III

ANIMAL BEHAVIOR AND THE PHYSIOLOGY OF THE NERVOUS SYSTEM

WHEN you see a moth fly towards the light, or a cockroach flee at your approach, you naturally assume that the animal has the same sort of feelings about the matter as yourself—the moth goes to the light out of curiosity or because it likes the light, and the cockroach realizes the danger and seeks safety in flight. But you really cannot be sure what the animal's feelings are; possibly there is not much of anything in the minds of these insects and other low forms of life. We must try first to explain their behavior without assuming human-like motives, for such an explanation would be simpler and therefore preferable to one that made unnecessary assumptions.

Insects do, in fact, behave in a very mechanical manner. Take the case of the moth. It has been found that the force with which a moth's wings beat is directly proportional to the intensity of the light that strikes the moth's eyes. Further, if just one eye is struck by the light (say the other is blackened), then the wing on the opposite side of the body does the beating; the wing on the same side beats feebly or not at all. If now, a moth is not headed directly for the light, one wing beats harder than the other, because one eye is in the shadow of the animal's own head and the other is not. The unequal beating of the wings causes the moth to turn, just as a boat would if one oar were pulled harder than the other. The moth continues to turn until both eyes receive the same amount of light, but the eyes are equally illuminated only when the moth is headed directly for the light. Both wings now beat with equal force, there is no further cause for turning, and since the moth is headed towards the light, its flight carries it towards the lamp from which the light is coming.

That the explanation just given is correct can be proved very simply. A moth, placed in a box which is uniformly illuminated from all sides, does not move in any particular direction, because both eyes are receiving the same amount of light; but if one eye is blackened so that the other eye constantly receives more light, then one wing beats harder than the other and the moth flies in circles.

It is obvious from this last experiment that the moth does not move to the light out of curiosity or from love of the light. A human being would find one eye about as useful as two in satisfying his curiosity, and when he got to the light, his behavior would not necessarily be different whether he possessed both eyes or just one.

The mechanical behavior of the sort just described for the moth can be well shown in connection with certain very small animals known as Paramecia. These are not very familiar animals on account of their microscopic dimensions. You might drink a glass of water without knowing that you were swallowing millions of Paramecia or even suspecting that there was anything unusual about the water apart from the fact that it was got from a slightly stagnant pond. In order to see the Paramecia you would have to examine a drop of water under a microscope. You would then see that they lacked a nervous system, and in general that they had a very simple structure. You would be struck first of all by their smooth, gliding motion through the water, in spite of the apparent lack of swimming organs; but if you examined a Paramecium very closely you would notice on its surface a covering of minute processes shaped like hairs, or rather like eyelashes, and known as cilia, and you would see that the cilia were constantly beating and causing the Paramecia to move.

Paramecia ordinarily swim about in all directions; but let us pass an electric current through the water, and see what happens. To do this, we insert wires from an ordinary dry battery into a drop of water that contains the Paramecia. By means of a key the electric circuit can be made or broken at will. So let us close the circuit. Immediately all the Paramecia move in the direction of the current and migrate towards the end of one of the wires connected with the battery, in particular, the wire connected with the negative pole of the battery. If the current continues long enough the Paramecia collect about the wire just as moths do about a light, and for a similar reason. Briefly stated, the reaction depends upon the fact that negative electricity reverses the beating movements of the cilia. With this simple fact in mind, let us analyze the reaction. We will begin with the Paramecia swimming in all directions. Let us focus our attention on an individual that is not headed directly for the negative pole so that one side of the animal is more or less facing this pole, and the other side is not. If we will think of negative electricity as issuing from the negative pole in straight lines very much as light does from any source, then we may regard one side of the Paramecium as in the shadow, as it were, of its own body, and on this side the cilia beat as usual. But on the side exposed to the negative electricity, their beating movements are reversed. This reversal of the cilia causes a turning movement, again very much like the turning movement of a boat when a person pulls on one oar and backs water with the other. The turning movement of Paramecium will continue until the long axis of the animal is parallel to the direction of the current. Now equal numbers of cilia on both sides are reversed. Moreover, only a few of the cilia at the front end are reversed; those farther back are not exposed to the negative pole, because of the animal's shape. There is now no further cause for turning, and Paramecium moves straight for the negative pole.

Note, now, that the reactions of both the moth and the Paramecium have very much in common. Both animals come to be fixed in such a position that the length of their bodies corresponds to the direction of the light or electricity, as the case may be. Or, to state the matter in another way, the body of the animal becomes oriented in such a manner that its long axis is parallel to the direction of the stimulus. This orientation is brought about automatically because the body, so long as it is not parallel to the direction of the stimulus, is more strongly influenced on one side than on the other, and a turning movement results. A mechanical response of this nature is known as a tropism.

Many of the apparently intelligent responses of insects and other lower animals are probably of a purely mechanical nature. You spy a cockroach on the wall with evil and evident intention, and the little beast makes a hasty retreat to some crevice; he seems to show all the outward evidence of fear and excitement, and of a conscious purpose to reach cover. But it is possible that we are reading all of these mental states into responses which are purely mechanical, just as we do when we say the moth goes to the light out of curiosity.

Insects get into cracks and crevices probably not because they are consciously aware of the protection afforded, but because contact of one portion of the body with any solid object tends to result in movements such that more of the body comes into contact with the surface, and the movements continue until a maximum surface of the body is in contact with the solid surface—and then the animal is in the crevice. This is simply another form of tropism. Furthermore, many insects do not go towards the light but away from it; the reaction is again a tropism with connections between eye and muscles the reverse of those mentioned for the moth. As crevices and cracks are usually dark, it is easy to see how the insect might go towards them in accordance with the tropism in question; and once he arrives at a crevice and touches it with his body, another tropism (involving response to contact with solid surfaces) carries him into it.

The insect does not really move to the crack with the object in mind of getting in and being protected. He gets there for one reason, and gets in for another; and the reason in both cases is in the nature of an automatic response.

Much has been written regarding the remarkable behavior of bees and ants, and their supposed powers of reasoning. A consideration of just one or two cases will suffice as examples. Ants will build a bridge across any water that is in their nest and that encircles their young, and come to their rescue. The bridge is built by piling up particles of dirt in the water. Here we have something that looks on its face very much like reasoning, but it is in fact merely a particular expression of a more general instinctive reaction which consists in covering up any debris or other material which the ants cannot remove from their nest. They build the bridge across the water even if there are no young to be rescued. That ants do not know enough to build bridges in order to attain some objective, can be shown by a simple experiment. Honey, of which the ants are very fond, is placed within easy reach of them in a dish. If now the dish is suspended by a string and raised slightly from the ground, say a third of an inch, so as to be inaccessible directly, the ants fail to get it; they do not build up a little mound of earth from which they might readily climb on the dish.

One of the things that have attracted attention in connection with ants is their capacity for communication. An ant which has found a supply of food soon returns to it with others; but she probably has no mysterious powers of communication by means of which she can describe to the others the location of the food supply. This can be shown by the fact that the ants cannot locate the supply if they are separated from the one that discovered it while they are on their journey to the supply. They must be led. But what caused them to leave the nest and follow? Ants are said to stroke each other with their feelers, and in this way, it is believed, they communicate. A certain kind of stroking means "follow me"; or, perhaps it would be better to say when an ant is stroked in a certain way by another, it automatically follows the latter. And the act of stroking may simply be an automatic response which an ant gives upon returning to its nest, after having come across a supply of food.

Of the numerous other cases of behavior which seem to involve the power of reasoning in the insects, only one other need be mentioned. A certain wasp, Ammophilia, which digs its nest in the ground, has been observed to seize a small stone in its jaws and use it to pound the loose soil with which it had filled up the hole to the nest. Now this appears at first sight like a close approach to reason, in that it involves the use of a tool. But is it really necessary to assume that there is involved here any radical departure from the insect's instinctive behavior? The act of lifting up small stones in its jaws, and the act of packing in dirt, are parts of the instinctive process of filling the hole to the nest. The wasp, in occasionally using a pebble in packing the dirt, is simply combining two acts normally involved in the nest-building instinct.

When we come to consider the higher animals, we find, together with greater brain development, greater freedom and variety of action. A moth butts its head against a lamp, no matter how many times it has previously done so. In contrast to this a higher animal has the capacity readily to modify its behavior in the light of experience. A child associates the pain involved in touching a flame with the sight of the flame, and it does not repeat, at least not very often, its first act of inexperience. Some connection has been made in the child's brain between the part involved in seeing the flame, and the part involved in feeling the pain, a connection which is referred to as association and which is at the basis of the learning process.

The power of association resides in the fore part of the brain (the part just back of the forehead). You naturally look to the structure of the brain for an indication as to how it works. If you examined a thin slice of the brain through a microscope, your first impression would be a confused mass of threads, but on closer inspection you could discover some order out of the apparent confusion. You would see numerous connecting units—millions of them in the brain as a whole—each resembling somewhat a minute uprooted plant with a main trunk and side branches and with several roots springing from a slightly enlarged bulb-like base. These are the neurones. They may be arranged simply end-to-end like the cars of a freight train, a "trunk" of one neurone ending near a "root" of the neurone next ahead; but as a rule the side branches make additional connections with other neurones. The adjacent neurones are, like the cars of the freight train, separated by a small gap, which, in the learning process, is somehow bridged over; and in this way originally separated parts of the brain are brought into communication with each other; that is, through the process of association.

The number of neurones in your brain was established at birth. Learning does not involve any increase in their number; it involves only the making of new connections between them. When you forget something, the "bridges" between certain neurones have been broken down and the small gaps again intervene.

A certain biologist conducted experiments on dogs to test their powers of association. We all know that dogs can learn and therefore have the power of association, but the biologist referred to was interested in precise information on the subject. He found that a dog could be made to associate almost anything with food, for example, the sound of a bell, or the scratching of a certain area of his skin. All that was necessary was to sound the bell (if this was involved in the connection sought) on repeated occasions when the food was presented to him. If now the bell was sounded, the dog's mouth watered even if no food were presented, showing that the dog had formed the association. In a similar way, the dog's mouth might be made to water by simply scratching a certain area of his skin. Moreover, the dog could make fine distinctions. If he had been taught to respond to a note of a hundred vibrations per second (as shown by his mouth watering), one of ninety-six per second called forth no response; or, if the scratching of a particular skin area had been made the signal for food, a slightly removed adjacent area could not be substituted. A curious fact came out in connection with these experiments. If there were removed from a dog's brain a certain area through which an association was known to take place, the signal for the presentation of food, say sounding of the bell, did not call forth in such a dog the usual response, namely, watering of the mouth, but instead the dog became drowsy and gradually went to sleep. The result is explained by a certain process which occurs in the normal animal, as well as the one operated on. When the dog hears the sound of the bell, he concentrates his mind on the idea of food. This concentration implies a suppression of all other mental activities; to use the technical term, there is an "inhibition" of activity in all parts of the brain except the area concerned with the association. If this area is removed, inhibition occurs just as before, when the bell is sounded, and since the area is now missing to which all mental activity would be restricted, the dog simply becomes drowsy and goes to sleep.

Our simplest thoughts and mental states involve the organized activity of at least thousands of neurones, possibly of millions. In dreams, the connections between the neurones are haphazard and disorganized. The process of inhibition is not in full swing, and the activity of the brain is not limited to a well coördinated set of neurones. There result the freakish connections characteristic of dreams. In hypnosis, there are lacking the usual inhibitions to suggestion, for which reason a suggested idea, thought, or action automatically goes into effect. Hypnosis is essentially an exaggerated state of susceptibility to suggestion. We are all normally more or less hypnotized, depending upon the extent to which we are susceptible to suggestion.

To the layman in psychology some of the things that have been written about the subconscious seem to exaggerate the aspect of mystery ascribed to it. We do some things subconsciously, but there is no more mystery about this than that we should be unaware of some habitual act, such as walking. Any act, if sufficiently often repeated, tends to become habitual, and drops out of the field of attention, although at first it may have involved a great mental strain; witness a child's attempts at walking or writing. Certain simple mental processes, if sufficiently often repeated, may also become habitual and drop out of the field of attention, and then you would regard them as "subconscious." I can readily conceive, for example, that a bank clerk might be adding up figures without thinking especially of what he is doing; in fact, his thoughts might be on something else, and in this case he would be adding subconsciously. It was inevitable, however, that much of the speculation springing up in connection with psychoanalysis and the subconscious should run wild, but psychologists, with occasional help on the part of biologists, may be confidently expected to set this new house in order.

Many of the apparently intelligent acts of animals are achieved in an accidental manner. This fact is indicated by certain experiments. Dogs were confronted with the problem of getting to some food from a cage, from which they could escape only after pressing a lever and opening the door to the cage. An inexperienced dog never went directly to the lever and pressed it. What he usually did was to nose and claw impatiently about the cage until by accident he struck the lever and was released. When confronted with the problem the second time, he did not approach the lever and make his escape directly, but he scrambled about again, this time, however, more or less in the part of the cage where he had met with success on the first occasion, and as a result the number of fruitless efforts was reduced. On the third occasion there was a still further reduction in the number of errors, and so on, until eventually just the right move was made. This sort of behavior is generally referred to as "trial and error." Many attempts are made, one succeeds by accident. The dog who sees his master open a gate does not reason, "Master has opened the gate by pressing the latch, therefore I should be able to open it in the same way." He does not even imitate his master in a blind way. He learns to open it very much in the same way as the dog did in learning to escape from the cage—by the method of trial and error.

When students of animal behavior first learned these facts, there was a tendency for some of them to take the stand that lower animals were entirely without powers of reasoning, that it was man alone who had this faculty, and that there was a big gap, therefore, between man and any lower animal in this regard. In taking this attitude, they were probably going to extremes. They forgot that many of the reasoned acts of man himself were based on the method of trial and error. You are given a puzzle to put together. You do not simply size up the situation and arrive directly at the solution. What you normally do is to manipulate the puzzle; you make a good many tries, most of them failures, but you are guided by them, just as the dog was, and finally you get the thing. Even the higher forms of reasoning, which apparently are pure abstraction, involve this method of trial and error. When you are confronted with a problem in mathematics, supposing now you are good at this sort of thing, you do not as a rule simply set your mental machinery into operation and arrive directly at the solution. You first make what amounts to a number of guesses, you try this and that possibility, and you finally hit upon one that leads to a result. The difference between a person who is good at mathematics, and the rest of us, is that the mathematician makes fewer irrelevant guesses than we, and he eliminates them more rapidly. When the dog learns to open the gate, this is the very process he goes through, but the whole thing is cruder and on a simpler basis. To be sure, the animal almost certainly does not go through a reasoning process that is consciously guided, such as when we reason that if A is greater than B, and B is greater than C, A is greater than C. But even men seldom use consciously this syllogistic form of reasoning. Once a problem has been got to the point that it can be put in the form of a syllogism, it is regarded as solved; the real difficulty consists in finding the proper clues to its solution, and this involves the making of guesses, as a rule. Reasoning by no means resolves itself entirely into a process of trial and error, but this process is an important element in the situation, and it has its crude beginnings in the animal mind.

One of the outstanding features of human behavior is the use that man makes of means to attain an end. This is especially evident in his use of tools. A machine is merely the outcome of a highly developed tool; the firearm, the printing press, locomotive engine, aeroplane, telephone, radio, all these and many others are really machines in the broader sense of the term. It is obvious that man owes his superiority over all other animals in large measure to his use of machinery.

To what extent do we find lower animals resorting to the use of tools, and adapting means to end? We naturally look to the monkeys and apes for manifestations of reasoning power, because these animals approach man more closely than do all others in regard to brain size and structure. Monkeys have, in fact, been observed to use sticks and other objects as tools. For example, if food is placed beyond the reach of a chained monkey, he will use a stick with which to rake it in. This, to be sure, is a very simple act, but you would hardly expect a dog or cat to make use of a tool in even this simple fashion, even allowing for physical limitations. The apes are among the few animals that agree with man in their capacity to use tools. Now, when we look for the cause of this, we naturally emphasize the matter of brain size; but there is another factor of importance which enters in. I refer to the development of the hand. It seldom occurs to us how much of our mental development we owe to the hand and its manipulative powers. There is a constant interaction taking place between the hand and the brain. The mere handling of an object imparts information as regards its nature and, moreover, the information so gained tends to increase manipulatory skill and leads to the use of the object as a tool. The whole theory of manual training is based on this fact; it involves a conscious attempt to approach the brain through the hand. In the process of evolution, a highly developed brain without nimble fingers to carry out its commands would have been useless; and on the other hand highly developed fingers without the brain to direct them would have been equally useless. There probably was, therefore, a constant interaction between the two in the course of racial development; progress in one was made possible by progress in the other. Other important factors, to be sure, were involved in man's mental evolution, especially his use of language and his social organization; but the development of the hand as a prehensile organ ought certainly to be included in the list, for it is in this connection that man became a tool-using creature, a creature who learned to attain his ends not just by tooth and nail, but by indirect means that were often much more effective.

In its general outline and operation, the nervous system is simple enough. You touch a hot stove, and automatically you withdraw your hand. One nerve conveyed the message from skin to spinal cord, another carried the message to the muscles which moved your arm. The spinal cord brought about the connection between incoming and outgoing message. I say that the connections were made through the spinal cord rather than through the higher brain centres because the feeling of pain is not necessary for this reaction. You would give very much the same reaction if your hand were burnt while you were asleep, and before you actually woke up and realized you were burnt. You have probably noticed that a person will withdraw his leg if the sole of his foot is tickled while he is in deep sleep and totally insensitive. This sort of response is of the simplest kind possible through the nervous system; it involves no act of will or reasoning. Other reactions of the same automatic nature are given when our eyes are touched and we wink, or when something in the throat causes coughing. These are all known as reflex acts. The connections which they involve through the spinal cord or lower brain centres are established at birth. The more complicated forms of behavior take place through the higher brain centres and depend upon connections which are made after birth, in the process of learning. They involve the hitching up of neurones originally not connected, and when behavior takes place through these complicated and new channels we refer to it as action based on reason or thought. In a reasoned act there are involved typically the same elements of nervous conduction as in the reflex act, a central part connecting incoming and outgoing messages; but in a reasoned act the central part of the process is long drawn out. Behavior, in other words, is a more general process that includes thought as one of its elements.

Reasoning, according to the view just presented, is closely connected with action. In fact, practically all of our mental processes are. The mind evolved in connection with action, for it was only in action that the mind could prove its usefulness. An individual who could foresee danger and avoid it obviously had an advantage over one who lacked this capacity; and in many other ways action became more effective under mental guidance. During the evolution of the race, and in the free state of competition under which it took place, those who lacked intelligence succumbed to those who had wits, and those who had wits succumbed to those who had more wits. In this way the mind gradually progressed under the influence of natural selection, from crude beginnings to its present high state of development. But all the while, the mind was primarily the tool to action. It was only in connection with action that the mind could justify its existence and come under the guiding influence of natural selection.

The origins of human behavior are discernible in the behavior of the lower animals. The difference between the two is in most respects a matter of degree, not of kind. But in one respect there does seem to be a genuine difference between them. Among the lower animals we do not find the more elevated forms of behavior that we designate as moral. Man seems to be exceptional in this regard. It was for this reason that moral philosophers of the eighteenth century postulated a certain faculty which was to be found only in man, and which they designated as the moral faculty or conscience. They claimed it was unanalyzable;

it was an unresolvable entity—a faculty, and that was all there was to the matter. Developments in the field of psychology have, however, shed new light on this problem. Present-day students of psychology and animal behavior make no attempt to deny the existence of a conscience and of the more elevated forms of behavior. Conscience and moral behavior are as real to-day as ever, but what these students have attempted to do is to analyze moral behavior, and to find out the simpler elements of which it is made. In so doing they have pointed out two things: first, the instinctive nature of all voluntary acts; and second, man's social nature.

An instinct has often been defined as a spring to action; the force from behind that is the basis of our desires and directs our acts into certain channels—witness the difference in the behavior of your husband before his hunger has been satisfied and after. If there are obstacles in the way of satisfying an instinct, a long train of reactions may be set up. A hungry person, without food or money with which to buy it, thinks of ways and means to satisfy his desire; he may try to earn the necessary money, or he may hit upon the happy expedient of dropping in at a friend's house for dinner. In any case, the long train of reactions through which he goes was determined by his desire for food. In this sense, the instinct is the urge—the spring to action.

The term "instinct" usually calls to mind the instincts of hunger and sex; but we must not overlook the existence of other important instincts, among them fear, or the urge to escape destruction; and anger, the urge to overcome persons and things that are obstacles to the free expression of other instincts. These, to be sure, are all instincts that suggest our animal nature, but without them neither the individual nor the race could continue its existence. It was precisely these matters that were of prime importance during our evolution, and it was about them that behavior shaped itself.

One of the instincts that always arouses our admiration, whether we see it expressed in man or in lower animals, is the love of the mother for her young, the urge to protect, caress, and nourish them. This maternal instinct is more strongly developed in the female but by no means lacking in the male. It is this instinct that urges us to protect the weak in general, and it is because of its stronger development in the female that women are more active than men in all forms of philanthropic and charitable undertakings. In the male it is aroused, especially during the period of courtship, by the female, and it converts the mere sex attraction into the more elevated and enduring form of love. It is this instinct, also, which is outraged by mistreatment of the weak, especially of children, and is at the root of our feeling of righteous indignation. The maternal instinct certainly must be taken into account in considering many forms of moral behavior.

Now the maternal instinct by itself would not suffice to account for the whole of moral action. Other facts have to be taken into consideration, and there is one fact in particular that is of especial importance; I refer to man's social nature. In regard to his social nature man occupies a unique position in the animal kingdom. In most other species an individual can, after a longer or shorter period of infancy and dependency, shift for itself and lead an almost isolated existence. But for man this would be an almost unthinkable state. He would be changed from the most powerful of all creatures to one of the weakest, from a thinking being with the power of language, to one whose mental furniture consisted almost entirely of his immediate bodily wants. His acts would be neither moral nor immoral; they would be non-moral. It is only in coming into contact with others that a child soon learns that some of his acts meet with approval and others with disapproval. Accordingly, he comes to set up certain standards of right and wrong, and his behavior becomes modified accordingly. To be sure, he has not yet achieved the highest plane of social conduct, but he is on the way. Moreover, it is only in coming into contact with others that the child distinguishes between himself and others. If he were entirely isolated, there would be no occasion for such a distinction; he would not think of himself as an individual distinct from others. The concept of self, therefore, depends, in its development, upon social contact. Without this concept, the sense of responsibility and moral behavior would be impossible.

Now, there is dependent upon the concept of self the expression of two instincts, one characterized by an emotion known as positive self-feeling, the other by the emotion, negative self-feeling. These instincts may be aroused in a large variety of ways. Very commonly praise, if it is properly dished out, arouses in us our positive self-feeling; but praise is by no means the only stimulus for this instinct. When, for example, a proud father tells you how clever his children are, he is really boosting himself, for he identifies his children with himself, and they arouse his positive self-feeling. A work of art arouses in the artist his positive self-feeling; the act of creating in general does, entirely apart from the praise of others. The instinct characterized by negative self-feeling is just the opposite in its effect to the one characterized by positive self-feeling. These two instincts are very important in their bearing on moral behavior. As the individual gains in maturity, his instincts in general become harmoniously organized about certain ideals of behavior, ideals which become so firmly ingrained in him that he comes to identify them with himself; and as a result, any course of conduct which conforms to the ideal arouses in him his positive self-feeling, and any course which defeats it arouses his negative self-feeling. The foundations are now laid for the more elevated forms of conduct.

This analysis makes no attempt at completeness, but I hope it will at least suggest that no adequate account of moral behavior can ignore man's instinctive make-up and his social nature.

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