wasp's nest. The workers fall to at "tidying up" at once; they put the house in order; they go out and gather paper; they help their mother to build new cells; and they assist in feeding and tending the still-increasing nursery. The first comb formed, you will remember, was at the top of the foundation column or foot-stalk; the newer combs are built below this in rows, each opening downward, so that the compound house or series of flats is planned on the exactly opposite system from our own—the top stories being erected first, and the lower ones afterward, each story having its

floor above and its entrance at the bottom. At the same time, the umbrella-shaped covering is continued downward as an outer wall to protect the combs, until finally the nest grows to be a roughly round or egg-shaped body, entirely inclosed in a shell or outer wall of paper, and with only a single gateway at the bottom, by which the busy workers go in and out of their city.

The nest of the tree-wasp, which we



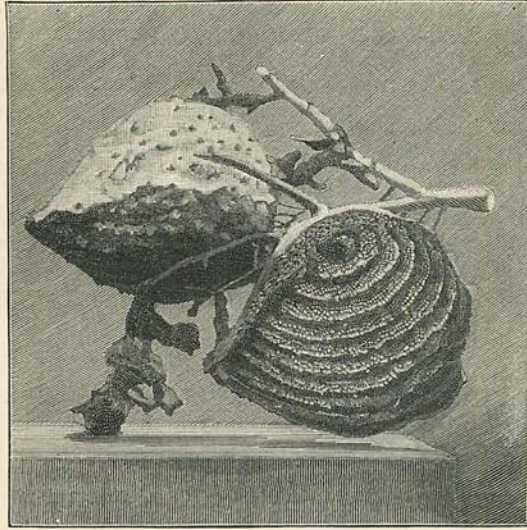
5.—NEST OF TREE-WASP, WITH PAPER PARTLY REMOVED.



have also been kindly permitted to photograph from the specimens at the Natural History Museum (Nos. 5 and 6), exhibits this final state of the compound home even better and more graphically than does that of our commonest English species.

By the time the workers have become tolerably numerous in the growing nest, the busy mother and queen begins to relax her external efforts, and confines herself more and more to the performance of her internal and domestic duties. She no longer goes out to make paper and collect food; she gives herself up, like the queen bee, exclusively to the maternal business of egg-laying. You must remember that she is still the only perfect female in the wasp hive, and that every worker wasp the home contains is her own daughter. She is foundress, queen, and mother to that whole busy community of 4,000 or 5,000 souls. The longer the nest goes on, the greater is the number of workers produced, and the faster does the queen lay eggs in the new cells now built for her use by her attentive daughters. These in turn fly abroad everywhere in search of nectar, fruits, and meat, or gather honey-dew from the green-flies, or catch and sting to death other insects, or swoop down upon and carry off fat, juicy spiders; all of which food-stuffs, save what they require for their own subsistence, they take home to the nest to feed the grubs, from which, in due time, will issue forth more workers. It is a wonderful world of women burghers.

As long as summer lasts, our queen lays eggs which produce nothing else than such neuter workers. As autumn comes on, however, and the future of the race must be provided for, she lays eggs which hatch out a brood of perfect females or queens like herself. It is probable that the same egg may develop either into a queen or a worker, and that the difference of type is due to the nature of the food and training. A young



6.—NESTS OF TREE-WASP, EXTERIOR AND INTERIOR.

grub fed on ordinary food in an ordinary cell becomes a neuter; but a similar grub, fed on royal food and cradled in a larger cell, develops into a queen. As with ourselves, in fact, royalty is merely a matter of the surroundings.

Last of all, as the really cold weather begins to set in, the queen wasp lays some other eggs from which a small brood of males is finally developed.

Nobody in the nest sets much store by these males: they are necessary evils, no more, so the wasps put up with them. It is humiliating to my sex, but I cannot avoid mentioning the fact, that the production of males seems even to be a direct result of chill and unfavourable conditions. The best food and the biggest cells produce fertile queens; the second best food and smaller cells produce workers; finally, the enfeeblement due to approaching winter produces only drones or males. We cannot resist the inference that the male is here the inferior creature. These facts, I regret to say, are also not without parallels elsewhere. Among bees, for instance, the eggs laid by very old, decrepit queens, or by maimed and crippled queens, produce males only; while among tadpoles, if well fed, the majority become female frogs; but if starved, they become preponderantly male. So, too, starved caterpillars produce only male butterflies, while the well-fed produce females. Little as we men may like to admit it, the evidence goes to show that, in most instances, superabundant reproductive energy results in female offspring, while feeble or checked reproductive energy results in male offspring. I know this is the opposite of what most people imagine; but, then, science not infrequently finds itself compelled to differ in opinion from most people.

The drones, or males, are thus of as little account in the nest of wasps as in the hive of bees. In both, they only appear for a short time, and for the definite purpose of



becoming fathers to the future generations. When they have fulfilled this their solitary function, the hive, or the nest, cares no more about them. The bees, as you know, have a prudent and economical habit of stinging them to death, so as not to waste good honey on useless mouths through the winter. The wasps act otherwise. They are not going to live through the winter themselves, so they don't take the trouble to execute their brothers: they merely turn the young queens and males loose and then leave the successful suitors to be killed by the first frost without further consideration.

And now comes the most curious part of all this strange, eventful history. We do not love wasps; yet so sad a catastrophe as the end of the nest cannot fail to affect the imagination. As soon as the young queens and males have quitted the combs, the whole bustling city, till now so busy, seems to lose heart at once and to realize that it is doomed to speedy extinction. Winter is coming on, when no worker wasp can live. So the community proceeds with one accord to commit communal suicide. The workers, who till now have tended the young grubs with sisterly care, drag the remaining larvæ ruthlessly from their cells, as if conscious that they can never rear this last brood, and carry them in their mouths and legs outside the nest. There they take them to some distance from the door, and then drop them on the ground to die, as if to put them out of their misery. As for the workers themselves, they return to the nest and starve to death or die of cold; or else they crawl about aimlessly outside in a distracted way till the end overtakes them.

There is something really pathetic in this sudden and meaningless downfall of a whole vast cityful; something strange and weird in this constantly repeated effort to build up and people a great community, only to see it fall to pieces hopelessly and helplessly at the first touch of winter. Yet how does it differ, after all, from our human empires, save in

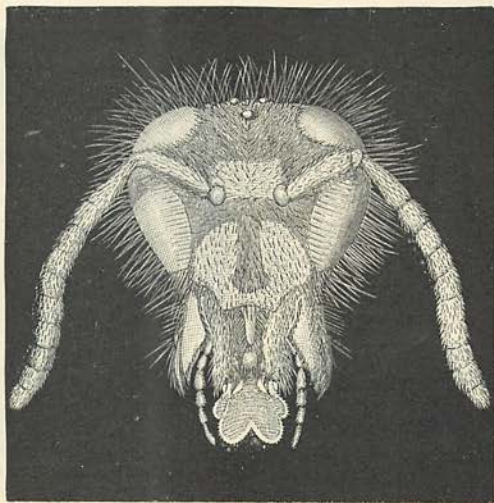
the matter of duration? We raise them with infinite pains only to see them fall apart, like Rome or Babylon.

So, by the time the dead of winter comes, both males and workers are cleared off the stage; and universal waspdom is only represented by a few stray fertilized females, who carry the embodied hopes of so many dead and ruined cities.

And now that I have traced the history of the commune from its rise to its fall, I must say a few words in brief detail about the individual wasps which make up its members.

And first of all as to the wasp's head. You will have gathered from what I have said that the head of the insect is practically by far its most important portion. All the work we do with our hands, the wasp does with its complicated mouth-organs. And the wasp's head is such a wonderful mechanism that some little study of the accompanying illustrations, though they may not at first sight look very attractive, will amply repay you. I will try to explain the uses of each part with as little as possible of scientific technicalities.

In No. 7 you get the head of a queen wasp, seen full face in front, with the mouth-organs open. The three little knobs in the centre up above are the simple eyes or eye-lets (*ocelli*, if you prefer a Latin word, which sounds much more learned). The large kidney-shaped bodies on either side of the head (here seen as interrupted by the antennæ or feelers) are the compound eyes, each of which consists of innumerable tiny lenses, giving the wasp that possesses them a very acute



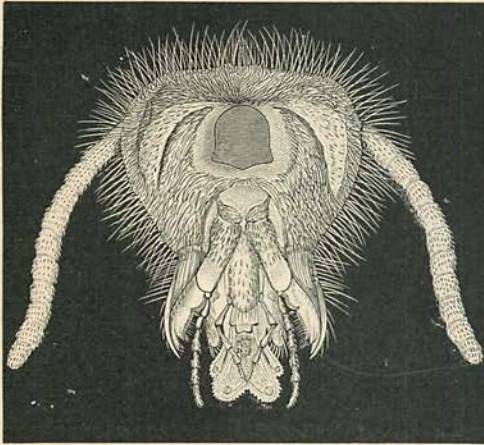
7.—HEAD OF QUEEN WASP, MOUTH WIDE OPEN: FRONT VIEW.

sense of vision. We do not know exactly what is the difference in use between the simple eyes and the compound ones; but either sort has doubtless its own special part to play in this complex personality. The antennæ, or feelers, again, with their many joints and their ball-and-socket base, are beautiful and wonderful objects. The various parts of the mouth are here seen open; conspicuous



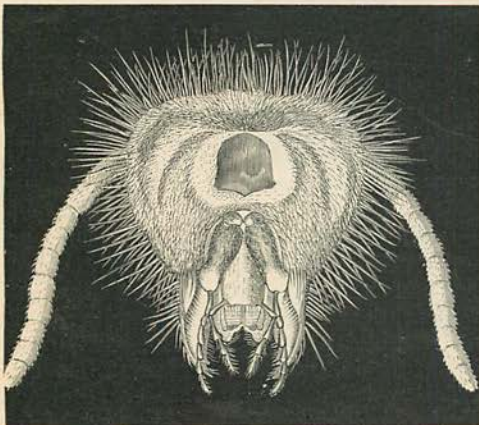
among them are the great saw-like outer jaws, used for scraping wood and manufacturing paper; the long, narrow shield; the broad tongue; and the delicately jointed palps, or finger-like feeders. Notice how some of these organs are suitable for cutting and rasping, while others lend themselves to the most dainty and delicate manipulation.

No. 8 shows us the same head, decapitated,

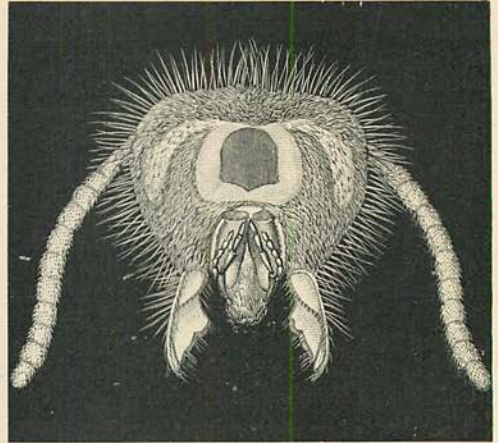


8.—THE SAME HEAD, MOUTH WIDE OPEN: BACK VIEW (DECAPITATED).

and seen from behind. The shield-like space in the very middle represents the point of decapitation—the cut neck, if I may use frankly human language. Below is the hollow or receptacle into which all the organs can be withdrawn when not in use, and packed away like surgical knives and lancets in an instrument case. Observe in the sequel how neatly and completely this can be done: how each has its groove in the marvellous economy of nature.



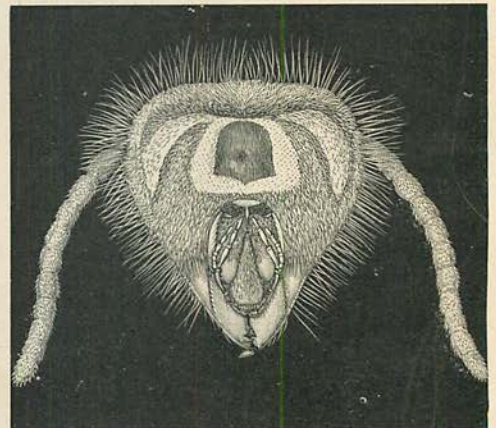
9.—THE MOUTH CLOSING: TONGUE WITHDRAWN: BACK VIEW.



10.—MOUTH ALMOST CLOSED: ATTITUDE FOR SCRAPING WOOD: BACK VIEW.

In No. 9 you see the organs closing (also a back view), the tongue having been now drawn in, while the saw-like jaws and the delicate feeling palps are still exposed and ready for working. No. 8 on the contrary is the feeding attitude.

In No. 10 (another back view), the palps have been turned back into their special groove, and the saw-like jaws are seen free



11.—MOUTH QUITE CLOSED: ATTITUDE FOR SCRAPING WOOD: END OF ONE MOVEMENT.

for working. This is the attitude in which the wasp attacks a park paling, in order to scrape off wood-fibre for the manufacture of paper. Here, as you see, the jaws are open. In No. 11 they are closed, at the end of a scrape. These two last attitudes are, of course, alternate. One shows the jaws opened, the other closed, as they look at the beginning and end of each forward and backward movement. You will notice also that, as usual, the insect's jaws work sideways, not



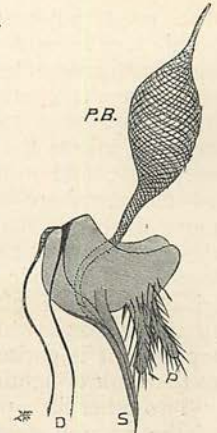
up and down like those of man and other higher animals. If you examine closely this series of wasp's heads in different postures, you will see how well the various parts are adapted, not only for rasping and manufacturing paper, but also for the more delicate work of wall and cell-building.

Almost as interesting as the head are the wings of wasps, of which there are four, as in most other insects. But they have this curious peculiarity: the two front wings have a crease down the middle, so that they can be folded up lengthwise, like two segments or rays of a fan, and thus occupy only half the space on the body that they would otherwise do. It is this odd device that makes the transparent and gauzy wings so relatively inconspicuous when the insect is at rest, and the same cause contributes also to the display of the handsome black-and-yellow-striped body. No. 12 shows us a queen with her wings folded: below is one upper or front wing, folded over on itself, and then laid across the under wing. No. 13 introduces



12.—QUEEN WITH FOLDED WINGS, AND ONE WING TO SHOW FOLDING.

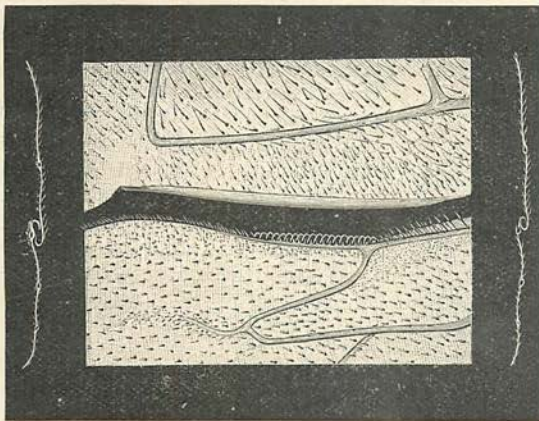
flies. Your wasp and your bee are women of business. They have therefore found it pay them to develop a mechanism by which the two wings on either side can be firmly locked together, so as to act like a single pinion. No. 13 very well illustrates this admirable plan for fastening the fore and hind wings together. On top you see the back portion of the front wing, with a curved groove on its inner edge. Below,



14.—POISON BAG, SHEATH, DARTS, AND PALPI.

you get the front portion of the hinder wing, with a series of little hooks, microscopic, yet exquisitely moulded, which catch into the groove on the opposite portion. When thus hooked together, the two wings on the right act exactly like one. So do the two on the left. But they can be unhooked and folded back on the body at the will of the insect. To either side of No. 13 you will notice sections of the two wings, which will help you to understand the nature of the mechanism. On the right, the wings are seen hooked together; on the left, they are caught just in the act of unhooking.

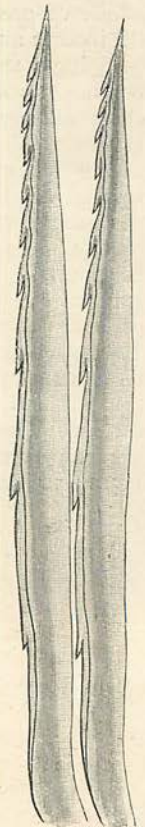
Last of all, and most important of all to ordinary humanity, we come to the sting, with its appendage the poison-bag. It is well represented in No. 14. The main object of the sting, and its original function by descent, is that of laying eggs; it is merely the ovipositor. But besides the grooved sheath or egg-layer (marked *S* in the illustration) and the two very sharp lances or darts (marked *D*) which pierce the flesh of the enemy, it is provided with a gland which secretes



13.—PART OF TWO WINGS, WITH HOOKS AND GROOVES.

us to a more characteristic feature, common to wasps with the whole bee family.

All these cousins possess by common descent the usual four wings of well-regulated insects. But it so happens that the habits of the race make strong and certain flight more practically important for them than the mere power of aerial coquetting and pirouetting possessed by the far less business-like butter-



15.—DARTS MAGNIFIED 300 DIAMETERS.



that most unpleasant body, formic acid; and when the wasp has cause to be annoyed, she throws the sting rapidly into the animal that annoys her, and injects the fluid with the formic acid in it. In No. 15 the darts are shown still more highly magnified. In the queen wasp, the sting is used both for laying eggs and as a weapon of offence; but in the workers, which cannot lay eggs, it is entirely devoted to the work of fighting.

Two other little peculiarities of the wasp, however, deserve a final word of recognition. One of these is the elaborate brush-and-comb apparatus or antennæ-cleaner, drawn in a very enlarged view in No. 16. Whatever the sense may be which the antennæ serve, we may at least be certain that it is one of great importance to the insect; and both wasps and bees have therefore elaborate brushes for keeping these valuable organs clean and neat and in working order. They always remind me of the brushes I use myself for cleaning the type in my type-writing machine. The antennæ-brush of the wasp is fixed on one of her legs; its precise situation on the leg as a whole is shown in the little upper diagram; its detail and various parts are further enlarged below. To the left is the coarse or large-tooth comb; to the right is the brush; and above the brush, connected with the handle by an exceedingly thin and filmy membrane, is the fine-tooth comb,



16.—WASP'S BRUSH AND COMB, FOR CLEANING ANTENNÆ.

will, with almost incredible flexibility.

Adequately to tell you all about the wasp, however, would require, not an article, but a very stout volume. I have said enough, I hope, to suggest to you that the wasp's history is quite as interesting as that of her over-lauded relation, the little busy bee. Indeed, I suspect it is only the utilitarian instinct of humanity that has caused so much attention to be paid to the domestic producer of honey, and so relatively little to that free and independent insect, the first paper-maker.



17.—TUCKS IN THE SEGMENTS.