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THE

NATURAL HISTORY OF INSTINCT.

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INSTINCT is a wide subject, presenting many different sides of interest. To the naturalist who studies the forms and habits of animals, the phenomena of instinct are of interest on their own account. Again, to the psychologist, who studies the phenomena of mind, the facts of instinct are of interest as proving the possibility of knowledge inborn or antecedent to individual experience. Lastly, to the philosopher, who studies the mutual relation of things in general, the facts of instinct are of interest just because they prove the possibility of such inborn or innate knowledge, and therefore because these facts bear upon any theory of knowledge in general which his other studies may lead him to form. This evening I propose to restrict the subject of the lecture to the first of these sides of interest, or the interest instinct presents to the naturalist: the interest which the phenomena of instinct present on their own account; therefore I have termed the subject of the lecture "The Natural History of

Sunday Lecture

Instinct." I shall endeavour to take a bird's-eye view, as it were, of all the instincts known to us, and I shall select for special description those instances of animal instinct which appear to me most remarkable, or otherwise most deserving of our attention. You will, then, understand that I shall have nothing to do with either the psychology or the philosophy of instinct. Nevertheless, it seems desirable at the outset that we should so far go into the psychology of the subject as to understand exactly what it is that we mean by instinct; because within the limits of the English language there is perhaps no term which has been used in a greater variety of meanings. In ordinary conversation and in general literature we find instinct used as a term to name all the mental qualities of animals taken collectively, to distinguish them from the mental qualities of man, which are termed rational. This popular classification, however, will not do, because there is now no doubt in the mind of any competent naturalist that the mind of an animal is constructed on the same pattern as the mind of a man, the difference between the two consisting merely in the difference of relative degree in which instinctive faculties predominate in the animal and the rational faculties in the man. What, then, shall we use as a scientific definition of instinct? After a great deal of consideration, I have myself put forward such a definition. In the first place, instinctive actions are manifestly adaptive actions. But not only are they adaptive: they are likewise consciously adaptive; for if they were not consciously adaptive, we should not be able to distinguish between them and such adaptive actions as are merely vital—such, for example, as the beating of our

hearts. Instinctive action, therefore, differs from vital action in not only being adaptive, but in being likewise consciously adaptive. Again, instinctive action depends upon knowledge which, as I have said, is inborn or innate, anterior to individual experience, and in this respect, you will perceive, differing from reason, which always depends upon knowledge gained by individual experience. Again, the knowledge on which instinctive action depends is knowledge which may not be knowledge of the relation between the means employed and the ends attained. Innate, inborn knowledge may not involve any rational acquaintance with the relation between the means employed and the ends attained. And, lastly, instinctive actions are actions which are performed by all individuals of the same species when placed in similar circumstances. To gather up all the points in this definition, therefore, we may say that instinct is a term which is used to designate all those faculties of mind that are concerned in conscious and adaptive actions antecedent to individual experience, without necessary knowledge of the relation between the means employed and the ends attained, but similarly performed under similar and frequently-recurring circumstances by all individuals of the same species.

Now, I have taken the trouble to go into this definition, partly for the sake of circumscribing the area which the present lecture is to cover, but partly, also, because my attention has just been drawn to a very friendly article—friendly in tone, and intelligent in its spirit—which appeared in the *Newcastle Daily Chronicle*, of November 21st, 1885. The writer of that article, after quoting this definition from myself (which I have cut out of the newspaper)—quoted

from a work of mine already published—remarks that if I were in the position of a political candidate, instead of a scientific lecturer, he would bother me with a few questions on the subject of that definition. Well, I do not wish to take any unfair advantage of my position as a scientific lecturer, and therefore I will answer the question which he has so courteously put. After quoting this definition, he frames his question upon the concluding portion of it. He asks, if it be true that actions called instinctive are those "similarly performed under similar and frequently-recurring circumstances by all the individuals of the same species," how do I account for the fact that in the case of almost every instinct we meet with individual exceptions? My answer is, that in all these cases which he gives as examples, and in all such cases it is possible to give as examples, the individual exceptions are of the nature of imperfections of animal instinct. But, obviously, if the instinct is imperfect, it does not fall within my category of instinct. It does not fall within my definition of instinct, simply because as an instinct it is imperfect; or in other words, as far as it is imperfect in individual cases, so far does it fail of being an instinct, and so far does it fail to be covered by my definition of instinct. The work of my own, from which he quotes this definition, is a work on "Animal Intelligence," and the object of that work is expressly stated to be that of rendering only the natural history of instincts without going in for the psychology of the subject. That is to say, it merely states the facts of animal instinct, without entering at all into any theory, either of origin, correlation, or anything else of the kind. But that work was only antecedent to another which has since been

published, and which is called, "Mental Evolution in Animals." In that work I have gone fully into the whole psychology and philosophy of instinct, and if my kindly critic will do me the honour of turning to the pages of that work I fancy he will find, not only his own question, but also every other question that it is possible to suggest in the way of difficulty, discussed with as much elaboration as I think he is likely to care to pursue. I mention this not only for his benefit, but also because I hope that any of you who may not have seen that work, may likewise do me the honour of getting it out of some of your circulating libraries; and I mention this, not because the work happens to be written by myself, but simply because it is the only work hitherto published which deals with the whole philosophy of instinct from an evolutionary point of view.

Trusting I have now made clear what it is I mean by instinct, I will devote the rest of the lecture to selecting those instances of the special display of instinct in the animal kingdom which, as I have said, appear to me the most remarkable. For this purpose I think it will be convenient to further restrict myself, looking to the great abundance of the materials, to those classes of animals in which the phenomena of instinct occur with greatest richness and abundance. I mean the invertebrate animals.

Taking first the case of larvæ, or insects which have not yet attained their perfect development—such, for instance, as caterpillars—the instincts manifested by larvæ are of interest because they often display higher elaboration of instinctive mechanism than occurs in the perfect condition of the insect. There is a kind of larvæ called the caddis-

worm, which lives at the bottom of fresh water streams. At the bottom of fresh water streams it constructs for itself a tubular shell, fitting close to its worm-like body. This tubular or cylindrical shell is constructed of a large number of small particles of gravel, sand, bits of leaf, and so forth, all glued together by a secretion from the animal's body. Now, it has been quite recently discovered by a very competent observer, Mr. W. MacLachlan, F.R.S., and principal entomologist in this country, that when the caddis-worm finds its tubular shell becoming too heavy, so that it has a difficulty in dragging it about the bottom of the stream, it will glue into the structure small splinters of wood, in order to cause the tubular dwelling to have less specific gravity, to make it lighter, and therefore more easy for the worm to drag about the bottom of the stream. On the other hand, if the worm finds it has placed too much wood in the structure, so that it is liable to the catastrophe of floating to the surface, it will then search about for little masses of sand or pebble, wherewith to increase the specific gravity of its dwelling, and so adjust it to the specific gravity of the water. There is a kind of caterpillar, eight or ten of which live in company inside the fruit of pomegranate. They eat out the fruit of the pomegranate by degrees, and as they do so, the pomegranate is apt to wither; when it withers, the stalk of the pomegranate is apt to break, and allow the pomegranate to drop. Now, it has been observed that in order to prevent this possible catastrophe—it is not a necessary catastrophe, it does not always happen that the pomegranate drops—these caterpillars, before they begin to eat out the inside of the fruit, carefully make a web, extending from the fruit to the

branch, so as to act as a stalk in the event of the natural stalk withering and allowing the fruit to drop, were it not for the artificial stalk supplied by the web. This foresight is very remarkable. There is in the south of France, and also on the north coast of Africa, a species of caterpillar which afterwards turns into the Bombyx moth. The instincts presented by this species of caterpillars are highly remarkable. In the first place, they are gregarious. Colonies of some five hundred or one thousand caterpillars live on the same tree. They are pretty large, about as long as one's little finger. When they have eaten bare the leaves upon one tree, they migrate to another, and they do this in what we may call military order. That is to say, one caterpillar acts as leader, and all the others follow him in Indian file, one behind the other. So they march off, a long line of caterpillars, yards in length. The head of caterpillar No. 2 touches the tail of caterpillar No. 1, and the tail of caterpillar No. 2 touches the head of caterpillar No. 3, and so forth, all the way down the line. Now, I had myself an opportunity of observing these caterpillars, and found that if I knocked out any one of the series, so as to cause an interruption in this continuous line, the caterpillar in front of the interruption immediately stopped, and began to wag his head. Then the caterpillar in front of him likewise stopped, and began to wag his head, and so on until all the caterpillars in front of the point of interruption were at a standstill, and all wagging their heads. Meanwhile, the caterpillar behind the point of interruption continued his march, and all the train behind him continued their march, and as soon as the head of the caterpillar behind the point

of interruption joined up, so as to touch the tail of the caterpillar in front of the point of interruption, so soon did that caterpillar cease to wag his head and begin to move, and then the next ceased to wag his head and began to move, and so on till the whole line was again in motion. The time required for this to take place I found to be at the rate of about one second per caterpillar. Now, if I removed the leader of this kind of follow-my-leader train, the next one in the series very rarely felt himself competent to undertake the task of leadership, but he would fall back upon the rest of the line, and the rest of the line, having lost their leader, would double back as they came, and in the result the whole line was thrown into helpless confusion—confusion so hopeless, indeed, that eventually, from having been an orderly line, they became a chaotic heap. After a varying period, some one member of this republic seemed to suppose it was time to begin to restore order, and assumed the leadership; as soon as they found a leader, like republics in general, they all followed in the wake. I now tried the effect of removing the last member of the series. The effect here of course was that there was no other caterpillar left to join up the interruption; consequently, we ask how long the whole line will remain stationary, wagging their heads? Well, they remained stationary for a very long time, but not for an indefinite period of time. I think after a lapse of four or five minutes they began to say, "There is no use waiting any longer," and they gave up wagging their heads, and went on again. But I thought it would be worth while to see under these circumstances whether I could deceive the caterpillar into supposing that I was a caterpillar. After

removing the tail member of the series, I took a camel's hair brush and began gently to tickle the tail of the last in order, and I found that the delusion succeeded. I was able to deceive the caterpillar into supposing that I was the caterpillar behind him, and he immediately stopped wagging his head and began to move on, and I could keep the whole line in motion so long as I continued to tickle the tail of the caterpillar. There is another very remarkable instinct manifested by these caterpillars which has only recently been observed by Lord Walsingham; and by his kindness I was able to see one of the extraordinary structures produced. It is not a European, but an African species. Here, when all the colony of these caterpillars have occasion to pass into the pupæ condition—the crysalis state—they form what you may call a collective cocoon, to accommodate the whole number. It is about the size of a good large melon, and of the same shape; at one end of the melon there is a minute hole, in order to allow of the exit of the moths when they come to maturity inside this melon-shaped cocoon. Now, a remarkable feature of this structure is, that if you dissect the melon-shaped mass, you find inside that each caterpillar has weaved for itself a separate cocoon. They all unite to weave the general, or enveloping cocoon, while each one constructs a separate cocoon for itself within the melon-shaped mass; and the extraordinary fact is, that all these separate cocoons are arranged around branch passages or corridors. All these branch passages or corridors converge to the general entrance hall, as it were, which leads out to the orifice, or the door. So that you may liken the whole thing to the state-rooms on board ship—rows of them along the

corridors, and all opening out into the common exit. You will agree with me in regarding this as one of the most extraordinary instincts that has ever been noticed when you consider that if any one of these caterpillars should make the smallest mistake, and build his cocoon slightly out of its proper place, with relation to the others, he would block up one of the corridors, and thereby prevent the exit of any of the moths behind him, when those moths came to maturity. Yet so perfect is the collective instinct of all this mass of caterpillars, that in this complex structure not one of the separate cocoons is built out of its place so as to obstruct any one of these corridors. So much for the intelligence of larvæ.

Coming now to the order of animals where instincts occur in the greatest profusion, and are of the most extraordinary kind—you know, of course, that I refer to the ants. In the first place, all the ants of every nest know each other personally. This is a very remarkable fact when you remember how many ants there are in a nest. It is still more remarkable in the case of the so-called American ant towns. In these ant towns there may be as many as from 1000 to 2000 nests, and each nest may be as much as four feet or five feet high. Therefore, in each nest there are thousands of individuals, and in the whole ant town the individuals are to be numbered by millions. Well, every one of these individuals know each other personally, so to speak. Because if you remove any individual from one part of the ant town to deposit him in another part, he is recognised as a friend; whereas if you take any ant from another ant town at a distance, and place him in this ant town, he is immediately fallen upon and slain. Now, this

seems to be a most remarkable fact. Suppose we parallel it in the case of ourselves. We should find it a very difficult and precarious matter to distinguish a Frenchman when he landed here, if we wanted to fall upon and slay him. Even if there were no moral repugnance to such an act, we should not be willing to take the responsibility of killing a man from his personal appearance. The ants, however, experience no difficulty. Something more remarkable still has been observed by Sir John Lubbock, a very competent observer. He found that if you take away the pupæ or crysalis, or so-called ant eggs, out of the nest, and hatch them away from the nest, and if you then return to the nest the ants so hatched, these ants are recognised as friends, although you will understand none of the ants in the nest could ever possibly have seen them. More remarkable still, he found that if you take away the queen ant before she lays her eggs, and allow her to lay them in any other place, and then return the ants so hatched to the original nest, all the ants immediately recognise the progeny of the queen as friends. Therefore, we must suppose that it is blood relationship which these ants are in some way or another able to distinguish. Another very interesting feature of ant intelligence of an instinctive kind is the power of communication. There is no doubt at all about ants being able to communicate up to a certain point. You can see them communicating by rubbing their antennæ together. The extent to which they are thus able to communicate has also been investigated by Sir John Lubbock, and he found that they could tell each other not only that there was food to be found somewhere, but also the place where the greatest amount of food was to be fallen in with.

He did this by taking three glasses, and connecting them with an ant nest by means of three tapes to act as roadways. In one glass he put a large number of larvæ, in another of the glasses a very small number of larvæ, and in the third glass he put no larvæ at all. Then into each of the three cups, or glasses, he placed a marked ant. All three marked ants immediately went back over the tapes to the ant nest. The one that came from the empty glass brought out no friends, the one that went to the glass containing the small number of pupæ brought out a small number of friends, while the one which went from the glass containing a large number of pupæ brought out a large number of friends. If ants are able to tell each other where the largest amount of food is to be found, however, they are not able to tell each other the precise locality. That is to say, it was necessary that the marked ants should be allowed to act as guides or pioneers of their friends on the way back, for if, while they were half way back, Sir John Lubbock suddenly removed the marked ant, all the others were at once bewildered, and did not know where to go, so that we may say that they are able to tell each other where there is a large quantity of food to be found. It is a kind of "Follow me; there is a quantity of food or eggs I have found." But they are not able to tell each other where the eggs are, such as "the first to the right, and the second to the left," and so on. There is another very remarkable instinct displayed by a large number of species of ants—that, namely, of keeping other insects for the purpose of furnishing them with a sweet secretion, of which they are very fond. These other insects, or so-called aphides, are somewhat larger than the ants. They regularly keep

these aphides to serve the function of milch cows. They always milk these milch cows by striking them with their antennæ—a peculiar tickling action, which causes the aphides to exude a sweet secretion, which the ant licks up. These aphides the ants keep carefully in their own nests; some species keep them outside, on the plants, and then they build round them little mud chambers, or stables, or stalls. These stalls have openings large enough to allow the ants to go in and out, but not large enough to allow the aphides to go in and out. They are, therefore, kept prisoners—or in stables if you like. Now, Sir John Lubbock has made the highly remarkable observation that there is one species of ant which goes out in the month of October to seek for the eggs of the aphides, which are laid upon daisies. Having found the eggs, they take them into their nests, cherish them there during the winter months, and hatch them out in March. As soon as the young aphides are hatched out, the ants convey them to the daisy plants again, for them to feed. This is one of the most extraordinary instincts on record.

Another highly remarkable instinct displayed by ants is the keeping of slaves. Three species of ants are in the habit of enslaving other species of ants. The slave-making species are of a red colour, and have a very avaricious temper. The ants which are submitted to slavery, on the other hand, are very properly of a black colour, and are not so warlike in spirit. Now, when the nest of a red slave-making species have occasion to replenish the number of their slaves, they send out scouts in various directions, in order to seek for the slave nests. When the scout has found a nest of these black ants, he goes back to the rest of the red ants, and then the whole nest of red ants turn out

in a swarm. They march in regular military order, naturally following the lead of the scout until the scout brings them to the nest of the black ants. As soon as this is the case, the red ants fall upon the black ants in enormous numbers, and a regular *mêleé* begins. Usually this battle terminates unfavourably for the black ants. When it does so, the red ants put a garrison into the nest of the black ants, and take away all the eggs that belong to the black ants. These eggs are conveyed home and hatched out in the nests of the red ants, to act subsequently as slaves. The slave-making ants become so dependent upon the services of these slaves, that they not only do no work for themselves at all, beyond the capture of slaves, but one species has gone so far in their indolence that they are actually not able to feed themselves, and require to be fed by their slaves. That is to say, if you deprive these ants of their slaves, they all die of starvation, even though at the same time you supply them with their habitual food.

Still more remarkable, I think, than the habit of keeping slaves, is the habit of keeping beasts of burden. This habit has been discovered by the naturalist Audubon, a very great observer, and he vouches for the fact that in the Brazilian forests there is a species of ant which has occasion to convey leaves from trees to its nest, as we shall see subsequently. Audubon declares that he has repeatedly seen this species of ant enslave another and a larger kind of insect, which is not an ant at all, but a kind of bug. This large, strong bug is regularly driven by the ants to carry the loads of leaves from the trees to the nest.

Another highly remarkable fact about the domestic economy of ants is that they not only enslave other animals

for the purpose of doing work, but they also keep a number of other slaves which serve no function at all in the economy of the hive, and therefore appear to be kept by the ants merely for the sake of gratifying some kind of caprice. That is to say, ants have power to keep these other kinds of insects just for the same reason, or absence of reason, that we ourselves keep domestic pets. There are thirty or forty different species of beetle that are made pets by the ants.

Another set of habits exhibited by ants are very, I think very, interesting, as showing a resemblance to the social condition of man; or, perhaps, some of us may think, as not showing such a resemblance. I mean in habits of personal cleanliness. All insects, as you are aware, are very scrupulous about keeping themselves clean. You can always see the blue-bottle assiduously at work when it seems he is already as much polished up as there is any occasion for. The remarkable thing about the ants is that they clean one another. The ant that feels in need of a brush-up goes to a companion ant and makes a gesture of supplication, which is very expressive. He kneels down and puts up his fore-legs, and the supplicated ant immediately sets to work and brushes him down. When the cleaning process is over, the relations are reversed, on the principle that one good turn deserves another.

Another point in which ants resemble ourselves is that of requiring sleep. The sleep lasts for three or four hours at a time; and during the time they are asleep they have been observed by Belt, who is a good observer, and by McCook, in America, to move their jaws, and feelers, and mandibles in the same way as we see a dog twitch his mouth,

nose, and feet, when asleep. Therefore these motions are very suggestive of the ant dreaming. Upon awakening, also, these ants have a habit of stretching their limbs as we do, and often of opening their mouths and gaping. In all these respects there is a wonderful similarity to ourselves.

Again, as to habits of play or recreation. These ants have habits of play and recreation, just like ourselves; and when they play thus, they run about and chase each other round grass stalks, stand on their hind-legs, and have wrestling matches; they play hide-and seek, and have mimic fights, and in all sorts of ways behave just like athletes.

Lastly, under the head of the general habits of ants, I may notice perhaps the one which is most remarkable—namely, that of conducting funerals. All the ants have a habit of taking away the dead ones from the nest and dragging them a long distance, but it is only some species which have the habit of conducting regular funerals. It has been alleged by two or three very good observers, that the ants will form regular processions, whereby to do, as it were, due honour to their dead. And these processions are always destined for one particular locality, which is the ants' cemetery. Here the dead body of the ant is deposited in its last resting-place with all due honours apparently. I say with all due honours, because in the case of the slave-making species, great care is taken not to bury slaves in the same cemetery as the masters.

So much as to the general habits of ants. Taking one or two species which display special instincts of a highly remarkable kind, I will first consider one which was noticed longest ago, by a naturalist who seems to have shown himself a good authority—Solomon. He is a good

authority as a naturalist, because his observations, though long supposed in the matter of ants to be what the Americans call "bunkum," have turned out to be perfectly true. I hope you all know the passage in Proverbs—"Go to the ant, thou sluggard; consider her ways, and be wise; which having no guide, overseer, or ruler, provideth her meat in the summer, and gathereth her food in the harvest." This observation was long discredited, and was especially denied by a great naturalist, Huber, who paid more attention than anybody else to the habits of ants and bees. But both Solomon and Huber were right. The difference or discrepancy in their statements arose merely from the difference in their geographical positions. It is only in one part of Europe that the ants display this harvesting instinct at all. They display it in Palestine, and no doubt Solomon saw it. It has also been noticed now that there is a species in the New World which displays it. In all these cases, the instinct is very much the same. It consists in the ants first of all cutting roadways from the nest to the ant fields. These roadways diverge in various directions, and along these roadways the ants run in a double line. The line outgoing is empty-handed; the line incoming is laden with grain. When the empty-handed line reach the grass fields, they disperse and pick up the grains which have fallen from the grass; or else they run up the stalks, cut away the grains which have ripened, and then either carry them down the grass stalks themselves or throw them down to their comrades beneath, thus showing an appreciation of the principle of a division of labour. The incoming train carry the grain in their jaws, and when they arrive at the ant-hill, it is put into a regular granary,

excavated below the ground for the purpose. In some way which is not at all understood, in these granaries the grain does not sprout. It is exposed to all the conditions favourable for sprouting—in a damp or moist soil not far below the surface. Well, as a matter of fact, it does not sprout. If it did, the ants would be deprived of nourishment. But what it is that the ants do to prevent the sprouting nobody has yet been able to discover. It is certain, however, that they take great pains to prevent the seed from getting too wet, thereby being rendered more apt to sprout. This is certain; because it has been observed that if the grain become too wet, the ants take it out of the granary and sun it, in order that it may be dried. Moreover, it is noticed that if for any reason one particular grain does begin to sprout, the ants immediately stop the further progress of the sprouting by nipping off the tip of the radical. This is a very remarkable fact, because although it is well known to botanists and horticulturists that by nipping off the tip of the radical you prevent the further germination of the seed, I doubt if it is known to anybody here who does not happen to be a botanist or horticulturist. Yet it is well known to those ants. A species of the harvest-ant in Texas, in America, exhibits a further refinement of this instinct, so to speak. Because Dr. Lincecum, who was the first to observe ants in that continent, positively declared, as the result of his own observations, that the harvesting ant begins by cutting down the prairie grass as a clearing, just as a colonist does. He declared that the ants go forth into the prairie to seek for the seeds of a kind of grass of which they are particularly fond, and that they take these seeds to the clearing,

and there actually sow them, for the purpose six months afterwards of reaping the grain which is the produce of their agriculture.

Of course this is one of the most remarkable instincts on record, and it was thought desirable that it should be confirmed. Consequently, McCook went to Texas for the express purpose of corroborating Lincecum's observations. Well, he corroborated all his observations with one exception—of the sowing of this plant. The reason why he did not confirm that observation was because he went to Texas at a time of the year when the sowing did not take place. He went to Texas at the time of the year when the ant-rice was growing, and he confirmed Lincecum to the extent of saying that he saw the ant-rice growing on the patches here and there, and growing nowhere else in patches like that throughout the prairie. Therefore we cannot say Lincecum has been actually corroborated in his observations as to the sowing; but at the same time, it is not fair to Lincecum, who is now dead, to say, as has been said in some quarters, that McCook has contradicted his observations. He has only gone there at a time of the year when it was not possible for him to corroborate the observations. Therefore I think Lincecum's statements are entitled to credence, because he was fully aware of the extraordinary nature of instinct himself, and he wrote to Darwin letter after letter on the subject, always insisting on the sowing of the plant rice. If this is the case, it is said the ant is entitled to be called not only a harvesting ant, but an agricultural ant.

Again, there is another species of ant we may similarly, with as much appropriateness, term the horticultural ant.

This is the one which, as I have said before, cuts leaves off the trees. They bite off the grass and throw it down, knots below receiving it. This they convey to their nests, and then lay it in folds one above the other, in order to constitute a kind of soil upon which there subsequently grows a kind of fungus, upon which they feed. Their object in collecting the leaves is to supply a soil for the growth of the fungus.

Lastly, there is another kind of ant which we may call the military ant. One species belongs to the Amazon, and another species is found in Central Africa. These animals display some of the most remarkable instincts in the animal kingdom, and which are all in the direction of military organisation. They have no fixed abode, but go about in enormous armies, comprising thousands of individuals, and they march in regular military order—one species in the form of a phalanx, and another in the form of a column. On each side of the column there are always running backwards and forwards a comparatively small number of individual ants, somewhat different in shape, and these evidently serve the functions of officers. They run about along the outside of the column, and give directions for dressing up, and so on, whenever they see there is any want of order, and generally conduct the movements of the host. From each side of the host there proceeds a number of scouts, who scour the country on all sides for a certain distance ; and when they come upon any kind of booty, such as a wasp's nest, they return to the main host to give the information. The direction of march is altered, the hordes of military ants swarm upon the wasps' nest, or ants' nest, or whatever it is, and there is no

animal in the creation that can withstand the assault. The only chance is to cut and run.

The instincts manifested by these animals are highly remarkable—so much so, that the whole lecture might have been devoted to this one species alone. But I will only mention one other fact in connection with them, and that is their habit of making bridges when they come to a stream; I do not mean a wide stream, but a rill, which they might think it desirable to cross. They make a sort of raft to begin with, and a clump of ants floats upon the surface of the stream. They join hands with the ants on shore, and thus allow themselves to be carried across the stream by the action of the current. This is a desperate resort, of course, because if the communications with the shore were to break off, they would all be drowned. They do not adopt this course if they can help it; they run up and down a long way to see if there is not any natural bridge, accidentally constructed by the fall of a piece of timber across the water. If they find such, which is not wide enough to admit of the column advancing except in single or Indian file, they save time—and it is a very remarkable thing, as showing the military organisation—by increasing the width with their own bodies; that is to say, they stick three or four deep upon each side, so that the other ants may run over their backs.

Coming now to bees, this branch of the lecture will not take very long, because the instincts of bees are closely analagous to those of ants. The cell-making instinct is the greatest exception; but without describing the exact method, I may say that Mr. Darwin has proved that the cell-making instinct depends upon certain mechanical principles. Buffon

long ago sought to account for the hexagonal form of the cells by an hypothesis of mutual pressure. This hypothesis was sustained by such a physical analogy as the blowing of a crowd of soap-bubbles in a cup. Buffon said that the hexagonal cells of the bee are produced by the reciprocal pressure of the cylindrical bodies of these insects against each other. This turns out to have been not very wide of the mark. Darwin has proved by experiments that this hypothesis was the true one—that the bees eat out the cells from the solid cake of wax, and the instinct is concerned in the bees standing at sufficient distance from one another.

The sense of direction is a very interesting fact. It has always been supposed that bees and wasps have some sense of direction, but that it is of some mysterious nature, and did not depend upon the recognition of land marks. This idea is the foundation of the popular saying that the quickest way is the bee-line. It occurred independently to Sir John Lubbock and to myself, last year, to try some experiments on the subject, and we both got the same results, though working independently. The way I worked was to place a bee-hive in a room with a window which I could open or shut. I then allowed the bees to get well acquainted with the locality; and after they had been in the room for about a fortnight, one night I shut the window—after all the bees, you understand, had gone home for the night. Then in front of the exit-hole of the bee-hive I slipped a glass shutter. When I came down in the morning, all the bees were imprisoned in the hive; they were buzzing about the inside of the glass shutter, as if they could not think what the dickens was the matter with the hive, as they could see through the glass shutter well, and could not get out. Then I

opened up the glass shutter and allowed about twenty bees to escape, and then shut it down again. The twenty bees that escaped immediately flew to the window, but it was closed. I was, therefore, able to get these twenty bees and place them in a box. I then spread a lot of bird lime on the front of the hive, where the bees would come home, and left the glass shutter closed, and the window open. I took my twenty bees in a box out to sea—the house being near the sea—a good way from the land, and let them go. Now you understand that if any of these bees came home, they would be caught upon the bird lime, and I should see them. As a matter of fact, none of the bees came back. Then I tried another lot in the same way, but let them go nearer home, on the sea shore; but none came back. I found they never could come back unless I let them go in the flower garden, near the house. These bees were always in the habit of going to the flower garden, and they knew their way back, and were caught on the bird lime. If I took them anywhere two hundred yards in the direction of the sea, where they were not accustomed to go, they could not find their way back, proving that the bees find their way back by observation of land marks, and not by any mysterious sense of direction.

I have tried the same experiments with ants in England and in Germany, with the same result, that they are completely lost if you take them more than a certain distance from the nest, beyond the distance that they know by personal observation.

To give an example of only one other instinct, I think I will mention what appears to me to be the most remarkable instinct in the animal kingdom. A species of wasp,

or wasp-like animal, called the sphex, lays up for its young a store of insects for them to prey upon when they are hatched out. The sphex insect stings the insects which it lays up for food in order partly to paralyse them: it does not kill them, because if they were killed they would decay before the eggs are hatched out into grubs, and would be no use as food to the grubs. The sphex insect therefore stings the prey only in a certain part of the body, where there is a large accumulation of nerve centres. It stings the spider, for instance, in the part of the body where there is the largest supply of nerve centres. The effect of stinging the nerve centres is to paralyse without killing him. It is a very remarkable fact that the sphex should have discovered this peculiarity. Still more remarkable, however, is that species of sphex which preys upon grasshoppers. It is needful to sting the grasshopper in three different parts of the body in order to produce this effect, and this is done. Lastly, there is another species of sphex which preys upon caterpillars; and here the nervous system is still more elongated, and it is actually necessary that the sphex should pierce the caterpillar in nine different parts of the body, each one very localised, and yet the sphex actually stings the caterpillar in those nine particular points.

This, I think, is the most remarkable instinct in the animal kingdom, because it appears to display some knowledge—or something which serves the same purpose—both of the anatomy and of the physiology of the insects on which they prey.

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