THE NATURE OF THE BEAST

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A Popular Account of Animal Psychology From the Point of View of a Naturalist

BY RUTH CROSBY NOBLE

Based largely on the scientific publications, lectures, and notes of the late G. KINGSLEY NOBLE, Ph.D., of the American Museum of Natural History

BOOK NO. 746

DOUBLEDAY, DORAN AND COMPANY, INC.
Garden City 1945 New York

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PRINTED IN THE UNITED STATES
AT
THE COUNTRY LIFE PRESS, GARDEN CITY, N. Y.

In Memory of

KING

His the sturdy roots and trunk of this tree;
mine but the branches

FOREWORD

THIS BOOK owes its origin and what it has of inspiration to two men of great vision and devotion to a cause: Brigadier General Theodore Roosevelt and my husband, Dr. G. Kingsley Noble—both of whom were called away long before their work was done.

As a trustee of the American Museum of Natural History and a member of the Explorers' Club, General Roosevelt had long been impressed by Dr. Noble's studies of animal behavior, and as an editor of Doubleday, Doran & Co. had persuaded him to undertake a book on the subject for his firm. Dr. Noble had shared with me his interest in this venture and had enlisted my help in arranging innumerable notes and papers in a section of his file labeled "Popular Book."

Some months after my husband's death the suggestion was made by General Roosevelt and by Roy Chapman Andrews, then director of the Museum, that I consider the writing of such a book. Because they felt that it should be primarily a natural history discussion, based largely on field work and with a minimum of rats, brains, and laboratories, I was perhaps too easily tempted. Though not a specialist in animal behavior, I had shared largely in Dr. Noble's field investigations, and had had varied training in natural science and some years of professional experience as assistant curator in the Museum's department of education. The opportunity to work more closely with my husband's papers, to write of our unusual observations and adventures, to organize my own knowledge of animal behavior seemed one not to be cast aside

The world is becoming increasingly "psychology conscious" and bookstores are crowded with volumes concerning the human mind, yet there has been virtually nothing of a popular nature on the psychology of animals other than apes. This book is therefore offered not as another textbook or even as an up-to-the-minute reference book, but as an informal introduction to the subject of animal behavior, illustrated so far as possible by Dr. Noble's experiments. For the general background I have relied on his lecture notes, on the excellent textbooks mentioned in the bibliography, and upon many other authors

whose work has received scant recognition in the necessarily simplified text. It was difficult in some cases to determine whether Dr. Noble's notes represented original thoughts and observations or were hastily jotted down from other sources. Thus in a few instances I may have incorporated too intimately into the text facts and theories which belonged to others.

There is also little mention in the chapters of the many loyal and capable assistants and students who co-operated with Dr. Noble and contributed immeasurably to the variety and success of his experiments. Most of their names will be found in the bibliography.

The first draft of the manuscript was read by Dr. Robert M. Yerkes, Dr. Carl J. Warden, Dr. Frank Beach, and Dr. T. C. Schneirla; and parts of it by Dr. Ernst Mayr and Dr. Ludwig Hirning. These distinguished scientists contributed many invaluable suggestions and criticisms for which I am deeply indebted, but none of them is responsible for any possible inaccuracies in the finished product.

With the declaration of war and General Roosevelt's immediate entrance into service, the editorial assistance and encouraging direction he had given were carried on by Mrs. Mary Slavin and later by Miss Clara Claasen. For the courtesy and understanding consistently shown me by the staff members of Doubleday, Doran, I am sincerely grateful. I also feel a deep sense of personal gratitude to my friend of college and early Museum days, Dorothy Greene Ross, who with her accustomed cheer and efficiency guided my first faltering footsteps. Bernard Greenberg kindly checked the Anolis lizard material and Emily Lowe was a delightful assistant in organizing the chapter on abnormal behavior.

To the New York Zoological Society belongs credit for much helpful information cordially given, as well as for photographs of zebra, geese, peacock, panda, and lion cubs.

To the American Museum of Natural History and to the WPA workers who assisted Dr. Noble there I am indebted for the remaining photographs, as well as for translations of much of the foreign source material.

If I have taken liberties with the word "we" and have on occasions intruded myself where I really did not belong, it was done with an easy conscience. In speaking of his hopes and achievements Dr. Noble always used the word "we," always included me unconsciously, though often as not I had done little but lend a sympathetic ear.

RUTH NOBLE

Englewood, New Jersey

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THE NATURE OF THE BEAST

CHAPTER I

ANIMALS' DOMAIN

JOHN BURROUGHS has written, "Man can have but one interest in nature, namely, to see himself reflected or interpreted there; and we quickly neglect both poet and philosopher who fail to satisfy, in some measure, this feeling."

In delving into the nature of the beast we shall indeed find much that illumines human nature; all too often in the following pages shall we see ourselves reflected in the doings of animals. Yet we must avoid, as our most dangerous pitfall, the opposite assumption: that animal behavior can be interpreted in terms of human conduct.

It has always been a temptation to ascribe to creatures of the wild human ideas and motives. Most of us were brought up on stories and pictures, often unforgettably enchanting, in which animals were dressed as humans, lived in well-built houses, talked to one another merrily, and even were concerned with such subtleties as table manners and a sense of humor.

Appealing though unrealistic notions of the parallelism of man and beast have their roots in every folklore. In the legends of all primitive peoples animals are personified and speak with human insight and wisdom. Often they are venerated as the reincarnation of departed human ancestors, or feared as the embodiment of gods and spirits. Again they are represented as our brothers, less fortunate in some ways, but quite understanding and ready if we befriend them to serve us with loyalty and unselfishness.

World Apart

The animal mind is not simply an immature or primitive human mind; the world which an animal senses is an entirely different world from our own. His home and his haunts do not appear to him as they would to us; nor do they smell or feel the same. If the animal is con-

scious of himself at all his ego concept is surely unlike our idea either of him or of ourselves.

Let us see if a few realistic observations, based on broadly representative animals, will help us clear away some of our false notions and realize in some measure the limitations of an animal's experiences and mental capacity.

What, for instance, would be our state of mind if we had no concrete image of our own selves? Parr[77] has pointed out that an animal without appendages cannot touch himself and thus cannot through feeling become acquainted with his own body.* Though long, sinuous creatures such as snakes or eels—or long-necked ostriches and giraffes—can turn around and see a large proportion of their bodies, a more rigid animal, like the mackerel, cannot see itself at all. There are, of course, mirrors in nature and an animal may occasionally chance upon his reflection; yet he lacks the powers of deduction to realize that the reflection is a counterpart of himself. This relative ignorance of self has its social implications. Having no adequate concept of his own body, an animal can have no clear conviction that his associates are of his kind. He does not consciously recognize his companions or even his offspring as being "birds of a feather"; his mate may be only a foreign object that has a special allure.

The world of a bat is difficult to describe in terms of human sensations. While most of our thoughts and actions are based on vision, the night-flying bat is directed largely by auditory stimuli. The familiar expression, "blind as a bat," is hardly apt, since most bats do see. But in their flights through city streets, about trees and telegraph poles, through caves and haylofts, they are guided by an extremely delicate hearing device. As they fly they utter little squeaks inaudible to the human ear. The echoes of these tiny sounds enable them, even when blindfolded, to avoid obstacles as close as two feet away.

The sensations of the common bullhead or catfish would be incomprehensible to even the most conscientious observer without the help of laboratory experiments. Partly nocturnal, the bullhead is thoroughly at home in muddy water or in the muck at the bottom of ponds. He can see, but vision is not important in his life. He has, however, an extremely delicate sense of touch, especially in the catlike whiskers or barbels with which he feels his way about. Moreover he has taste organs all over his body which enable him to test the water, the reeds, and other substances about him. In brooding, the female or the male continually tests the eggs by tasting them with fins or body.

*For references, see Bibliography, p. 210.

Precise investigations over a long period of years were necessary before we had any clue as to the inner drives of the female wood tick that clings to a dog's ear after a run in the country. Not having eyes, the tick uses her skin to see with, or at any rate to sense light with. She is also extremely sensitive to minute changes in temperature and to the odor of perspiration. In her native woods she climbs slowly up a branch and there waits for a victim to pass. Though the tick has no knowledge of the appearance of a dog, nevertheless her attraction toward a warm acid object eventually secures for her the red blood necessary to ripen the eggs in her body. She may have to wait a long time; some ticks have been known to live eighteen years without food.

Investigation

The question naturally arises: How do scientists know that the bat, the bullhead, and the wood tick have such extraordinary sensitivities? How have they learned that many animals—for example snakes and bees—have sensations totally foreign to human experience, while other animals—like the bat and the bullhead—have one or more of our senses developed to a phenomenal degree? In short, by what paths does the psychological explorer enter the animal's domain?

In general, what science has been able to add to the centuries-old accumulation of practical knowledge has come about through thousands of painstaking studies in field and laboratory. Only by the most conscientious application of every resource open to investigators have they been able to glimpse the animal's world, to grasp insofar as possible the realities of his existence.

The only legitimate place to begin the study of an animal is in its own habitat, where it is surrounded by its own kind. The field naturalist constantly makes new observations on life history and behavior, as well as on appearance and food habits. By watchful waiting he can learn much of the animal's reactions toward its family and its friends. He takes clear and detailed notes on the spot and often is fortunate enough to obtain photographs or motion pictures. Sometimes he sketches; sometimes he is able to make phonograph recordings. Yet, even when aided by field glasses, the vision of man is limited; and the confidence and patience of his subjects are not to be relied upon. Animals often refuse to perform on schedule and the watcher can seldom be sure of a front seat.

To supplement the information secured in the field live animals

are frequently brought to the zoo or aquarium for further study. The American Museum of Natural History is one of the few museums equipped for such investigation. There the experimental laboratory, like the modern well-managed zoo, attempts to reproduce as nearly as possible the natural habitat of the field. Lizards are given sun lamps and windows which let in ultraviolet rays, so that they may not miss too keenly their southern sunshine. Salamanders and frogs which live in clear streams are supplied with spring water, flowing and aerated; for those preferring still water, more stagnant pools are simulated. A great many tanks of various sizes domicile the fish. The usual rats and guinea pigs are easily housed in cages. Greenhouses on the roof have provided humid atmosphere and lush vegetation and a rookery where herons, sea gulls, pigeons, hens, and owls have felt themselves at home.

Day and night, year in and year out, these animals can be observed at close range. Many are laboratory-bred or at least laboratory-hatched. Some become subjects in experiments carried on by the Museum's research staff; others are never disturbed in their life of ease but are maintained as normal controls.

It is not always possible to analyze an animal's behavior from watching its normal reactions. In the field of human psychiatry much light has been shed upon normal conduct through study of abnormal cases —abnormalities which sometimes are functional but more often result from infections, chemical unbalance, or injuries to the nervous system. So in the laboratory certain phases of the animal mind can often be understood by artificially inducing abnormality. With the normal specimens or controls always available for comparison, it is possible to determine what happens to the experimental animals when parts of the brain are anesthetized or operated upon; when glands are removed or glandular preparations administered; when uncongenial company is thrust upon them or when they are deprived of their accustomed companions.

No one need feel uneasy about the humaneness of such experimentation; every precaution is taken to avoid possible suffering to any living specimen. Animal investigation is a calling in which regard and often affection for animals play a large part. In his endeavor to extend our knowledge of the animal world the typical experimenter is guided by the highest sense of responsibility for his charges no less than by the respect his science instills for all life, however humble.

Two typical cases will illustrate the methods of conducting such indoor exploration and exemplify the advances it makes possible in our knowledge concerning animals.

There was for a time on exhibition in the American Museum of Natural History a device showing a room as it looked to a human being. When a button was pressed the scene changed and the room was seen as it might appear to a dog. All the color had gone from the room, for the dog is color-blind. The furniture showed no striping, for the dog has poor discrimination of line. The walls seemed to converge, the ceiling had come down toward the floor in the back of the room, the shape of the table had changed remarkably; for the perspective of a dog is more foreshortened than ours. The reaction of most visitors to this exhibit was, "How do you *know* the dog sees like that?"

We cannot put ourselves in the dog's position and thus obtain first-hand knowledge of his sensory impressions. But we can derive much accurate knowledge from careful study of the dog's visual apparatus and his responses to various stimuli.

A common laboratory method of testing color vision in the dog is to conceal meat behind one of two contrastingly colored doors. The food is always identified with the same color. If the dog chooses the correct door he can get to the meat. The wrong door is always locked. At first the rewarding color is made much brighter than the other, and the animal quickly learns to go toward it. After the habit is well established the light behind the "correct" color is moved backward and the light behind the "incorrect" color moved forward. In this manner the brightness of the two colors—the "gray value" of the hues—is equalized. When this equalization takes place the dog's habit is lost; in the course of a thousand trials he cannot learn to discriminate between two colors of equal brightness or gray value.

The second case deals with the solution at the Museum of a long-standing problem concerning poisonous snakes.[12] Rattlers, copperheads, and moccasins have long been known as the pit vipers because of a unique organ in the form of a pit between the nostril and the eye, but the function of the organ had been undetermined in spite of much observation and anatomical study. The investigators found it to be a sort of biological thermostat which, reacting to the proper degree of heat, starts the reptile into dangerous action.

The apparatus for this experiment consisted primarily of two electric light bulbs differing only slightly in temperature, but identical in size, shape, and covering, and attached by metal arms to a revolving rod and a motor. As these bulbs swung back and forth the pit vipers would invariably strike at the warmer bulb, even though the positions of the bulbs were frequently interchanged. Though the temperature of the swinging bulbs differed by less than two tenths of a degree centigrade the warmer bulb drew the strike.

To determine the exact mechanism by which the reptiles were enabled to make this fine temperature discrimination their various sense organs were shut off one at a time. First the snakes were blindfolded, using adhesive tape pads blackened with India ink. Then their nostrils were plugged with cotton soaked in collodion. Finally the entire upper surface and sides of the head were covered with adhesive, leaving only the pits exposed. In no case was the striking ability of the snake seriously affected. On the other hand, merely filling the pits with a 10 per cent solution of collodion prevented the blindfolded snake from striking at all. As soon as the collodion was removed the reaction was resumed. To further test the sense of smell dead mice—one warm, one chilled —were attached to the light bulbs; but even then the warm moving object was alone effective. Again and again the experiments were repeated, eliminating one factor and adding another, always with the same result.

At last it was proved to the investigators' satisfaction that the radiant energy of warm bodies is sensed by the pit vipers at distances where humans could not possibly feel it, and even at distances where thermometers would record no effect. The experiment gave convincing evidence that the thermal receptors which register this fine discrimination are the facial pits. The same organs also proved sensitive to air vibrations. In similar experiments with boas and pythons, which have no facial pits, the same sensitivity to warm objects was observed; but in these species the organs were found to be in the lips and they were not sensitive to vibrations.

Through long ages philosophers have recognized in man a universal but eternally frustrated longing to put himself in another's place, to truly understand those who are near and dear to him. This is as hopeless as trying to imagine infinity or immortality. No matter how we struggle to tear away the boundaries of space and time we cannot efface the idea of limit somewhere. Though we try most earnestly to put ourselves in the place of another there is a double barrier to our ambitions. We cannot vividly imagine experiences and emotions which we have never had; and we cannot free ourselves completely from our own ideas and prejudices.

If this intimate knowledge of our dearest human companions is difficult, how much more perplexing it is to try to understand the animals about us. Not only are their impressions of the world radically different from ours, but their mental powers are far more limited. We who live so much in our minds and who base our thoughts so largely

on the written and the spoken word, who remember the past so vividly and plan so resolutely for the future, can only dimly perceive the mind which lives almost entirely in the present, which knows only the sensations of the moment. With a few possible exceptions the very process of imagining seems to be utterly foreign to animal nature.

Today the form and physical characters of most animals are pretty well known; their classification is fairly well mapped out. But we realize as never before that there is a vast field of unexplored territory in our knowledge of the habits of animals. Why do they behave as they do? Why do some groups react one way to a stimulus, another group just the opposite? What inner spirit sways their destiny; what forces drive them on to certain goals?

CHAPTER II

WORLD OF SENSATION

Senses

ALL THAT any mind can know of the world, or can conceive in the wildest flights of its fancy, comes directly or indirectly through the senses. Hence, in exploring the animal mind, we must start with the realm of sensations. To understand what an animal "knows" or learns we must first discover what he smells and hears, what he sees, tastes or feels.

The sense organs which bring to the animal this information of his environment are known as receptors, and a distinction is often drawn between the *distance receptors* and the *contact receptors*. Sight, sound, and smell bring news from distant objects, warning the animal of danger or inviting him from afar to a meal or a mate. Taste and touch are of use only for testing objects in actual contact with the body.

In analyzing the life of animals we are handicapped by our own sensory peculiarities and shortcomings. To begin with, our lack of an acute sense of smell hampers us in conceiving of a life where *smell* is of vital importance, where survival depends largely upon the functioning of the olfactory organs. Certain sharks, if their nostrils are plugged to eliminate the sense of smell, will starve in the midst of plenty, because they are unable to recognize food by sight as do the trout, by taste like the goldfish, or by vibration like the pike. Some other fish, such as the blind goby, can recognize their *mates* only by odor. Put in a tank with a female goby sealed in a collodion tube, the male will be quite unaware of her presence; but if a small hole in the tube lets the odor permeate the water he will immediately approach her. In cases like this the race could not survive even one generation without the sense of smell.

Museum experiments on reptiles have also contributed to our understanding of olfaction.[65] Though only a few species of snakes have thermostats or facial pits, most snakes and lizards have duplex olfactory systems. They smell not only through their nostrils but *with* the tongue

and with Jacobson's organ. By flicking the long-forked tongue, so often mistaken for poison fangs, they can pick up odors along the ground and convey them to this organ in the roof of the mouth. In the laboratory Ameiva lizards seem to get along very well when their eyes are blindfolded. They can locate food even when it is buried. Blindfolded females of species which brood are able to find their eggs and distinguish them from others, even when the eggs are removed from the brooding site. But with nostrils and Jacobson's organs also incapacitated, they are virtually helpless in these fundamental situations.

Most of us are reasonably familiar with the olfactory powers of the larger game mammals. Many such animals can scent an unseen enemy five or six hundred yards away when the wind is in the right quarter. Society makes good use of extraordinary smelling ability of bloodhounds, which can pick up the trail of lost children or escaped convicts hours after their disappearance. Yet, so far as is known, the champion smellers are found among our fragile moths and butterflies. In certain species a male can scent a waiting female a mile away. A farmer on Long Island exploits the olfactory powers of insects to help feed his ducks. He keeps several female moths inside a cage and as the males flock to the scent the ducks capture these for food.

In the lower invertebrates there is probably no difference between the sense of smell and the sense of *taste*. Both are dependent upon the same sense cells and are classed together as *chemical* sense. Both were originally developed to test a water habitat and the two, even in man, still require moist tissue to be effective. As animals left the water and took up life on land their senses of taste and smell were no longer scattered widely over the surface of the body but became confined to the mouth and nose. The olfactory tissue, restricted to the nares, is sensitive to extremely dilute particles suspended in the air. The taste buds, found on the tongue and other mouth areas, respond to more concentrated materials provided they are in solution.

Even in many insects both smell and taste are found distinct and amazingly well developed. Not only can male moths scent their mates from long distances, but it has also been shown experimentally that a monarch butterfly can taste a .0003 per cent solution of sugar (a human being, not less than .5 per cent). Nor can our sense of taste compare with that of the minnow, which can detect sugar 512 times and salt 184 times more readily than we, or of the housefly, which easily distinguishes sugar from saccharine.

Despite the important role *hearing* plays in the life of man, the sounds which his ear detects may be quite different from those which

the animals about him are sensing. Few bird lovers guess that the robin, when it halts and cocks its head as it hops about on the lawn, is listening to the soft movements of the earthworm in the ground beneath it. The "silent" dog whistle, lately advertised for dog owners, affords a popular demonstration of the dog's ability to hear sounds inaudible to man. When this gadget is blown the neighbors detect no sound, but the animal stops in his tracks and comes bounding home. The whistle emits sound waves at a frequency of about 30,000 a second. Normally we sense only waves between 20 and 20,000 a second.

Even among different species in a single group such as birds there is often a great variation in sound perception. The starling's ear is tuned to highly pitched sounds, the pigeon's to lower ones. In perfect correlation with this hearing ability, the starling's call is a high squawk, while the pigeon's is a low coo.

Although our visual apparatus is perhaps the best for general purposes, we lack for special situations the eagle's farsightedness, the horse's keen sensitivity to slight movements, the bee's and ant's ability to see ultraviolet colors, and the ant's and possibly the owl's sensing of infrared. We cannot, like the four-eyed fish of the American tropics, look up in the air and down into the water simultaneously.

In many respects human senses are superior to those of the animals. For instance, most mammals have no color vision. They see reds and blues, greens and yellows only as lights and shades. Moreover, they are themselves drab in color. The amount of color in animals tends to parallel their ability to perceive color. In actual life there are no "pink elephants"; pink would not be detectable to an elephant. That there are gaily colored fish and birds indicates that fish and birds have a well-developed color sense. The mandrill, which ranks high among the primates, has a brilliant and startling face and also the color vision to discern the gaudy complexion of his rivals. To a bull in the arena, however, the matador's flaming red cape is actually not so enraging as a pure white cape would be.

Generally speaking, the lower an animal stands in the evolutionary scale the more he depends on the sense of *touch*, and the more closely are his experiences restricted to the immediate environment. Sea anemones have been known to remain in the same rock crevice for thirty years, sensing little except the feel of the rock on which they rest, of the water or the air which bathes them, of the small fish which are grasped as food, of the inorganic matter which is rejected.

Animals which live in darkness are especially dependent on touch. On an expedition in 1927 we had opportunity to study at first hand the

life of the Ozark caves. Most of these cave animals are blind and many are equipped with a rich growth of sense papillae or bristles with which they feel instead of see approaching enemies and prey. Similarly, nocturnal insects sacrifice vision and specialize on feeling devices such as the feathery antennae of the cecropia moth. The vibrissae or face hairs greatly assist the mouse in its nocturnal journeys around house or field.

Many animals—for instance, certain salamanders—will not rest until they can feel themselves tight up against a stone or a log. A young fox when weaned from his mother's milk will not eat meat unless his sense of touch has been stimulated by the victim's fur. The elephant with its mobile, sensitive trunk, the raccoon and the monkey with their hands, are said to familiarize themselves with a new environment more quickly than horses, which do not have these feeling devices.

All too often we think of the senses only in terms of sight, smell, hearing, touch, and taste, forgetting the more obscure but equally important senses of vibration, balance, temperature, pain, and those of the viscera and muscles.

The sense of *vibration,* probably a variation of the sense of touch, is extremely useful to some animals. The spider is made aware of a victim in its web by its vibration. A blinded pike will discover food just by the vibration of the water. If hungry he will follow and snap at the end of a pencil moved back and forth in the aquarium, yet pay no attention to quiet food near by. Many crawling animals are especially sensitive to vibrations in the ground.

The sense of *balance* or *equilibrium* is largely dependent upon the semicircular canals located in the inner ear of higher animals. It is this sense that makes it possible for a cat dropped from a height to land on all fours. Fish in turbulent waters, tree frogs on swaying branches, birds battling against the wind make automatically the proper movements to maintain their equilibrium. We are most keenly aware of this sense when things go wrong. We get dizzy and lose our balance when spun around abnormally; frogs whirled on a revolving table make compensatory head movements similar to those of dizzy humans.

Other animals beside the wood tick and the pit vipers are especially sensitive to temperature changes. The bedbug is attracted to its warm-blooded prey from a considerable distance. Frogs react consistently to changes in temperature and humidity. There is some truth in the popular belief that the call of a tree toad prophesies or "brings" rain. What actually happens is that the warm moist air releases the mating instinct in the tree toad; the first sign of the male's exuberance is his soft crescendo trill. However, it is the warmth and humidity which bring out the tree toads, not the tree toads which bring the rain.

It is largely the *kinesthetic* sense, the receptors for which are located in the nerve endings of muscles, tendons, and joints, which controls posture and bodily movements and which indicates the weight of objects we heft. Through this sense an elephant is made aware of the resistance of the tree he is trying to uproot with his trunk, and a fish is informed of the resistance of the stone he is clearing from his nesting site. Toads trained to detour around a plate-glass obstruction continued for several trials to follow the roundabout route even after the glass was removed. Evidently they had established kinesthetic or motor habits—probably combined with visual reactions—which made it difficult for them to change from their accustomed pathway.

Visceral sensations—those of the internal organs—bring the animal a desire for food, for fresh air or water, the sex urge, and the warning to hibernate for the winter. There seem to be no particular sense organs which receive these inner stimuli, but single receptor cells located throughout the viscera probably relay their messages to the brain. Little is actually known of these internal sensory mechanisms. Ordinarily man and the animals are unaware of their visceral sensations, though they react irresistibly to them.

Persons of sympathy are especially inclined to speculate as to whether animals experience *pain*. Undoubtedly higher animals have, like humans, pain cells throughout their bodies and react much as humans do to painful stimuli. We think of pain, however, as a state of consciousness, a sensation registered and retained in the brain; and it is improbable that animals ever attain a consciousness quite comparable to our own. Certainly lower forms, like starfish, can have no conscious feeling of being hurt. Even earthworms and insects with their primitive brains seldom betray pain. If an earthworm is cut in two, both brain end and brainless end go mechanically on their way. A bee will keep on feeding when its abdomen is removed and a dragonfly will eat its own abdomen if it is inserted in its mouth. Even apes appear to be less sensitive to injury than humans. In captivity they show little fear of medical treatment and often mutilate themselves with no great show of discomfort.

Function and Structure

In all life, function goes hand in hand with structure. Without sense organs, or their efficient substitutes, there can be no sensations. Obviously we cannot see without eyes. It is less evident but equally true that

we cannot see without a nervous system and a brain; that specially constructed eyes are necessary for distance vision, for ultraviolet vision, for orientation in space. It is the brain and not the sense organ which actually interprets sensations when the sensory nerve is stimulated. Even with eyes closed we can still see objects in our dreams, or by rubbing our eyes we can experience a vivid display of color. We "feel" an arm, even after it is amputated, because the nerves of the stump still react to stimulation.

Sensitivity is a characteristic of all living matter, plants as well as animals. In one-celled organisms there is a general sensitivity of the entire cell; it might be said that the protozoa "feels" or "tastes" or "sees" with its whole body and reacts with its whole body. Yet even within the single microscopic cell certain areas seem to be more sensitive than others to particular stimuli. Cilia may produce added sensitivity to touch; pigment areas, added sensitivity to light; there are often tiny connecting fibers to improve the slow conduction.

Although a sponge is a creature of many cells there seems to be little specialization among them, each cell performing both sensory and reactive duties. The lowly hydra advanced two steps in the development of its nervous system. First it attained a limited specialization of sensory cells and motor cells, then it acquired a network of nervous tissue connecting the sensory with the motor cells. Although this *nerve net* did not assume any leadership of activity, as does the higher nervous system, it did at least bring about a closer co-operation among the parts.

In jellyfish the nerve net is concentrated into a marginal *nerve ring* around the edge of its umbrellalike body. Along that ring are found simple aggregations of sense cells, primitive sense *organs* with a degree of specialization and co-operation.

The elongated animals with bilateral symmetry possess further differentiation of sense cells into sense organs, coupled with concentration of these organs in the head region. In insects and worms a double nerve cord with many branches runs ventrally the length of the body, connecting the sensory areas with all the body parts. This double cord is joined at intervals by cross fibers which give it the appearance of a ladder. This *ladder type* brought far greater efficiency and diversity of function than was possible with the diffuse nerve net. The *spinal cord* of vertebrates running dorsally did not arise from the ventral nerve ladder of insects; it was entirely an innovation.

The locations of sense organs in many animals often vary greatly from the positions of similar organs in man. The "ears" of a katydid may be said to be in its knees; those of a grasshopper on the sides of its

abdomen. Some insects have taste cells on their feet. The scallop has a row of primitive eyes along the edge of its mantle; the starfish, similar eyes at the ends of its five rays. The earthworm, like the wood tick, has no eyes, but senses light through cells in its skin. On the other hand, most insects have not only one pair of compound eyes, which are used primarily for day vision, but also three simple eyes with which they see in the dark or in their burrows. The delicate antennae of insects and other arthropods may contain organs of smell, taste, or touch.

The scientist's problem in analyzing the animal's world of sensations is not easy even when he himself has similar sensory equipment. His deductions are greatly complicated when the animal under observation possesses organs which man does not have and whose functions are often not yet understood. Reference has been made to the facial pits of poisonous snakes and to Jacobson's organ, found in most reptiles, in many other animals, and even in the human embryo.

Water-dwelling vertebrates, including fishes and amphibians, have rows of small sensory depressions, called *lateral line organs,* around the eyes, over the head, and down the sides of the body. Evidently these organs sense the vibrations of the water—or perhaps its pressure or current—just as the ears of land dwellers sense the vibrations of the air. The lateral line organs probably help the animal to maintain its equilibrium and posture, and there is some evidence that they are sensitive to changes in temperature or to solid obstacles in the water.

In the so-called "living fossil"—the sphenodon of New Zealand—and in many other primitive vertebrates is found a fairly well-developed median eye above the usual lateral eyes. This organ was probably very important to the primitive animals which moved over the bottom of ancient seas and needed to be aware of what was going on overhead; but its usefulness in modern times is extremely doubtful. Though reason suggests that it should be a light receptor, experiments seem to indicate that its present owners can get along just as well without it. In man the tiny remnant of this primitive organ, the pineal body, lies deeply buried between the cerebral hemispheres. Descartes thought that this little knob might be the seat of man's soul. More modern scientists think it has become a gland of internal secretion, but its exact role and its importance remain to be demonstrated.

Sense organs are easily tired and require a changing stimulus for their continued functioning. A sustained impulse soon fatigues the sense cells and they fail to register further impressions. One sound repeated indefinitely soon goes unnoticed. The city dweller becomes so accustomed to the constant sound of traffic that the silence of a night in

the country disturbs his sleep. Visitors to the perfume shops of Paris discovered that their noses soon went on strike.

One spring day a baby skunk was brought into the laboratory. It was thought safest for the baby's reputation to perform a slight operation and remove the scent gland. All went well, with little discomfort or unpleasantness for the patient or the surgeon. The latter washed up and went to a motion picture theater. In a short time a neighbor exclaimed to her companion, "I smell a skunk!" The surgeon's nose had become fatigued and no longer smelled the "perfume." Politeness prompted him to leave, but he stayed on, confident that his neighbors' noses would likewise become adapted to the odor.

The necessity for a changing stimulus undoubtedly accounts for the fascination of movement. A toad will repeatedly snap at a flickering match, mistaking it for food, yet ignore a fat worm well within reach of its sticky tongue. Many spiders and birds seem unaware of quiescent insects and react only to moving ones. Coincidentally, the instinctive movement of many insects is largely a stop-and-go procedure, which betrays them less than would continuous motion. Bees are summoned by the motion of flowers, even though they be artificial ones on a lady's hat. A scarecrow with flapping arms—or with a necklace of shiny tin—is more effective in frightening crows than a static or drab figure.

Perception

Most of our impressions of the things about us do not come from single sights and sounds, smells and tastes, but from the synthesis of these sensations. Our chief superiority over animals, in the field of sensations, lies in our ability to perceive or construct more complex relationships. The term "perception" implies a great deal more to a psychologist than simple "sensation." It involves the integration of different sensations or of changing sensations.

When looking out upon the world we are conscious not only of such precise qualities as color and shadow but also of more general factors such as distance, shape, movement, and position. In listening we do not hear just sounds but we identify those sounds as the chug of a distant train, the annoying buzz of a mosquito, or the welcome voice of a friend.

Animals, too, often display remarkable discrimination and understanding of relationship. In one experiment on orientation through sound a dog was trained to find food beside a bell which rang. He was

then placed in the center of a circle of wooden boards, one of which concealed the food and the bell. When the bell was rung the dog was able to go immediately to the right board and obtain his food. Even when there were over sixty boards around him he almost invariably chose the right one.[83]

The perception of distance, which is involved in migration and orientation, is evident in many lesser ventures. The chameleon, which shoots out its extravagantly long tongue to capture an insect, has to have good aim—i.e., a good sense of distance and direction. Likewise, the peripatus, famous to zoologists as the "missing link" between earthworms and arthropods, ensnares its cockroach prey by squirting sticky threads at him. The archerfish of India is said to hover near the surface and shoot drops of water at near-by flies, thus disabling them and bringing them within reach of his jaws. Even at a distance of three feet he can hit the mark.

Many kinds of experiments have tested other powers of discrimination in animals. In one investigation chickens were found to respond to varying degrees of brightness. First they were trained to take food from the lighter of two gray backgrounds. Later the dark background was replaced by one much lighter than either of the first two. The chickens now went not to the one they were accustomed to but to the new one, which was lighter still.

This experiment[83] was later refined to demonstrate that the trained chicks would not only respond consistently to the lighter background but were not to be fooled by a background which seemed lighter though it was actually darker. In this case a strong light was directed upon the darker background, making it appear very bright. The chickens, however, stuck to their original choice, the one which was actually lighter in color. They were not even fooled in later experiments by colored lights playing upon their food.

The paramount importance of relationships has been emphasized by the Gestalt or configuration psychologists. They hold that an animal or a human always reacts to the situation as a whole or to elements in relation to the whole, never to completely isolated parts of it. An octopus, though he has well-developed eyes, will pay no attention to the crab which is his natural prey unless he finds it crawling along the bottom of the water. When the crab is dangled on a string in front of him he remains apparently unaware of it, for the pattern is unfamiliar. A brooding bird will become very much excited by the sight of an egg in its nest yet act entirely indifferent to the same egg away from the nest.

The refinement of perception necessary for the creation and appreciation of beauty seems to be peculiar to man and in a slight degree to higher apes and monkeys. Though many animals have tone discrimination and a sense of rhythm they are probably incapable of deriving pleasure from music. Though they are keenly sensitive to light, shadow, form, and often to color, they seem to find no artistic appeal in a painting or a beautiful landscape. It is true that birds and fish are attracted by bright colors, that birds and frogs respond to serenades of their own kind; but these are practical and not aesthetic reactions. Even the Stone Age man painted murals on the walls of his caves and decorated his crude implements with etchings. But in nature we have as yet found little evidence of the appreciation of pure beauty.

CHAPTER III

CREATURES OF INSTINCT

ANIMALS ARE essentially creatures of impulse. In performing the necessary activities of life they depend far more on automatic controls than on rational guidance. In general they are born not to reason things out but to react to particular signals.

An approaching enemy causes the spines of a porcupine or the fur of a cat to bristle in defiance. The first warm spring rain brings hordes of spadefoot toads to meadow pools, where they call, mate, and lay their eggs, then disappear—perhaps for months—in their earthy homes.

A passing shadow stimulates an oyster to close its shell, a mosquito larva to swim downward, or a barnacle to pull in the "hind legs" with which it has been kicking food into its mouth while standing on its head.

Thus we speak of animal behavior as being predominantly instinctive or innate. It is aroused not by an act of will but by stereotyped impulses arising spontaneously from definite nerve mechanisms. Only in the highest animals do learning and experience play a leading role; and even here very few species ever acquire the ability to figure things out for themselves. The vast majority of creatures continue generation after generation to repeat automatically the activities of their ancestors.

Inherited Codes of Conduct

An animal inherits from his forebears not only a definite type of body structure but distinct patterns of behavior commonly known as *instincts*. These codes of conduct are in general as precise and constant—as characteristic of the species—as the trunk of an elephant or the color pattern of a butterfly. The ardent singing of the oriole and the skillful weaving of its treetop nest are as much a part of the bird as its flaming plumage of orange and black. "The fox will lose its hair, but not its tricks."

The most convincing evidence that these patterns of behavior are innate—that they are not acquired by individual experience or thought out spontaneously by the creature itself—comes from animals which since birth have been isolated from other members of their species. A beaver raised from babyhood by the French naturalist Cuvier, and suckled by a human mother, was able to perform its woodchopping, cartage, and masonry work as efficiently as its cousins brought up in beaver society. A female cardinal bird, taken from its nest when very young for scientific observation, was kept as a household pet by a Cornell student. After the first winter had passed, while still in a cage on the veranda, she was wooed by a brilliant male from the wild. Becoming interested in the courtship, the owner released her and eventually had the intellectual and aesthetic satisfaction of watching the female build the characteristic nest and hatch out a family of her own.

The lives of many animals are so arranged that the young never mingle with their parents, never have an opportunity to learn from them. Though most young songbirds are protected by their parents during their earliest days, normally they strike out for themselves soon after leaving the nest. They are sexually mature well within a year and are able to carry on their own courtships and nest building without ever having seen their parents or companions performing these activities. In many insects the entire adult population dies with the coming of cold weather and the species is maintained only by the more resistant eggs which hatch in the spring. Yet the young go through the identical program which every member of the species has adhered to for untold generations. The vast majority of fish, amphibians, and reptiles, after laying their eggs in a suitable locality, abandon them to the elements. Certainly education plays little part in such a scheme of life.

Instinctive behavior, though innate, does not necessarily appear full-blown at birth; but the elements from which it can develop and manifest itself at the proper time are present. When very young songbirds are disturbed in their nest they show no sign of fear or any instinct to escape or to fight. At this stage they are physically helpless and could do nothing if they tried. As soon as they attain motor co-ordination, however, fear and the instinct to flee suddenly appear. Baby mammals are born with the instincts to suckle and to resist restraint; through the process of *maturation* or growth they gradually develop the instincts to swim or crawl or walk, or perhaps to wash their faces. Much later comes the instinct to mate.

In any individual the development of behavior is directly dependent upon the growth of his nervous system. "Nerve cells, like seeds planted

by the gardener, spring up and grow according to a definite pattern," it has been said. As the growing plant spreads out its ramifications of twigs, movements are increased and refined in all parts of the organism which bore the sprouting seed. Various neurological studies on young chicks, toadfish, rats, kittens, opossums, and humans demonstrate that each stage of behavior appears only when the controlling nerves have grown into the appropriate muscles.

In one experiment very young salamanders were kept under anesthetics for eight days and during this time naturally were unable to learn or practice new movements. Their nerves kept on developing normally, however; and at the end of the period the anesthetized group exhibited the same motor abilities as the controls which had been allowed to retain their wits and their freedom. Grafting experiments on salamanders have shown that a limb transplanted to a normal limb position will move in normal limb fashion. But if transplanted into the ear region, the limb will be controlled by the nerves of this region and move in co-ordination with swallowing or gill movements.

Tropism, Reflex, Instinct

For convenience innate behavior is frequently divided into three categories. The simplest type of reaction, called a *tropism,* is a steady automatic orientation of the whole organism to a stimulus. The amoeba's avoidance of excessive heat or acidity, the moth's attraction to the flame, the need of the catfish to feel the bottom of the pond beneath him, are all tropisms.

A rather ridiculous news note may serve to illustrate a tropism. Sportsmen and bookmakers on the French Riviera were reported to be exhilarated over the new sport of racing thoroughbred cockroaches. The cockroaches were numbered and placed in a glass race track, the goal of which was a large black box. When the signal was given a bright light was thrown upon the insects who, being "negatively phototropic," raced excitedly to the welcome darkness of the box.

A *reflex* is a more rapid and specific reaction, involving limited parts of the body. Every zoology student learns that the leg of even a recently decapitated frog will "jump" when the nerve is stimulated. This jump is a reflex. So is the flashing of a skunk's tail, the stinging of a bee, the erection of a rabbit's ears.

In the simplest reflex a stimulus, which may be either external or internal, is picked up by a sensory neuron or nerve cell. It is conducted

through an afferent nerve fiber to a central exchange (typically the spinal cord in vertebrates) which immediately sends orders through a motor neuron to the required muscle. The brain does not necessarily have anything to do with the transaction. Sometimes it is informed of the matter afterward: we snatch a hand away from the fire before we are aware of the action. Often the brain remains in total ignorance, as in the unconscious flick of an eyelid. In actual life it is doubtful if a reflex or any other phase of behavior can be completely isolated. An endless variety of tropisms, reflexes, instincts, and habits constantly play upon one another to shape the final activity.

The more complicated patterns of innate behavior may be termed *instincts*. Although they involve a series of reflexes they differ from reflexes in more than their intricacy. A characteristic feature of instincts is the frequent delay in their completion. A persistent urge toward some biological goal is incited by a given signal and will not be satisfied—perhaps for days or weeks—until that goal is attained.

Insects are the great specialists in the field of instinctive behavior. The history of a female monarch butterfly, though intricate, is mapped out for her in the germ cell. In a small grove on the Connecticut shore we used to look forward each year to the autumn migration of these insects. Sometime during the last few days of August or the first days of September the trees would be almost brown with resting butterflies and the air would be filled with fluttering wings. Vast numbers of these fragile creatures fly southward. In the spring the females come slowly back, always keeping pace with the sprouting milkweed on which their eggs are laid. As the larva hatches from the egg it begins to feed greedily upon the succulent milkweed. When its figure has attained the proper dimensions it bundles itself into a snug chrysalis which has been called "the most beautiful gem in Nature's jewel casket." In about twelve days the humble pupa emerges as a fully formed butterfly. Larva, pupa, and butterfly—three distinct types of existence! Yet the butterfly conducts herself as perfectly in one situation as in another. Her ancestors have handed down to her a code of behavior which works magically for all normal situations. But it is worthless for unexpected emergencies.

Even more precise patterns of instincts are found among the social insects, such as ants, bees, and wasps. Not only are their individual lives directed by these inherent forces, but also their attitude toward their fellow creatures, their position in society, their responsibility to the colony. A new colony of ants is hatched each spring from the eggs laid the previous autumn by the queen. Never do the workers have an op-

portunity to learn from others how to perform their household duties; never do the fighters take a year off for military training. Yet they know their lessons perfectly. Even when isolated from the colony, if the proper materials are available they will immediately set to work at their allotted tasks. Instinctive behavior is peculiarly appropriate for most insects; in the short span of their lives there is little time for learning the many activities they are called upon to perform.

Fishes, frogs, and reptiles (the so-called lower or cold-blooded vertebrates) are stolid creatures, slow to depart from the paths of their forebears. Their mechanical responses to food, their primitive methods of reproduction, their dependence upon specific aspects of their environment tend to keep them conservative, reacting in the same old way to the age-old formula.

With the advent of birds and mammals (the higher or warm-blooded animals) life becomes greatly enriched by keener sensations, by more varied environments, by instincts that are beautifully adapted to their enlarged experience and at the same time lend themselves to adjustment. Much greater speed in all nervous reactions is evident in warm-blooded animals. The nerve impulse is in part a chemical change, and like other chemical processes it tends to proceed more rapidly in a warm medium.

Instinctive Activities

The world "instinct" is a generous, motherly one which shelters all kinds of progeny under its protecting wings. Many technical writers, while accepting the concept of instincts, avoid the actual term, contending that it has been used to extinction by popular writers and has lost all specific meaning. One school of thought has substituted the word "drives"; another school stresses "needs"; others, "appetites," "desires," "impulses," "goals," "tendencies," "satisfactions." We shall retain "instincts," however, for the word seems as natural as the processes for which it stands.

Variously grouped under these overlapping terms, different authors list a wide assortment of activities and qualities: hunger, flight, sex, thirst, parental care, need of sleep, respiration, digestion, migration, defense, repulsion, revulsion, attention, need of approbation, hunting, collection, gregariousness, domination and submission, play, imitation —in fact virtually every phase of animal life. Though the word "instinct" is commonly used to denote such generalized concepts it is preferable to restrict it to the specific activities involved. Thus it is more

precise to speak of the instinct of a rattlesnake to follow the scent of prey or to strike at warm moving objects than it is to refer broadly to its "hunting instinct."

The most important activities of an animal are naturally those which make for self-preservation. To maintain his physical well-being in a favorable environment he must find food, water, protection, rest; and if the race is to survive he must reproduce.

To attain these ends there must be a *state of readiness* in the animal himself; for his food-catching or his sleep-regulating mechanisms to function he must normally be hungry or tired. To set off the various activities there is usually a *stimulus,* either a single sensation or more frequently a complex perception. Hungry young gulls will respond at first to the bright red spot on the parent's beak. Older gulls react to the sight of various food objects. Both the inner readiness and the external stimulus may be influenced by many factors. The final form which any instinctive activity assumes is dependent upon the interplay of these factors, plus, of course, the animal's motor equipment. Even though an animal is hungry, his reactions may be restrained by fear or by fatigue; some types of food may not be as tempting stimuli as others; some may demand too strenuous an effort to acquire; some may be totally beyond the reach of his kind of legs or wings or jaws.

Hediger[20] has claimed that the most important instinct in animals is that of flight. "Satisfaction of the food impulse and of the sex urge may be postponed, but escape from a suddenly appearing superior enemy bears no postponement! Escape, flight, is paramount in the entire behavior; it is the first obligation of the individual for the preservation of its own existence, hence, of that of the species." It is the only instinct for which an animal remains in a state of constant readiness; even in sleep he usually remains keyed up to certain well-recognized danger signals. The appearance of an enemy always finds the animal ready to flee, regardless of hunger, thirst, fatigue.

It is therefore not surprising that animals have developed very definite patterns of escape. "The flight of an animal does not consist of a haphazard jumping or flying away, but of a most specific flight reaction, the full significance of which is revealed only when the biological peculiarities of the pursuer and the pursued are carefully considered," Hediger adds. For example, "the hippopotamus always escapes toward the water (or dives down when surprised there); the closely related pygmy hippopotamus in the same situation does not make for the water but for the nearest thicket." Some species of lizards always run up a surface when alarmed; other species always run down.

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Not only is the method of his flight dictated by innate forces, but the distance which an animal will allow between himself and his enemy can usually be predetermined in feet—often in inches. This "flight distance" is consistent within any given species, but may be temporarily increased or decreased according to season, sex, age, the nature of the enemy, or the type of terrain.

Even though an animal manages to evade its enemies it cannot live very long without eating. Instincts connected with the obtaining of food occupy an important place in animal behavior and usually take precedence over other instincts except at certain seasons when the tremendous sex urge or a strong brooding impulse forces the animal to forget its hunger temporarily. It is common knowledge that every species of animal has its own food preferences or idiosyncrasies. To be sure, some animals are virtually omnivorous. Our pet skunk would eat fruit, nuts, grass, insects, birds, small mammals, besides delightedly poking its head into a glass jar to dig out the last bit of peanut butter or jam. In general, however, the appetite is much more limited. The koala, a small bearlike mammal of Australia, will eat only the leaves of a few species of eucalyptus. Red tree mice of the Pacific coast seem unable to live unless they can feed upon the pine needles of the Douglas fir trees.

Certain signals are normally required to touch off food-catching activities. Among vertebrates it is probably most frequently the *sight* of prey or fodder which stimulates the hungry animal to approach food. The blind mole responds to the *sound* of worms or insects falling into its burrow. *Olfaction* is also important. The squirrel who hides his nuts in the summer can smell them when he wants them in the winter, even though they be buried under a blanket of snow. Many fish find their food through the sense of *touch* or of *taste*. It is generally true, however, that vision and smell are much more important among higher land-dwelling animals for food catching, and that taste becomes restricted to the testing of food in the mouth before swallowing it. It has been demonstrated experimentally in amphibia, for instance, that the stimulation of olfactory tissue will cause a general searching movement of the head or body, while the stimulation of a taste bud will give rise to a snapping or swallowing reflex.

Instincts Are Automatic

Animals tend to behave in stereotyped patterns, even though they may be unaware of the purpose of their activity or unable to foresee its

results. In an unusual situation the instinctive response may be retained even though it makes no sense and is sometimes dangerously detrimental. The baby chick is hatched with the instinct to run away with the worm he has found, lest his greedy brothers and sisters snatch it from him. But a chick that has been reared in isolation and has never known hungry companions will still run away with his worm.

The French naturalist Fabre described a simple and amusing experiment on processionary caterpillars. These insects are accustomed to parading in single file as they go on their food-foraging trips. Fabre managed to introduce a bowl into their line of march so that they continued their procession in an unbroken ring around the edge of the bowl. For eight days they kept up their endless march before the circle was broken.

Under normal conditions, however, innate behavior is perfectly adjusted to the animal's needs and environment. The casual observer would certainly be impressed as well as enchanted by the sight of a family of tiny, newly hatched turtles slowly but surely making their first trip from their high and dry nest to a near-by pond. A remarkable power of insight, he might think, guided them unerringly to their new water home.

One drizzly afternoon in late September a company of twenty-two baby snapping turtles was observed trudging along a path leading to Carman's River on the south shore of Long Island.[56] A little search soon found the remains of the nest and the eggshells from which the young turtles had so recently hatched. What unseen force directed them to the water? It was not moisture, for the air all around was saturated with the drizzling rain. It was not odor, for often the breeze blew toward the water; and they paid no attention to a small ditch near by. Was it gravity? Color? Light?

The baby turtles were gathered up and taken to the Museum where they could be watched performing under controlled conditions. In the laboratory they were later joined by a batch of painted turtles likewise from the south shore of Long Island and a batch of young musk turtles which had hatched in the Museum's incubator.

They were placed in a partitioned tank in the laboratory darkroom, and similar experiments were performed on all three groups of freshwater turtles. One of the first things discovered, by tilting the tank, was that they were all "negatively geotropic" ("not earthward turning"). That is, on an uneven surface they tended to climb upward. This explained one point: it was this tropism or simple instinct which enabled them to crawl out of their nest dug in the ground.

But the answer to what led them to the water needed further investigation. In the darkroom tanks were tested their responses to humidity, odor, temperature, gravity and moisture, light, color, and combinations of these stimuli. The clue was finally found in their response to light, which was very pronounced and even took precedence over their instinct to crawl uphill. Bright light and large patches of light were equally attractive. Since turtle eggs are laid near water, the bushes, trees, and higher ground usually obscure the horizon behind the young turtles, and the brightest portion of the sky lies toward the water. Thus, while unconsciously satisfying their innate attraction for light, they were enabled to arrive where they ought to go. (Similar conclusions were drawn by Parker in 1922 from work with loggerhead turtles.)

Not all instincts are as simple as those of the young turtle. Evolution not only has perfected behavior but frequently has organized it into very intricate patterns. It was at one time believed that all activity was built up of simple reflexes, as a house is built up of bricks. More recent observations upon embryological material indicate that the earliest movements of an organism are general in character and that the individual reflexes which develop with the growth of specific nerves gradually assume dominance over the generalized movements. Whatever the origin, we cannot ignore the chain formation evident in many complex instincts, where the functioning of one activity leads automatically to other activities in a long-range cycle of events. In the courtship ceremonies of many birds, the gradual unrolling of the mating instinct is vividly dramatized.

During the summers of 1936 and 1937 a faithful watch was kept on several colonies of black-crowned night herons on Long Island. At the same time a rookery of these birds was established on the Museum roof. Thus it was possible to compare field observations with the more continuous observations of the laboratory.[18]

Definite traces of reproductive instincts appear very early in heron life. The young birds tend to go in twos and at times become very much excited playing with sticks, symbolic of nest building.

In the spring the mature male arrives first from the South, establishes himself in a certain territory and is ready to greet the female with an enticing stick ceremony. To this he adds a song and dance further to attract her attention. For the time being he assumes a servile attitude as if to give her confidence and encouragement. When she finally joins him, the pair unite in a mutual admiration and courtship ceremony, bowing to each other, erecting their long head plumes and breast

COURTSHIP OF BLACK-CROWNED NIGHT HERON

In courtship male selects and defends territory.

Female is attracted by male's overtures and twig playing.

Male first assumes subordinate role, often bowing low.

Pair indulge in mutual display. Erection of plumage more marked in male.

By billing and sparring male wins dominant position essential for mating.

Male becomes excited at appearance of eggs.

feathers, exchanging vocal greetings, their red eyes often bulging with excitement and their mouths wide agape. These mutual activities may seem superfluous but are important in cementing the marital bond which lasts well through the nesting season.

After the male has succeeded in arousing the interest of his partner he gradually abandons his humble attitude and becomes more and more domineering. His useless twig ceremony changes to more practical nest-building activity. As the nest progresses the male may bring twigs to the female, who is more inclined than he to stay at home and do the actual construction. This stick passing probably serves as another emotional bond between them. The male becomes greatly excited by the sight of an egg in his nest (even one transferred from another nest before his own mate has laid). At once he begins to brood the egg and during the first few days assumes the greater domestic responsibility.

The long chain of instinctive behavior described is impressive in its elaborateness and highly successful in the bird world; but it is largely automatic, each reaction depending on a previous act or signal: the male with sticks arouses the affections of the female; the egg in the nest sets off the brooding activity of the male. The pair are probably unaware that they are building the nest for the eggs. Even in brooding the eggs, they do not look forward to the hatching of their family. If any stage in the pre-established order fails the chain or cycle may be broken. The male could not devise another system and the female could not understand it if he did. In typically instinctive behavior there is no inner resourcefulness.

Adjustment and Improvement

Though much has been said about the blind and irresistible nature of instincts, it must be made clear that these directing forces are not necessarily rigid in form. Many well-defined instincts require a certain amount of adjustment according to the environment of the animal.

The "flight distance" of an animal, though consistent among individuals of a species, may vary according to several factors. Animals in sanctuaries will allow nearer approach than those in the wild. Beavers and certain other mammals maintain a greater flight distance during the day than at night. A human being can often approach a wild animal more closely on horseback or in a vehicle than he could on foot. When the human alights and reveals himself as a potential enemy the animal at once increases the distance between them. The discovery of

this fact has been exploited by many photographers of large animals. By approaching lions, for example, in a car they have been able to take close-ups which otherwise would have been impossible.

Animals which are instinctively attracted to one kind of food in the wild will often accept convenient substitutes in the laboratory or zoo. The meat eater may be satisfied with fish or even ripe bananas. Even in nature the predator may resort to berries or grain in times of stress. Or the reverse may happen. Prairie dogs are normally herbivorous, but when a plague of grasshoppers invaded certain prairie dog towns the little mammals attacked en masse and consumed vast numbers of the insects.

Walking-stick insects are normally reared on privet, but they can without difficulty be transferred to ivy. Walking sticks, however, overcompensate in their adjustment. If one generation is reared on ivy the next generation will be happy only on ivy! What mysterious something, carried from parent to offspring, accounts for this change of tastes? That is a riddle still to be answered.

Food adjustments are often amazingly precise. Many animals have an uncanny talent for selecting foods with the proper vitamin or mineral balance. They hit the mark the first time, not through trial and error. What "tastes good" or "smells good" to them evidently changes subtly according to the ever-changing chemical needs of the body. For example cattle deprived of their normal ration of phosphorous develop a craving for bones, even though they have never seen or tasted bones.

Instincts not used tend to disappear, just as others through practice can often be improved.[14] Dr. Frank Chapman of the Museum's bird department has made observations on the effect of experience on nest building. On a visit to Barro Colorado, an island in the Panama Canal, he settled himself in a chair before a 24-power binocular to study the nest building of the oropendolas. These tropical birds are skillful weavers who protect their young from the violence of the trade winds by securely suspending the nest bag from the treetops and providing soft leaves and bark at the bottom to cushion the eggs when the pouch is blown about. Colonies of these nests deck a tree like some strange tropical fruit.

Dr. Chapman watched two groups of oropendolas. He saw the individual birds of one group attach the first green tendril to a limb skillfully and rapidly, select their building materials deftly, and proceed with the difficult weaving without hesitation. Their diligence, their strict attention to business, and their efficiency indicated to him

that they were experienced nest builders. He observed that the birds of the second group went about their work haltingly. They devoted six days to the choice of a site. They lost many of the tendrils and fibers they had carried in and did not seem to know what to do with those they still held. It was two weeks before he could note in his diary that the first one of this group had successfully completed the loop that formed her nest's doorway. These birds had the instinct for nest building; they could weave but they did not know what to weave. Dr. Chapman concluded that this was their first attempt at homemaking and that they, unlike the group of skilled oropendolas, had not yet perfected their instinctive ability by exercising it.

With this adjustment and improvement of inherent tendencies we approach the realm of learning. Though animal behavior in general is directed by instincts, the older an animal becomes—or the higher his position in the evolutionary scale—the more surely shall we find that his instinctive behavior is modified or supplemented by experience. In most cases, however, it is impossible to tell where instincts leave off and learning begins. In exploring the animal mind, as well as the human mind, we cannot hope to follow an infallible chart. We must plan in terms of broad areas and great open spaces, not permitting ourselves to be confused by ever-shifting boundary lines. We must also remember that, though we have discovered much concerning animal behavior and in many ways have been able to trace its development and relationships, the riddle of life itself—the fundamental nature of consciousness and activity—has never been solved. There will always be a vast terra incognita beyond the horizon.

CHAPTER IV

ANIMALS CAN LEARN

TRACES OF LEARNING occur much earlier in the life of an individual and in far more primitive animals than most of us would ever suspect. There is now ample evidence that mammals, including man, may learn in a slight degree before they are born and birds before they hatch from the egg. In fact, if defined simply as the *modification of behavior through experience,* learning may be regarded as a property of all living organisms.

Lower Invertebrates

Even among the one-celled *protozoa* we find that individuals can gradually adapt themselves to light, can improve through practice their ability to back out of unfavorable situations, can learn to avoid overacid water, and to reject sand grains or dye particles as undesirable food. They cannot, however, profit permanently from their experiences. As soon as conditions change they have to start "learning" all over again.

Among primitive creatures with radial symmetry—the sea anemone and the starfish, for example—a condition which seems extraordinary to our human viewpoint is present; namely, that *parts* of animals may "learn" independently of the whole. One single delicate tentacle of a sea anemone may learn, independently of its numerous associates, to avoid wads of paper offered as food. One arm of a starfish may learn to assume an unaccustomed leadership over its four associates. Though the diffuse nerve net of the sea anemone and the more compact nerve ring of the starfish carry messages from one part to another and to some extent co-ordinate the separate reactions, these primitive nervous machines are not adequate for retaining memories over long periods of time or for directing the diverse activities of the animal.

Mollusks and Worms

Far better managers are the *mollusks:* the clams, snails, octopi. Though their bodies seem extremely grotesque and shapeless to us their nervous systems are comparatively well organized. There are several centers of co-ordination: the visceral ganglion, the pedal ganglion, and, most important of all, the central or cephalic ganglion, which might be considered as a poor and distant cousin of the brain. Thanks largely to this organ, the individual mollusk can learn the valuable lesson of self-control and direction. He can inhibit activities in one area which might conflict with activities in another. This *inhibition* is not just a negative quality; it is a remarkable innovation which becomes more and more important in higher animals. Mollusks can also adjust themselves to strange features of their environment. A fresh-water snail placed in an aquarium was at first greatly excited by the movements of his tadpole associates, but soon learned to accept them without disturbance. Sand snails have even been trained to run a simple maze. In mollusks and worms learning progresses along new channels. While modification of behavior in the lowest organisms is primarily due to changes in the tissues themselves and therefore known as physiological learning, in higher forms it is increasingly facilitated and eventually controlled by a nervous conduction system, which is in turn increasingly regulated by the brain.

When the *worms* began to specialize on bilateral symmetry and head-first progression it was natural that the most important sense organs should be clustered at the front end where they acted as a sort of reception committee to meet the incoming stimuli. It was likewise natural that the central nervous system should eventually develop a nerve center or brain at this end to collaborate more intimately with the sense organs. Worms, insects, crabs, spiders, and vertebrates—all have evolved brains; and upon the complexity of these brains depends largely their capacity for learning.

Psychologists have determined the ability of worms to learn by means of a simple labyrinth comparable in form to a T-shaped highway intersection. The road to the right led to soft comfortable soil, while that to the left was made disagreeable for the worm by putting in a strip of sandpaper and two electrodes which produced slight electrical shocks. Five times each day the experimental earthworm was placed in the shaft of the T-shaped channel. On the fourth day it showed a definite tendency to avoid the uncomfortable left-hand channel by turning

right. This tendency soon became a well-established habit. In a later series of experiments conditions were reversed. The left-hand arm of the T was made comfortable and the right slightly charged with electricity. It took an even shorter time to break the worm's habit of turning right and to teach it to turn left to find comfort and safety. The experiments proved that even such lowly creatures as earthworms learn after much experience to follow the easier road. Strangely enough, earthworms may be trained to keep to certain paths even after their heads are cut off or their brains removed. While the brain is an asset it has not yet become the dominant and indispensable part of the nervous system that it is in higher forms of animal life.

Arthropods

Insects, crabs, and spiders (all members of the group called *arthropods*) are highly instinctive creatures, yet they can learn. Certain insects in captivity have been tamed; that is, they have learned not to fear their human captors. A group of crayfish even learned to come to the edge of their bowl for feeding. Fiddler crabs have been taught to move in the direction of their small claw, though their normal tendency is to move toward the large one. The despised cockroach can be trained to go left or right, or even to remain in the light when its natural impulse is to seek darkness. "Trained" fleas, however, are not trained but merely hop and jump along in their accustomed ways while harnessed to miniature carriages.

Though learning may extend instinctive behavior in arthropods it does not change the pattern fundamentally. Rather astounding feats of learning, in addition to extremely complex instincts, are exhibited by the social insects. These forms, like higher vertebrates, have a comparatively long period of protected youth in which to learn.

In nature, bees, excited by the "round dance" of a fellow worker who has located a rich hoard of nectar, note and remember the flower smell that clings to the discoverer; and by that odor they learn to identify the honey-laden source of her supply. It is not that they accompany the bee whose dance has told them of her find; nor yet that the heavily laden flowers attract them from afar, since the bees' sense of smell operates only at a short distance. It is an act of learning and memory. Sallying forth to search for food in all directions, they recognize somewhere the remembered fragrance and help themselves to a meal.[21]

In line with the strictly utilitarian policies of wartime Germany Von Frisch—the German scientist who made the above discoveries—has recently worked out their practical applications. He has found that bees can be trained to certain odors by consistently experiencing them in association with food such as sugar or honey solutions. The bees will then go to any objects to which these given odors have been attached. By spraying, with an odor to which bees have been trained, flowers that normally lack attraction for bees, the desired cross-fertilization may be readily accomplished.

Fish

In the evolution of vertebrates the role of learning becomes increasingly obvious. In general their longer life span, their more varied environment, and their richer social contacts bring them a wealth of experience and at the same time demand a high degree of individual adjustment. Instinctive behavior becomes more and more modified until in humans it is cloaked almost beyond recognition. Yet learning is not something which can be created de novo; it can only be built up step by step from the basic instincts. No matter how much any animal may learn, he can never go beyond his inherited potentialities.

However, the lowest vertebrates, *fish,* are not outstandingly versatile. Leading as they do a comparatively monotonous aqueous existence, they have little need to adjust their behavior to changing surroundings or weather. Some, however, learn very quickly to avoid traps, undesirable food, or dangerous enemies. In the aquarium they learn to come to certain spots for feeding or to follow artificial pathways.

Newly hatched jewel fish are innately attracted toward moving red objects and are thus naturally held together close to the waving red fins of the parent. If the parent is removed from the tank the young will school near a waving red disk in preference to a blue, yellow, or black disk. But if the fry are brought up by a foster parent of a closely related species having black fins instead of red, they will learn to respond to waving black disks.[58]

The tiny guppies which find their way into almost every household and schoolroom learn through visual discrimination to recognize the sex of their guppy companions. A male brought up in isolation and then placed in a tank with others will, in his ignorance, at first attempt to mate with males and females alike. But after experiencing a few ferocious attacks from the other males he soon learns to avoid brightly colored guppies and to confine his attentions to the more somber fe-

males. That this is due to learning of color pattern and not to an instinctive attraction to certain odors, movements, or the like is evident from several factors. After his unfortunate experience he will avoid a genuine female painted to look like a male. On the other hand, he will court a dull-hued female in an adjacent tank, or even the male of a dull, inconspicuous variety.[51]

Amphibians

The learning capacity of the average *amphibian* is probably little higher than that of fish. However, the shift from a water to a land environment brought a far greater variety of sensory stimuli and demanded a more delicate co-ordination of response and inhibition. When a toad was fed red ants the single experience of being stung taught him to inhibit next day his usual snapping instinct when confronted not only with these ants but even with spiders and flies; he forgot his lesson, however, after a few days. In many cases amphibians show a marked ability to remember what they have learned. Toads fed only once a week learned their dinner hour after only thirty or forty feedings and displayed distinct excitement on these occasions even before food was presented. A pond frog, taught to run a maze, still remembered the correct path after the lapse of a month. On the other hand, toads and frogs seem utterly unable to acquire the new habit of seizing food which does not move; even after months of training they would starve in the midst of succulent meal worms, unless those meal worms wiggled.

"It all depends" is one of the most important phrases in any language. The humble amphibian, like the ambitious human, finds that he can learn better under certain conditions than under others. It all depends upon many factors: his own physiological state, the weather, the distractions, the degree of his hunger. Axolotl salamanders learned to distinguish a piece of meat from a similar-appearing piece of wood, but during the breeding season they made many errors. During the period of metamorphosis (which might be compared to human adolescence) other axolotls completely forgot their training and had to be taught all over again.

Birds

The behavior of birds is in many ways like that of the social insects. Their specialized life in the air has demanded an array of specialized

instincts and at the same time relieved them of many of the adjustments essential to earth-bound creatures. They learn a great deal but are not as dependent on their learning as mammals.

Careful observation may sometimes reveal unsuspected learning in the everyday routine of life. Newly hatched chicks instinctively peck at any small bright object but soon learn to distinguish wholesome food from pebbles or worse. Similarly chicks standing in water did not drink until they accidentally pecked at their feet and discovered the satisfying results. The quickness of their learning is in keeping with the speed of their other reactions. One feeding of red worsted and they never go back for more!

Two thousand years before Christ man was exploiting the learning and hunting ability of falcons, hawks, and other birds of prey. The taming and training of these wild birds would have been impossible were they not capable of considerable learning. The first step in this sport, which still flourishes today, is the taming of the young bird, usually a female taken from the nest shortly before she is ready to fly. The bird must learn first of all to become accustomed to the master and to recognize in him the sole source of her food. Then—perched on the fist of her master—she is introduced to other persons and to animals and busy street scenes. Gradually she is allowed more and more liberty, at first on a leash and later free, but she learns to return always to the master's glove at a call or a whistle.

Then comes her training in retrieving. A lure, which may be a recently killed pigeon or a piece of beef tied to a tuft of feathers, is tossed out a short distance from her perch, but she has to bring it back to the glove for sampling. Her chief reward, however, is not the lure but the accustomed meat given by the master. With practice she learns to pursue more and more active quarry and to retrieve it from greater and greater distances. For a dead pigeon may be substituted a live one, at first with wings severely clipped. Then an unhampered pigeon is released, at first near by, later at a distance. Eventually the falcon is allowed her freedom and may fly out of sight in the sky or several miles over the countryside but, true to her training, she continues to return the quarry to her master's hand.

In close association with humans many kinds of pet birds learn tricks which appear extraordinarily clever. The mischievous exploits of tame crows never cease to amuse and impress grownups as well as children. William Carr tells of the twenty-seven tame crows at the Trailside Museum at Bear Mountain, New York. Jo, the favorite, who was with him for nine years, had finally to be disposed of because he had learned

to steal car keys from automobiles in a near-by parking space. This bit of learning was only a modification of his instinctive attraction to small shiny objects. There is, however, some experimental evidence that crows and their near relatives may be capable of such higher types of learning as insight and reasoning.

There may even be a suggestion of tradition in birds; that is, a passing on of learning (by imitation, not by physical inheritance) from one generation to another. Canaries from such renowned haunts as the Harz Mountains of Germany may have a tradition for beautiful singing derived from a few past masters. Though the songs of birds are fundamentally instinctive they may in some cases be perfected (or warped) by imitation of more experienced singers. Individuals reared in isolation have a characteristic song but often fail to develop the full range of performance attained in nature. Canaries brought up with nightingales tend to copy their singing. The repertory of hens and pigeons, however, seems little influenced by their companions.

Mammals

Life and success for mammals is inextricably bound up with learning. From earliest youth the mammal is much influenced by factors and personalities outside himself, and often these experiences profoundly affect his later life.

The plasticity of the brain and therefore of the behavior of mammals bears a close relation to their longer period of protected childhood, a period which allows a slower maturation of instincts and consequently a higher degree of individual modification. Under parental protection the young can leisurely acquire knowledge which will be useful to them in later life; through exercise and play they can develop physical skills such as fleeing, attacking prey, fighting an enemy. There also seems to be a certain amount of active parental or social education. A mother bear will push her young cubs up a tree when it is time for them to climb. A mother carnivore will often bring back living captives to the den where the cubs can become acquainted with their future victims and practice attacking them under experienced supervision. Later on she may take the young on hunting expeditions and provide them with more realistic training in the field.

The education of a young lion has been described by Hill.[28] "The cub is born with a deep-seated hunting instinct. One youngster will stalk and pounce upon another or on the switching tail of the mother,

with the same eagerness and thrill exhibited by a kitten. During the year and a half of cubhood this play develops into a hunting and killing technique. Skill comes through long practice, imitation of the old lions, and obedience to warning growls of the mother. Most of the prey consists of large and strong animals, well equipped for self-defense, and a cub's first attempts to kill are made under the watchful care of the mother lioness. An untrained lion kills by clumsy mauling.

"In certain parts of Africa lions commonly prey on the powerful Cape buffalo, while in other areas where this animal exists they leave it alone. Probably the lions that have been brought up by buffalo killers learn how and carry on the tradition. A failure with such game is generally fatal to the lion."

The swimming and fishing activities of otters—the very habits which are commonly accepted as distinguishing characteristics of these animals—are believed to be learned rather than instinctive. Young otter pets, allowed to run at liberty with ready access to pools, pay little attention to water but play and seek food on land. In nature, however, the mother otter gives her young a thorough training in aquatics. In teaching them to swim she first starts out with them on her back, thus accustoming them to water. On these excursions she gradually lowers her body into the water for longer and longer periods. The first struggling movements of the young develop naturally and painlessly into effective swimming strokes. Later on they are taught to dive, to circle, to stalk fish, or to corner them in holes.

Their fishing lessons begin with feeding from the mother's mouth. Later she flaunts larger fish in front of her young—at ever-increasing distances which necessitate pursuit. Eventually the growing cubs learn to search out their prey by turning over stones, stirring up the muddy bottom, or poking their heads into the muck for eels.[83]

Some animal psychologists warn us against having an exaggerated idea of the "school of the woods," a pleasing fancy derived from romantic animal stories. Admitting that parents may protect their young and introduce them gradually into the complexities of various activities, they nevertheless doubt that the parents teach anything the little ones did not know or would not come to know by instinct. Yet reliable observers in our national parks report mother bears teaching their cubs to beg—surely not an instinctive activity—and enforcing obedience with cuffs and spanks.

In chimpanzees the period of infancy is considered to be about four years. During this time the mother cares for her baby, plays with it, exercises it, and forces it into many learning situations. The young

chimpanzee learns many things—such as food preferences, emotional reactions, manipulatory skills—from his mother and often from his father, as well as from ape or human associates. And, of course, he learns to profit from his own experience. In the lives of chimpanzees instinct seems to be inadequate and learning essential for success. An inexperienced male or female appears unable to carry out the normal reproductive activities without assistance or instruction from others.[93]

What Is Learning?

It is certain that animals learn. Yet what we really want to know is *how* they learn—and that is a difficult question. No one has ever seen what happens inside of brains and nerves when learning takes place.

In terms of psychology the ability to learn is fundamentally the ability to form *associations*. Strange objects and novel situations assume meaning for the animal as they become tied up with well-established sensations and activities. Learning thus enables the animal to extend his activities into broader fields and also to react more precisely to details in his environment. Furthermore, higher animals seem to be endowed with a degree of curiosity, a spirit of exploration which of itself leads them to seek new experiences.

One cannot consider learning and associations without referring to Pavlov's famous experiments on the *conditioned reflex* in dogs.[78] When a dog sees food his mouth normally begins to water. The Russian scientist perfected a technique to measure precisely this flow of saliva. He then tried the experiment of ringing a bell every time the dog was offered food. Soon it was discovered that the dog's mouth watered at the sound of the bell, even though the food itself was withheld.

One advance led to another in Pavlov's laboratory until the first simple experiment eventually developed undreamed-of ramifications. The second important step was the demonstration that, if the food was regularly offered two minutes *after* the bell rang, soon the flow of saliva would occur two minutes after the bell, even though the food was again temporarily withheld. This became known as the *delayed conditioned response* and in turn led to work on inhibitions, sleep, and hysteria.

A certain type of conditioning or rapid learning, termed *imprinting*, has been suggested by Lorenz of Vienna.[38] In his view an impression may be quickly and unconsciously recorded in the brain much as an

image is fixed on a photographic plate. Such imprinting may occur early or late in the life of an individual and greatly affects its behavior, often without its awareness. Thus, Lorenz noted, the first creature that a gray goose sees on hatching it takes to be its mother. Usually the gosling's first impressions are of the mother goose, so she becomes the object of its attachment. But an incubator gosling which was picked up by its keeper and played with immediately after it left the shell adopted the keeper as a mother and followed him everywhere, even to going swimming when he swam.

One of the simplest forms of learning is the acquisition of new *motor habits.* We have seen how instincts may be improved or perfected through practice, how in cases of necessity they may even be modified in certain details. Where the instinctive drive is not too strong and practice is persistent the animal may acquire new physical skills which though not inborn soon become quite as spontaneous as instincts.

Many activities which we casually refer to as instinctive or as reflexes are really learned *habits.* We say (fallaciously) that it has become instinctive for us to use forks (in nature there are no forks!); that we step on the gas or steer our car "by reflex." Even a cat does not instinctively catch mice. She does have an innate drive to pounce upon small moving objects; but if brought up in a cage with mice she will know them only as friends. Once she has been taught to catch mice, however, she will keep up the habit.

Animals are often faced with unexpected problems and entirely new situations which have to be dealt with. In such dilemmas most individuals resort to a variety of activities—all more or less directed toward the solution of the problem—until eventually one of the activities is successful and may upon repetition become learned. This is usually referred to as *trial-and-error learning.*

Learning, like all other psychological functions, is seldom clear-cut. Just as it is impossible to say where instinctive behavior ends and learning begins, so is it impossible to analyze precisely the different kinds of learning: discriminative, conditioning, trial-and-error, imitative, reasoning. Insight and reasoning, which appear in the more advanced animals, will be discussed in the chapter on higher intelligence.

Reward and Punishment

Reward and punishment in one form or another are almost inevitably associated with the learning process in animals as well as with their

training. Experiments at Columbia University have demonstrated that a combination of reward and punishment is more effective than either factor alone. Three groups of rats were subjected to a simple brightness discrimination test. The first group were rewarded with food if they made the correct choice; otherwise they were quietly removed. The second group were punished by an electric shock if they made the wrong decision. The third group were rewarded for correct choice and punished for errors. This group far surpassed the others in learning the necessary discrimination. They required but 33 trials against 56 for those punished, and 293 for those who received only a reward.

We have seen how concrete rewards and punishments—as favorite foods, a receptive mate, electric shocks, and unpleasant sandpaper—play their part in the learning process. Yerkes and others who have worked very closely with individual animals over a long period feel that less tangible satisfactions and dissatisfactions are even more important, though of course difficult to measure.[94] Thus the approbation of his master rewards the dog, as that of the trainer rewards the circus pony. Similarly child psychologists have found that children will work harder for added prestige than they will for rewards of candy. Play has been used as an effective reward with monkeys: when the animal made the correct response he was gaily swung about by the experimenter. In nature, becoming acquainted with a locality rewards a roaming animal, since it frees him from timidity and uncertainty, prepares him for immediate action, and permits him to rest or sleep if there is no call for action. The mere completion of any activity undertaken is the simplest type of reward. Conversely, failure to carry it through is a punishment. There is gratification, too, in shortening the distance to a goal or in attaining it more quickly. Even animals like to "use their heads to save their feet."

Training Animals

All these aspects of instinct and learning are of primary importance in training animals for domestic or exhibition purposes. The first thing every trainer should bear in mind is that he must take advantage of the animals' native abilities in selecting the tricks for which they are being coached. He trains a falcon to hunt in the air. He would not attempt to train a dog to fish, as he does the cormorant. Cormorants are born fishermen and dogs have inherited aptitudes for trailing or guarding.

Even within a single species there is an enormous variation in native intelligence and in learning ability. Shepherd dogs and police dogs are carefully bred for proficiency in guarding or in trailing; only the superior offspring are selected for training or allowed to pass on their qualities to future generations. In Seeing Eye dogs one of the most important requirements is a capacity to foresee danger approaching the master even when the dog himself is not threatened. This peculiar ability appeared strikingly in certain strains which constituted about 15 per cent of the kennels. Breeding especially for this, the percentage has been raised to 94. Learning, it may again be stressed, can only occur within the limits of innate endowment.

The trained animals of circuses and zoos have had to learn much to master the tricks and stunts with which they delight spectators. But the learning of any one individual is far less extensive than the thrilled audience guesses. The elephants rolling tubs and barrels, the seals balancing and throwing balls with their snouts, the tigers leaping through flaming hoops, and the monkeys riding horseback or performing on trapezes, are doing things foreign to their normal experience but not to their natures. Elephants roll pieces of sun-baked clay anthills about in their native forests; seals on a rocky islet pose characteristically with their snouts held high; wild monkeys hang tenaciously to their mothers during the early months of infancy and later balance precariously in treetops and swing from swaying branches. The trainer who prevails upon a dozen lions and tigers to assume and maintain certain positions in an exhibition cage has undoubtedly studied and exploited the animals' innate reactions to "flight distance." Sometimes he finds that learning is aided by manipulating parts of the animal's body. Laboratory workers have found that raccoons and dogs learn more rapidly when guided by putting the paw through the performance. Rats memorize a maze more readily when guided by a leash during early attempts. The elephant trainer even employs cranes in teaching his charges to rear on their hind legs, to sit on a stool, or to toss the trunk in the air. Most trainers believe that with groups of animals a tendency toward suggestibility or imitation of others definitely facilitates learning.

From time to time the public and even the scientific world has been impressed by reports of horses and dogs who could count. One of the most famous of these was Clever Hans, of Germany, who, it was claimed, could tap out the letters of the alphabet with his hoofs, spell and form sentences, add, subtract, multiply, divide, tell time, and even discriminate musical notes in chords.

The owner of Clever Hans was a sincere, conscientious gentleman who believed firmly in the prodigious mind of his horse and fortunately had no objection to having him examined by animal psychologists. Soon it was discovered that the horse could answer the questions only when his owner or one of the testers was visible to him. Through long and close association with his master Clever Hans had become keenly sensitive to the minute changes in attitude, the almost imperceptible movements of the head which the master or the tester would unconsciously make in response to his own thought processes. There would be a release of tension when the correct answer was attained, not realized by the man but keenly observed by the horse. Though the horse's reading ability had been grossly exaggerated, his visual acuity for slight gestures had not been sufficiently recognized.

As we watch in amazement the performance of the circus menagerie or the tricks of household pets we must not forget that these animals have been taught by human beings. Unaided, they could not have learned to do these seemingly clever things. Under human guidance they progress by small steps from one familiar activity to another slightly modified experience. The circus trainer knows that it is hopeless for him to start training his subjects before the maturation of those instincts which are to be utilized in the performance. He knows, too, that teaching them will be a long, slow process. He handles the beasts with infinite patience and skill, rewarding the desired conduct with praise and with choice tidbits, trying to eliminate the undesired behavior with threats or mild punishment. Eventually the circus act is ready for presentation—an evidence of the trainer's patience and perseverance and of his understanding of the mental processes of his charges, as well as of animal intelligence. It should be remembered, too, that it is only the animal with exceptional talent and skill—just as it is only the exceptional human being—that is chosen for public performance.

Nature and Nurture

The weighing of instinct against learning is but another phase of the controversy between nature and nurture: heredity and environment. For "nature" and "heredity" are general biological terms which stress innate structures and behavior, while "nurture" and "environment" imply the effect of experiences encountered throughout life. There are still schools of thought among both biologists and psychologists which hold that almost everything in life depends upon heredity. Other

PARENTAL CARE

ne chimpanzee mother cares for her young for several years. Not only does she attend its physical needs, but also plays with it, exercises it, disciplines it, and teaches it.

schools—particularly the behavioristic—stress the belief that any child, given the proper training or conditioning, can be directed in any desired path.

The majority of scientists take the middle road: the point of view that both influences are important; in fact that they are inseparable. They believe that it is the *interplay* of heredity and environment, instinct and learning, which shapes our destinies. No matter how poor a set of instincts we may have inherited, we still can hope for improvement.

CHAPTER V

INTELLIGENCE TESTS

ONE OF THE OUTSTANDING contributions of modern psychology has been the development of objective tests for measuring various factors involved in the concept of intelligence. Performance tests, aptitude tests and, perhaps best known of all, general intelligence tests have been perfected to a high degree and are widely used. Boys and girls in many progressive communities are brought up on them from earliest school days. By such tests the higher education of millions, their placing in the military services, their jobs later on, and indeed their whole lives may be said to be guided. Everyone nowadays speaks glibly of the I.Q., though few can define or explain it.

Is there anything in the study of animal psychology comparable to this measurement of human intelligence? Is there a reliable instrument for distinguishing between a bright beast and a "dumb" one? Or is there any way of ascertaining if dogs in general are smarter than horses, or owls wiser than crows?

All we can say is that animal psychologists have made a good beginning in a very difficult field. While they have not discovered—and probably never will discover—any simple scale for measuring the general intelligence of all animals, they have devised ways of testing certain aspects of intelligence—i.e., sensory discrimination, general learning capacity, retention of memory images, ability to perceive relationships.

Difficulties Involved

The difficulties involved in testing animal intelligence are enormous. As we have pointed out, the animal cannot explain to us just how he is thinking out his problem; we must find out indirectly, from his behavior. Nor can we explain to the animal the test with which we confront him. Especially at first, many animals find it hard to catch on

to what is asked of them; though rats, once they have gained experience in one kind of test, appear to respond to other kinds more readily. We must contrive a problem simple enough for the animal to grasp, and of a type which will hold some natural interest or challenge for him. Some animals seem temperamentally more co-operative than others. Chimpanzees often appear as interested in their problem as the experimenter, while gorillas are likely to be negativistic, stubbornly ignoring the tester's suggestions, though perhaps well able to perform the task. Many species of monkey are far more nimble in manipulating things and can do simple tests more easily than gorillas, but certainly they are not as intelligent.

In comparing different species it is difficult to find apparatus that fits the varying sizes of animals or that can be operated with equal facility by paw, nose, trunk, prehensile tail, beak, or whatever the animal uses.

Again, it must be considered that, just as the span of life varies greatly with different animals, so their periods of mental growth and maximum mental ability come at different ages. Thus a year-old chimp may in certain respects surpass a human baby of the same age; but the baby soon starts forging ahead. It is not always possible to provide a succession of problems so graduated as to enable an animal to progress to the highest point that his capacities permit, as has been done with tests for humans. To all of which must be added the major difficulty of getting the animal to do his best to solve a specific problem at a specific time, or indeed to perform at all.

Experimental Background

The rapid development during the last half century of experimental methods for studying animal behavior sprang primarily from the efforts of psychologists to measure the animal's ability to learn. Thorndike of Harvard was the pioneer and for many years the leader in analyzing animal intelligence and in devising novel laboratory techniques. His studies, which began to appear in 1898, were largely centered upon cats and their reactions in various *puzzle* or *problem boxes*. Typically the animal, hungry at the time of the test, was confined in a cage just outside of which was placed a tempting bit of food. The door of the cage could be opened by a simple latch or bar. The cat, of course, had no understanding of locks or latches, but in his eagerness to reach the food he seemed to try this movement and that, this bar and that,

until he chanced upon a successful solution. After a few similar experiences he learned to open the door without hesitation. Thorndike believed that this learning was almost entirely a matter of trial and error; that satisfying experiences were remembered, painful ones forgotten.

During the next several years Thorndike and many other scientists put dogs, rats, squirrels, porcupines, raccoons, monkeys, and even sparrows, cowbirds, pigeons, and chickens through their paces in problem-box situations. Though these experiments shed much light on the general rules of learning, they were of less value for comparative work because of difficulty in manipulating devices and because solution was often a matter of chance. Nor were they a fair indication of the animal's native intelligence or of his capacity to meet emergencies in the wild.

Many superior animals have, like humans, strong individualities and resist domination by others. In human society we do not consider that those most easily regimented are necessarily the most intelligent. In training elephants for heavy industrial work much greater success has been attained with Asiatic species than with the African; but it has never been determined whether this success is due to the superior learning ability of the Asiatic elephant or to its comparative lack of spirit —or to the higher skill of Asiatic trainers. Domestication is a process which often interferes with natural impulses and may thus be demoralizing in itself: for instance, a lion born in captivity seldom brings up her own offspring. The problem box, though it may teach the animal an unnatural skill, does not teach us what the subject is capable of in his own environment.

Far better suited to the animal's natural activities—such as the rabbit's laying out paths through the underbrush—is the learning of a *maze,* a type of experiment which, conceived soon after the problem box, quickly surpassed it in popularity with animal psychologists. In the myth Theseus, after slaying the bull-headed monster Minotaur, finds his way back through the Cretan labyrinth guided by Ariadne's thread. The experimental animal in the laboratory maze has no thread to guide him but gradually learns through experience which paths are blind alleys and which bring him nearer his goal, be it food, drink, a mate, or physical comfort.

A typical experimental maze was for a time set up in the Museum. Visitors watched a trained rat trace his path through the intricate series of passageways, invariably choosing the correct pathway, avoiding blind alleys, finally winning his reward of bread. In learning the maze

the rat had entered many blind alleys, made many errors at first. Upon succeeding trials, however, he seemed to remember and avoid many of his former mistakes and eventually was able to go directly to his goal. The behavior of the rats in learning mazes has been found to resemble closely that of human beings confronted with a like problem.

Maze experiments conducted in the Museum laboratory by Dr. Beach[7] demonstrated the enormous variation in learning ability among *individual* rats. The same rats were also tested for excellence in performing complex instinctive activities, such as mating in the male, or maternal care in the female, nest building, cleaning of young and nest, retrieving of young when scattered. By comparing the two scores it was evident that the best learners were also those who carried out their instinctive duties with the greatest ease and precision. This parallelism was additional proof that learned and instinctive behavior are not two separate entities but only two manifestations of innate endowment. That the mating and maternal behavior was instinctive and not learned had already been ascertained by raising both males and females in isolation and then observing their first reactions to mate or young before they had an opportunity to learn from others or from practice.

It has been possible to standardize the maze to a degree and to control its complexity by varying the number of turns and blind alleys, thus making it a convenient measuring instrument for many types of comparative studies. By varying conditions in the maze or in the animal itself the effects of such special factors as temperature, time of day, amount of light, age, nutrition, fatigue, and drugs can be determined. By successively depriving the animal of one sensation after another (by blindfolding, plugging his nose, et cetera) and then putting him to the task of learning the maze, we can observe his dependence upon particular senses in finding his way about. Through carefully conducted surgical operations much information has been obtained as to the different brain areas involved in diverse types of learning.

Learning Tests

Learning ability is by no means all there is to intelligence but is probably its most important component. Certainly no animal or human could perform a difficult mental task if he were not able to profit from past experience—in other words, to learn. Interestingly enough, despite great individual variation any given species, provided a fairly large group is tested, is remarkably consistent in the number of steps it is

capable of learning and the number of trials it requires to master a given problem.

The maze, as a measuring instrument for general intelligence, serves to indicate speed and facility of learning, rather than absolute levels of learning capacity. Some generalized results with various animal species may be summarized as follows:

Earthworms, after numerous trials, succeed in mastering the simplest type of maze wherein a choice is to be made at a single point. Higher crustacea, including crabs and crayfish, can learn to find their way in a maze having several blind alleys and various kinds of turns. Terrestrial insects are quick at learning mazes, probably from their natural ability to follow paths between home and feeding ground; in nature an ant must learn to wend its way through the intricate three-dimensional network of the colony.

Working with frogs and turtles in various types of labyrinths, Yerkes has reported results which may be considered representative of the learning capacity of amphibians as compared with reptiles. Frogs required one hundred trials before succeeding in mastering a maze with two cul-de-sacs. A simpler maze, having but one cul-de-sac, was conquered in fewer trials. Turtles, on the other hand, needed only twenty attempts before they learned a maze with four cul-de-sacs, and reduced the time required to reach the goal from thirty-five minutes to half a minute. A maze with six cul-de-sacs they mastered in twenty-five attempts, decreasing the time consumed from ninety minutes to three or four minutes.

The old-time problem box has been modernized and glorified by Jenkins. With the subject given unlimited time, this new "multiple-plate" box is employed to show absolute levels of learning capacity among different animal orders. The animal is placed inside a large circular cage, in the center of which is a small cage containing food. On the floor of the outer cage are three metal plates which must be depressed in a certain order to open the door of the food cage. The animal first learns to obtain his reward by stepping on *one* plate. When that is well established the requirements are gradually increased; the animal must depress not one but a combination of plates in a certain order, as from plate 1 to plate 2, then 3, 2, and so on. Stepping on a floor plate is an activity equally simple for most species. The plates are so wired that a slight electric shock may be given if desired to warn the animal that it is "on the wrong track." Though this appears to be an easy problem, the animal cannot go on adding plates indefinitely. No matter how many times he is put to the task, at a certain point he

reaches the limit of his learning capacity. Beyond that—if coaxed or threatened unduly—he may break down completely.[87]

To date, guinea pigs, white rats, cats, and monkeys have been tested in this multiple-plate apparatus. Using from twenty to thirty individuals of each species, the highest single scores (number of plates mastered) were: monkeys 22, cats 7, white rats 2, and guinea pigs 1: results which confirm other evidence as to the respective intelligence of primates, carnivores, and rodents.

Memory Tests

An important factor in human intelligence is "breadth of view," a quality dependent upon a wide observation and memory of surroundings and associates. Memory itself is complex, including both *recognition* and *recall*. Men and women often can recall vividly scenes and episodes of their earliest youth; as well as recognize persons, places, and names which they are totally unable to recall. Memory in animals is probably largely a matter of recognition; it is doubtful if animals can recall memory images as we do.

Learning itself could not take place without at least a minimum of memory. In testing a multitude of objects and situations the animal has to retain a certain impression of what brought failure and what success. Only by remembering can he see things in new relationships and thus learn new ways. Most animals have a wide and intimate acquaintance with their home territories. Others are guided on long journeys by their recognition of conspicuous landmarks. Some animals seem to ignore their associates consistently; others recognize one another as individuals and friends. In the laboratory it has been found that many fish recognize one another as individuals. A pet crow is reported to have learned an amusing distinction between the right and left hand of its keeper. The right hand which customarily offered food was always recognized and fondled as a friend; the left hand which restrained the crow was resented as an enemy.

Interesting figures have been published[82] showing the varied and in most cases surprising length of time over which different animals can retain the solution to problems they have learned in the laboratory—such as maze running, opening problem boxes, or discrimination tests. After the correct responses had been fairly well established the animal would be removed entirely from the experimental situation and brought back to it at a much later period. It was found that in some

cases an earthworm could remember the correct response for three or four weeks, a fiddler crab for ten days, a cockroach for three weeks, a turtle twenty-one weeks, sparrows and cowbirds twenty weeks, guinea pigs sixty-three days, porcupines one hundred days, raccoons one hundred and forty-seven days, and monkeys almost three years. Dogs and squirrels remembered a color discrimination test for a month.

The presence of some sort of "ideas," comparable to our memory images, is believed to be demonstrated by the so-called *delayed-reaction tests*. Some of these tests involve apparatus and preliminary training of the animal, but they are not different in principle from the simpler, more direct hiding experiments. In the latter the animal is allowed to see food placed in one of several boxes, but he is not allowed to approach the boxes until after a certain delay. If, on his release, he goes directly to the box with food he would seem to have been activated by some sort of symbolic reproduction of the hiding episode. Whether this is in the nature of a visual image or merely a form of recognition or association is still a matter of controversy.

Experiments were tried several years ago of hiding food from bears. While the bears looked on from their cages various kinds of food were concealed in the snow. Half or three quarters of an hour later the bears were released and allowed to look for the food. Not only did they remember where the food was hidden but they even knew where their favorite tidbits were to be found. Nor were they fooled by the "jokers," the empty containers. It has long been known that in nature mountain lions hide or bury their kill and return to it at frequent intervals to enjoy a meal. Hunters have noticed, however, that a bare carcass is never returned to; the animal undoubtedly remembers that it has nothing more to offer him.

Bierens de Haan conducted some very informal tests by concealing food (while the animal was looking on) in his pocket, in his hand, under a flowerpot, under a cloth, in a drawer, et cetera. Some of his grades—based on successful recoveries rather than on the time element—were: cebus monkey 30, coati 27, two raccoons 26, two lemurs 24 and 23, squirrel 14.

Many different types of delayed-reaction tests have been made on chimpanzees. There was found to be a striking difference in the ease with which these were mastered. Tests depending on spatial relations—such as locating food in definite places, for example—were found far easier for the chimpanzees than those depending upon such factors as color or personality discrimination.

Chimpanzees have especially distinguished themselves in solving

multiple delayed-reaction tests, competing not only with monkeys but also with humans. Tinklepaugh[84] arranged a pair of receptacles in each of several rooms. Conducting his subjects one at a time through the rooms, he hid the food in one receptacle in each room. Later the subjects were taken back over the course and allowed to reclaim the food as best they could. A pair of macaque monkeys, Cupid and Psyche, averaged 79 per cent correct choices, working in five rooms. A pair of chimpanzees, Bill and Dwina, averaged 90 per cent correct, using ten rooms. In a similar setup it was found that the monkeys were no less confused with three pairs of receptacles than the chimpanzees were with sixteen; and the human subjects scored no higher than the chimpanzees.

Relationship Tests

Another ingredient of intelligence is the ability to discriminate and to grasp relationships. In discussing perceptions in Chapter II we pointed out the dog's ability to judge the relative position of a bell which indicated food, and the chick's ability to discriminate between two shades of brightness on the cardboards from which he was pecking. Bees have been trained to sip sugar water only from a triangle, and monkeys to find food in the heavier of two boxes.

Certain other relationships which seem quite obvious to humans are surprisingly difficult for animals to grasp. Such, for instance, is the connection between a string and the food tied on the end of it. An inexperienced dog or cat, seeing a string within reach, tied to a tasty morsel which is out of reach, usually will perceive no connection between them and will gaze longingly but in vain at the tidbit. Even apes and monkeys who have learned this relationship will have difficulty in distinguishing the correct string from several other strings, especially if they cross or converge. The animal always tends to pull the string which is in direct line with the prize. His ability to figure out—with experience—these confused connections is again a partial indication of his intelligence.

The best-known device for determining this ability to perceive relationships is the *multiple-choice* apparatus. Hamilton in 1911 designed a simple model consisting of an enclosure with four exits along one side. One of these exits had to be opened to obtain food outside; the other three were locked. The factor to be learned was never to use in one trial the door which had been opened in the previous trial. Hamil-

ton felt that this involved putting to account an abstraction retained from previous experience. Humans, monkeys, dogs, cats, rats, and a horse were tested in this enclosure. The humans and the monkeys seemed to "get the idea" almost from the start; the cats and dogs attacked the problem with some evidence of intelligence but often lapsed into random trials. The horse and the rats were downright stupid, trying the same door again and again, seemingly unable to profit by experience at all.

Yerkes later enlarged the multiple-choice apparatus to include sixteen compartments, which were utilized in small groups at a time. The point was to discern such relationships as left, right, middle, alternation, et cetera. In any one experiment the position of the group of compartments used would be shifted back and forth in order to avoid definite place learning. Food was always to be found, however, in the compartment to the left, or to the right, or in the middle of the group used. Pigs proved to be outstanding performers in this type of experiment. They learned to react to right, then left, then to alternate from right to left. They could also identify the middle of three or five compartments, but became confused with seven. Rats and two crows got the idea of left and right; a monkey caught on to second from right and second from left. A tiny European siskin (a bird) surpassed even the pig, the monkey, and the chimpanzee in selecting the middle of a series. Four chimpanzees and an orangutan failed to match the score of the pigs.[87]

The faint glimmer of *art appreciation* which appears in primates would seem to be impossible without a certain degree of discrimination and abstraction. A cebus monkey, when given colored chalk, made the semblance of a design. Apes frequently adorn themselves and their homes with daubs and streaks of wet clay. Many primates are fond of keeping or of decorating themselves with bright ribbons, hats, flowers, almost anything of an ornamental nature. A mother ape was observed plucking the white hairs from her youngster's eyebrows, then standing back as if to appraise or admire the effect. An interest in motion pictures need hardly be considered art appreciation; but many apes and monkeys seem fascinated by the flow of imagery before them and are keenly responsive to pictures of objects and events which have particular significance in their lives. However, the ability of certain apes to recognize images in a mirror seems to be overemphasized as an evidence of intelligence. Cats frequently respond to their own reflections, as do sunfish, snakes, and robins.

Imitation Tests

In ascertaining the I.Q. of a year-old human baby one part of the procedure is to get the baby to imitate a simple action such as ringing a bell or shaking a rattle. In animals, too, the ability to imitate is an indicator of intelligence.

In discussing imitation a distinction is usually drawn between innate suggestibility and a more or less deliberate attempt to reproduce the activity of another animal. The former type will be dealt with more fully in the chapter on animal societies. The latter belongs clearly in the discussion of learning and intelligence.

Though true imitation undoubtedly occurs in the more intelligent birds and mammals it is a quality very difficult to demonstrate experimentally. While common sense might suggest that any animal should be better able to perform a trick if he has seen another do it before him, there is little evidence that this is so in lower animals. One experiment on fish has given positive results. Inexperienced fish were found to learn a simple maze more readily if they could watch the performance of a fish who already knew the correct course. Thorndike, however, found no evidence of imitation in his work with problem boxes. His cats could not seem to grasp the significance of latching devices any quicker by seeing a human or another cat manipulate them properly. These early experiments were hardly fair proof, for they required that the animal be moved in and out of the problem box and that a considerable lapse of time intervene between observation and performance.

More recent experiments upon monkeys, conducted by Warden and his associates at Columbia,[88] have made use of a double cage equipped with identical puzzle devices. When a trained monkey was introduced in one compartment of the cage the untrained subject on the other side could readily observe and imitate the activities of his enlightened associate. Various easy problems were employed, most of them involving the finding of a much prized peanut concealed behind a door which could be opened by means of simple latches. With this apparatus a high degree of imitative learning was indisputably demonstrated in cebus, rhesus, and weeping capuchin monkeys. Other animals are yet to be tested but it is probable that dogs, cats, and raccoons will also prove good imitators.

Of course monkeys and apes have long been popularly regarded as notorious "apers." Not only are their instinctive reactions released upon the slightest suggestion from others, but they are frequently known to

pick up traits rather foreign to their own ways of doing things. A monkey brought up with a cat soon adopted the cat's method of lapping up milk; and Darwin reported a dog who learned to lap his paws and wash behind his ears in an entirely feline fashion. Monkeys and apes in captivity frequently copy their human caretakers and visitors. Young chimpanzees brought up in human families readily adjust themselves to such artificial accessories as bassinets, clothes, eating utensils, and even handkerchiefs, napkins, and diapers. Were the performing apes of zoos, country fairs, movies, and circuses not endowed with an urge to imitate, their trainers would find it almost impossible to teach them such complex activities as dressing and undressing themselves, riding bicycles, lighting matches, and smoking.

CHAPTER VI

HIGHER INTELLIGENCE

THOUGH ANIMALS may lead lives rich in sensations and instincts, though a degree of learning may occur even in earliest infancy and in the lowest forms of life, such forms of higher intelligence as reasoning, foresight, inventiveness, and symbolism appear to be limited to a comparatively few species.

Only man and apes and a few other mammals (and possibly a few birds) are equipped with the complex nervous machinery essential for these higher processes. Only they have built up and enhanced their primitive brains with layer upon layer of gray matter or associational tissue, thus attaining literally, as well as figuratively, an efficient "thinking cap." This *cerebral cortex* (or brain peel) may be visualized by holding the left hand protectingly over the right clenched fist. The fist is the *old brain,* common to all vertebrates, the organ which gives punch and drive to their behavior. The protecting left hand is the *new brain* or cortex which has grown over the old brain and has become increasingly prominent in higher animals. Though a well-developed cortex may continue to participate in simpler sensory and instinctive responses, it alone contributes the "extra stuff" which makes possible extensive memory, association, and relative perception. The size of an animal's thinking cap is roughly indicative of the intelligence of its owner.

Much that is erroneously regarded as mental acuteness in animals must be attributed to refinement of instinct or to long periods of learning. For instance a mother rat will appear surprisingly intelligent and solicitous when she retrieves her young and returns them to the nest from which they have been removed. But she will also retrieve young rabbits or young chicks if they are placed near by. The mainspring of her action is not sagacity but rather a strong generalized instinct to put small live things in her nest. Instinctive behavior, no matter how per-

fectly it may fit the need to the occasion, is quite different from intelligent "thinking."

Again, birds and other animals may give an exaggerated appearance of omniscience when they find their way home after long journeys. True, this phenomenon requires remarkable learning of landmarks in addition to keen senses and a strong homing instinct; but planning and thinking seem to play no part. The bird returning from the south in the spring is probably not intellectually aware of the advantages of his home territory, nor could he of his own knowledge and volition map out in advance his homeward course.

Reasoning and Insight

Reasoning involves a conception of cause and effect, an ability to "put two and two together." Though it is based on learning, it is more than mere learning. We have seen that most animals, when confronted by a new problem, try anything and everything until they chance upon the right solution. This trial-and-error procedure remains characteristic of much human and animal learning. But in addition human beings and a few higher animals have the ability to understand the problem before attacking it, or to do their trial-and-error experimenting mentally.

In some cases the solution of a problem appears to come in a flash and, once discovered, is retained indefinitely. This has become known as *insight*. It has been illustrated by comparing the reactions of an octopus, a hen, a dog, and a primate to a tempting bit of food on the other side of a barrier. The octopus, seeing the food on the other side of a glass partition, is incapable of working out any method of obtaining it except by direct assault which the glass repels. The hen, attracted by grain on the other side of a fence, tries to go through the fence and when obstructed makes many random movements which at last put her in a position where she can reach the food directly. The dog struggles between the instinct to go through the barrier and a dim realization that he might go round it, as he finally does. But a chimpanzee or a young child sees through the problem immediately and runs around the fence without hesitation.

Raccoons and cats also give evidence of insight and reasoning, though experimental results are not entirely conclusive. A raccoon tied to a rope was placed in sight of a piece of meat. The rope would have been long enough to reach the meat had it not been caught at an angle by a loose peg. In a short time the raccoon found that by pulling out the peg

or walking around it he could obtain the prize. In nature, too, raccoons have a wide reputation for strategy. When hard pressed in a chase, experienced coons have been known to lead hunting dogs into water and then drown them by climbing on their heads.

A few experiments, comparable to the meat and string problem, have been tried on dogs with only fair results. In addition, many impressive tales have been told of reasoning behavior in the home or field—many of the stories no doubt true. But in general it is surprising that dogs show as little insight as they do. For instance dogs delight in a fire and in playing with sticks. Why have they never caught on to the simple trick of putting sticks on the fire to make themselves warm?

Since the turn of the century universities, research foundations, and individuals have taken a very active interest in the study of primates—convinced that knowledge gained of the mentality or physiology of these animals will be of inestimable value to the understanding of human functions. In America the leader and for many years the "dean of primatologists" has been Dr. Robert Yerkes, an early defender of the presence of "insight" and the generally high mentality in anthropoid apes.[94]

Under his farsighted direction were organized the Yale Laboratories of Primate Biology in Orange Park, Florida. Here a large group of apes comfortably housed in spacious outdoor cages are studied by highly trained biologists. Precise records of the normal behavior of the apes—so far as normal behavior is possible in captivity—are kept; and a continuous series of carefully controlled experiments are conducted. Various "intelligence tests" and "special aptitude tests" have been devised. Though chimpanzees are the most practical and available material for experimentation, studies have also been made on orangutans, gorillas, and gibbons—the three other types of anthropoid apes. In addition a variety of monkeys have served as "guinea pigs."

An incident which occurred at Orange Park is strangely suggestive of the flashes of insight which we all experience when trying to solve our human problems. Mamo, a young female chimpanzee, was given the task of obtaining a banana placed in the middle of a very long narrow box with both ends open. With Mamo watching him, the experimenter placed the banana in the box through an opening on top and then securely locked the cover. Mamo was then allowed fifteen minutes to try to get the banana out. This was repeated on twelve different days, Mamo spending virtually all of her time in struggling with the locked cover, in trying to smash the box, or in sulking and complaining. Eventually, however, while playing with a pole purposely laid near by,

she happened to look in the open end of the box. Quick as a flash she somersaulted to the opposite end. Reaching in with her arm and finding it inadequate, she went immediately for the pole and in no time at all had obtained the desired fruit.[83]

The ape laboratory conducted on the island of Tenerife by the German psychologist Köhler contributed the observations which have been frequently used as classical illustrations of insight in primates.[85] All of Köhler's apes discovered the method of using an available box as a footstool in attempting to reach, for example, a bunch of bananas suspended just beyond their grasp. Gradually they learned to use other objects—tables, ladders, blocks of wood—for the same purpose. Later, when the first available box was too low for their purpose, they piled two, three, or even four boxes on top of one another in clumsy but successful attempts to build a ladder. They even took their keeper in hand, pulled him toward the fruit, and leaped upon his shoulder in order to snatch the bananas. When he bent his knees the apes attempted to pull him erect by the seat of his trousers.

Tschego was one of Köhler's star performers. When bananas were left outside her cage and one or two sticks put inside it, she tried desperately to reach the fruit with her hand but finally gave up her efforts. A half hour later, when some younger apes approached the food, she suddenly picked up one of the sticks and with it dragged the bananas into the cage. Nueve, another chimp, also learned this trick by sudden inspiration. When these apes were given two and even three rods, each too short to reach the bananas but so shaped that the end of one could be slipped into the end of the other, they learned to fit them together and to use the double or triple length to rake in the fruit. On one occasion when another chimpanzee found that a rod was too large at one end he gnawed it until it would fit into the hollow end of the other. Some chimps were smart enough to use a short stick to pull in a longer one which they realized would reach the prize.

Foresight

In 1824, Emerson at the age of twenty wrote in his *Journal,* "Man is an animal that looks before and after." We have noted the limited capacity of most animals for recalling past experiences. Planning for the future is even more difficult. Foresight, like insight, is largely restricted to humans, though we find in animals much that resembles it —usually falsely. It is doubtful that the squirrel hoarding nuts is able

to picture the coming winter with its blanket of snow. Burying objects and hiding them in cracks are activities so natural to these animals that even pets in captivity will try to hide nuts and small articles about the house or in the folds of a bedcover. Even the mother squirrel building her nest probably has no conception of the family soon to arrive. Both hoarding and nesting are primarily instinctive.

Hingston[29] describes a species of Indian wasp as an example of this unthinking "foresight." The female in building a dome-shaped cell of mud leaves a hole at the top; through it she lays an egg close to the ceiling, to which it normally adheres. Then she fills the cell with caterpillars and closes the hole as if planning very carefully for the protection as well as the future of her young. Thus the egg is to remain out of reach of the caterpillars while it is developing; as soon as it hatches the baby wasp will have an abundant supply of food. But if the hole in the cell is so enlarged that it will not hold the egg near the top of the dome the mother insect still lays the egg in the same spot. In this case she is only tossing her young into the arena soon to be filled with caterpillars.

Natural-history literature is replete with descriptions of seemingly anticipatory behavior in wild animals, especially small mammals. During the summer conies gather great quantities of hay and pile it neatly into numerous haystacks which are gradually consumed during the winter. Kangaroo rats store seeds; pine squirrels, cones from numerous conifers. Short-tailed shrews hoard snails as well as beetles and other insects, many of them alive. These are all undoubtedly instinctive activities; they are frequently carried out even in localities where there is no need to provide for seasons of scarcity.

Similarly bears appear foresighted in their tendency to feed and fatten up enormously in the fall, then to "den in" for a winter's sleep. But the Florida black bear does exactly the same thing in spite of the fact that the weather remains warm and food is available all the year round.

Many animals may attain a certain foresight by conditioning or associative learning. A cat always fed after its owner visits the icebox will soon learn to anticipate its dinner when the icebox door is opened. Lloyd Morgan used to dig worms for a moor-hen chick. In a short time the bird learned to associate worms with the process of spading and would come running from a distance as soon as Morgan took his spade in hand.

A similar anticipation of an invisible reward is seen in the laboratory animal running a maze. It has also been demonstrated in goats by a

simple experiment. The goats were introduced to two identical covered food boxes, one containing bread—of which they were particularly fond—and the other containing grain. The contents were changed frequently so that the goats never knew which one contained the favored food. If the goats opened first the box containing grain they would not bother to eat it but instead turned confidently to the other box in anticipation of the bread.

Again, monkeys trained to expect a banana as a reward for certain efforts were visibly disappointed when they received lettuce. Though reasonably fond of lettuce under normal circumstances, they stubbornly refused to accept it in place of the anticipated banana.

The coyote is renowned among hunters for his cleverness, and there is much in his behavior that suggests foresight and reasoning. When the skies become suddenly clouded it is said that he will start building a V-shaped dam to direct a stream of rain water into a prairie dog's hole. Then he will stand guard, ready to pounce on the poor creature when it is driven from its hole by the flooding rain. The coyote, like the fox, the rabbit, and many other animals, will frequently elude hunting dogs by doubling across his own trail.

One of the most impressive mental achievements of animals is the proficiency of certain individuals for handling currency. This accomplishment obviously suggests reasoning and foresight, and is believed by some to involve a type of symbolic thinking akin to the use of words. The most extensive experiments in this field were contrived by Wolfe at Orange Park.[92] Chimpanzees, trained to operate a mechanical device which demanded a certain amount of work, were rewarded with poker chips. The chimpanzees then learned to deposit their poker chips in a slot machine, called a "chimpomat," and to receive real food in return. Later the experiment was enlarged to include chips of different colors, each of a different reward value. A white chip would be a "promissory note" for one grape; a blue chip, for two grapes. A brass coin, contrary to the brass ring on the merry-go-round, was worthless. In another series of experiments different colors were used to indicate various *kinds* of reward: orange, banana, milk, or perhaps an opportunity to play or to "join the fellows." In all these studies the chimpanzees exhibited a remarkable facility for interpreting their wages in terms of their acquired value.

Similar observations on a pet dog have been reported informally by E. S. Russell.[80] His fox terrier learned readily to retrieve pennies tossed a short distance away and to bring them back to his master in exchange for a piece of cheese.

Gunda, an Indian elephant at the New York Zoological Park, proved particularly apt in handling currency. In less than a day he learned to pick up pennies from the floor, raise the lid of a small box high above his head, drop the pennies into it, and register them by ringing a bell. If the bell did not bring forth biscuits or peanuts he kept on ringing until they appeared. Soon the keeper discovered that the cash register and the deposit box did not always agree. The elephant would put the pennies in the box, then slyly take them out in order to be able to repeat the performance and ring the bell for additional reward. On one occasion, hearing him ring up four pennies in quick succession, the keeper detected the elephant withdrawing a secret deposit, placed as if for safekeeping on the flat top of the wall of his enclosure.

Use of Tools

Though there are many highly talented artisans even among insects and lower invertebrates it is in general only the most intelligent vertebrates who are capable of using *tools* in their trade. The very few who *invent* tools are prodigies indeed.

Rather amazing examples of tool using appear now and then in lower forms, but these seem to be entirely instinctive in character. Sand wasps pound the sand around their nests with a pebble held in their jaws. The red weaver ants of Ceylon, unable themselves to spin thread, use their own larvae as distaffs in their nest making; holding the larvae with their jaws, the worker ants press them gently, first against one of two leaves, then against the other, until the sticky secretion from their spinning glands gradually fastens the leaves together.

Learning and perhaps a bit of reasoning supplement strong instinctive tendencies in other forms. A mere tree finch was observed breaking off twigs and using them to pry insects out of holes too deep for its beak. Both wild and domestic elephants frequently break off branches and use them to brush away flies, or occasionally to protect their heads from intense sunlight. Eskimos believe that polar bears kill sleeping walruses by throwing large rocks or cakes of ice at them; it sounds like a tall tale but polar bears in the zoo have been seen throwing large objects for ten or twelve feet. In Panama red spider monkeys, when chased or frightened, break off good-sized branches and throw them at intruders. In other places monkeys are reported to throw cocoanuts at those they dislike or fear and to use stones to crack open nuts. A mother

spider monkey has been observed holding a vine for five youngsters to climb upon.

In captivity monkeys as well as apes often develop a high degree of skill in handling tools, but this facility is largely acquired by imitation of humans and should be regarded as evidence of learning rather than inventiveness. Almost any simple mechanical activity may be readily copied. Macaques have become expert in handling hammer and nails. Orangutans at the New York Zoo learned to ride a bicycle and to use keys and table implements. Chimpanzees can accomplish such delicate tasks as stringing beads, threading a needle, and sewing.

Sometimes great ingenuity is demonstrated in adapting man's tools to the special needs and habits of the animal. A cebus monkey was very resourceful in circumstances requiring the use of one tool to obtain others out of reach. A macaque enjoyed experimenting with a saw, but he insisted upon using it in his own strange way. Holding the saw with his teeth and his feet, he cut sticks in two by rubbing them over the saw.

Köhler's chimpanzees spent much of their playtime catching ants with straws. Like boys fishing from a bridge, they squatted in a row along an ant pathway, each holding out a straw until it was covered with ants. Then they quickly drew it in and licked off the insects. This would appear to be very clever and original, but it has a broad instinctive basis. A young gorilla was wont to put *himself* in the ants' runway and to lick the insects off his fur. In their native habitat young gibbons were observed placing their *hands* on a tree trunk overrun with ants, and then licking off their hands.

Yet rudiments of true creativeness are not entirely lacking. An orang discovered for himself the use of a lever and on his own initiative twisted straw to use as a lasso. A cebus monkey rolled up newspapers to fashion a rake with which he might obtain prizes out of his reach. Köhler's chimpanzees caught on to the idea of fitting one pole inside another to make a long tool.

Such spontaneous use of tools requires not only insight but also well-developed senses and good motor and manipulatory machinery. It is especially correlated with the possession of hands, in turn largely dependent upon upright posture and bipedal locomotion. Which came first—the physical or the psychological; hands or the intelligence to use them? From the classical age to the present day man has speculated on this question. Anaxagoras said it was due to possessing hands that man is of all things the most intelligent; Aristotle held that our hands are tools and that nature gives tools to the most worthy.

Language

While man shares insight and ability to use tools with the apes he alone communicates with his fellows by means of language. No other living creature has learned to use words as symbols of objects, situations, or acts. By means of these symbols he projects his ideas into the minds of others. Through them he is able to profit from the experience of others, both in the past and in the present. With the aid of language, written as well as spoken, he has entered into the realm of ideas, a realm probably closed to most animals.

Although many animals recognize some words and a few can utter them, they do not actually use words as symbols. Birds have been taught to say whole sentences, but the individual words have no meaning for them and they can never put them together to express a new idea. A sophisticated parrot may shout, "My heart is afire with the love of liberty!" but he has no conception of patriotism. A parrot trained to say, "Open the door," when he hears a knock will say the same thing when the tap is on a box instead of a door. One parrot, however, learned the word "adieu" and would say it to persons he did not like.

Cats have been trained to respond in different ways to the expression, "I must feed those cats," and "I will not feed them"; but it required 380 trials to fix the habit, and the conditioning was to the sound of the phrase and not to the meaning of particular words. As we saw in connection with Clever Hans, some animals are highly sensitive to slight movements and minute differences in tone. Often it is from these, rather than from words, that animals take their cues.

Try this on your dog. First say in a gentle, friendly tone, "You're a bad dog. Go away!" He will be happy, wag his tail, come near for petting. Then say in a harsh voice, "Nice doggie, come get your dinner!" He will be sorrowful and slink away. A certain dog, trained to retire promptly at the command, "Go to your box," causes much amusement when he obeys with equal alacrity the phrase of similar sound, "Hole in your socks!"

Some dogs have learned to connect particular words with particular objects such as hat, ball, stick; but a sentence has no meaning for them. Fellow, the distinguished dog studied at Columbia University, recognized four hundred words spoken by anybody.*

Monkeys are notorious mimics, but neither the structure of their

*Fellow, who died of a brain tumor, was mounted and is now on exhibition in the American Museum of Natural History.

brains nor that of their vocal organs is adequate for imitating words. Several baby chimpanzees, brought up in families with human babies, seemed to understand very well verbal remarks and commands made to them, but revealed no inclination to express themselves in even the simplest of words.

There is, however, one outstanding example of a young orangutan showing ability to learn and to use meaningfully the two words "papa" and "cup." William H. Furness, the only successful teacher of human speech to apes, worked daily for six months trying to teach the young orang these words, even using a spatula to maneuver the young animal's tongue. One day the man and the ape went into a swimming pool together. The orang became terrified as the water deepened and clung frantically to her master, kissing him and crying, "Papa," over and over again. One night when ill and evidently very thirsty she begged plaintively, "Cup, cup, cup."

In the chapters on emotions and animal societies we shall see that animals communicate with one another to some extent by means of expressive gestures and sounds, but this is quite different from having a language.

Machinery of Intelligence

Again we turn to the theme that thought and behavior alike are dependent upon structure. To understand the development of intelligence in animals we must understand the evolution of their brains, and especially of that part known as the cerebral cortex. The psychologist has to work hand in hand with the anatomist; in fact he must be somewhat of an anatomist himself.

Fundamentally the brain is only a thickening of the spinal cord and consists of the same nervous tissue. The interior of this elongated cord is made up of gray matter or active nerve cells. Surrounding this is white matter, or insulated nerve fibers, which connect the nerve cells with other parts of the body.

Even in the most primitive fishes the thickened end of the cord became divided into three distinct parts which were to maintain their identity throughout evolution. These three parts were the forebrain, the midbrain, and the hindbrain, or in more homely terms, the nose brain, the eye brain, and the ear or balance brain.

It is interesting that the forebrain should have been the part to develop most extensively. From the very beginning it has appeared to be

the most progressive, the most co-operative, the most adaptable. This is probably because the sense of smell was originally of utmost importance, other senses arising mainly as reinforcements to it. With the exception of birds and primates, olfaction continues to be important throughout evolution, though it gradually shifts more and more of its responsibilities to the other senses. The forebrain (of which the cortex comes to be an important part) continues to increase enormously in size and influence until eventually it constitutes the greater part of the brain and in man is responsible for his highest intellectual attainments.

The midbrain and the hindbrain show some increase in size among amphibians and reptiles. As these creatures forsook the water and perfected life on land the senses of sight and hearing naturally assumed much more importance than they had in fishes. In birds these two brain parts developed prodigiously, even at the expense of the nose brain. The greatly enlarged eye brain permitted remarkably keen and accurate vision for seeing things at a height; and the enlarged balance brain (especially the cerebellum) brought perfection of body control essential for flying. A hawk will pounce unerringly upon a small chicken in the barnyard; a gull will dive down upon a fish swimming in the sea. Vultures will flock from the four winds to a recent killing. It cannot be stressed too frequently that the size and proportions of an animal's brain are directly correlated with his activities.

Yet, as we have seen, neither the eye brain nor the balance brain managed to keep pace with the forebrain in the long run. The remarkable development of this part came about through the amassing upon it of associational tissue: external layers of gray matter and supporting bands of white fibers which connected one area of the cortex with another or with the lower centers deep within the brain and cord. It was this close integration of one part with another—in an area largely removed from immediate sensations—that made possible the retention of experiences and relative thought. The first dim promise of man's thinking cap, the first faint shreds of associational tissue, appear in the roof of the forebrain of reptiles. In mammals we find the larger swellings appropriately called hemispheres. Gradually these grow over and around the other parts until in apes they form a generous "monkey hat" and in man they are greatly expanded into an enfolding bonnet or "thinking cap."

As the cortex enlarged during evolution it became curiously folded and wrinkled. A deep median cleft separated the two cerebral hemispheres, which in turn were divided by deep folds into temporal lobes at the sides, frontal lobes at the forehead, occipital lobes at the back

of the head, and parietal lobes on top. Innumerable grooves and convolutions further increased the surface area of the gray matter.

Many intricate studies have been made in efforts to map out the landmarks of the brain. Neurologists have long had hopes of eventually identifying each area with certain definite functions. More recent experimentation indicates that much of the cortical tissue is generalized rather than specific in character. If parts of it are destroyed there is a loss in the general efficiency of certain functions, but not an elimination of specific activities.

There is strong evidence that certain large areas of the human brain have developed a degree of specialization. From the crown down toward the ears is a motor area in which the control of different parts of the body may be fairly accurately localized. Hearing centers are in the temporal lobes at the sides; vision in the occipital lobes at the back. There is, however, no justification for the teachings of old-time phrenologists that one's character and talents can be diagnosed by means of the bumps on the skull.

Our brain is always active, even during sleep. It is sending out electrical impulses or brain waves which can be recorded very precisely by attaching electrodes to the skull. With amplification we can actually hear our brain chugging along. Just as the electrocardiogram may diagnose heart ailments, so has the electroencephalogram become invaluable in analyzing disorders of the brain.

Herrick has said that there is more than twice as much thinking tissue in the most ignorant and uncultured man as there is in the most highly educated chimpanzee that ever lived. In this thinking tissue there are sixteen billion cells—far more than there are visible stars in the heavens; these cells are hooked up by a communication system as intricate as all the telephone exchanges in the world put together.

So we see that man has a priceless treasure in his highly developed thinking cap. It is his unique possession, the only thing which clearly distinguishes him from his animal companions. Yet despite this effective cortex, with its layer upon layer of gray-matter padding, man can never quite suppress his old fish brain, the chief center of his emotions and instincts. Though deeply buried, it is still there, structurally and functionally, and at times it seizes control of the body. We all know the saying, and perhaps the feeling, "It's the animal in us." We cannot break entirely from our primitive reactions. Beneath the superstructure of reason, experience, imagination, and judgment we have the same animal drives which motivate the fish, the reptile, the lower mammals.

CHAPTER VII

EMOTIONS

IN VARYING DEGREE animals appear to be subject, like ourselves, to a multitude of feelings and emotions which sometimes lead them on to prodigious activity and occasionally leave them in helpless paralysis. While mankind, however, is supposedly able to control its emotions by intelligent thought or action, animals have far less restraint and for the most part act as they feel. Animals, Heinroth maintains, "are sentimentalists with extremely little intelligence."

Range of Emotions

The richness of an animal's emotional life is in direct proportion to the variety of his sensations and the perfection of his nervous machinery. In primitive animals there can be little differentiation of emotions, just as there is little differentiation of sensations. There is evidence only of general excitement or of vague feelings of comfort or discomfort: we cannot imagine an amoeba being angry or a jellyfish afraid.

The beginning of strong primitive emotions such as fear and anger may be assumed to occur in animals as low as the octopus and the insect, for even these forms not only display reactions of flight or attack when confronted by an enemy, but also reveal the intense inner disturbances so characteristic of emotions. Waves of color will sweep over the octopus and the pupils of his eyes will dilate in anger. Yet the more subtle emotions, which depend upon delicate sensitivities and associations, must be foreign to such creatures. We cannot conceive of an *embarrassed* octopus, even though he does turn pink when disturbed. We can imagine an *angry* or an *excited* bee, but not a *proud* or a *jealous* one.

Jealousy, however, is not uncommon in the animal kingdom. Young howling monkeys frequently are jealous of a new arrival in the family.

They will try to snuggle up to the mother and push the new baby away. Apes and pet otters may react most peevishly to real or fancied slights on the part of their caretaker. Jealous dogs are common objects of observation and amusement, as are ashamed dogs who slink about the house with head hung low and tail curled down between the legs.

In the higher mammals we find an endless number of factors that produce emotions. There are innumerable material needs and comforts to be attained and standards to be lived up to. Intangibles and a vast number of subtle satisfactions are also regarded as important in life. Food, protection, and a mate are no longer the only goals to strive for; food must be appetizing, congenial company is preferred, and one's social status must be taken into account.

The emotionality of animals varies enormously among species, individuals, and even within the same individual. Even closely related species are often very unlike in temperament. Though nothing could be tamer than a well-trained house cat, efforts to make household pets of young wildcats have been singularly unsuccessful. In the laboratory a decided contrast has been noted between the work attitudes of rhesus monkeys and those of cebus monkeys. In experimental situations the rhesus is all activity, but not necessarily well-directed activity. He quickly flies to pieces if things go wrong. Though the cebus is probably no more intelligent, he is more orderly and persevering, often pausing as if he were trying to figure things out.

Yerkes has noted a great *individual* variation among the apes in his charge; and Altman has reported similar variations among female experimental pigs. Tiny was neurotic, solitary, and resigned in her attitude; Bessie was clumsy and pugnacious, somewhat masculine in her behavior; Jerry, placid and friendly, took an active interest in her pig neighbors.

Within the individual, emotions may be influenced by many external and internal factors. Some animals are vivacious during the day and lethargic at night; others just the opposite. In most animals a seasonal rhythm controls the sexual and parental emotions. In birds increased illumination may enlarge the reproductive organs and arouse emotional behavior. Frogs become lively with moisture and warmth; reptiles with warmth and sunlight. Experimental mammals, like people, are found to be more alert in a fairly cool environment and to become drowsy with too much warmth.

Diet affects body chemistry and especially the endocrine glands, which in turn profoundly influence behavior. "Feeling your oats" is a common saying which reflects the old observation that horses fed too

heavily on oats become extremely mettlesome and high-spirited. Chickens lacking a proper diet become irritable. Young rats brought up on a magnesium-deficient diet become excitable, then apprehensive and fearful, and finally end up with convulsions. To a large extent animals "are what they eat."

Complexity of Emotions

Emotions are highly complex phenomena. To a certain degree they involve the whole body and bring into play all types of activity: reflex, instinctive, learned, intelligent. Each emotion probably has not only its own outward expressions but also its own characteristic feeling tone and its own set of nerve mechanisms and physiological reactions. While human psychology should concern itself with all these factors, animal psychology must be limited more largely to observable reactions.

Emotions may be initiated by an external stimulus (such as a loud noise or the sight of an enemy) or by internal factors (such as glandular activity in sexual unrest, or conditioning and memory in higher animals). Nervous impulses, whether arising from the sense organs, the sense cells of the viscera, or the cortex, proceed to certain emotional centers in the old brain. Here it is believed they are reassembled into three activity squadrons which start out along different paths to fulfill their respective missions. The first group go out to the skeletal muscles, inducing large movements such as escape and attack as well as finer expressive gestures. The second group travel along the sympathetic nervous system to the internal organs, inducing the visceral upsets so characteristic of emotions. A third group are directed upward toward the cortex, where they are responsible for bringing about varying degrees of emotional control, co-ordination, and consciousness.

Inner Turmoil

Human beings have long been aware of internal disturbances as a part of emotional experience. These feelings of upset are caused by very real factors. Delicate instruments long known to doctors and physiologists can accurately measure heartbeat and respiratory rate. The galvanometer measures changes in the electrical condition of the skin, due to secretion of the sweat glands. Well-established chemical

tests demonstrate changes in the composition of the blood and glandular secretions. The "lie detector" is a practical outcome of such experimentation and measurement. Though it cannot always reveal untruth, it does register with uncanny precision many of the internal changes that take place during emotional strain, despite every effort to maintain outward calm.

Obviously we can never be sure how animals feel inwardly; but we can ascertain from these measuring instruments that animals have internal upsets comparable to ours. An increased respiratory rate in emotional excitement has been observed not only in fish but in insects. The supply of red corpuscles in the blood has been found to increase enormously in a cat frightened by a barking dog. Britton and Kline, working with tropical snakes, crocodiles, and mammals, showed that emotional excitement produced an increased sugar content in the blood and also a heightened body temperature.

It has only recently been recognized that these internal changes, far from disabling the animal in his hour of need, are vitally important in fortifying him for the emergency.[5] The great need in a physical struggle is an abundant supply of energy for added muscular activity. This demands an increased amount of fuel and an increased availability of oxygen to burn up the fuel and release the energy. Meeting this need is the particular responsibility of the sympathetic nervous system. It increases the fuel supply by stimulating the liver to release its store of sugar and by hastening the circulation of the blood. The latter is accomplished both by speeding up the heartbeat and by constricting the small arteries of such temporarily unimportant parts as the skin and digestive apparatus, thus forcing into the muscles, heart, and brain the blood so essential for combat. This explains the incidental paling of the skin and the stoppage of digestive processes in strong emotions. With the speeding up of the circulation, increased oxidation becomes essential, and we find the respiratory rate also quickened, the bronchioles of the lungs dilated, and oxygen-carrying red corpuscles released from the spleen. The secretion of the sweat glands allows the escape of excess heat; the erection of hairs may serve to insulate the body or may be chiefly valuable as a bluffing device, making the animal appear larger and more ferocious.

The sympathetic system also stimulates the adrenal glands to secrete adrenalin into the blood, and this chemical in turn seems to influence the viscera in exactly the same way as does the nervous stimulus itself. If injected into the blood of a normal animal it, too, will quicken the heart, depress the digestion, contract the spleen, and so on. In an emo-

tional situation adrenalin augments and prolongs the effects of the nervous system. In addition it is largely responsible for reviving fatigued muscles and seems to be solely responsible for hastening the clotting of the blood, an important function in actual combat.

Closely allied to the sympathetic system, and like it in its limited association with the central nervous system, is the parasympathetic system. In general the activity of these two subordinate agencies is antagonistic. While the sympathetic tends to arouse the organism to great exertion, the parasympathetic seems responsible for restoring it to normal. The parasympathetic appears to be active in some of the pleasanter emotions; laughter actually facilitates the digestion. Sometimes, however, strong stimuli will affect the parasympathetic system through the sympathetic. For instance, emptying is a parasympathetic function, and in times of great stress animals and humans often have difficulty in controlling their bowels or their bladders.

Old Brain Mechanisms

Fundamentally emotions are primitive phenomena and as such are largely taken care of by the old brain. In general they are prompt and uniform reactions, persisting from youth to old age and occurring characteristically in all individuals of the same species.

Experimentally it has been found that emotions may occur even more forcibly in animals whose highest brain centers have been eliminated. This was first demonstrated in 1892 by Goltz's dog, which lived in good health for more than eighteen months with its cortex removed. It lost all learned behavior and showed no ability to regain this loss, but its anger reactions were similar to those of a normal dog and appeared upon the slightest provocation. Since then this condition has been repeatedly observed in many laboratory decorticate animals and has been termed "sham rage."

By cutting away a little more of the brain tissue of experimental cats, so that certain parts of the old brain were also removed, it was found that the animal no longer showed reactions of rage—either internally or externally. By process of elimination the precise centers essential for the expression of rage were finally identified by Bard in an area of the old brain known to neurologists as the hypothalamus.[6] Bard's discovery was also confirmed by Ransom, who found that rage patterns could be artificially induced by electrical stimulation. When an electrical current was applied to these *rage centers* his cats clawed, lashed their tails,

struggled to free themselves from the apparatus, snarled, and tried to bite as realistically as if they were facing their traditional enemy. Nor were the reactions only external. That the sympathetic system was also stimulated was evident from the dilation of the pupils, the deep and rapid respiration, the erection of the fur, sweat on the pads of the feet, and the cessation of digestive movements. Ransom further showed that animals in which these rage centers were damaged became drowsy and emotionally sluggish. Rhesus monkeys, normally wild and aggressive, became tame and tractable, but not permanently.

It should be pointed out that this "rage center"—or any other center—is not solely responsible for all the factors involved in emotional reactions. Isolated elements of behavior may occur in an animal with only a spinal cord, and relatively more in an animal with portions of the old brain intact, but the integration of separate reflexes and other simple activities into an effective workable whole takes place within these limited areas.

The brain center for the expression of *fear* has not been definitely established, although it, too, has been proved to be in the old brain. Animals in whom the cortex has been removed may still react to fear stimuli, though not as readily as they do to rage. This was discovered by chance in a decorticate laboratory cat. When the safety valve of an autoclave was opened, resulting in a sudden loud noise of escaping steam, the poor cat lowered its head, crouched, mewed, and then dashed off, slinking rapidly with body and tail close to the floor. She collided blindly with objects in her path and finally took refuge in a corner, crouching and mewing plaintively. Some work has been done to ascertain the center for the expression of *pleasure,* such as tail wagging in dogs and purring in cats, but the results are inconclusive.

Cortical Function

Though the old brain contains the centers for emotional expression, it must not be assumed that the new brain or cortex does not play an important part. The old brain and the new brain are not two separate organs. There are innumerable nervous connections between them and their functions mingle and overlap in many ways. Generally speaking, these connections make it more natural for man to control his emotions with his thinking cap and, on the other hand, to embellish his thoughts with the warmth and sparkle of emotion. In the words of Cowper, "The heart may give a useful lesson to the head."

A cortex brings to the animal more abundant stimuli which arouse emotions. Perceptions, memories, conditioning, as well as concrete images, may produce this excitement. A dog conditioned to fear a brandished stick no longer reacted to the stick when his cortex was removed: he no longer remembered the connection between stick and punishment.

"Brainy" animals can also *respond* more *precisely* to emotional situations. We have seen that decorticate animals display poor direction in their expressive activities. In sham rage, dogs and cats may snap at themselves, not at their tormentor. The frightened cat collided with objects in her pathway. Animals with a cortex do not have to rely upon their primitive reactions but can learn or contrive many new ways of escaping, fighting, impressing their friends or winning a mate.

The highest function of the cortex in emotions is perhaps that of *control.* Animals without this organ have little ability for inhibiting their emotions. Primitive animals, such as squids or fish; young children or young apes whose cortex is not well developed; experimental animals with cortex removed—all tend to indulge in uncontrolled emotional behavior upon the slightest stimulation. "Laughing gas" is so called because the mild anesthetic temporarily impairs cortical restraint and often releases laughter and other emotional expressions. Dogs can, of course, control their emotions in many ways. Remembering punishment, they may show their teeth but refrain from biting. Reptiles, with a minimum of gray matter, may also learn this inhibition. Gorillas are believed to be restrained in their emotional expression. They are stoical in pain, and though giving evidence of curiosity about the doings of their neighbors, they seem to hide it under a veil of indifference.

The cortex also brings a greater awareness of emotions. The peculiar quality which we think of in humans as emotional consciousness probably results from the interplay of the cortex and the old brain centers. To what extent animals share with us these feelings it will always be impossible to tell.

A half century of research has proved the inadequacy of the old James-Lange theory of emotions which long held sway. In 1884 and 1885 the American psychologist William James and the Danish physiologist Lange independently formulated the theory that emotional feeling was entirely the awareness of bodily upset: that we were afraid because we shivered or ran; not that we ran because we were afraid. This theory was never without its critics. One contemporary said it was

not just any bear that makes us run, but a bear that we recognize as dangerous.

Many of the observations which have disproved this theory have come, as James prophesied they would, from hospital cases where injuries have interfered with the normal connections between the viscera and consciousness. For instance Dana in 1921 described an intelligent woman who, after suffering a fracture of the neck, lived for many months with absolutely no sensations from her neck down. Yet her personality was unchanged and she continued to experience emotions of grief, joy, affection, and annoyance. Other patients with facial paralysis continue to feel mirth though they cannot express it in laughter. On the other hand, physicians sometimes find patients who, because of brain injuries, cannot stop laughing or crying yet insist that they are not mirthful or grieving.

Many experiments on laboratory animals have cast further doubt on the validity of the James-Lange theory. Cannon, for instance, successfully removed from cats the sympathetic nervous system, thus making visceral reactions impossible. He found, however, that the animals still showed facial and motor reactions and evidently experienced emotions.

Other scientists were able to produce the visceral upsets artificially both in humans and animals by the administration of adrenalin. In this case the human subjects stated that they felt nervous and jumpy but not as if they were experiencing a real emotion. Again, the visceral reactions are found to be very much alike in many intense emotions such as anger, fear, and pain; yet the emotional consciousness in humans and the overt activities in animals are highly differentiated—a state of affairs which could not be true according to the James-Lange theory.

Expression of Emotions

Though we are primarily conscious of the *internal* emotional upsets in ourselves, it is largely through the *external* reactions that we assume similar feelings in our human and our animal companions. Typically each emotion has its own outward expression common to all individuals in any given species, yet often varying widely from one species to another. For instance affection may be expressed in dogs and many other mammals by lapping with the tongue, in cats and many birds by rubbing the head against the beloved object, in humans and chimpanzees by embracing, holding hands, and even kissing. In any given animal or species, however, it is not difficult to identify a variety of emotional

patterns. The list of emotions commonly recognizable in a dog would be a long one. We have mentioned dogs as being angry, afraid, ashamed, jealous, affectionate. Equally familiar is the picture of the joyous dog, who prances about gaily, barks loudly and abruptly, and strenuously wags his tail; his eyes are wide open and his ears pricked up. The disappointed dog moves slowly, with tail, head, and ears reflecting his own dejection.

External reactions may be large movements involving the whole body—as fighting when angry, fleeing in fright, pursuing a mate, hunting for companions, dancing in glee or in fury. Many animals will tremble or "break into a cold sweat" from fear and anxiety. It has been said that all animals, right down to the earthworm, display a tense general excitement during courtship and mating. Finer reactions in posture or movement express some of the more subtle emotions. Yerkes has described the retiring behavior of a "bashful" gorilla; and Heinroth reported a goose which appeared greatly shocked and indignant when it chanced upon the love-making of its goose companions.

Often we find expressive gestures involving only limited parts of the body. An angry skunk will stamp furiously on the ground with his front paws, then bristle his fur and flash his tail in the air, using his scent gland only as a last resort. An ape will express his displeasure by shaking his hand or striking it rapidly against the ground. Chimpanzees, like people, will scratch their heads or the sides of their bodies when perplexed. Darwin[19] suggested that the erection of dermal appendages was perhaps the expressive reaction most general among higher vertebrates. In reptiles special crests, dewlaps, or scales are spread in threat or defiance; in birds it is the feathers, while in mammals it is the fur, or the quills in the case of the porcupine. Though man does not have fur he well knows the feeling of having his hair stand on end.

Many emotional reactions are intricately related to color. Most of us know that apes as well as humans grow pale from fright, blush with shame, or become crimson with rage. Even shrimps, octopi, and walruses turn red with excitement, while many fish and lizards take on an additional brilliance of color under emotional stimulus. There is little truth in the saying that "he who can blush is not quite a brute."

Major Hingston[30] has devoted a book largely to the relation that color and pattern have to the two primary emotions of fear and anger. In fear the animal tries to conceal himself; all his reactions tend to make him inconspicuous so that his enemy will not notice him. In anger he becomes aggressive and seeks to make himself as brilliant and threatening as possible.

Because movement is conspicuous the alarmed animal will often freeze or play dead. He also makes himself as small as possible and orients his body so that only his concealing coloration is directed toward the eyes of his enemy. The dog, when browbeaten or shamed, draws in his tail and hangs his head. The defeated cock will leave the field of battle with feathers drawn tight to his body and his tail held low.

The angry animal spares no effort to make himself impressive. Nature endows many creatures with special threatening devices which they instinctively use to best advantage. The angry lion spreads out his dark, impressive mane and waves his tail with its conspicuous dark patch. Those species of bears which possess striking spots on the breast or those goats which have beards usually rise up on their hind legs when in a fury; bears and goats without these awe-inspiring signs tend to remain on all fours. The excited fiddler crab brandishes his big bright claw, and even caterpillars assume attitudes of defiance and ferocity. The comb of the rooster, the wattles of the turkey, the blue face of the mandrill (large West African baboon) and the bright red buttocks of certain other baboons all become brighter during anger or sexual excitement and all are displayed ominously by their owners.

We think of emotions in humans as being betrayed chiefly by facial expressions. There is far less subtle play, however, in the facial muscles of animals. It is claimed that the higher apes do on occasion grin fatuously and chuckle with pleasure, and when tickled titter like schoolgirls. It is not always safe, however, to rely on human comparisons. The same expression often indicates different emotions even in closely related species. In mandrills and black baboons, for example, baring the teeth is equivalent to a grin, indicating friendliness; but in all other baboons the same gesture indicates anger and threat.

Human beings often express their emotions in outbursts of language. In addition to words they have a large array of vocal expressions which may be understood by peoples of all countries and by many of their animal associates. Weeping, laughter, a yawning "oh-hum," disgusted "bahs" and "ughs" are sounds which betray feelings far more vividly than words. As can be seen in many homes, when parents and children are merry the dog also responds with exuberance; but when the children are punished and wail their resentment the dog starts to wail with them.

Conversely, humans are sensitive to the emotional utterances of animals. We identify immediately and sympathetically the howl of a lonely dog, the cry of a captured hen, the warning or the love notes of birds. Even frogs, the lowest animals to have a voice, display some

variety in their calls. The characteristic song of some frogs we brought from an expedition to Santo Domingo was a bark, though they squealed like pigs when alarmed. As a waggish headline writer put it:

BARK LIKE DOGS; SQUEAL LIKE HOGS.
WHAT DO YOU THINK OF DOMINICAN FROGS?

Though animal calls probably arose originally as expressions of sexual emotion, they became more and more diversified during the course of evolution and assumed a variety of meanings: warning and fright, call to young, resentment, pleasure, food begging.

Darwin believed that emotional expressions were merely the remnants of once biologically useful movements: that the baring of the teeth in anger, for instance, is the vestige of an impulse to attack and bite; that it survived not because of its present utility but because, like the appendix, it had been useful long ages past. Wallace Craig,[16] however, while according full credit to the great evolutionist, maintains that even Darwin was "not sufficiently an evolutionist," that in his intense preoccupation with biological factors he did not attach sufficient importance to the psychological value. Craig believes that emotional expressions are their own raison d'être, that they survived because they were in themselves extremely useful, not because they were outworn mechanical devices not yet shaken out through the sieve of natural selection. In Craig's view emotional expression has two very important psychological values. First it serves as a means of communication whereby one individual can influence or control another; thus "the cat with her back up, her tail thickened, and with spitting and growling, tells her tormentor, more forcibly than words could tell it, that she is ready to scratch and bite." Secondly it has a meaning for the individual himself and affects or controls his own behavior. Thus a dog, through the trembling of his limbs, the rapid beating of his heart, and other expressions of emotion, holds himself back from fighting a larger animal. Expressive behavior is even more important in animals than in humans, for while we can also communicate with words, animals must depend solely upon emotional expressions.

Emotions and Instincts

Emotions are like instincts and have their roots in instincts; but we have seen that the two terms are not altogether synonymous. Many a controversy has been waged over the relationship between them.

MacDougall expressed the belief that emotion was but the affective aspect of instinct: that anger was the feeling of an animal when stirred by the instinct to attack an enemy. Other students find in emotion a conflict of instincts; that is, an animal driven by one instinct to attack, and by another to protect himself by refraining from attack, is consumed with a flood of anger. A third group has the parallel theory that emotions are due to the thwarting or frustration of instincts: that when an animal is prevented by circumstances from carrying out his usual responses an emotional upset results. Lastly we have the theory, similar to that enlarged upon in previous pages, that emotions are internal automatic responses corresponding to the more familiar external instinctive reactions.

Loosely speaking, we may say that some emotions are "instinctive" while others are "learned." A squid has an innate fear of the odor of an eel. If an observer waves his arm near a squid the animal will not be disturbed in the least. But if the observer smears a little eel secretion on his finger and dips it in the water the squid dashes frantically away. Some innate emotions give an exaggerated impression of being directed toward specific objects and of being miraculously adapted to the needs of the animal. For instance fear of crows seems to be instinctive in owls, fear of owls in song sparrows. An owl raised in isolation so that it will not be prejudiced by the fears of other owls does not react when shown a white crow; but if shown a black crow, or anything black resembling a crow, it displays extreme fright. Similarly a song sparrow in captivity is afraid of even a picture of an owl. In such cases the emotion may be stimulated by any object of a certain size, shape, and color, and not exclusively by the zoological specimen itself.

Most animals seem to have an innate fear of the unknown and inexplicable. Romanes long ago wrote of a dog terrified by a bone drawn across the floor by an invisible thread. Loveridge has written of a mongoose terrified by a black hat blowing across a steamer deck. Watson reported a healthy baby who was frightened only by the opening and closing of an umbrella. Birds and dogs may also fear an umbrella. Köhler's apes were terrified by the sight of a camel, and two oxen passing by their cage affected them as would a purge. With most animals any strange moving object above a certain size produces fright. The same is true of children: a vague horror of incomprehensible movement or shadows accounts for their almost universal invention of "spooks." Animals, too, dread unfamiliar sounds and unusual disturbances in the gloom.

Incidents which are partly familiar and partly inexplicable impress

us as weird or uncanny. Chimpanzees have shown horror when presented with extremely crude dolls of straw and wood, resembling only vaguely their primate acquaintances. When, in the course of Museum experiments on mate recognition in herons, it became necessary to cover the head of one partner with a colored red balloon (leaving only the eyes and bill exposed), the other partner displayed extreme fright. But in every case the masked bird had merely to call a few times to reassure its partner before normal billing and gesturing were resumed.

In animals that are not well integrated there may occur a conflict of emotions and reactions, stimuli which arrive through one sense organ arousing different feelings from those which arrive through another. A mother duck, moved by cries of distress, came to the rescue of young birds of another species; but failing to find on them markings characteristic of her own young, she attacked them as enemies and killed them.

Like instincts, "instinctive emotions" may be evident at birth or they may express themselves only as the individual matures. Watson[89] claims that there are three unlearned emotions in the human infant: rage, love, and fear; and that fear is induced by two types of stimuli: sudden loud noises and lack of support. These innate fears may or may not appear in the zoo as they do in the nursery. When it thundered a lion cub always tried to hide its head in the keeper's lap. Baby chicks fear loud noises and loss of balance. Puppies and young monkeys show fear when they feel themselves falling. Guinea pigs, who are well developed at birth, may display fear of shrill squeaks; the white rat, on the other hand, does not even hear until his fourteenth day.

The maturation of emotions, like that of instincts, coincides with the physical development of the individual. Tender emotions arise with pregnancy and the early stages of parenthood. In many higher animal groups expectant mothers will become more sociable in temperament and will often reveal an attraction toward all young animals. In the zoo or the barnyard they may adopt—and even kidnap—the young of other species. A mouse about to have her litter takes particular notice of young mice, smells them, picks them up in her teeth and carries them to a corner. In like manner a nanny goat, just before she becomes a mother, begins to respond to the sounds made by the kids about her. Frequently there is poor discrimination at the height of parental excitement: cats and apes may nurse squirrels, guinea pigs nurse rabbits, and a dog may nurse kittens, rabbits, or even bones.

As emotional levels rise at times of mating and parenthood, so do they wane when these periods are over. The season past, males and

females no longer stimulate each other. The mother white rat, who was frantic when her ten-day young were disturbed, showed little concern when they were taken from her on the fourteenth day.

Learned Emotions

Among higher animals a multitude of emotional reactions are acquired through conditioning or learning. Strictly speaking, it is the new *object* of emotion which is learned and not the new emotion itself. Many of these learned reactions are useful. A young robin, warned by its mother on the approach of a cat, will thereafter fear the cat as its enemy and probably be better off because of that fear.

Many of the conditioned fears in this world, however, are unnecessary and only impair efficiency and enjoyment of life. To cite a common case, neither humans nor chimps are born with a fear of snakes. Most adult apes, monkeys, and humans, however, have probably been prejudiced by the attitude of their parents or companions and have learned to shudder at the sight of snakes or even at pictures of them. Thanks to science teaching in school, many youngsters today do not share this horror but have learned to distinguish harmless snakes from poisonous ones. Certainly in a civilized community an indiscriminate fear of snakes is unnecessary.

Even birds can sometimes learn more fears than are good for them. Colonies of murres often nest on small rocky islands along our North Atlantic coast in close proximity to colonies of great black-backed gulls.[82] In general the gulls are more active in the air, more alert to danger, and more vocal in expressing their fears and their resentment. The murres have come to depend to a large extent upon the warning cries of the gulls. The gulls in turn profit by eating a small proportion of the murres' eggs—normally those which have been abandoned or are not vigorously defended. On many occasions, when human visitors have landed upon the islands, the murres have been badly frightened by their inexplicable guests and even more so by the vociferous scolding and screaming of the gulls. After several such visits by humans they became so thoroughly conditioned to the cries of the gulls that they reacted to them even when no actual menace was present. They often fly away en masse, sometimes never to return, sometimes returning later on only to find a large proportion of their eggs eaten by the gulls. Thus their conditioned fear may needlessly cause the abandonment or the destruction of whole colonies of murres.

Emotions and Health

Galen, the first great anatomist, held that "the passions and affections of the soul affect most our health." And modern psychiatrists are finding that an increasing number of bodily ills and actual diseases can be traced to emotional upsets.

Normally, when a dog sees food his saliva begins to flow and his digestive system becomes active; but when he sees a cat these digestive processes suddenly stop. In the field we have noted that courting lizards will cease their activities when angered by the intrusion of a rival; courting birds, when something occurs to frighten them. In colonies of captive apes solitary confinement has been found to be one of the most severe punishments. The isolated animal mopes and grows listless, losing his appetite, his spirits, and eventually his health. Dogs, white rats, and many birds become listless and "homesick" when moved from their accustomed environment. Shrews and many birds whose hearts are especially sensitive to stimulation are reported as "dying from fright" when picked up and handled.

Though health often demands that we try to control our emotions, or better still to avoid them, an occasional outburst of feeling when pressure becomes too great should be recognized as a desirable safety valve. A child when he has reached the end of his endurance will give way to a temper tantrum; but he is angelic when it is over. Monkeys too, after throwing themselves on the ground and kicking and screaming with rage, emerge with a gentler mien.

In his famous essay on self-reliance Emerson advises us to place more confidence in our emotional impressions, in which we may find the accumulated experience of untold generations of ancestors. In a difficult situation or a sudden emergency "our spontaneous action is always the best," he said. "Trust your emotion."

CHAPTER VIII

SOCIETIES

FIFTY MILLION YEARS AGO—judging from certain geological formations—ants had established and perfected the complex social organization to which they still adhere. Fifty million years ago enormous colonies of bats gathered in caves long since crumbled.[4] Then as now the bats must have been shining exponents of racial tolerance. Not only individual bats but various species of bats learned long ages past to live together in harmony; their fossil remains have been found resting side by side in European deposits, often in regions even now occupied by their descendants. How immature and unstable our human states and institutions appear in contrast to those of ants and bats!

Today we find in the animal kingdom an infinite variety of association and community life, from the casual meetings and companionships brought about by mutual tastes and activities—where individual behavior is only slightly if at all affected by social contacts—to highly organized states with division of labor, social strata, and political or military control.

Many of these associations are the result of pure accident, the meeting of congenial souls about a favorable feeding locality, as buzzards gather at a kill, Japanese beetles collect on a colorful hollyhock, or a group of fishermen congregate along a favorite pier. Perhaps they are influenced not by food but by a tropistic tendency toward light, as when amoebae gather in the brightest part of the pond. Often the attraction is warmth: snakes crawling into the warmer earth, bats flying into a cave, city mothers airing their babes against a sunny façade. Sea birds come together in great numbers on isolated islands for nesting; and many burrowing animals live in colonies because they need a certain type of soil in which to dig their shelters. In all these cases the interest is primarily in the food or the locality; there is very little interest in one another among the individuals of each group. Nor is there much that could be called social behavior. Yet it is no small

step toward socialization when animals—by nature rank individualists —learn to tolerate one another for the sake of enjoying their meals at a favorite eating place or establishing their homes in the most desirable locality. Some animals do not seem to possess this adaptation. Pike and hyenas not only prefer their own company but are definitely antagonistic to their fellow creatures.

The accident of birth plays a most important part in keeping animals together. Young coral polyps remain on the ancestral coral branch because they grew there and never had the urge or the motor ability to break away. Many fish and most insects never know their parents but grow up in close association with innumerable brothers and sisters. Baboons and bees are born into well-established societies, just as most persons are born citizens of their parents' country.

Social Instinct?

There are many groups, however, which seem to be the result of a genuine craving for society. Many animals appear to have an innate attraction toward others of their kind and are restless when alone. Can we attribute this tendency to a *social instinct?*

The broad concept of a gregarious or herd instinct has now gone the way of many other generalities, having been broken down much more precisely into many different types of species attractions. Scientists have learned, for instance, that schooling fish are held together not by a vague "schooling instinct" but rather by common reactions to certain movements and in some cases to odors or to vibrations. Colonies of birds are held intact largely by common reactions to sounds and to movement. Odors are especially important in keeping reptiles and mammals together.

In higher animals youthful learning and tradition strengthen their social habits and keep them in close harmony with the group. The experiences of young sea gulls within the gull colony undoubtedly influence their return to the colony in later years. And young bison, born into the herd, soon learn to look upon their associates as an integral part of their environment.

There is no doubt that animals, like people, form personal attachments with other congenial individuals not only of their own but of other species, and that they derive real satisfaction from this companionship. Prairie dogs are said to visit back and forth between one another's burrows and to give every appearance of enjoying such neigh-

borliness. Though it has been said that wild baboons attack sheep on African farms, several cases have been reported of strong friendships between individual baboons and sheep. A red fox has been observed to frequent the feeding ground of caribou and to run among them, brushing their flanks or leaping at their mighty antlers, from which they were playfully shaken off. Nearer home, a mutual friendship often seems to develop between the circus elephant or horse and the dog that rides him in the act. An African rhinoceros in the Philadelphia Zoo improved markedly in disposition when given a domestic goat for companion. The rhinoceros would endure without retaliation a great deal of playful butting and fighting on the part of the goat.

Other strong but less personal attachments are frequently seen between the members of different species. The gopher turtle's burrow may be inhabited by a motley crew of boarders: the gopher frog, lizards, mice, and insects—all living together as a happy family with no apparent purpose or result. Many species of crabs like to have sea anemones on their backs. The crabs take the sluggish anemones traveling, keep them in clean, clear water, introduce them to richer feeding grounds. On its part, besides helping to camouflage the crab, the sea anemone paralyzes the prey with its soft stinging tentacles. The crab, tearing the dinner to pieces, eats the larger portions himself; the sea anemone is satisfied with the crumbs. An intimate and mutually helpful association occurs in Africa between oxen and oxpecker birds. The birds sit on the back of the cattle and rid them of parasites; being more alert, they also warn the oxen of the approach of danger.

As to how far these attachments are learned by the individual, or to what extent they are instincts acquired through natural selection because they were mutually beneficial in the past, is not always certain. We only know that they exist and that in many cases they have become more or less characteristic of the species.

Advantages of Socialization

Most important, no doubt, is the advantage of *protection,* of strength through union. A herd of musk oxen when attacked by wolves will join in a huddle, calves inside and adults facing outward with their horns in position to ward off the enemy. Wild horses in defense stand with their heads together and heels out ready to kick the aggressors. There is also a confusion element in numbers which many naturalists believe of great importance in protection. An attacker confronted by many

defenders has his attention distracted. Grinnell tells of a large flock of birds which he saw driven by an enemy into thick woods. Though each bird at once hid, a strange twittering "confusion chorus" immediately started up, seemingly from every branch and leaf, and utterly bewildering to the listener. Sometimes protection involves a division of responsibility. The worker ant profits from the protection of the soldier. Adélie penguins take turns guarding the young birds of the community from attacks by skua gulls. A sentinel stands guard over a group of resting antelope and remains alert at his post until relieved by another.

It has been pointed out that many interesting experiments can be conducted by nature under the protection of the group. Types of behavior and of individuals—as the queen ant and the drone bee—can arise and survive because they are protected. The individual animal has more opportunity for exploration and play when freed from the necessity of being constantly on guard.

Animals frequently come together in numbers for *food foraging*—the second major advantage of socialization. Wild monkeys sometimes descend upon farms and orchards in packs of a thousand or more. Though single wolves are satisfied with small game when it is plentiful in the summer, in winter they unite in packs to surround and bring down larger prey. On lakes of Southern California white pelicans fish in effectively organized squadrons which act as living seines in driving the fish to shallow water.

Another advantage is that *work* may be more effectively accomplished when there is a large group to share the responsibility. Just as one man could not build a skyscraper, so it would be impossible, despite their reputations for industry, for one beaver to build a beaver dam or one bee to build a beehive. Moreover, the actual speed and production are found to be automatically increased when two or more individuals are doing things together—a phenomenon known as *social facilitation*. In work, too, we find division of labor.

Again, in many cases animals gather primarily for *mating*. Males and females who during most of the year are content to lead solitary lives or who prefer to mingle with their own sex will in early spring join in large mixed groups. Frogs and salamanders gather at the ponds; masses of snakes emerge together from their hibernating den; deer come together in troops. Were it not for these social gatherings the sexes might not come in contact and the species would soon become extinct.

In times of stress or of *adverse conditions* many animals, by nature

more or less solitary, join in large aggregations. Not only do groups hibernate from the cold of winter but often smaller groups estivate for protection from the heat and dry air of summer. Great numbers of reindeer migrate long distances to new grazing territory in times of famine. Baboons, though they often venture off by themselves during the day, come together in close huddles at night. Birds sometimes roost so closely together at night that they rest on top of one another several layers thick. Gecko lizards, nocturnal in their wanderings, will frequently aggregate in the daytime. Sheep, widely scattered over a hillside, will rapidly flock together in fright if an airplane passes overhead. Among many creatures—and this is probably true of humans—the emotional urge for companionship seems strongest when they are in trouble. Flood, famine, war make us all crave the proximity and companionship of our kind.

Allee[2] has pointed out many other subtle advantages of social life which would never be suspected were it not for experimental work. Sometimes advantages are found where disadvantages would be expected. We have heard so much of the dangers of *overcrowding* that we learn with surprise of the dangers of undercrowding. It has been found that a certain amount of crowding stimulates growth in fish and in mice. Fish and tadpoles regenerate lost parts more rapidly in a slightly crowded environment. Goldfish thrive better in pond water that has been conditioned by the presence of previous goldfish; they also learn more quickly in a group. Chickens, fish, and other animals eat more when several companions are eating too—another demonstration of social facilitation.

Invertebrates

Among invertebrates individuals are largely brought together through accident of birth or through mutual attractions to certain aspects of their environment. Their movements and reactions toward one another are almost entirely automatic, in keeping with their instinctive natures. Yet social influence and suggestibility are not entirely lacking. A pair of horseshoe crabs about to spawn will be hastened in their duty if confronted by another pair already in action. When one cricket chirps others will immediately join in. When one firefly flashes all flash in unison until soon a definite rhythm is established. The chirping and the flashing undoubtedly facilitate mating by drawing large numbers to one locality.

A similar suggestibility may account for the enormous swarms of

locusts which occasionally migrate over the United States and other countries in such incredible numbers. These insects seem to have a strong attraction to one another and an irresistible impulse to orient their bodies in harmony with those about them. As smaller groups meet larger ones they are drawn to one another as if by a magnet and continue in ever-increasing hordes in their mass flight over the country. This tendency of one individual to respond in unison with those about him is called *infectious behavior*. It plays an important part in social relations from insects to man.

Certain species among the Hymenoptera, which include ants, bees, and wasps, and the Isoptera, which include termites, have developed instinctive societies the intricacies of which never cease to astonish students and laymen alike. In these social insects colonial life has come about from the female's peculiar equipment for providing the larvae with an advance food supply—as by laying her eggs upon prey—or for remaining with her first-born and feeding them until they in turn mature and take over the responsibilities of nursing and housekeeping.[90]

In forming a new ant colony the winged queen, after being fertilized by a male during the "nuptial flight," settles in a new burrow and eventually lays a batch of eggs. While the eggs are developing she licks them and cares for them, meantime keeping herself well nourished by eating a few in addition to eating her own wings. When the larvae hatch from the eggs she is thus able to feed them secretions from her own body. But as soon as the first larvae have developed into workers she shifts this feeding responsibility to them and devotes herself entirely to egg laying. Her motor equipment degenerates and her reproductive apparatus develops prodigiously. In some species she may survive ten years under favorable conditions and lay as many as one hundred million eggs.

However instinctively they assumed their duties, the ant workers profit from the arrangement. Though food for which they forage outside the nest is suitable for the larvae, but not for them, they receive their reward by licking from the bodies of the larvae a fatty substance secreted as they are fed. There is also a continual exchange of regurgitated food among the adults themselves.

The division of labor in an ant colony is largely a matter of structure, and this in turn is largely a matter of feeding. Gluttony turns the active queen into a sluggish egg-laying machine. Moderate feeding gives rise to ants with big heads who assume the tasks of soldiers. More frugal feeding develops the typical worker. Males develop from unfertilized eggs.

What keeps these ants together is largely their co-operative system of feeding and their devotion to the scent of the tribe. (Recent evidence seems to indicate that behavior also plays a part.) The constant exchange of food gives to all a uniform odor, by which they recognize one another and are guided home from foraging trips. All who do not bear this characteristic odor are treated as enemies. Individuals from one colony will, if placed in another, be immediately attacked and destroyed. But if they are brought in as eggs and develop with the others, so that they have the same family odor, they are calmly accepted. Outsiders, if bathed in alcohol to remove their foreign odor and then immersed in a concoction of juices from the bodies of family members, likewise win acceptance. There also seems to be a mutual satisfaction and stimulation derived from stroking each other, tapping heads, and rubbing antennae, activities that may be compared to licking in kittens and cows and grooming in monkeys and apes.

Schooling in Fish

From time immemorial man has been awed and puzzled by the enormous schools of fish in lakes, rivers, and seas. Even the most primitive fishermen must have wondered what strange forces directed these creatures and held them together in such numbers. Modern scientists have ascertained that the social life of fishes is, like that of insects, almost entirely instinctive. The schooling fish has a keen eye for movement, a tremendous urge to follow objects of a certain size traveling at certain speeds. This is often demonstrated by means of a device consisting of one cylindrical aquarium inside another. The inner aquarium is stationary and holds a fish of a normally schooling species. The outer aquarium has vertical stripes of adhesive tape and can be rotated. When the outer aquarium is turned in one direction the fish starts swimming toward the stripes. When it is swung in the opposite direction the fish turns on his tail and again follows the stripes. A definite speed seems to be specially alluring for each species; for if the stripes whiz by too rapidly or are unduly retarded the fish ignores them altogether. That this is due to a visual impulse is indicated by the fact that blinded fish are in general unable to follow a school. It has also been noted that schools of herring or young catfish break up at night.

Color as well as movement evidently plays an important part in group attraction. Coral-reef fish who travel in schools are apt to be gorgeous in hue, while rugged individualists who hide alone in crevices

are protectively colored. Undoubtedly the bright colors and conspicuous markings make it possible for the members of a school to recognize their own kind in an area where so many species find sustenance.

Each species may have its particular method of group recognition and social reaction. Fish reared in isolation and then placed in mixed schools usually end up with their own species. Similarly fish brought up by a foster family forsake their benefactors and return to their own kind when possible. Guppies, when frightened, instinctively move upward and thus segregate themselves at the surface of the water from other groups. Some fish are thrown into panic by the odor of the cut skin of one of their species, so that injury to one individual will isolate that species from other members of a mixed group.

Fish are especially likely to school when frightened or when faced with adverse circumstances. Some fish come together only under these conditions. In the Museum laboratory it was found that jewel fish would school when large objects were waved in front of their tank, when the temperature of the water was suddenly lowered, or when they were first introduced into a new aquarium.

Reptile Aggregations

The most conspicuous gatherings of reptiles are those of hibernation. Among snakes a dropping temperature stimulates the scattered individuals to move into warmer and more protected areas. They do not find these situations entirely by chance but follow the trails laid down by the skin odors of snakes who have gone ahead. During two autumns in the early 1930s, while making field studies of hibernating DeKay snakes near the section of Flushing which later became the site of the World's Fair, we witnessed a parade of these snakes across a street on their march to winter quarters.[87] A young friend of the Museum, Samuel Yeaton, here discovered the first recorded hibernating den of DeKay snakes. The snakes had appropriated an old rathole, which though only eleven inches deep contained seventy-six DeKay snakes, ten garter snakes, and one water snake. In general the crowds of snakes gather on slopes facing south, in rather limited areas. Several large groups were found occupying the upper tunnels of anthills, while the ants had moved three feet down into their "basement." In January 1933 the Museum was notified of a snake den uncovered during the building of a road near Stony Point, New York; in it were found in close proximity a group of rattlesnakes, copperheads, and black snakes.

More recently, during an early spring trip to Florida, we were thrilled to discover a den of water moccasins—the first known den of such snakes—in a pile of loose stone on the southeastern bank of the Santee River. Just beginning to emerge from hibernation, the moccasins were still lethargic, sunning themselves lazily on the rocks.

Often it is assumed that snakes show no social behavior except at times of hibernation and during breeding, which usually occurs as they emerge from their winter retreat. Snakes are like fish, however, in their tendency to foregather whenever they are upset by unfavorable conditions. If frightened while in an exposed situation, large numbers of certain species form into compact masses, sometimes in tight balls which hold together like birds' nests. Just as larger groups hibernate in winter, so when the summer heat becomes too great or the air too dry small groups estivate in protected areas. In such close contact less water is lost by evaporation through the skin. Aggregation lowers the respiratory rate, thus further conserving water which would be lost through the lungs; it also lowers the metabolic rate, making it possible for the snakes to get along on less food.

In order to study their social instincts under controlled conditions four hundred DeKay snakes were brought to the Museum laboratory. As in fish, there was a strong attraction toward movement; but color seemed to have no part as it does in fish. The snakes showed no interest, for instance, in companions who had been drugged, nor in very lifelike wax models from the Museum's exhibition cases. But when placed in a large confined area with a small group of live companions cut off by a glass partition, they did their best to get through the glass; and when confronted with a mirror, they were attracted toward their own moving images. Olfaction plays a secondary role in attracting individuals to each other but is even more important than vision in helping them identify their own species.

Years ago we collected material in Santo Domingo for a rhinoceros iguana group now in the reptile hall of the American Museum of Natural History. Though these primitive lizards build their caves in jagged limestone cliffs, usually surrounded by few neighbors, we found them to be gregarious at least in their egg laying. We discovered five different nests in the soft sandy areas near one of the caves. On an island in an inland salt lake we found hundreds of spiny-tailed iguanas, a more gregarious species, living like prairie dogs in a community of burrows dug in the sand. The marine iguanas of the Galápagos Islands are an especially social-minded group; thousands cavort over the rocks together, splashing in the waves, feeding on seaweed, and living in the

crevices of the rocky shores. Brilliantly scarlet crabs live in intimate association with the iguanas and, like the tick birds, gain a livelihood and at the same time perform a welcome service by picking the ticks off the iguanas' hides.

Bird Colonies

Among birds the picturesque flamingo colonies, the enormous bird island associations, and the fantastic weaver-bird trees are known to most, as are the large migratory flocks of ducks or swallows. But few stop to consider the nature or causes of these social phenomena. Colonies of birds are formed chiefly through a common interest in a favorable nesting locality. There is often a close family union while the young are developing, but this usually (except in geese and cranes) breaks up late in the season; and when the colony migrates southward in the fall it is as a group of individualists.

With their quickened breath and heartbeat and their high body temperature, birds are continually active, "all a-twitter," swift to respond to everything going on about them. Being especially sensitive to sounds and movements, not surprisingly they have developed a wide variety of calls and gestures. Their common reactions to these stimuli form their strongest social bonds. By certain calls one bird may advise others in a flock of the nearness of food or of approaching danger; though it should be made clear that the calling bird does not intentionally inform his companions but is merely expressing his own pleasure or dismay which the others catch from his call. Certain gestures are equally significant. If a gull stretches its neck or a duck lifts its wing in a particular manner the other members of the flock prepare at once to fly. These movements are emphasized by colors and markings. The white feathers of a robin are call colors to keep the flock together when flying at night. So keen is bird sensitivity that moods often spread through the group with electric celerity from the slightest sound or gesture of one individual.

In 1935, Lorenz[88] published a unique study of the social reactions of birds which immediately became the subject of mingled admiration, bewilderment, and controversy. Over a period of years Lorenz had maintained hundreds of wild and domestic birds in a state of semi-freedom at his home near Vienna, and had analyzed their every movement with mathematical precision. Though many of his interesting observations have been mentioned throughout these pages, it is im-

possible to present his theories adequately in such limited space. Lorenz stressed the point of view that though humans perceive things in their entirety animals react mechanically to a limited number of stimuli coming from any one object. He classified social situations into contacts with different types of *Kumpan* or companion: the child companion, the sex companion, the social companion, and so forth. In each situation certain outstanding colors, markings, movements, sounds of the *Kumpan* would act as signals or "releasers" which invariably called forth in the subject the activity appropriate for that situation. These basic reactions were regarded as instinctive and absolutely unalterable by learning, though certain "appetent" aspects of them could be modified. For instance, Lorenz held, the pattern of nest building was innate for any given species but the choice of materials could be influenced by experience.

In many birds the image of the *Kumpan* is acquired during certain early periods of unusual sensitivity through the process Lorenz termed "imprinting." We have mentioned the gray goose which adopted its human owner as its mother. Lorenz also tells of a jackdaw which through imprinting at various ages had grown up with a human being as a *parent,* a crow as *flight* companion, and a young jackdaw as *child* companion. However, birds such as curlews and certain ducks seem to be born with an innate knowledge of their parent and are satisfied only when the normal parent is at hand. Some sort of innate attraction to its own species is evident even in the cowbird: though brought up as a parasite in the nest of another species, the young cowbird will eventually return to his own flock.

The personal factor is much stronger in birds than it is in fish; and birds are also better able to profit by learning. They come to know their companions intimately as individuals and often form strong attachments with them. Lorenz observed that his jackdaws recognized their companions even after they had been away for several months. Moreover, these jackdaws frequently brought home with them strangers who from that moment were treated as members of the colony.

This increased "thinking in terms of the group" marks another avian contribution to social progress. Resident hens when confronted by a group of newcomers distinguish the new hens from their own group. Jackdaws are also able to keep the group in mind, acting together against intruders (unless the latter have been properly introduced by members of long standing). Group recognition also implies a certain appreciation of co-operation. A catbird is said to defend the nests of other birds and even to feed bird orphans. A romantic nature story has

been recorded of swallows in a French inn. Three times the swallows had started a nest in the chandelier, and each time the maid had swept it down. At last all the swallows in town flew into the place and combined to make a nest that the maid no longer had the heart to destroy.

In our yard we have had the thrilling spectacle of screaming robins, orioles, rose-breasted grosbeaks, sparrows, wrens, and even bluejays uniting against a tiny screech owl. A similar assembly came to our very doors to protest against a monkey which we had placed in a cage on the veranda.

Mammal Herds

Herds of bison, flocks of sheep, packs of wolves, prairie-dog towns, colonies of viscachas, troops of monkeys—these are all familiar terms indicating general knowledge that many mammals are typically found in groups. Some of these groups consist of only a few individuals; others may number thousands. Some are largely accidental gatherings; others are very closely united by family bonds, personal ties, infectious behavior, common experiences, and many other attractions.

We have seen that scent plays a more important role in the mammal world than it does among fish and birds. Thus it is probable that a mammal is bound to his associates by many congenial smells: one common to the group, another indicating a receptive mate, and an endless variety each peculiar to a different member of the species.

The sense of touch appears to possess added social significance in mammals. Monkeys have their grooming; porpoises are said to follow the prows of ships because they enjoy the tickle of the spray upon their bodies; cats and ocelots delight in rubbing against other creatures in whom they have confidence; baby seals, kittens, and camels lick each other and are licked by their mothers. Even the most recalcitrant animals in captivity frequently succumb to the stroking and petting of their caretakers.

On the whole the senses are more uniformly developed in mammals than in the animals below them. The vision of mammals is excellent for distances and for movement, though not for color. Members of a herd often move in unison because they respond to flash marks, as young fawns respond to the flashing of their mother's tail. Hearing is very acute; most mammals in the wild have the ability to turn their ears, prick them up, or otherwise direct them to receive the maximum sound. It is not surprising that they have developed a variety of calls and a high degree of communication through sounds, though this is

probably involuntary, as it is in birds. A beaver, if startled, will give a resounding slap with its broad flat tail, thus warning the whole colony of imminent danger.

Certain groups of mammals give evidence of a high degree of co-operation. In escaping an enemy or pursuing prey coyotes often organize relay races to tire out the antagonist, one coyote cutting in on another and giving him relief. Hamilton[25] tells of coatis (allied to raccoons) which hunt in bands through the forests of tropical America. Part of the group range through the trees, scaring out iguanas from their resting places among the branches. As the iguanas fall to the ground they are seized by the coatis following below. Monkeys will gang together belligerently upon the slightest disturbance and may pelt their real or imaginary enemy with any material at hand. According to several distinguished African explorers, elephants may unite in lifting a fallen companion, and by supporting it between their bodies, lead it away from danger.[1]

To a greater extent than other groups mammal societies are based upon reproductive instincts and activities. In general, social organization of these groups corresponds to their reproductive period; individuals remain together in large herds only while the sexual impulse or interest is paramount. In most large mammals sex interest and the capacity for reproduction are usually limited to certain periods of the year, a rutting period generally but not necessarily in the fall. In apes, monkeys, and man, on the other hand, the sex impulse and with it social cravings are more or less continuous.

After mating takes place the larger herds usually break up into smaller units. Occasionally pairs remain together as in human monogamous marriage; but in most cases the male is only a seasonal visitor, inclined besides to promiscuity. Most frequently, when the herd disbands, the adult males go off in one group and the females and young in another. When it is time for the cubs to be born the females usually isolate themselves and begin their own family circles, which may or may not join the others later.

Primate Societies

We of the New World may if we wish assume a petty conceit in that the monkeys of our hemisphere are on the whole far more social and agreeable creatures than those of the Old World. For instance large numbers of howler monkeys live in harmony and friendliness on Barro

Colorado Island in the Canal Zone. In 1934, Carpenter[11] estimated a population of between four and five hundred individuals on the island, divided into about twenty-five clans averaging twenty members each. One typical clan numbered two adult males, seven females, three infants, and four juveniles. Their society might be said to be communistic, in that any individual may lead the others; there is no permanent leader. Food is plentiful and consequently there is little competition. These monkeys are not pugnacious by nature, their minor differences being quickly settled by threat and by howling. They are well named, for their howls can be heard sometimes for three miles. In fact their howling is probably one of their strongest social bonds.

Similarly Kühlhorn[86] writes with great respect of the capuchin or cebus monkeys of Mato Grasso. The capuchins travel through the dense jungles in troops of from eight to eighteen individuals, all evincing a strong attachment to the group and a fear of becoming separated from their companions. They find each other among the trees by an enticement call which is as constant and distinctive but not as resonant as that of the howling monkeys. Their explorations seem to be limited to one territory and they progress through the trees in definite order, the half-grown youngsters in front, then the older animals of both sexes, the females with young, and last of all the leader, usually an old male but sometimes an old female. In either case the leader seems to direct from behind the movements of the troop, to turn aside the enemy where possible, to protect his charges, and to round them up if they are lost.

In striking contrast to these are such Old World monkeys as macaques (rhesus monkeys) and baboons. The former have been studied in their native haunts of southern Asia by Carpenter[13] and in 1938 four hundred of them were brought by him from India and released on a small island near Puerto Rico. Baboons have been investigated by Zuckerman[95] both in Africa and in an enormous colony transported to the London Zoo. The large troops of baboons are divided definitely into family units of the harem type. Pugnacity is general. Not only are the males selfish and brutal to their wives, but the females frequently abuse their young and snatch food from their hungry mouths.

Among apes, gibbons seem to be socially in a class by themselves. In Siam, Carpenter[12] found the social unit among them to be the monogamous family. Unfortunately this can hardly be attributed to the high state of their social development, to their comparatively close relationship to humans, nor to their ideals of marital fidelity. Both males and females are vicious in temperament and both are intolerant of others of

their own sex. In their effort to banish all rivals the males early drive away their own sons, as the females do their daughters. Both sexes are much alike in size, and in general seem to enjoy equal rights and responsibilities.

Under most difficult circumstances Nissen[43] made intimate observations of chimpanzees in their native jungles of French Guinea. These highly developed apes roam in bands of eight or nine, the unit appearing to be that of the polygamous family. Though one male is master, all members seem to be devoted to each other and despondent when they are separated. In studying the large groups of chimpanzees at the Yale Laboratories in Florida, Yerkes[93] found many instances of co-operation among these animals. For example they occasionally passed food to a chimpanzee in an adjacent cage. To some extent they took care of their sick and injured, sometimes pulling out slivers or extracting pus from sores. Similarly they would co-operate with him when medical treatment was indicated, and they seemed to understand and be anxious to help out in many experiments. One chimpanzee with a load of food too heavy to pull in alone would tap a companion on the shoulder and motion that a little help was needed. Then both tugged together to pull in the load. Two gorillas were also observed to help each other haul a log.

One of the strongest social bonds among apes and monkeys is love of grooming and of being groomed. This pastime, which always causes much mirth among visitors at the zoo, is often referred to as flea picking, though it is seldom concerned with vermin. Grooming is a much more accurate term. It chiefly implies cleansing the hair of dust, pieces of vegetation, and occasionally insects, but seldom fleas. Individuals often may be seen begging or demanding this attention which obviously brings them intense satisfaction. The desire of monkeys to groom each other is an instinctive one, apparently brought about automatically at certain ages by the feel of fur. Youngsters will start their grooming when stimulated by the touch of the fur of any animal or even by a tanned skin. Grooming may not be without its aesthetic appeal. It has been observed that a certain male macaque seemed to derive pleasure not only from tidying his female's hair but also from experimenting with her appearance, even to the extent of hair plucking.

No straight broad path of evolution leads from the lower animals or even from the apes to human society. Though we find in animals such institutions as monogamy, harems, and "co-operatives" it is probably only by chance that they resemble human institutions. Almost every conceivable type of grouping can be found in human society as well as

among animals; but there are vast fundamental differences between the two sets. Virtually nothing in animal society corresponds to human intellectual intercourse, and there is but slight premonition of that adherence to tradition which becomes such a power in human behavior. Both of these qualities stem chiefly from the possession of a language, which makes it possible for one individual to pass on the ideas which he has acquired from others or discovered for himself.

CHAPTER IX

SOCIAL RANK

IN HIS ESSAY, the *Conduct of Life,* Emerson wrote: "Every man carries in his eye the exact indication of his rank." Though eminent as a naturalist and philosopher as well as a writer, Emerson probably did not suspect that this observation was as true of many vertebrate animals as it was of man. Each chicken in the barnyard, each elephant in the herd has his own position in society and carries, as it were, the badge of that rank in his eye.

To some extent this fact is well recognized in a practical way by persons long in intimate contact with animals. Farmers have observed that when a new cow is added to a herd of cattle there will be much unrest and a long series of fights until the exact status of the newcomer has been definitely established—until she has settled down "in her proper place" in cow society. A New York State game warden has observed that deer on the range come to the trough in a very definite order. Individuals low in deer society must wait until their superiors have become satisfied and leave the table. Herds of wild horses recognize a leader. In a dog pack each dog has his place and rank. Dispersal of trout in a stream indicates a social gradation. The big trout usually settles in the most favorable spot, while the little trout who swims upstream to the big one's hole is immediately driven off.

Competition versus Co-operation

These individual differences and strivings toward mastery come about through competition between members of a group. We have just discussed the bonds that hold animals together and induce them to cooperate with one another. Competition, a continuous aversion for one another, is diametrically opposed to co-operation; like sex, it tends to break down the group, while co-operation builds it up. Any organiza-

tion is a continual struggle between co-operation and competition, between altruism and selfishness, socialism and rugged individualism. This struggle is keenest in the more loosely knit organizations. Social differences are less noticeable in the permanent, well-knit societies where long racial experience has proved that co-operation pays, and least evident among the animals which have no social organization. Among the last named everyone is frankly out for himself; he does not care where he stands with respect to his neighbor, for he is not interested in his neighbor; he will fight when his material needs are threatened but social ambitions are unknown to him.

Pecking Orders

The first extensive studies of the social stratification of animals were those of the Norwegian scientist Schjelderup-Ebbe in 1922. Observing common barnyard fowl, he discovered in them a definite plan of social structure which he termed a *pecking order.*

The rooster almost invariably stands at the head of his harem. He can peck any other individual in the group without being pecked back. Below this despot is a second individual who can peck the other hens but not the rooster; and so on in a descending line. Each can peck those beneath him in the social scale and not get pecked back, but it would be a grave error in etiquette and judgment to peck one higher in the social scale.

The individual high in the pecking order has a great advantage, for he can help himself first to food and threaten or drive away the upstarts who seek to share it with him. He allows these others to eat only after he is satisfied. He can mate with any females he desires or settle himself in any favored locality. Others may not approve of his actions but they have not the spirit to protest. Now and then an individual rebels but is promptly shown his place. For the most part the despot maintains his authority by bluff and threat, by that badge of office in his eye. Seldom does he have to resort to force. The Norwegian scientist believed (others have disagreed with him) that individuals at the top of the order were usually reserved, dignified personalities who got what they wanted without contention, while those at the bottom of the scale were vicious and eternally quarreling among themselves. Among hens, as frequently among people, the newcomers are pariahs against whom the whole community is arrayed until they have proved their worth.

Since 1922 scientists have studied these social distinctions in many

groups of animals and have found interesting variations in this type of behavior. Further work has shown that the pecking order, even in hens, does not always assert itself in a simple straight-line system by which one hen invariably pecks the one below her. Pigeons and shell parakeets studied at the University of Chicago seem to have triangular systems in which no one bird wins all the combats, but only a majority. Individuals who are dominant under certain conditions may in turn be dominated under other conditions. In this case the birds at the top of the order were said to possess a *peck dominance* but not a *peck right*. Their power was relative, not absolute. Peck dominance is considered an advance over peck right because it involves the recognition of other factors besides weight and strength; in such dominance psychological aspects may have their influence.

Though as a rule males seem to be more dominant than females, on many occasions the females manage to assert themselves. Among the Chicago parakeets, when the sexes were mixed after isolation, all the females dominated all the males. Here also a group of fourteen white king pigeons of mixed sexes were dominated by two aggressive, unmated females. Among most animals with social hierarchies females may be despots under certain varying conditions, and in these cases the dominance behavior of the female is in no way different from that of the male.

Class distinction is not marked below fishes. The recognition of social standing seems to demand a type of relative learning impossible without a well-developed brain. Among the vertebrates there is evident a certain irregular *evolution* of social dominance: from the straight-line pecking order where one individual is despot over the entire group and demands by threat or force the subjection of all others, to the higher types where the dominant animal is recognized as a leader rather than a despot and where there is a group loyalty to him which eventually acts as a social bond in holding individuals together. In the lower forms is found a system which recognizes only individuals, while in higher forms there is group sentiment and recognition. In the former case a pecking order disrupts social unity; in the latter it welds the group together.

Social Climbing Among Fish

In the Museum laboratory we have made studies of the pecking order in many varieties of aquarium fish—particularly swordtails[64] and jewel fish. We have had many tanks of these fish under close observa-

tion over a period of several years, and by tattooing them have been able to recognize the individuals and follow their social triumphs and setbacks. It was found that many fish devote most of their energies to trying to improve their social status. Every fish by threat or blow seeks to gain dominance over every other member of the school. Early in life swordtails develop a straight-line "nipping" order similar to that of hens. One fish can strike another without receiving a blow in return, and the second can pass the blow to a third. Fish at the top of the social ladder have first choice of mates; they also enjoy easier access to food, as shown by the fact that in periods of famine they lose less weight. The larger, heavier fish usually have an advantage, as do those more brightly colored and energetic. A swordtail fish whose sword is cut off will generally drop in the dominance scale, though he may later regain his position by fighting. All this is probably a matter of subtle learning, each individual having found by experience or observation just how far it is safe to presume upon another's authority.

Apparently every member of the school knows every other as an individual, and every subordinate seems eager to grasp the first chance to overthrow the despot. A determined assault upon him frequently brings a complete revolution within the group and a new position in the order for each individual.

A revolution may also occur when a large newcomer or a group of new fish is introduced into the aquarium. In these fracases there is no group cohesion; everyone fights for himself against old comrades and newcomers alike.

Dominant fish do not permit subordinates to fight near them without seeking to "punish" them. From this it must not be assumed that the despot has any sense of civic responsibility; apparently it is only that the gestures of an aggressive subordinate stimulate the dominant fish to similar aggressive behavior. In fact every individual tends to attack any subordinate who threatens the fellow above him.

Among swordtails, as among most social animals, the dominance hierarchies are disrupted at sexual maturity by the sex drive of the males. There results a new order, with the females confining their blows to females and the males to their own sex. This "chivalry" is probably due to a latent sex interest in the male which keeps their aggressive drive against females in check.

In nature the social distinctions of fish are dramatically revealed to the explorer who descends in a diving helmet into the fantastic undersea world. One summer, as guests of the Oceanarium at Marineland in Florida, we studied the coral-reef fishes off Miami. An old wreck was a

favorite haunt to which we often descended with our hands full of hacked-up marine crayfish as bait. Holding out some bait to an opening in the wreck, we would soon see a large, protectively colored Nassau grouper emerge, seize the bait, and immediately retreat to his hiding place. Here was a non-social animal who did not have to worry about upholding his social position, since he did not associate with others. We saw him, for instance, chase a gray grunt out of his hole.

We were especially interested in small schools of doctorfish who also hid much of the time in the crevices of the coral or of the wreck, but who usually had company in their retreats and in their frequent outside sallies. These fish were not at all interested in our crayfish bait but fed by browsing around with their small teeth. White spots on their tails act in dim light as social bonds or flash signals. Other white spots indicate the presence of a lateral dagger or spine with which, evidently, they fight when necessary to uphold their social positions. There seemed definitely to be a dominance scale among these fish. The largest one sideswiped with his tail any others who wandered from the fold.

Another loose-schooling group of fish with a probable "nipping" order were the grunts. We often saw two individuals separate from the school, expose the red lining of their mouths, and fiercely lock jaws—undoubtedly in an effort to establish dominance.

Rank Among Lizards

Among colonies of Anolis lizards running free in the greenhouse there is a certain degree of social stratification on a territorial basis.[28] During the greater part of the year each lizard keeps largely to itself in a private retreat on some shrub or roof beam. But during the breeding season social contacts become closer and competition infinitely stronger. Mature males appropriate as much space as they can control and varying numbers of females are attracted to these areas. In each group an immediate temporary hierarchy is established with the male a despot over his harem and the females ranking below him. This type of hierarchy, which occurs only during the breeding season, is known as *sexual dominance* and should be distinguished from the more general *social dominance*.[52] Among fish, where both occur, one type can be definitely separated from the other; thus when the temperature of a tank is lowered sexual dominance disappears, but social dominance is retained.

A mature male holds his position largely by size, by brilliance of

coloring, by erecting the dewlap on his throat, and by bobbing up and down threateningly before his rivals. Now and then he has to fight. If the dominant female in his territory is sufficiently strong and belligerent she may succeed temporarily in monopolizing the attentions of the male. This "monogamy" is seldom enduring, however, due to the persistent competition of harem associates and visitors. A new female entering the harem would ordinarily rank low among the residents, but the lord and master is little influenced by the social jealousies of his wives. His favorites are not necessarily those high in rank; indeed he is likely to have an eager eye for the newcomer. When a female low in rank is especially favored by the male she may rise in the scale, probably owing to her stimulation and added self-assurance, not to the acknowledgement of the others. Like many humans, she raises her social status by marriage.

Because previous experience enters so fully into the social life of these lizards we find that if a group of males is thrown together in a large cage it is not always the largest individual who becomes dominant in the cage; nor, if the despot is removed, is it always the next heaviest lizard who then assumes authority. Previous social contacts, and stage in the breeding cycle, may radically upset the natural stratification. It may be pointed out that what appears to be social recognition may possibly be only a natural reaction to conditioned behavior. Thus the very servility of an underling lizard who was consistently suppressed in the past, rather than the overlord's memory of previous conquests, may incite the latter to further attacks.

Pecking Order in Birds

Personal sentiments, with their unpredictable attractions and prejudices, often complicate social relations. A rooster will favor certain hens rather consistently, though there be no difference discernible to the human eye, and though another rooster will display an entirely different choice. Individuals may develop lasting antagonisms to one another. On the other hand, two tyrannical geese became close friends and together held authority over their pond.

Undoubtedly some sort of personal bond is established between the rooster and the members of his harem. His leadership is not based exclusively on force; it may have elements of protection and consideration. Though he rarely feeds a hen, as some cocks do, he frequently calls her to food, then picks it up and drops it. When he spies a bird of prey

flying overhead he calls to his hens and hustles them into the cote, himself entering last. Similarly the despot in a colony of jackdaws will often seek out and lead home a wandering member of the flock.

As with lizards, many a female bird has bettered her social position through "marriage." A male jackdaw returned to Lorenz' colony after several months' absence and immediately succeeded in making himself master of all the others. For mate he took a small, retiring female hitherto a social nonentity. The very next day this female was observed successfully browbeating the former despot. Not only did all the other jackdaws at once seem aware of her new importance but, most surprising of all, she did herself. Her whole attitude was changed from timid withdrawal to dignity and self-assurance.

Among the immature herons on the Museum roof, striving for social position could be observed and seemed to be related to head position. When a pair of the young birds are together they spend much of their time performing a "billing ceremony," the bird which holds its head higher being dominant. This stretching of the neck for dominance is doubtless an extension of infantile competition for food: as the parents brought back food to the nest the youngster which could stretch its neck highest obtained the most sustenance and consequently the greatest strength and prestige.

It has been observed that when the two sexes among birds are equally large and strong but the male is more decorative, he becomes dominant; otherwise either may be dominant. Often a male may lose his prestige with the loss of his breeding plumage, just as the swordtail fish suffers social ignominy with the loss of his sword. There is a related case of an artificial unicorn produced experimentally by transplanting a horn bud upon the brow of a cow. Horns being important in cow society, this unusually decorated individual was accepted as undisputed leader of the whole herd.

Leadership in Mammals

A dog's relation to his master is the outcome of his heritage of instincts. He has transferred to the human family his social impulses, his primitive urge to join a pack, and his instinctive recognition of a leader. Inasmuch as his master has control of the food and the punishment, he recognizes in him the overlord. A large powerful dog occasionally attempts to rebel against this overlord; the owner has to confirm the fact that he is master. A well-trained dog need not be a browbeaten dog.

Subordination to a master is natural for him, though in the wild that master would have been one of his own kind.

In some animal societies leadership is entirely divorced from despotism. Though he may have won his way up by force or bluff, the overlord often is the first to run when real danger threatens. It is the individual most alert to danger, most mindful of his fellow creatures, most ingenious in escape, who is followed unconsciously as *leader*. Thus Darling[17] found among the red deer of Scotland that the alert and dignified carriage of an experienced mother with young commanded the respect and obedience of the herd. The leader of a herd of caribou was reported by Dugmore to be an old and experienced female.

In any group the despot may hold sway for years or only for days or hours. The dominance is generally less permanent where a female is recognized as "overlady," for when the breeding season arrives she normally subordinates herself to a male in mating and does not assume control again for some time. Female dominance in animals is believed by some to act against the evolutionary survival of the group, for if the females are too aggressive the males are afraid to mate with them. Dominant males, on the other hand, force themselves upon as many females as they desire.

There is undoubtedly a fundamental relation between dominance and sex. Aggressive behavior appears to be not only characteristic of but also essential to the masculine role. In many forms it is augmented in both males and females by the administration of male sex hormones. Subordinate behavior is often accentuated by treatment with female hormones. Abnormal aggressiveness results in sadism—persecution and violence even to the point of killing; abnormal subordination leads to masochism, a craving for abuse and suffering. Both are found in human psychology and criminology. It is therefore probable that further study of the dominance-subordination relationships among animals will lead to a deeper understanding of human social relations and perversions, and to wiser methods of dealing with them.

Though the despot is recognized in most mammal groups, there often seems to be no further stratification of society below the top, neither the straight-line system as in hens nor the more complicated systems found in other birds. This was found to be largely true of white mice and also of cats studied in the laboratory of New York's Psychiatric Institute.[91] One cocky and swaggering tomcat, by no means the largest in the assemblage, would attack each newcomer, male and female alike, with aggressive movements identical to those of sexual forays. In no time the newcomer was cowering with the other victims, afraid to cross

the master in any way or even to eat until the master had had his fill. When the despot finally became ill and was removed peace and communism reigned for a few days. Then the next most aggressive male began to strut and assert his command in exactly the same manner.

Dominance Among Primates

Especially among primates we find social strivings that are amazingly suggestive but not necessarily the equivalent of similar traits in human behavior. It is, of course, most difficult to understand fully the delicate personal adjustments of these active animals in the wild, despite months of patient observation. By watching baboons or other Old World monkeys in a zoo, however, even the casual observer can readily identify the overlord.[39] Pompous and self-assured, he goes about his activities with no regard for the needs and feelings of those about him, who constantly and timorously look to him for approval. They dare not do anything contrary to his wishes. The overlord has first chance at the food, enjoys his choice of mates, sleeps or wanders about where he pleases, and bullies any subordinate against whom he happens to have a grudge. If he wishes to be groomed, or to groom another monkey, he will resort to beatings if necessary to enforce his will.

Often these privileges are asserted purely as symbols of dominance, to emphasize his mastery. Though not hungry, he may refuse to let the others feed, at least until they have given some token of submission as if to assure him that they are grateful for the privilege bestowed upon them. It is all too reminiscent of self-righteous man, happy to confer favors upon those who know their place and are duly appreciative.

Among Old World monkeys the overlord is a stern disciplinarian in controlling the behavior of his subordinates. If fighting occurs he will come down from his perch and chastise them. Such intervention (also observed in fish, lizards, song sparrows, sledge dogs, et cetera) is probably not a conscious effort to restrain the group but an instinctive response to the stimulus of seeing others fight. Under the despot's iron hand the others not only cringe in fear but sometimes are literally "scared stiff" and lose all muscular control. Only during periods of play is discipline relaxed; then they all romp together without restraint or discrimination.

The great apes and New World monkeys do not fight to any great extent among themselves, nor do they appear to be jealous of one another. The brutal despot is conspicuously absent in clans of howler

monkeys, several males often taking turns in leading their associates through the treetops.[11]

In chimpanzees true friendliness and a simple sort of altruism emerge. Families live together without viciousness. The male expresses dominance, but never violently; it takes rather the form of teasing and play. The subordinate female seldom shows signs of fear. When her mate becomes too rough or teases her beyond endurance she may run at him screaming, expressing her resentment in no uncertain terms. In Old World monkeys such an outbreak would constitute a serious affront to the male's prestige and the female would be ruthlessly suppressed and punished. Instead, the male chimpanzee retires with a grin, as devoted to his mate as ever. It is generally true among these higher primates that the dominant individual is looked up to as a protector, not feared as a tyrant. Grooming among them is marked by mutual satisfaction and is not regarded as an enforced service. They are friendly among themselves and often are equally fond of humans.

Side Lights

No one as yet has satisfactorily analyzed the exact nature of dominance; evidently no one has determined even in his own mind whether it is an attitude, an emotion, an instinct or drive, or whether it fits into some other category. Nor is it known whether subordination is a quality in itself or merely the lack of aggression. Certainly dominance is based upon hereditary factors, both physical and psychological, but it is also greatly influenced by experience. Size is probably the most important single factor in commanding obeisance, though not the only one. Among animals of the same size confidence, cockiness, and boldness are often deferred to even when unsubstantiated by superior ability. Yerkes found that social rank among his apes was determined by age, vigor, alertness, resourcefulness, and temperament. Bluff also is highly important. So is familiarity with the home territory; the newcomer is always at a disadvantage and must submit at first to a modest position, though he may later work up in the scale. Between two monkeys dominance may often be established upon the first meeting: they look at each other; the one who looks away first is subordinate to the other. Usually there is no physical violence; occasionally fighting is necessary to settle the issue.[59] Degree of intelligence may also play a part in establishing dominance. In an attempt to correlate intelligence and social position, intelligence tests were given to a group of six hens. The despot

was usually found to have the highest I.Q., but among the subordinates there seemed to be no agreement between social status and I.Q.

If a despot is ill or seriously injured an individual of lower standing is likely to revolt and usurp the throne. All too frequently the subordinates will take advantage of the illness or injury of a despot to bite and bully him to death.

Even a strong master may sometimes be overthrown by an organized rebellion. On one occasion a young female rhesus monkey managed to enlist the support of several subordinates against their common master. They attacked him, bullied him, and broke his spirit so completely that he became subordinate to every member of the group. The young female became dominant and wreaked her vengeance upon him without pity. Yet when the two were placed together in a separate cage she lost her courage without the support of her former champions and again assumed the subordinate role.

The custom of "passing the blow" seems to be as common among animals as among humans. When an individual is attacked or threatened by his superior the impulse is not to hit back but to take it out upon an inferior. Each one passes the punishment to the one beneath him until finally the youngest screeches for the leader, who puts an end to the fracas. This passing the blow occurs again and again in chickens, in fish, and in primates. It is also said that a member of a dog team when bitten or whipped assails the dog in front of him, without reference to the real source of the attack. Incidentally, the leading dog always holds his tail straight up; the others' tails hang low.

This passing of the blow might seem to work to keep the underling forever down; but there are other ways in animal society by which one can go up. Thus a goose rather low in society may pick out a scapegoat and scream and threaten him as loudly as possible. If he cackles loudly enough another higher goose will come to his rescue and help him abuse the scapegoat. An emotional bond is thereby established between the attackers, and the instigator of the trouble is raised in goose society.

Portielje[79] mentions a similar "cry-baby" propensity among the young baboons in the Amsterdam Zoo. They howl and scream at the slightest threat, thereby awaking the protective or parental instinct of the despot, who rushes indignantly to their defense. They soon observe the success of these tactics and appear to use them deliberately to extort favors from their comrades, who fear the despot's wrath.

Respect for superiors may have its educational aspects. When a chimpanzee is given a cocoanut for the first time he has great difficulty in opening it to get out the meat. But let him sit next to a chimpanzee

who knows how, and he will learn within a few minutes—provided the more experienced individual stands above him in the social scale. If the teacher is of low status the student will learn very slowly.

Species Dominance

There may be a rank order not only among individual animals but among different species.[27] To illustrate, the European ibex, chamois, and roe deer live in overlapping territories and are biological competitors. This produces a "biological hierarchy" wherein the chamois must retreat when the ibex raises claim to a portion of the land occupied, and in turn the roe deer must retreat before the chamois. In the same way the golden eagle dominates the common raven, which dominates the Alpine jackdaw.

Some groups of animals do not seem to have such biological competitors. Consequently they lack any sense of group inferiority and are never found subordinating themselves to other animals. This is true of the American bison and of the ibex. It is a factor of tremendous importance in the domestication of animals and in the training of them for circuses, two processes demanding that the animal subordinate himself to the human. Trainers have long realized that animals low in the social scale can be more easily induced to submit to man and to execute his orders than can socially superior animals. Though the ibex becomes tame, Europeans have never been able to subordinate it to their service. Similarly the American bison has seldom been domesticated despite long efforts by Indians and whites. It is believed that the ancestors of the horse, the dog, and the cow, which have so long been submissive to man, were not large powerful types but rather inferior ones accustomed to adjusting and submitting themselves to superior groups.

Several morals for humans may be drawn from a study of dominance in animals. First it should be frankly recognized that in a competitive social world class feeling is a natural deep-lying instinct. It is the reason for much that is unfortunate in human society, though it should not be used as an excuse for further unhappiness. In other words social standards should not depend upon what is instinctive but on what is best in the artificial environment created by our own confused intelligence. Man's instincts for food, sex, curiosity have to be controlled; so, too, should his instincts for self-assertion and aggressiveness.

Yet neither human nor animal society can overlook the fact that individuals differ enormously in their talents and capabilities. A success-

ful society must encourage and make the most of its gifted individuals and not expect too much of the poorly endowed. Dominance is not always synonymous with ability in either animals or humans. All too often the individual in the highest position is neither the ablest nor the most intelligent.

CHAPTER X

STAKING OUT TERRITORY

Property Rights

MANY ANIMALS appear to have a highly developed sense of property. At one time or another they display a well-marked tendency to take unto themselves as much territory as they can lord over or defend against rivals. This domain they seem to regard as a definite part of themselves, and they resent any intrusion upon it.

Moreover, these claims are recognized by their fellow creatures. The one who first occupies a certain territory usually is accepted as its rightful owner; and the conviction that he has a right to his property seems to give him added strength as well as assurance in defending it even against stronger and more aggressive trespassers. On his part the would-be usurper, faced with such moral indignation, definitely suffers from a feeling of guilt or fear, and on approaching another's domain is generally scared away at the slightest threat of violence. If it comes to combat, an invader will not fight as hard to steal another's property as he would to defend his own.

Ecological Niche

The strong attachment animals show toward certain areas is based on many factors, physiological as well as psychological. Underlying all other considerations is the need of an animal to maintain certain environmental conditions required for the successful functioning of his body. A sea animal must live in salt water; a cold-blooded vertebrate cannot survive in extremely low temperatures. Sometimes the living requirements of an animal are very precise, demanding an extremely restricted environment. Students of invertebrate life have found, for instance, one short stretch of sea beach to be divided into many zones, parallel with the tide line, each zone being inhabited by creatures many of which differ from those of neighboring zones as distinctly as if they were on

separate continents. One group of animals found abundantly at the high-tide line will give way to another group a few feet, even a few inches, below that line. Each species requires its own particular humidity, salinity, temperature, and its special type of terrain and food supply.

These exact relationships of an animal or a plant to its environment form the basis of the study of ecology. The specific environment necessary to the functioning of the animal's body is called its *ecological niche.* In general lower animals are much more closely bound to a limited area than higher animals.

Personal Territory

Not only is an animal's existence limited to a certain ecological niche or desirable locality, but within this range most animals either individually or collectively take possession of fairly well-defined *home territories.* The reasons for which they prize these estates differ according to species and season.

Often a definite station or home is situated in a central locality and the area of varying extent around it is defended as a *feeding territory,* the practicality of which is obvious. It is important for all of us to be familiar with the food supply of our neighborhood, to make sure that such supply exists and is maintained. Moreover, the division of a large feeding area into smaller territories is of value in limiting the population of any one section and thus assuring the equitable distribution of available supplies. Animals who live in large groups seldom are dependent upon a limited source of food. Colonies of gulls, though nesting together, spread out over the water for their sustenance. Bison and deer graze over large areas. The feeding territory of a lizard probably is limited to a few trees and a few yards up and down those trees, while the foraging area of an elephant may extend for many miles. In summer, when small game is abundant, a fox will confine his hunting to fairly restricted areas; but in winter, when most small animals are in hiding or in hibernation, he has to extend his range many times over. Incidentally it seems to be true that "a fox will seek distant chicken coops." It has been repeatedly observed that a henyard in very close proximity to a fox den will seldom be disturbed by the fox. The theory is that the fox regards the henyard as part of his territory—or at least neutral ground—and hence it is "against his principles" or, more correctly, contrary to his training and his instincts, to attack here except in defense.

Neutral ground is another phase of the animal's recognition of prop-

erty rights. Though individuals or groups of animals may bitterly resent intrusion in their own territories, just outside these sacred precincts there often seems to be a common area where they meet their neighbors and even their prey with amity and friendliness. The case is cited of a male swan who furiously rejected the advances of a strange female when she tried to come into his breeding territory, but fell a victim to her charms as soon as she had retreated beyond the vicinity of his nest. Even in compact colonies of birds, where the individual territory can be measured in inches beyond the nest, a narrow zone of neutral ground may exist. This device has been observed to function among herring gulls to protect the young birds who occasionally stray from the nest. These gulls are colonial but their nests are very widely spaced from one another. Though the young wander around the sand rather freely they seldom go beyond the bounds of the family territory. If they stray onto neutral ground they are still unmolested. But if they wander too adventurously into the territory of other birds they are not recognized as nice neighbors' children and are attacked as interlopers and devoured as legitimate prey.

Furthermore, the size of territory may depend upon the irritability or the emotional state of the animal. Herring gulls have greatly reduced territories when protected, but should a catastrophe occur, such as a fox taking the young, the parents spread out into much wider areas, sometimes fifty feet in diameter.

Rugged individualists of human society should not be tempted to argue their case on the basis of this natural instinct of animals to acquire and protect personal property. It is never safe to draw sweeping parallels between animals and humans. In the animal kingdom can be found all degrees of property recognition; and even the same animal may often be highly inconsistent, though his attitude usually is appropriate to the situation. Many species, including wild horses, hares, and mountain sheep, seem to be vagabonds and show no interest in established residences. Furthermore, as we have seen, there is a great deal of successful socialism in animal society: colonies of birds, troops of howler monkeys, hives of bees may own property in common and defend it in common.

Reproductive Aspects

The average person thinks of territory chiefly in connection with the attachment to home and familiar surroundings; the field psychologist

uses the term chiefly in connection with a sexual phenomenon. We have just seen that the urge for territory differs considerably according to the season and the emotional state of the animal. Though many animals live in large groups amicably during the fall and winter and seem to enjoy and profit from one another's company, as soon as breeding season approaches the whole attitude of the individual changes. The male, especially, becomes very active, aggressive, and jealous of his male companions—seemingly intent above all else upon ridding himself of their presence. Thus to the student of animal behavior the word "territory" usually implies *sex territory,* an area appropriated and defended by a sexually excited male, in which he can advertise his charms and his love and to which he can lure some susceptible footloose female.

Among most of the songbirds that enliven our gardens and native woods during the spring, the males precede the females from the south and place themselves in some conspicuous shrub, the "singing post," where they sing exuberantly and display their plumage to the utmost. Once established, they proceed to drive away by threat or force all rivals who try to set up calling stations too near them. However, a stranger who resolutely enters the territory and neither retreats nor fights when threatened is welcomed as a female and accepted as mistress of the domain.

Sex territory, so characteristic of most birds, is found also in most egg-laying and nest-building vertebrates such as certain fish and lizards. Here, too, it arises from the sexual interest of the animal in an area suitable for nesting and functions primarily to test sexual readiness of the female and to make possible the formation of domestic ties.

Nesting territory is the area appropriated and defended for the actual building of the nest and rearing of the young. It must have available not only building materials but a plentiful food supply for the rapidly growing young. Nesting territory is not to be confused psychologically with sex territory. The distinction may seem superfluous in species such as the song sparrow, where the two territories coincide. Nevertheless, sex territory is a sex responsibility, nesting territory a parental one. Defense of the former is against rivals; of the latter against enemies threatening the nest or the eggs. Endocrine studies indicate that the two territories have a different hormonal basis. Defense of the sex territory seems to be brought on in nature by the male sex hormone, especially active during the breeding season. It can sometimes be induced in females by the artificial administration of the male hormone. Defense of nest and young is stimulated by the pituitary hormone, *prolactin,* and

can be regulated in the laboratory by injecting varying amounts of this chemical.

Song Sparrows

Probably no one in the United States has followed the movements of birds with more patience and understanding than Mrs. Margaret M. Nice, "amateur" ornithologist only in the original sense of bird "lover." By means of bird banding she was able to follow over a period of years the domestic vicissitudes of a dynasty of song sparrows who nested about her home in Ohio, and with delightful intimacy she has written of the territorial struggles of these cheery birds.[42]

The first spring of her study a mild-mannered male song sparrow whom she named Uno laid claim to a definite area around her house, while the more aggressive 4M established himself in the lower part of the garden and the meadow beyond. Early the second spring, however, 4M arrived from the south about a week earlier than Uno and took over not only his own territory but that of his erstwhile neighbor besides. Uno, returning to find himself crowded out of his own estate, protested vehemently in song and puffed out of his feathers belligerently. 4M tried in vain to scare and chase him from his rightful domain, but mild little Uno refused to be dislodged. A fight became inevitable, ending not in bloody defeat for Uno but in his convincing the intruder that he would not stand for such thievery. 4M retired to his own territory and each continued to sing unmolested by the other.

For almost one week Uno and 4M continued their singing, often averaging seven songs a minute for long periods of time. As song-sparrow migration was at its height, the two property owners had a dreadfully busy time keeping transients off their land.

Then all at once the birds ceased their singing; their matrimonial advertisements had been answered. Uno was seen approaching a strange song sparrow. When he threatened, the newcomer only flipped its wings and chirped, "Eee-eee-eee." When attacked, the newcomer did not budge. She was a female, later to be known as Una. As she became at home in the territory she defended it almost as vigorously as her mate, even uttering a squeaky song on rare occasion. In defending their territory their hostility was most marked toward other song sparrows, though, we are told, eighteen other species, "ranging in size from the ruby-crowned kinglet to the imposing chewink" were "hustled off by Uno, and eleven of them by Una."

Territory is not necessarily a hard and fast concept. There may at

times be a great deal of trespassing back and forth. Uno and Una had from the first a hankering for 4M's rosebush and often sneaked into it, sometimes unobserved and sometimes to be driven off in fury. In the fall there was far less quarreling. Territories were no longer defended. The individualists had to some extent become socialists. Uno apparently went south for the winter with his pals, but 4M stayed in the garden all winter, often eating weed seeds in company with tree sparrows, juncos, and cardinals.

In February the urge for reproduction again seized 4M and again he guarded his territory and appropriated Uno's. Once more Uno returned to find 4M in possession. This year, however, he seemed more confident; and 4M was perhaps distracted by a new mate. After a few harmless skirmishes Uno succeeded in re-establishing his claim, including the much disputed rosebush. In another two weeks he, like his neighbor 4M, had accepted a new wife. Six days later Una arrived but did not seem disturbed to find her hearth occupied by another. She easily adjusted herself to a new home and a new mate in the near neighborhood.

Sunfish

Over a period of years we have observed in the laboratory similar though not identical territorial behavior in Siamese fighting fish, in jewel fish, in Anolis lizards, and in black-crowned night herons. At Lakehurst, New Jersey, we have made field studies of the fence lizard and on the banks of small ponds throughout that state have sat for hours watching the proprietary antics of the sunfish.[47] In the lovely village of Saddle River, New Jersey, several famous water-lily farms attract suburban dwellers—especially the proud owners of goldfish pools—from far and near. Clear streams have been dammed and diverted into rectangular pools spread out over the meadow like a checkerboard. Their surfaces are brilliant with enormous gaudy water lilies and lotuses from all corners of the world, while beneath the exotic blanket swim goldfish of all sizes and degrees of brightness, along with other wild and cultivated fish, polliwogs, and turtles.

In July the shallow edges of these pools are dotted with the "nests" of little sunfish, lovingly known as "sunnies" by the boys who, despite their affection, catch them with bent pins and string. The male fish appropriate certain territories and in the middle form "nests" by patiently and constantly sweeping away with their tails all silt, sticks, and pebbles. These clearings are readily evident to the visitor strolling along

the bank. Less evident but even more interesting are the watchful males who lurk, usually in partial concealment, with intent eye on their property, ever ready to sweep away the drifting silt, chase unwelcome interlopers furiously, or greet a female visitor. When an intruder approaches, the brightly colored males prick up their "ears" or opercular flaps, spread out their fins, and try to "look big" to scare away the rival. If the intruder retires to neutral ground—about four feet away—the master is satisfied and does not pursue him further. But if the visitor is a male and has the audacity to return the threat or to trespass within an invisible two-foot boundary, the argument turns into fierce combat.

It was quite simple to instigate a violent attack merely by placing a mirror at the side of the nest. Seeing his handsome reflection, the owner naturally assumed it to be an extremely bold rival who should be promptly dispatched. (Many persons will have observed, perhaps without realizing it, similar mistaken behavior in birds. A robin, nesting near a house or a garage, often will mistake his reflection in a window for a rival and turn again and again to attack it. He is not trying to get through the transparent window, as the watcher may suppose, but is protecting his territory from an imaginary rival.)

The female sunfish is not so passive a bride as the female song sparrow. If she likes the looks of a certain nice clean nest she enters with confidence and starts swimming around it as if it had always belonged to her. The male, all excited and easily enticed by her sinuous movements, follows her round and round the nest. So susceptible is he to these movements that he will follow a dead fish on a string, a paper model, or even a leaf on the end of a cherry switch, provided it swings at the desired rate. If the movements are rapid, jerky, straight rather than circling, his defense mechanism reasserts itself and he again resorts to attack.

The mutual swimming movements are very important in stimulating and synchronizing the egg laying of the female and the fertilization of the eggs by the male. After egg laying the female disappears, leaving the male to guard and cleanse the eggs as he had the nest.

Mammals

In the opinion of Burt[10] the majority of mammals, but not all of them, lay claim to definite areas and regard them as their own. In determining his definition of territory Burt states: "The best and simplest of these, in my mind, is by Noble (1939): 'territory is any defended

area.' Noble's definition may be modified to fit any special case, yet it is all-inclusive and to the point."

Among mammals territory is more a matter of home defense than it is of sexual jealousy. Burt points out, however, that territory should not be confused with *home range,* the area which an animal or a group of animals frequent but which they do not monopolize or defend against others of their species. Woodland deer mice limit their foraging and their activities to definite areas with which they are familiar, but they are not intolerant of their neighbors. The home range of an opossum is restricted geographically but not socially, often overlapping that of other opossums.

Other mammals, however, do claim personal territory and defend it jealously against all intruders. Burt has observed that chipmunks are by nature unsocial; during three seasons he watched an old female drive all comers away from her domain beneath his house. Any chipmunk within a fifty-yard radius was put to flight, but beyond that limit she was not at all concerned. The viscachas of South America, though living in close communities, have, like many colonial birds, their own small holes or nests which they ardently defend. Groups of apes and monkeys, however, apparently own territory in common and unite in defending it against other individuals or groups.

Territorial law is also applied in training animals for circuses. Hediger[20] states that the experienced tamer enters the show cage ahead of his animals in order to demonstrate that *he* is taking possession and must be regarded as master. The animals who come in after him enter a territory already occupied. In getting bears and lions accustomed to working together it is important that the bears, less aggressive than the lions, be made to enter the cage first.

Psychological Factors

What instincts, emotions, associations influence an animal in his attitude toward property? Most important of all, no doubt, is his need for self-preservation. He has a feeling of security if he stays in an area thoroughly familiar to him, for practical strategic knowledge of the terrain is always of value in self-defense. In many cases his security is enhanced by a home that is also a stronghold, be it a burrow, cave, or nest.

Scientists[86] have reported a talented showman who could train wild mice for country fairs in less than half an hour by exploiting the mouse's

fears and his urge to seek shelter. He first allowed the mouse to become familiar with an artificial mousehole in a bag slung around his neck. The mouse immediately adopted this as a refuge and quickly returned to it along a cord whenever he was placed on the experimental table. The trainer gradually put sticks, small ladders, and other apparatus along the homeward path and soon had the mouse unwittingly performing a great variety of tricks in his zeal to get back home.

Another factor often cited is that of sheer laziness, the feeling that it is easier to remain in a familiar niche than to form new habits. In the animal world as well as the human we find for the most part an eternal satisfaction with the status quo, an unwillingness to give up present security and reasonable comfort for future uncertainty.

In addition certain creature comforts crave satisfaction in a home or home territory. The squid, for illustration, is thigmotactic—likes to feel himself tight up against as many surfaces as possible. To him a happy home is a crevice in the rock into which he can squeeze himself snugly. In France, where squid are commonly eaten, fishermen are often seen poking among the rocks at low tide to pry the squid from their comfortable beds. The earthworm dislikes the sunshine; he needs a home that is dark, and he travels abroad chiefly at night. However, Von Uexküll asserts that the mole digs his home in the ground, not from an antipathy to light but because he is uneasy in a draft. If placed in an experimental box with dirt walls and a glass ceiling, the mole will appear to be as content as if surrounded by soil.

Home may even be cherished as a retreat from the madding throng. All creatures have something akin to our being on our guard when with others, and to our feeling of relaxation when we are for a time alone. We, too, often defend our homes from others simply because their presence is irritating to us. Young English robins take possession of *isolation areas* with the evident desire of enjoying their own company in peace.

These feelings of familiarity and security, together with the creature comforts of home, and no doubt many agreeable associations, gradually build up in the animal what we would call a love of home. Brückner has said that an environment, more than affection, welds. "The attachment which lasts throughout the mating time of large birds which are monogamous throughout their lives is due as much to the nest as to the partner," he declares. This is perhaps also true in human society. Advisers on marital relations often urge young couples to acquire property, to buy a home and furnishings, in order to cement more solidly their personal affection.

Homing and Migration

Though animals may make extensive journeys away from home—by accident, migration, or other factors—nevertheless they possess a remarkable fidelity for the spot they have identified as their own. Moreover, they reveal an extraordinary ability to find their way home, often over distances and terrain which would be hopelessly bewildering to humans. As Mayr says of birds, "It seems as if the bird were tied to his home with an invisible rubber band and that, no matter what you do with it, it will be pulled back."[40]

The exact nature of the homing instinct continues to defy explanation. In desperation many naturalists have sought to explain the mystery by attributing to animals a sort of "compass sense" which directs them in their travels. This is sometimes referred to as a sixth sense, assuming erroneously that there are only five other senses, when in fact there have already been described about forty. Most naturalists are of the opinion, however, that animals do not possess a compass sense; that their amazing talent for orientation is due to an extremely sensitive adjustment to the usual sense stimuli.

Some authors explain homing ability as a sort of retracing of a learned route, an ability through some organ such as the semicircular canals to keep in mind every turn and forward movement the animal has made. Others have suggested a magnetic sense, an ability to orient according to the magnetic fields of the earth. There are many reasons why these theories do not hold. Frankly, no one knows!

The most familiar and impressive illustrations of homing come not from nature but from animals which have long been associated with man. Thousands of years ago the homing ability of pigeons was recognized and ever since then these birds have been especially bred for flying power, visual acuity, and strong attachment to cote. Today pigeons are carefully trained to find their way about over ever-increasing areas. They are even trained by the Signal Corps for night flying, for homing in an airplane, for carrying two-way messages.

Astounding, too, are the accounts told by owners of dogs or cats which, lost or transferred to new localities, uncannily have found their way back to their original homes. These cases, authenticated in many instances, perhaps give us a magnified impression of the tendency of animals in general to return home from far away. It is the exceptional case that we hear about; little is said of the many lost pets that never come home.

A certain amount of experimental field work has been done, as for instance with terns, starlings, swallows, dogs, cats, bats, field mice, squirrels, crabs. These investigations confirm the existence of a remarkable geographical sense but have not as yet analyzed its nature satisfactorily.

The attachment to home is not confined to higher animals but is found in many lowly organisms. Limpets are small single-shelled mollusks that sit tight and fit tight on rocks along the shore. So closely are they associated with their own home spot that the shell is minutely carved to fit into all the small irregularities of the rock surface and it is almost as if they were growing there like oysters. Yet they have not lost their power of locomotion. They browse around to some extent, feeding upon algae, but in general they stick to their home site, which soon becomes neatly scarred from their presence. If removed by a curious experimentalist, they may return home from a distance of more than four feet. If one limpet is placed on the niche of another the latter soon pushes him off. A lost limpet seems to retrace his path exactly, evidently guided by contact sensations. He is virtually blind but has sensitive feelers on his head.[80]

In trying to solve the mysteries of *migration* the psychologist is confronted with the problem not only of how animals get back home but of why they start off on their long journeys. On the whole, migration strikes the naturalist as a most sensible process, enabling the individual to live in the most nearly equable temperature throughout the year and providing a means to an abundant supply of food and other favorable conditions. Yet we cannot expect animals to be so foresighted as to realize this. In making their journeys they are not propelled by "common sense" nor by a fear of cold weather or famine. Most of the birds who go south have never known snow and ice or suffered from a dearth of insects or berries.

Typically, migration is a shifting between breeding ground and another area not associated with breeding. Migration toward the breeding site is associated with the enlargement of the gonads and may be considered as part of the reproductive cycle. It would be impossible without the homing instinct. The fall migration, on the other hand, is probably a generalized tendency to follow gradients of temperature, light, and food.

Though we think of these long seasonal journeys primarily in connection with birds and mammals, many lesser creatures have separate breeding and feeding grounds. Land crabs migrate to the shore to lay

their eggs in the water. Many species of frogs, toads, and salamanders, though normally living on land, migrate to the ponds in spring to breed and lay eggs. Loggerhead turtles and many sea snakes migrate from water to land for their egg laying. Eels migrate from the rivers and lakes of Europe and America to the depths of the Sargasso Sea; and salmon migrate from the sea to the headwaters of northern rivers. The migrations of fish are probably directed by chemical and temperature factors.

Homing in Fence Lizards

In 1934, with the assistance of William Hassler and George Lipsey, studies were made of homing among the fence lizards of the New Jersey pine barrens.[48] In order to follow the movements of individual lizards throughout the year every lizard found was tagged with a small aluminum skin clip bearing a number. In addition, to permit identification at a distance, one or more spots or narrow bands of bright yellow or red paint were placed on some exposed part of the lizard's body. We knew the paint would be lost at the first molt, but hoped this would not occur until after courtship. It might be assumed that a lizard released in the pine barrens with the infinite possibilities of concealment would never be seen again; but of the 226 lizards tagged from March to June, 155 were seen on another occasion and a large number many times.

As the season progressed it became evident that the fence lizards did not move aimlessly through the barrens but that each tended to confine himself to a fairly definite territory. One male was observed on ten different days patrolling an area approximately a hundred and twenty feet on either side of his home log. The lizards do not remain in their territories from indolence or because they are too stupid to go elsewhere; indeed, during the spring they are extremely vivacious and move actively about within the invisible boundaries of their estates. That they stay in these areas through choice was proved by a series of experiments. One was with a male which between April 2 and May 22 had been seen on twelve different days, always on or near his home log pile except for one day when he roamed two hundred feet away along one of the roads. He was transferred seven hundred feet from his home territory in a different direction from that of the road, across a dry, open field entirely unsuitable for lizards, who prefer to keep within dashing distance of cover. To our surprise he was back in eighteen days.

To check on whether this lizard had moved south under attraction of the cranberry bog rather than through a desire to reach home, another male was caught on the far side of the field and released on the bog side, four hundred and twenty feet away. In seven days it, too, had worked its way home. Tests for distances greater than nine hundred feet did not succeed, and many lizards failed to return home from shorter distances. Females seemed more content than males to remain in new territories where they were placed. Whether this was due to lack of initiative or to greater adaptability the reader may decide.

Protection of Interests

So impelling is the urge of the male animal to defend his territory that it seems at times to take precedence over other apparently more vital activities. Though territory is presumed to function primarily as an aid to reproduction, family responsibilities often are neglected for territorial fights. Howard mentions a reed bunting who attacked a rival bunting trespassing on his territory yet disregarded a weasel that was threatening his nest and his brood. Among the Atlantic gray seals a large bull in his zeal to protect territory will even overlook the transgressions of his females. As Darling[18] puts it, "The social behavior of the breeding season is based on territory more than upon personalities, for the bull seems primarily concerned in preserving his particular bit of ground, rather than keeping the cows within it. For example, I have seen an amorous cow turn away from a lazy bull and go into a neighboring bull's territory where she received immediate advances. All well and good, there was no quarreling about that, but when a strange bull emerged from the sea within the lazy bull's sphere of influence he was chased away by the lazy one, who was now stimulated to remarkable activity and agility."

Defense is by no means limited to territory. An animal, like a human, may become attached to goods and chattels as well as to real estate and put up a stiff fight to preserve them. Sometimes, and among some animals, the young or the females will be most ardently protected. Many birds and nest-building mammals will accumulate and defend a variety of nesting materials: 1728 gnawed napkins were found within the wall of a London restaurant infested with rats. Among animals who hoard food defense of territory includes defense of food stores. Squirrels and other rodents often guard their stores more vigilantly than their real estate; the dog holds tenaciously to its bone, the cat to

its mouse. Crabs will often resist the removal of the plants and animals with which they camouflage their shells. Primates will collect all sorts of things—cans, rags, sticks. Chimpanzees will adorn themselves with banana skins, ribbons, or flowers, and refuse to be parted from them. Always the animal appears to collect and guard what he wants for a particular need or purpose. There is little evidence of a general collecting instinct, a tendency to gather and hoard objects prized for themselves alone.

A study of fighting in animals clearly refutes the argument of militarists who claim that war is a biological necessity, that it is nature's method of controlling population, of insuring the survival of the strong and the elimination of the weak. So far as populations are concerned, it is certainly not true. Throughout the animal and human kingdom there is a very definite rhythm, a rise and fall in population according to natural law.

Nor is fighting essential in keeping up racial strength. It is true that many social animals ostracize or even kill members of their own group who act abnormally, be it due to physical illness or to a psychological cause. This may be the result of an instinct to maintain racial strength or to insure that the movements of the group be unhampered by defectives. Or it may be caused by the miscarriage of the instinct to punish interlopers, the intimate associate of old being no longer recognized when his behavior has become modified. It is also true that animals kill other species for food; war, however, is between members of the same species. Though fighting and defense of territory are common types of behavior, it is seldom indeed in a natural environment and in normal circumstances that murder occurs and still less frequently the mass murder we call war. Only in certain species of ants and bees do we find armies going out to destroy their own kind; and this phenomenon should be considered a freak of instinct rather than a general biological practice.

Animals in general lack the power of organization necessary for a united attack of one group upon another. Their craving for power is individual, and their efforts to maintain this power are individual. Though in some fishes and birds large numbers may react in common to an enemy, it is an unorganized attack—each individual out for himself. Among social mammals communal territory is often defended as a group. There is even a certain degree of leadership for flight or defense, but this never becomes effective for offense.

Wallace Craig[15] has demonstrated that in all animal groups racial strength is maintained despite a definite tendency *not* to fight. He sees

no evidence to support the theory that war is a natural phenomenon essential for the highest development of the race. In fact the evidence points in the opposite direction. Those species which fight least (except for food) are biologically more advanced and in a more progressive state than are the closely related species which do more quarreling. Other things being equal, peaceful animals are superior to fighting animals.

This pacifism in animals does not, of course, spring from a consideration of ethics as it often does in humans. It is the result of a hard-boiled long-range demonstration that fighting does not pay and is not necessary. Tolerance and readiness to get along with others advance the species further in the long run.

But no animal follows the policy of non-resistance. It is essential that he stand up for his rights and protect his interests. Basing his statement upon close observation of pigeons, Craig points out that though animals are quick to react to aggression by threat or fighting this impulse does not crave expression without cause. A well-fed, well-housed, well-mated pigeon will be healthier and appear to be happier in his peaceful environment than one given many occasions to fight. Fighting is not a primary appetite demanding constant satisfaction as does the need for food, rest, and a mate. Fighting is only one manifestation of the instinct for self-preservation. It is not enjoyed or sought for on its own account. An animal does not look for a fight except in play, where no one is injured. This is true even of gamecocks, who are quite peaceful when not artificially prodded to battle.

Defense does not demand the annihilation of the enemy, only his removal or his compliance with the law. When the enemy is driven from the territory, or admits defeat, the victor will retire without malice. The pigeon living on a ledge will shove the transgressor off the edge and forget him as he flies away.

It is not always easy to solve problems of conflicting interests even in a pigeon cote. Animals, like humans, occasionally find themselves in complex situations where it is difficult to determine rights and privileges. Sometimes the combat is prolonged, not unto death, but often for several days or weeks. When this occurs pigeon owners have learned that by studying the situation, adjusting certain cages, transferring certain neighbors (not arbitrarily but in accordance with pigeon territorial law), they can remove the causes of dissension and terminate the struggle. So may it be with man!

CHAPTER XI

SEX RECOGNITION

WHEN WE THINK of men and women, so sharply distinguished by tradition and social organization as well as by physique and clothing, it is difficult to realize that sex recognition may present quite a serious problem among lower animals. Our history, our family life, our economy—as well as a large part of the niceties of our social relations—are built upon the recognition and interplay of the two sexes. Only in exceptional cases during a normal social life do we have difficulty in distinguishing a man from a woman. Nevertheless, there is often serious difficulty, well recognized by sociologists and religious workers, among young men and women in *finding one another,* in coming into wholesome contact that will provide opportunity for making happy marriages.

Finding One Another

Both these problems have to be solved in nature. As was pointed out in Chapter I, an animal probably does not have an objective idea of himself as we do, and therefore cannot recognize a prospective mate as being similar to himself though different. Even apes and monkeys, and in fact many tribes of primitive peoples, have no intellectual concept of sex or of its implications in the reproductive cycle. Moreover, many animals are such confirmed isolationists that bringing together the males and females requires extraordinary procedures, as for instance the large mixed assemblies of many mammals during the breeding season. The mingling of the sexes comes about more simply among species which live in colonies or herds or come together at certain food stations, drinking holes, or hibernating dens. But even among such animals unsuspected conditions must be satisfied before successful mating can take place. In this chapter we shall deal with the process of *pairing,* the consideration of factors which bring animals together for the pur-

pose of mating. In the next chapter, on courtship, we shall see that additional activities are sometimes required to stimulate the partners to the act of mating and to strengthen the marital bond in preparation for their parental responsibilities.

Mating Instinct

In all creatures below the primates mating is almost entirely instinctive. The complex pattern of behavior that characterizes each species is meticulously carried out by each individual, even by those who may have been brought up in captivity and never had a chance to learn through observation of others. Many animals normally possessed of a cortex can carry on essential mating activities even when this area has been removed and only the old or instinctive brain remains. The reproductive activities of the male are to a large extent instinctive responses to different phases of the female's oestrous behavior.

Learning contributes an increasing number of accessory elements the higher we go in the scale. Even fishes often learn to know their mates as individuals and to orient their sexual behavior toward the familiar partner. Mating activities can be conditioned in many ways. In a herd of mammals a young male frequently learns to suppress his amorous instincts if he has been threatened or attacked by an overlord whenever he showed interest in a female. A female monkey may learn to flaunt her charms—to prostitute her sex—solely in order to keep on the good side of a dominant male and thereby obtain an added share of food.

Like most other instincts, mating is dependent upon two essential factors: a state of readiness in the animal and an adequate stimulus for releasing the appropriate behavior. The first factor—the inner state of sexual emotion—is associated with the enlargement of the reproductive organs and the secretion of hormones into the blood stream. With the great majority of animals interest centers in mating only during a comparatively short period of the year. During the remaining months the organs are reduced and the animals' activities become almost entirely non-sexual in character. In birds the mating season is primarily in the spring; in deer and many large mammals it is in the fall, thus in both cases enabling the young to make their first appearance in a warm and fruitful world. Monkeys and apes, like humans, are more or less receptive during the entire year. Each species of animal seems to have its own inherited sexual rhythm, but this may be influenced by

light, weather, food, health, and emotional factors. Farmers have found, for instance, that hens will lay more eggs if the period of daylight is artificially lengthened.

As a rule sexual unrest is more marked, continuous, and prolonged in the male than in the female. Likewise the male is usually more aggressive in mating and thus has the brighter colors, the louder voice, the added devices for threat or attack. In females the period of sexual receptivity is far more limited, though it may return rhythmically if pregnancy does not intervene. This period of oestrus has long been recognized in higher mammals, but there is now ample evidence that a similar condition occurs even in snakes, frogs, and fish. The female sunfish, jewel fish, fighting fish, and zebra fish actually seek out the male and often initiate the courtship ceremonies. Many female toads and tree frogs approach the calling male and nudge him as if seeking attention; oestrous leopard frogs suppress their usual warning cry when embraced by males. Females of many species of birds have gestures and calls "of invitation" to the male and frequently fight among themselves for his favors. Though references were made in the past to "marriage by capture" among lizards, further work has shown that the female is seldom an unwilling victim. In fact among Anolis lizards her co-operation seems to be essential. It is in response to an inviting bend of her neck that the male is stimulated to seize her there. Thus successful mating involves not only "recognition" and acquisition of a female, but it must also be a female in the mood for mating.

The second requirement for the proper functioning of the mating instinct is an adequate external stimulus. In lower animals the attainment of a mate must rest upon a few simple cues of a direct sensory nature. In higher animals a greater number of senses become involved and fairly complex perceptions are built up.

Sensory Cues

In solving any problem of life the animal, like the human, uses what powers and tools nature endowed him with. An animal with good eyes probably will make use of them in choosing a mate as well as in finding food or avoiding an enemy. The mate in all probability will be especially marked by color, pattern, or movement to catch his wandering eyes. If voice and hearing are well developed song will likely enter into the game of love.

Vision is by far the most important single sense among the verte-

brates as a whole, bringing many kinds of messages to the brain. *Color* and *brilliance of pattern* are commonly associated with sex attraction in both the animal and the human world. *Luminosity* is particularly important for night creatures or for those living in the black ocean depths. In these forms we are likely to find that special eyes and an instinctive attraction toward light have developed parallel to the luminosity. Every little *movement* may have its special meaning. Sometimes a single gesture will identify a partner; sometimes complicated patterns of behavior are necessary for recognition. To a male gull the sign of a receptive mate is an individual who begs for food. In the laboratory male jewel fish whose customary movements had been altered by drugs or intoxication were no longer recognized by their mates but were driven furiously from the home territory. The male sea horse, who possesses a pouch for brooding the family eggs, tempts the female by displaying his empty pouch. Repulsed by one female, he will swim rapidly to another until eventually one responds by depositing eggs in his sac. As we have seen, a common factor in sex recognition, especially among species which hold territory, is the male's challenge to everyone who approaches his territory: if the newcomer fights back or displays, it is a male; if it remains passive or holds its ground, it is a female. In general the male is more active and restless like the sperm he produces, while the female tends to be passive like the egg.

Sound is of importance among nocturnal or otherwise concealed animals. The calls of katydids, frogs, owls, and alligators assume added significance where vision is impossible and luminosity does not exist. The only lizards with a voice are the nocturnal lizards. Moose are nocturnal during the breeding season and the cow attracts the bull to her by a special call, often exploited by hunters. Birds are especially responsive to calls.

We have learned that certain moths and butterflies can find their mates by *scent* even over distances as great as a mile. Some male moths can even discriminate between a virgin female and one which has already mated. Odor is one of the factors in sex recognition among salamanders, and also among snakes and rabbits. Many mammals —wolves, cougars, dogs, et cetera—who mark their territories by leaving their scents, undoubtedly are also influenced by these odors in hunting for mates.

Touch is often essential for distinguishing sex—as in snakes. Some male spiders make known their suit by plucking the strands of a female's web. If she is in the mood and likes the vibration she accepts him as a mate. If she is not in a state of sexual receptivity she may

ignore him or, missing her cue, mistake him for prey. In most cases, after appeasing her desire, she will eat her erstwhile lover. Biologically this is not so great a tragedy as it seems to our human point of view. He has served his purpose; what better end than to make the final sacrifice and help nourish the expectant mother of his progeny?

The male lamprey eel evidently distinguishes sex by means of his *kinesthetic* or muscle sense. With his suctorial mouth he attaches himself to another individual clinging similarly to a large rock. If the second lets go its hold on the rock it is a male, and the two float downstream together to separate anon and swim back to try their luck once more. But if the second individual maintains its hold on the rock it is recognized as a female, and the two unite in a vigorous churning of the water in which the eggs and sperm are deposited and mixed with sand.

Though in many species the sexes cannot be distinguished by even the most practiced eye, in others there are marked differences in size, structure, coloring, or behavior. These are known as *secondary sex characters,* in contrast to primary differences in the actual sex organs. They may appear temporarily during the breeding season, or they may be permanent. Though frequently useful for sex recognition, they often have other functions. Thus the scent glands in moths and butterflies or the yellow face of the female spotted turtle play an important part in sex recognition; the antlers of male deer and the spurs of roosters, however, are weapons for defeating undesirable rivals. The color and song of most male songbirds and the bright dewlaps and crests of many lizards advertise territory and bluff other males. The nuptial pads or horny protuberances on the thumbs of many male frogs are used for maintaining the grip on the female during egg laying. The marsupial pouch of the female kangaroo, as well as the brooding instinct of a hen, are devices which insure the proper development of the young.

Frogs

One of our earliest studies in animal behavior—a study combining field and laboratory work—was of sex recognition in the frog. Down in the pine barrens of New Jersey, almost under the shadow of the huge hangars at Lakehurst, we followed for several years the mating behavior of brilliant little Anderson tree frogs and of fence lizards.[69]

Through the cedar swamps run many clear streams of acid, copper-colored water, with which sailors in olden days used to fill their ship casks to take on long journeys because it stayed sweet so much longer

The male snake, ready to breed, is attracted by the movement of other snakes, even by the moving image of himself in a mirror.

The female Anolis is attracted by the expanded dewlap of the courting male.

The male *Hyla andersoni* attracts the female by calling with inflated pouch.

than ordinary water. In many places these streams have been dammed and the cedar trees cleared away in order to form cranberry bogs—favorite mating grounds for the daintiest and most dapper of frogs, *Hyla andersoni*. This little creature is impeccably attired in brilliant green, with a purple waistcoat and neat white facings; wherever his arms and legs relax against his body dabs of golden orange glitter.

When we first visited Lakehurst in early May the frogs were singing lustily from call positions in young saplings or in blueberry bushes along the edge of the bog. The song was a long series of loud *quanks* sounding somewhat like a duck with a cold in the head. Evidently the females had not yet emerged from hibernation. We became convinced that the songs of a few early comers helped to direct the movements of later males and females toward ditches and streams in the bogs. Our convictions, however, in connection with this single species should not be taken to apply to all frogs. In other species, such as the leopard frog, sound does not seem to be essential.

The first activity of frogs, upon emerging from hibernation, is the fulfillment of their reproductive duties. Warm spring rains wake these amphibians from their winter sleep and arouse in them the instinct to proceed toward areas of water and wet vegetation. The odor of wet plants and the voice of their fellow creatures both seem to have a definite attraction. Members of each species evidently are attracted only by the calls of their own species, for in any given area pond frogs, hop-toads, carpenter frogs, and Anderson frogs tend to remain in their own corners and do not mingle with the others, a factor which greatly assists the pairing-off process.

Frogs are nocturnal breeders and we spent many long nights with a flashlight watching their comings and goings. The light does not seem to interfere with their activity and only blinds them to their human observers. One night we decided to specialize on individuals and forget the distracting hordes about us. We were thus able to follow closely three individuals through most of the night. Our first male was calling early in the evening from a maple sapling about five feet from the ground. Later he hopped down from his perch and resumed calling from the edge of a small sphagnum-filled ditch irrigating the cranberry bog. As we watched we saw a female coming from the distance directly toward the voice. Several times she circled around the male and finally hopped right up to him and nudged him. At first he seemed to pay no attention, then suddenly he turned and embraced her. Together they hopped to the ditch where egg laying and fertilization took place on soft beds of sphagnum.

Though frogs have attained the ability to breathe air and to live to some extent on land, they have not yet developed apparatus for internal fertilization and must therefore lay their eggs in water as do the fish, a liquid medium being essential for the swimming of the sperm to the egg. Frogs have, however, developed the nuptial embrace of higher forms, thus increasing the chances of fertilization and requiring fewer eggs than fish generally lay. The male frog hangs tightly on the back of the female, maintaining his grip by means of the nuptial pads which grow on his thumbs during the breeding season and fit snugly under her arms. The female initiates the egg laying. The contractions of her body as she expels each cluster of eggs evidently stimulate the male to release the sperm directly upon them. The pair may remain together for several hours, but there is no further bond between them.

Though in the case of our Lakehurst hyla it appears to have been the voice and the perseverance of the female that brought the pair together, things do not always go so simply with frogs in general. If exceedingly amorous, the male will usually embrace anything resembling a frog that comes his way or that his eyes rest upon. It may be a piece of wood or another male, but naturally he does not long find them satisfactory. Here his powers of discrimination are called into action: he is soon made aware of his mistake. If he finds that the shape and girth of the embraced object do not fit into his innate ideal of a mate's figure, he will eventually release his hold. Or, again, if the seized male croaks in protest, the embrace is broken. Only when all innate requirements as to shape, size, softness, passivity, silence are satisfactorily fulfilled, when both parties are assured that all is well, does egg laying progress normally.[53]

In wood frogs, if water is injected under the skin of a second male until he is as plump as a female, the first male will embrace and hold onto the artificially fattened male as long as he would to a female.[62] Many nights we spent bending over aquaria lighted only with a red light such as is used in photographic darkrooms, trying to analyze the factors which brought the sexes together. By presenting love objects of widely varying shape, texture, and behavior to the male, we found this factor—which crops up so frequently in animal mating—to be perhaps the most important single one: that the male directs his amorous activities toward any more or less satisfactory object. If it puts up resistance he desists. If his advances are accepted passively, or if the female is warmly responsive, he continues his courting to the end.

Fence Lizards and Other Reptiles

Along the edge of the cranberry bogs fence lizards[48] make their homes in great heaps of fantastic tree trunks cleared out of the bog years ago to make cultivation possible. These piles offer perfect refuge for the lizards, which, though so near the swamp, live lives vastly different from those of the tree frogs. Lizards are creatures of the sun. While frogs must always be near moisture and would otherwise dry out and perish in hot weather, the lizards have dry, scaly skin and must receive a good deal of sunshine. In the laboratory we found that the behavior—and especially the reproductive activities—of our lizards would be subnormal unless the animals had generous rations of sunlamp treatment.

Their mode of sex recognition also varies greatly from that of their tree-frog neighbors. In the first place they have no voice. Moreover, they do not congregate in large numbers as they emerge from hibernation; on the contrary, they are sluggish and retiring when the warming sun first wakes them from their winter sleep underneath the logs or inside the loose bark of dead trees. At Lakehurst a few scattered males could usually be found early in March sunning themselves on warm protected logs, but they were still extremely lethargic and could easily be caught by hand. Not until the latter part of the month did they display the slightest interest in each other and then a mild chase was observed.

The females appear early in April and at first they are entirely ignored by their future suitors, whose spirits have not even yet been sufficiently warmed up. Such early spring indifference stands in striking contrast to the tremendous emotional excitement of birds who, endowed with mechanisms for making their own blood warm, are not dependent on the sun.

Both male and female lizards appropriate territories and defend them against outsiders. The territories are not precisely defined, however, and there is some wandering back and forth, especially among the females, who are evidently attracted by the males' coloring and vigorous movements.

Experienced males can recognize sex immediately, by color reinforced with movement. If a male is dropped into the territory of another male the latter either goes into full display, compressing his sides so that his handsome blue lateral stripe stands out in shimmering brilliancy, or else dashes forward in a violent attack. If the trespasser is a

dull-colored female the male never displays but, giving a series of rapid courtship head nods, runs forward to secure a grip on her neck. As she becomes quiet the male, still retaining his hold, curls his tail under hers so that the cloacas meet. Fertilization is internal in reptiles, as it must be in all forms where the eggs are covered with a tough membrane or calcareous shell, or where the young develop within the body of the female. Lizards and snakes are equipped with a double copulatory and clasping organ (two "hemipenes") which insures the passage of the sperm and demands little more than submission on the part of the female.

Our male fence lizards could distinguish sex so rapidly and at such distance that we wondered just how it was accomplished. Females were therefore painted to resemble males and were dropped into the males' territory on long threads. This usually evoked the fight reaction. Others were painted with gold, silver, yellow, and other brilliant hues. Mercurochrome stained the lizards not red but green with a touch of pink. Any gaudily colored lizard, whether male or female, was usually treated as a rival male. Conversely, a male that had his legs tied in such a way that he did not show his blue sides was treated as a female. Similarly, anesthetized males lying flat on the logs were actively courted. These experiments seemed to show definitely that in this species color was the chief basis of sex discrimination.

Lizards, snakes, turtles, and crocodiles are all reptiles but they employ many different devices for sex recognition, depending largely upon the kind of lives they lead. Male snakes are primarily attracted by the sinuous movements of the female, but actual sex recognition depends upon olfaction.[59] During the breeding season the odor of copperheads can often be detected day and night by human strollers through the hills. Rivalry and territory defense play little part in snake life and there is seldom any differentiation in color between the sexes as there is in many lizards and birds. Mating itself is not consummated until the tactile senses are also satisfied by such factors as the texture of the female's skin and the coiling of her body. Copulation is similar to that of lizards, except that the neck bite is lacking and position is maintained largely by the body coils.

Among spotted turtles,[60] inhabiting shallow, brackish streams, pairing is the result of search by the male, in which the bright yellow face of the female serves as a beacon. Though the female's body be concealed in the mud and silt of the stream bottom, her bright face attracts him immediately. If a stick painted black and yellow is stuck in the mud he will be similarly drawn toward that. Even in courtship actual

mating will not take place unless the female lifts her head and displays to her suitor her gaudy saffron complexion. The copulatory methods employed by lizards and snakes are obviously impossible with turtles, who have adopted the single organ and the dorsal mount characteristic of most mammals.

Flickers and Other Birds

The common flicker[49] well illustrates the intricacies involved in sex recognition among birds. Most of us are familiar with the *flick, flick, flick* of the male bird and with his resonant drumming on hollow trees and rooftops. The females are definitely attracted by his advertisement and often several come at the same time in response to his call. In this case the females fight and display among themselves, trying to establish which one will approach the male. Their threatening display, like that of the male, consists of a *we-cup* call, of head bobbing with uplifted bill, of wing and tail flitting. The male, meantime, is attracted by their calls and they are stimulated to greater activity by his presence; but he takes no active part in aiding one or the other in the contest. Both males and females fight and both are brightly colored with conspicuous patterns of brown, yellow, and white. Males fight only with males, however, and females only with females. When a female has driven off her rivals she utters a soft nasal call heard on no other occasion. This "invitation to mate" is given while she moves along a limb and then crouches. The male invariably follows and accepts the invitation.

Some years ago a thrilling dramatization of sex recognition was staged in a rambling old willow in our back yard. A pair of devoted flickers were digging out a nesting hole just a few feet from a window. Though male and female are practically identical in size and coloring, the male is distinguished by a heavy black "mustache." While sex is recognized primarily by calls and behavior, experiments with these flickers showed us that mature birds learn to recognize the mustache as a badge of maleness.

We were able to trap the female and without difficulty attached on her cheeks, with household cement, some black feathers which we felt duplicated quite satisfactorily her husband's mustache. When released she flew straight to the hole and alighted on its edge. The male was not there and she remained a few seconds alternately peering into the hole and looking about outside. A moment later the male flew in and

dropped down beside her, then flew to a near-by branch. It was some moments before he realized that he was cavorting with a mustached companion! With a start he drew back and, barely recovering his balance, lunged viciously forward.

Then began a long chase lasting nearly two and one half hours. Along the branches, back to the trunk, up to the nest hole, and again out on the branches the male mercilessly pursued the mustached female. As he drew near he spread his tail threateningly and tilted it, displaying the bright undersurfaces to the maximum. The female answered with a soft feminine *we-cup*. Frequently she lifted her wings in defense as the male pecked at her head, but at no time did she fight back, though our previous experiments had shown her to be a more valiant defender of territory than the male. Again and again she returned to the hole, only to receive such an onslaught that she lost her balance and fell several feet before catching hold of a branch. After ten minutes of rough treatment she led the male away from the tree and five minutes later he returned alone. Two minutes later the female came back and again *we-cupped* softly as the male drove her out on a limb. . . .

A moment later she dove to the ground. The male followed and, holding his tilted tail nearly vertical, gave an extraordinary display before lunging at her again. Once more she flew away and this time it was possible to follow the pair as they scrambled over a burned field a hundred yards beyond the elm which had seemed to mark the boundary of the male's territory. Finally, after the struggle had lasted all morning, the male drove the female into a culvert where she was rescued and placed in a cage.

Unfortunately for her, the full measure of her suffering for science had not yet been exacted. She had proved that, to a male flicker, a mustached companion was positively a male rival to be driven from his home. Was the reverse also true? Was a flicker without a mustache necessarily a female? We found that a female, even without a mustache, could not qualify as a mate unless she gave the proper call and gestures. Next morning we attached a stuffed specimen of a female flicker on a limb very near the nest. Then we placed the live mustached female on the limb near by.

At six-thirty the third morning the male was back at his calling station giving vociferous flicker calls. These were interspersed with loud drummings on the dead limb he had used before the female arrived. He paid no attention to the mounted female but continued to have conflicting attractions toward the live bird. He was enticed by her soft

we-cup and her occasional flicker, yet when he saw that mustache his fury let loose immediately. When for a time we had a mounted male attached to the branch he would fight and threaten the specimen as if it were an actual rival.

At last the female was relieved of her strenuous role. We removed the black feathers and replaced her own. She was released but she had not forgotten her former injuries. When the male approached her she in turn lunged savagely at him. He did not peck back, but returned to her more and more frequently, sat quietly a few inches from her, now and then *we-cupped* softly. From all appearances the redecorated female had once more been accepted as a mate.

Mammals

Among animals endowed with keen olfactory powers it is logical to expect well-developed organs for secreting odoriferous substances. Almost all mammals have especially strong odors at the time of breeding. Hunters report that the scent of deer, moose, and elk can often be detected, by even the weak nose of a human, when at a considerable distance from the animals or long after they have passed by. Such scents undoubtedly play a large part in bringing the sexes together and in stimulating sexual interest. Sometimes the female is attracted to certain odor posts or territories advertised by smell, as bird territories are advertised by color and song. Sometimes the male is attracted by the odorous secretions of the female. There is much evidence pointing to the importance of olfaction in sex recognition, but unfortunately very little proof. To the human investigator odors are difficult to detect or to measure.

More than any other factor, possession of the cortex influences the mating behavior of mammals. First, by closely integrating all the senses, it relieves the mammal of dependence upon any one sense. Experiments on rats[8] in the Museum laboratory have shown that the most successful stimulus for setting off the mating instinct in the inexperienced male was the actual presence of a receptive female, one who acted and sounded, felt and smelled appealing. It was found, however, that if any one sense—vision, smell, touch—was eliminated, mating would still progress, albeit with decreased efficiency. If two or more senses were eliminated activity was usually frustrated in the novice but not necessarily in a more experienced individual.

Instinctive patterns are not nearly so rigid in mammals as they are in

lower organisms; in the anthropoid apes they are actually inadequate for successful mating. Male chimpanzees cannot effectively carry out their sexual functions without experience or without receiving instruction from those already initiated.

In apes and monkeys sex interest and the association of the sexes is more or less uninterrupted, but even here the urge is strong at times and weak at other times. The differences in size, strength, and behavior between the sexes, the factor of personal recognition, and the powers of discrimination make the problem of sex recognition an easily solved one. The perennial sociability of these animals makes unnecessary any special devices for bringing the sexes together. There is, however, a rhythm of sexual receptivity among the females and a recognition of this fact among the group. In the primates the importance of odor seems to have receded and color vision has once again appeared. The zoo visitor is well acquainted with the bright swollen buttocks—red, yellow, blue, green—of various monkeys and apes. These swellings are indicative of the sexual state of a female and are carefully observed by the group. Zuckerman,[98] in his study of baboons, remarks that in a "monogamous" family the bond between a male and his female is closest at the time when her sexual skin is most swollen, and that in a harem containing more than one female priority is almost always taken by the female showing full sexual-skin swelling.

In the higher primates social and psychological factors assume greater importance. Courtship is a mutual affair and may be initiated by either male or female. In the copulation of most forms the dorsal mount typical of other mammals is maintained, but in the sex play of younger apes (where size differences have not arisen) and in some adult forms, the ventral embrace occurs and is believed by some to be indicative of mutual regard and high social development.

In the course of their lives many animals learn a great deal from experience and usually profit thereby. Often they learn to tell females from males in the sense that they discriminate between love objects and competitors. Learning also brings about violent prejudices and antagonisms toward certain individuals, and equally violent attachments to others. Men who have had the opportunity of observing animals closely—in the wild, at the zoo, on the farm—are acquainted with the fact that certain males and females will have nothing to do with each other, though they respond immediately to others.

That an animal may sometimes be unable to profit by learning is illustrated in the episode, related by Von Uexküll and Kriszat,[88] of a bird which had become inexplicably attached to a human. The male

SEX RECOGNITION

A male flicker is identified by his black mustache. This shows a female with artificial mustache glued on.

The male (right) is about to attack (as a rival) his erstwhile mate, now disguised as a male.

The female with mustache removed is again accepted by the male.

of a young pair of bitterns in the Amsterdam Zoo had "fallen in love" with the zoo director. The latter, to avoid interfering with mating, kept out of sight for some time and was gratified to see the acquaintance between the birds ripen into love. Matrimony followed and, as the female sat on her eggs brooding, the director essayed an appearance. No sooner had the male spied his former love companion than he chased the female from the nest and by repeated bows seemed to indicate that he wanted the director to take the place where he rightfully belonged—on the eggs, brooding.

CHAPTER XII

COURTSHIP

Laughing Gulls

JUST NORTHWEST of Nantucket Island stretches Muskeget Island—to humans a barren sweep of sand, beach grass, and poison ivy but to many sea birds a native land and breeding place. Here every spring about twenty thousand pairs of laughing gulls, along with many hundreds of herring gulls and terns, gather to mate and bring up their families.

Moderately social creatures, the laughing gulls at first settle down in loose flocks of ten to one hundred, each flock in a small area which later becomes the center of the scattered nesting community. At this time the birds display not the slightest interest in courtship, private property, or family affairs. The days are spent with the group in feeding, flying, and the usual neighborly visiting and squabbling. Many idle moments are passed playing with twigs, grasses, and clamshells.

The initial indication of sexual awakening is the loud, clear "long call," a spring glorification of the winter's slow, broken squeak. This call, given by either male or female, often is taken up lustily by other members of the group. Virile males frequently are aroused to charge the calling bird and sometimes run as far as thirty feet to challenge it. If itself a male, the singer usually retreats for a considerable distance in the face of this challenge, in some instances completely deserting the group. If a female, she holds her ground or retreats a short distance, drawing herself up defensively into an erect posture and "flagging her head"—turning it stiffly from side to side.

These maneuvers are but the first step in the long and difficult process of determining partners. Before a male and a female can embark in peace upon their marital adventure they must deal with many complicating factors and often bitter competition from other members of their sex. The following field note[74] describes only one episode taken from a vivid but protracted drama:

Group of eight birds. One of three very erect birds (male) suddenly lowers head in pairing charge posture and runs at another (female), which responds by posturing erect and retreating one or two feet. The charging bird then runs after two others which fly away. The male again charges the first bird, which again postures erect and flags its head; is pecked in back of the head; does not retreat but continues posturing and flagging. After a number of such charges, the entire group has flown away except for the male and two females.

Eventually one of these females succeeds in driving the other away, and thus the pair is formed.

The victorious male and female can now devote themselves to the equally serious business of courtship. They indulge more and more earnestly in the mutual ceremony of courtship feeding, which at this point is purely symbolical. Long plaintive "sex moans" are produced by the male, sometimes in flight, sometimes during the feeding charge. Though male and female are identical to the human eye, they learn to distinguish each other from their associates, both by movement and by calls.

There comes a day when the pair, now intimately acquainted but probably not yet actually mated, desert the group to set up their own establishment. Apparently the male goes first, selects the ground, and with his "nest enticement call" attracts the female to him. Another field note tells us:

A new pair appears to be selecting a nesting site about twenty feet from the blind. This area was never occupied before. The male, just before landing, begins to moan; on landing assumes feeding charge posture and continues to moan. Female is circling about overhead, finally lands alongside male, who is still moaning. Female goes into a frenzy of food begging.

The nesting territory is defended vigorously by the male and at times by the female. The new phase of their life is characterized by periods of more realistic food begging. The male frequently brings fish to the female, he maintaining an upright position and she assuming a begging attitude comparable to that of young about to be fed in the nest. These ceremonial feeding postures are extremely important in that they lead directly, and seem to be essential, to the positions assumed in actual copulation: the female crouching, with head turned back to grasp the male's beak or to peck his breast gently; the male poised on her back, calling and flapping his wings. Though fertilization is internal in birds, the male does not possess an intromittent organ. The sperm is transferred only by contact of the cloacal regions, by the so-called "cloacal

kiss." To accomplish this the co-operation of the female and the synchronization of her tail movements with those of the male are essential.

In the privacy of their new home plot the pair busy themselves with building materials. In general the male is more active in collecting sticks and grass blades, the female in constructing the loose nest which rests directly on the ground. The nest is completed shortly before the female is ready to lay her first egg; but even before this time the brooding instinct asserts itself in both male and female gull. Both birds give every evidence of enjoying their brooding, one member often appearing reluctant to leave the nest when relieved by the other. It is pertinent, psychologically, that in this system of mutual relief at the nest may still be seen the ceremonies and sex calls used in the earlier courtship.

Jewel Fish

The tiny jewel fish has long been a favorite with laboratory worker and tropical fish amateur alike. Its enormous capacity for reproduction, the brilliant colors it assumes during breeding, the intricacies of its courtship and parental behavior make it a vivid and fascinating subject for study.

The first evidence of breeding in the jewel fish is that the male dons his nuptial colors and begins to defend as territory a particular corner of the aquarium, usually an area containing a small rock which can be used as a nest site.[68] The male will attack any fish which enters this territory, and unripe fish of either sex usually flee promptly before his assaults. Other males ready to breed may fight back, and a fierce struggle may ensue from which the original occupant usually emerges victor. The egg-laden female is attracted by the symbolic nesting movements of the male and when threatened by him stands her ground and retaliates by spreading her fins in a feeble gesture of defiance. If the male's attack is particularly vicious she may flee temporarily but soon returns even though seriously bitten.

After the female's intention to stay in the territory has been tested with a few threats and proved by her insistence, both sexes display and gesture to each other, often quivering together as if in ecstasy, sometimes in the usual horizontal position, sometimes standing on their heads. This "head standing" is an ever-recurring motif in their courtship ceremony, a position symbolizing that taken later in cleaning the small rock that is to be the "nest" for future eggs. There is also common digging in the sand and increasingly realistic rock cleaning.

Whether the work is actually accomplished or only suggested the pair form an emotional bond which will last well through their reproductive cycle.

In cleaning the nesting site both sexes nip off with their mouths mold or other undesirable material adhering to the surface. Genital tubes for expelling the eggs or milt protrude from both sexes and are brushed frequently but at first ineffectually over the surface of the chosen rock. This physical contact further stimulates the emotions and mutual activities of the pair. At first there may be more or less slapping of one another with their tails, especially if disturbed.

The actual egg laying lasts from one half to two hours, the male synchronizing with the female by dragging his genital tube over the egg mass at frequent intervals during the laying. Usually the female leaves the rock after depositing a short row of eggs and the male takes her place to inseminate them. The eggs are guarded and fanned alternately by both parents. Mates recognize each other personally, especially by details of the face, and drive off other fish. If the eggs are removed from the rock to another part of the aquarium the parents show remarkable skill and visual perception in finding them again.

When the young have hatched, the parents usually pick them up in their mouths and spit them out in depressions previously prepared in the sandy bottom. They are removed from one pit to another at varying intervals until the yolk is sufficiently absorbed to let them rise as a cloud of very active wrigglers above the hollows in the sand. They are carefully guarded for a week or longer, frequently until the pair are ready to spawn again. With abrupt movements of the fins the parents retrieve the young if they wander away.

Elements of Courtship

The two case studies of the laughing gulls and the jewel fish, fundamentally alike yet representing widely separated groups, illustrate animal courtship at its most complete manifestation. Courtship in most other forms exhibits few if any additional details, and indeed is on a far simpler basis, often lacking many of the elements evidenced in that of the laughing gulls and jewel fish. As we shall see, courtship is a much deeper, more varied and meaningful affair than most observers would imagine.

First, evidence increases that much of courtship formerly regarded as an aesthetic appeal to the female is in fact devised chiefly for in-

timidating her. Again and again it has been found—in birds, mammals, lizards, fish—that successful mating cannot take place unless or until the male has attained dominance over the female. The pairing charge and the feeding charge of the male gull, the attacks—sometimes ferocious—of the territory-guarding jewel fish are obviously not meant to allure and impress the female but to intimidate her. In the jewel fish the threat of even slightly brighter colors, larger size, and general aggressiveness tends to subordinate the female. In the feeding ceremony of the gull the dominance of the male over the female is more gently expressed by the male's insisting upon holding his head a little higher than that of the female. If she lifts her head too high she is promptly put in her place with a few sharp pecks. (A recent paper by Greenberg and Noble,[23] however, stresses the distinctiveness of fight and courtship patterns in Anolis lizards.)

Second, the formation of pairs, though an important part of courtship, does not necessarily indicate actual sexual union but only the first step, analogous to betrothal. In both laughing gull and jewel fish, male and female were brought together because the receptive female refused to give way before the threatening charge of the male. In both cases it was necessary for the pair to clear the ground of competitors before they had the satisfaction of each other's company without interference. The male gradually eliminated his masculine rivals; the female drove off all interested females. Thus the vaunted state of monogamy was attained, not through idealism or practical considerations but through primitive sexual jealousy.

Third, in species which live together for a long time and together share the duties of parenthood, the courtship is more complicated, consisting of mutually stimulating activities performed by both partners and often lasting well through the breeding season. Usually both sexes are alike in appearance, the colors and markings undoubtedly serving to accentuate the mutual ceremonies, to warn enemies which might destroy eggs or young, and to assist the young in recognizing their parents.

These ceremonies borrow and frequently reproduce patterns of behavior which were exercised in infancy or which anticipate nesting and parental activities. Almost from the first the gulls were interested in sticks and this tendency became stronger and stronger until actual nest building was begun. The ceremonial begging of the female and the feeding of the female by the male carried back to infancy. The begging posture later evolves into a crouching posture signifying the willingness of the female to mate, while the male feeding posture also functions

more realistically in mating, and still later in feeding the female and the young on the nest. The cry which a laughing gull gives when feeding its young is identical to that which the courting male gives to attract the female. In nest relief are reproduced many of the ceremonies of earlier courtship. A large part of the jewel fish's courtship were movements suggesting nest cleaning and egg laying. Much of their mutual attraction toward the red color of the other probably persisted from the time when as small fry they were attracted by the waving red fins of their parents.

There is an economy of behavior patterns in nature, and those devised for one situation are frequently used in another.[52] The biological value of this transfer seems clear. The future parents must associate together, react in common, if bonds are to be formed that will hold them as a pair during the entire breeding season. They must develop behavior different from the feeding or locomotion of non-breeding members of the group. As with humans it seems to be true that the more exciting and interesting things the pair can do together the firmer becomes their bond of attachment. It may also be mentioned that the human male and female often like to assume childish attitudes during their days of courtship; and each receives with delight a certain amount of parental solicitude from the other. Psychiatrists even say that it is a wholesome sign when husband and wife continue to talk baby talk now and then in the privacy of their home.

One of the important functions of courtship is to *synchronize* the mating and parental activities of male and female. It is essential not only that an animal do the right thing but that he do it at the right moment. It has been experimentally proved, for instance, that most of the discrete activities of courtship are instinctive, that in higher animals they may be carried on even when the cortex has been removed, and in many species even when the entire cerebrum has been eliminated. But without the higher centers of the brain the organization of these activities is completely disrupted. The fish with forebrain removed is still effective as an individual but his social relations are disorganized. He can no longer adjust himself to others or deal with situations involving relationships of one individual with another, such as dominance. Though capable of the act of fertilization, he does not know which eggs to fertilize, or when. Even in normal individuals this "understanding" does not come about automatically but must be built up through courtship practice.

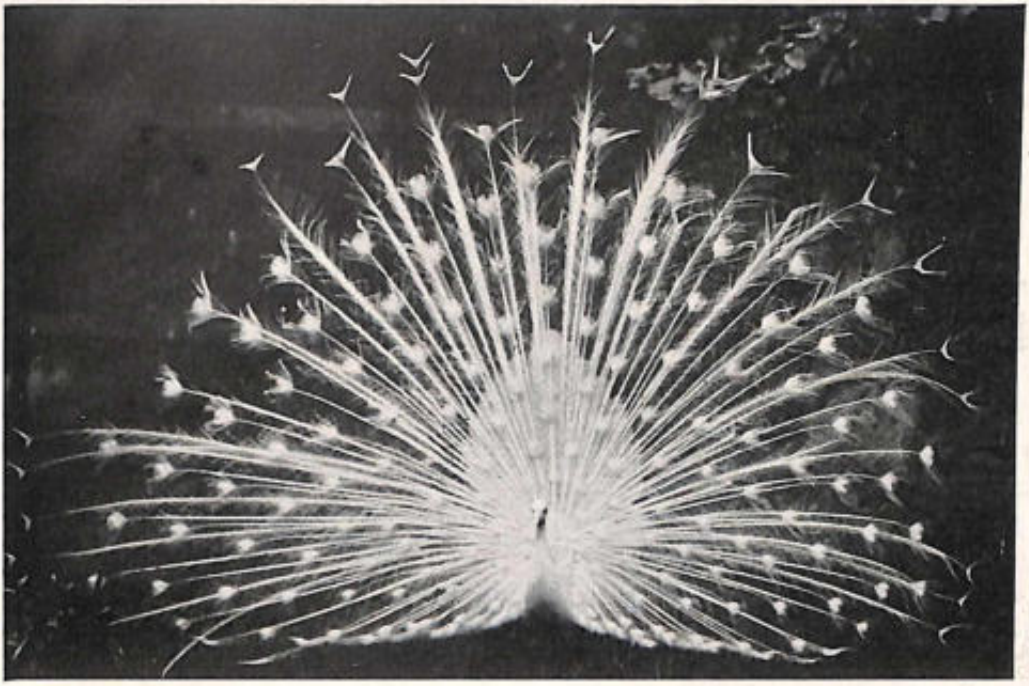
Emotional Stimulation

Yet it would hardly be accurate to say that courtship is nothing but intimidation and parental training. There can be no doubt that it also serves the more romantic purpose of stimulating the sexual emotions. We have frequently stressed the fact that animals are highly suggestible; that though they have no language their emotional expressions are readily understood and responded to by their companions. Response may in turn stimulate greater excitement as an emotional state spreads rapidly from one to another. It has been observed in the laboratory that courtship activity is contagious in that the movements of one bird, fish, or lizard may start the other to court. Similarly the courtship movements of the male when repeated by the female serve to stimulate both to increased activity.

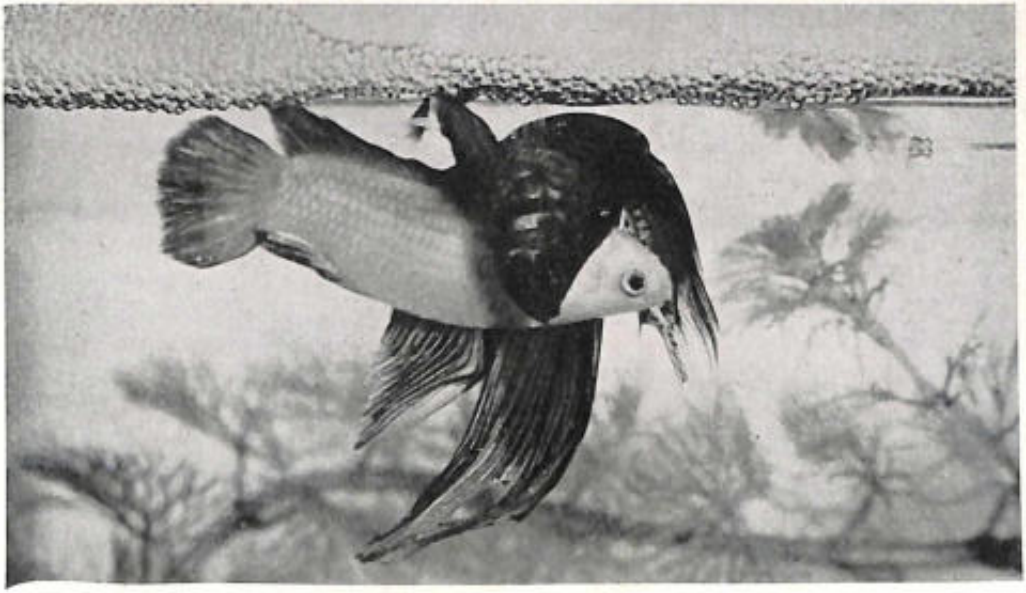
Sexual emotions are aroused chiefly by visual stimuli, but also by tactile impressions, odors, and sounds. Female doves reared in solitary captivity can be made to lay eggs (infertile, of course) by keeping a male in the next cage; the emotional stimulus of seeing his bowing and scraping starts some change in their endocrine glands that may lead to egg production. Even caressing a virgin pigeon's head with the finger, thus simulating the billing of the male, may have the same effect. Among many animals the males possess, particularly during the breeding season, special organs for self-stimulation or for caressing the female. The male Ameiva lizard has a "comb" of fringelike organs on the upper part of its hind legs with which he scratches the female's back and sides, evidently soothing her resistance and arousing her sexual ardor. The male painted turtle has elongated "fingernails" with which he strokes the female's face. Odors seem to have an exciting effect upon salamanders, snakes, and mammals; calls and gestures upon birds.

When both animals are in a state of sexual readiness the mere presence of the other is usually stimulating. Female flickers fight with each other much more furiously when the male is looking on. Groups of male salamanders become wildly excited when a female appears. Territory in itself may be sexually stimulating. Nesting materials, such as twigs or bits of string, as well as food objects may be presented by the male to the female or passed back and forth between them. Thus the penguin may give his mate stones for her nest, while the gull makes gifts of fish.

Though the mating cycle may be largely physiological, the psychological factors most decidedly enter in. For instance, a frightened bird



In the peacock, courtship and display are largely confined to the male; nest building and care of young to female.



The male fighting fish, *Betta,* is conspicuous in color and movement. He monopolizes courtship and family responsibilities as well.

will not mate; and a breeding fish, if frightened, suddenly loses his bright nuptial colors. Again, as is well known, previous experience speeds up the mating process. Even the weather seems to affect the mind and mood of courting animals. Field observers have noted that in bad weather the courtship dances of many birds are apathetic affairs, resulting in many unfertilized eggs and few offspring. The organic changes during reproduction are largely controlled by the pituitary gland, which is situated at the base of the skull and which undoubtedly works in close collaboration with the brain.

In the animal world, as in the human, feminine coyness occurs frequently. There, too, it seems to have a double meaning. Though the female will appear to discourage the male or to escape from his unwanted attentions, in reality she may be "leading him on." In animal no less than in human courtships nothing seems to be quite so stimulating as a little resistance or a bit of a chase.

When the female spotted turtle is approached by the male her usual response is to move away from him, but she looks coyly back over her shoulder as if to make sure that he is following her. In the case of the horned dace it has been noted that the female may come many times to a waiting male before she remains over the nest long enough to be seized by him. Huxley[31] says of the redshank, "The hen will often suffer his approach till he is quite close, then shy away like a startled horse, and begin running, upon which he folds his wings and runs after. She generally runs in circles, as if pursuit were not wholly disagreeable to her, and so they turn and loop over the gleaming mud." Darling, who studied the red deer of Scotland so long and intimately, found that the hind played an active part in courtship. Though she frequently ran away when approached by the stag, she would stop and wait for him, rub against him, lick him, then run on again—to wait once more for his approach.[17]

Aside from leading the male on, there is often a genuine reluctance on the part of the female, especially to excessive mating. So strong is the sex urge during the reproductive season that certain controls are necessary in the interest of biological economy and the welfare of mother and young. Unless social and living conditions are fairly satisfactory, a territory established with food and nesting materials available, the female bird is seldom receptive to the advances of the male. When mated to one male she generally refuses others. If a ripe, unfertilized female Gambusia minnow is approached by a male she offers no resistance. If, however, she has already been fertilized she repulses the male and sometimes kills him. In this fish the female's attitude is one

of indifference and never one of active partner seeking as in the stickleback and jewel fish.

Relation to Life History

Though courtship is found most perfectly developed among birds and man, it may also occur in many far more primitive animals. It is not at all true that finesse in courtship indicates a high stage of evolution. The pattern is dependent far more upon the life history of an animal and its special needs and anatomy than upon its high or low position in the animal world. As illustration, in insects we find an infinitely greater variety and complexity of courtship than in mammals. Among fishes alone there are many species in which the male and female have little to do with each other, the eggs being laid in the water and the male seeming much more excited about them than about the female. Yet we have seen that other fishes which brood their eggs or young may have an intense courtship with personal recognition and attachments and a certain degree of marital fidelity and devotion to young. Highly developed as they are, apes have little that is comparable to, or suggests the origin of, the niceties and intricacies of human courtship.

In frogs and toads, after the sexes have recognized and found each other, certain precise movements are essential before egg laying and fertilization can progress normally. These movements might well be considered rudimentary courtship. In the tailed amphibia, the salamanders, we again find highly organized courtship developing in very primitive creatures. In this case it is the necessary accompaniment of the specialized method of fertilization which these salamanders have evolved, a method not at all common in the animal kingdom. In most of the species inhabiting our Eastern ponds and streams—the spotted, the dusky, and the marbled salamander—the males discharge their sperm in tiny packets called spermatophores. These are usually deposited in the water or on damp ground and the female must be prevailed upon by courtship to pick them up. The success of this method of mating demands a high degree of stimulation and co-operation on the part of both sexes.

In the marbled salamander[55] the males precede the females to the breeding ground, already in a state of high tension and restlessness. When the females arrive the males become increasingly active, performing a *Liebesspiel* in which they dash around, rubbing each other

with their snouts, butting one another, and waving their tails. Then they approach the females, caressing them with cheek and snout. As marbled salamanders are chiefly nocturnal or secluded creatures, vision is minimized and smell has assumed the leading role both in sex recognition and in the arousal of courtship activities. In the males of certain species special hedonic (from Greek word "pleasure") glands situated on cheek, chin, or tail base secrete substances during the mating season which definitely attract the female. Odor is only part of the essential whole, however, for it was found in laboratory experiments that the female was interested in the odor only after she had been stimulated by the courtship movements and caresses of the male. When chemical mixtures, derived from the glands, were administered artificially, she did not respond. Maleness and femaleness, as well as species differences, can probably be distinguished by odor.

The female marbled salamander becomes increasingly excited by the nudges, pokes, and perfumes of the male who, incidentally, is provided with specially elongated front teeth that may aid him in caressing her. She may follow him around for as long as an hour, while he waves his tail back and forth, undoubtedly wafting his fragrance toward her. Eventually the male is aroused to discharge the spermatophores, shaped like miniature tree stumps, with a broad base of very sticky gelatinous substance, a whitish stalk, and a top layer in which are embedded millions of spermatozoa. The female appears highly stimulated by the spermatophore and picks it up either directly in her cloaca or with her appendages, passing it back to the cloaca. Experiments again show the indispensability and precision of courtship. The female will not be at all interested in spermatophores unless she first has been stimulated by the male's caresses and odors.

Efforts in the laboratory to crossbreed various closely related species of salamanders were unsuccessful. It was found that the required stimuli and the resulting reactions were so distinctive for one species that they meant nothing to other species. Neither member of a mixed pair could become attuned to the unfamiliar maneuvers and especially to the unfamiliar odors of the other. Even if the cross-fertilized egg could develop normally, which in most cases was physiologically impossible, interbreeding could not occur because of psychic incompatibility. The same difficulty has been encountered by other workers in trying to breed various species of sticklebacks and of birds. For example, a white stork, which clappers as a nest greeting, and a black stork, which hisses, were very much interested in each other but could not break down the barrier between them.

By Day and by Night

Other interesting studies have been made in the Museum illustrating the important influence exerted by environment upon courtship.[22] The reproductive behavior of the common American chameleon (*Anolis carolinensis*), a day creature, was compared with that of the Western banded gecko, a nocturnal species. This difference in their daily rhythm affects their whole life: feeding, protection, sociability, courtship. In both species mating, though dependent upon the willing submission of the female, is promiscuous with very little psychic content, no personal interest in each other, no marital or parental bonds. While vision is supreme in the day creatures, odor and touch are more important in the night. Thus the male chameleon displays at a distance, and this display evidently serves to attract the attention of the female. If she is unreceptive she has plenty of time to run away before he approaches her. Being considerably smaller than he, she could not resist him otherwise, though she may fight furiously with her more nearly equal female associates.

In the nocturnal gecko, where visual display would be useless, the male reserves his courtship until direct contact is established. If he seizes a male or an unreceptive female he is fought off. In this species the female is as large and strong as the male and can readily protect herself if she is not interested. However, inasmuch as the dominance of the male over the female is essential to successful courtship, the females, though physically able to defend themselves in case of need, are not belligerent by nature and do not fight among themselves as do the chameleons. It has been pointed out that, in the absence of size superiority of the male, aggressiveness in the female would act against race survival.

Associated with the fact that the geckos depend less upon vision, we find that they are more social than chameleons and tend to form in groups. Though inclined to remain in certain localities, they do not defend individual territories vigorously as do the chameleons, or fight extensively among themselves. This social tolerance is highly important in nocturnal species for bringing the sexes together.

Another factor contributing to the successful courtship of the nocturnal lizard is the intense stimulation and persistence of the male. He becomes so excited that he loses all sense of discrimination and must at all costs continue mating activity once it has started. Nothing—not even being handled by a human—will deter him. It is as though he

feared that once his mate was lost he could not find her again in the dark.

With the reduction of vision in the gecko, olfaction seems to possess added significance both for sex recognition and for stimulation, though this has been difficult to establish clearly. In courtship the male frequently flicks his tongue and brings his snout in contact with the female's tail region, often biting the tail. It so happens that the tails of lizards are autotomous, that even in nature they are commonly broken off without permanent damage or discomfort to the owners. In the laboratory it was possible without undue cruelty to remove the tails of four pairs of geckos, attaching those of the males to the females and vice versa. When new males were added to the group it was found that out of twelve reactions female bodies were courted five times and female tails five times, and only twice was any interest betrayed in male parts. With so few case studies these observations could hardly be considered proof of the importance of olfaction, but they at least suggest that odor does reinforce behavior. Additional evidence was obtained from the observation that when the nostrils of the geckos were plugged courtship was entirely eliminated.

Sexual Selection

Among species—and especially among birds—with a marked difference between the sexes we are more likely to find ardent wooing but of a shorter duration. Often the male goes through elaborate courtship dances while the female remains on the whole passive. In this case the brilliant displays are almost entirely intimidatory or excitatory. The development of strong emotional bonds would be futile, for the female usually assumes alone the burden of brooding the eggs and often of feeding the young, while the male confines himself almost exclusively to fertilization. Thus the male can afford to be strikingly colored; the female needs the more to be inconspicuous in color and behavior. Owing to the lack of family ties, marital relationships in these forms are likely to be polygamous or promiscuous, and this in turn tends to bring about further differences between the sexes. Males that are conspicuous in pattern, attractive, and strong mate successfully with several females and transmit their outstanding qualities to many offspring, while less favored males are not able to mate at all.

Earliest history tells us that man long ago was fascinated by the gorgeous display of the peacock. To the peoples of the Eastern Hemi-

sphere the peacock is the symbol of pride and vanity, as was the turkey to the natives of America. The male peacock spreads his covert feathers into a magnificent fan, puffs out his throat, holds up his head, erects his chest, and struts haughtily before the female. Movement and contrast add to the effect of the show. First he turns his back on the hen and flips his short tail at her, then suddenly turns about and quivers his fan, thus giving a glorious shimmer to the whole. The exhibition is definitely directed toward the female and usually she is impressed. So strong is this urge for exhibitionism during the breeding season that, like many other birds, the peacock will often transfer his sexual display to other animals, inanimate objects, or human beings. Nor can there be any doubt that in the process of impressing others the peacock succeeds excellently in impressing and stimulating himself. It should be pointed out, however, that the erection of feathers and the strutting, so exaggerated in the courting male, are frequently used as a general emotional outlet in females as well as males, in young chicks as well as mature adults. Many reasons may be advanced why the peacock can afford to be conspicuous. He does not help in the incubating of eggs or the care of young, and his bright colors may actually be of service in distracting enemies from the biologically more essential mother and young. Moreover, in his natural habitat in the dark jungles of India he flies only short distances and is adequately protected by the dense vegetation.

Some of the most beautiful sights in nature are those of courtship displays: the spread of a peacock's tail, the antics of the birds of paradise, the brilliant waving fins of the Siamese fighting fish, the singing oriole. It is not surprising that early naturalists took it for granted that such sheer beauty was its own excuse for being. It was to be admired; and by whom more appropriately than by the prospective partner? It seemed obvious that nuptial adornments and display in the more aggressive sex were meant solely to appeal to the aesthetic sense of the more passive sex.

Charles Darwin was one of the first to read a deeper biological meaning into these performances. In explaining evolution he did not attempt to make the principle of natural selection the directing force of all progress. Many evolutionary changes he laid to sexual factors and much of the beauty in the world he attributed to sexual selection. Many pages of evidence were marshaled which seemed to prove that the gorgeous colorings, striking patterns, beautiful songs, and occasional dances of male animals had come about through feminine choice (sometimes vice versa). If the most dashing male were the most suc-

cessful suitor he would be the one permitted to hand on his spectacular qualities to future generations.

Further research after Darwin's death tended to minimize the importance of feminine choice. Naturalists pointed out that the mind of an animal was not capable of appreciating beauty or deliberately choosing between two situations (though of course Darwin did not imply that the choice was conscious). Moreover, they noted that much of the conspicuous display was directed toward male rivals rather than toward the female object of the wooing; that all too frequently the females had no opportunity of making a choice. These scientists showed many ways in which display functioned, ways in which the female was only indirectly involved.

Sometimes *social* or *dominance* factors seem to have been responsible (through natural selection) for the conspicuous markings of one sex. For example, the bright blue face of the mandrill is believed to have arisen not as a sexual characteristic but as a threatening device by which a vigorous male might attain dominance over his social group, including males and females alike. Similarly in the small, closely schooling fish—the red-bellied dace—the bright colors seem to have a social significance, holding the group together even in mating, which is itself a communal affair. So strong are the social bonds in this species that several males may mate with one female, together fertilizing the eggs as she lays them in the community nursery.

Display as an *advertisement* also affects courtship and thus the process of evolution. Whether it be a plot of territory or the individual's own person that is being advertised, display undoubtedly attracts attention and produces results in the animal world as it does in the business world of man.

In the guppy bright colors probably serve primarily to aid *sex recognition*. The same is true, indirectly, of trout and salmon. Field work on these fish indicates that the somber-hued female selects the territory and that she attracts the males to her by her nesting activities. The brightly colored males, accepting each other as rivals, struggle among themselves for a position near her side. Sex colors aid sex recognition and intimidation of other males but do not attract the female.

Throughout the animal world bluff plays a greater role than allurement in controlling form and color. It has long been recognized that *intimidation* is a common and important aspect of display. Though its function in dealing with the female has only recently been stressed, many naturalists have observed its use in driving away rival suitors, maintaining social position, and defending territory.

The common barnyard turkey is a jovial acquaintance of us all. His gobbling, strutting, and pompous exhibitionism made him a symbol of vanity long before he became associated with Thanksgiving abundance. That the Indians in their day were impressed by the turkey is evidenced by their fancy for turkey feathers. Audubon observed many years ago that wild turkey courtship was not entirely a matter of simple wooing. As soon as the males hear the call of the female, he pointed out, they rush to the spot and, whether or not the hen is in sight, fan out and erect their tails, draw their heads back on their shoulders, lower their wings with a quivering motion, and strut about in a pompous manner, at the same time emitting a series of puffs and stopping now and again to look and listen. They continue this puffing and strutting whether they see the female or not; and while thus engaged they are likely to fall into fierce battles among themselves.

Today there is increasing evidence that sexual selection in the true Darwinian sense of female choice may occur and may to some extent direct evolution. Female Anolis lizards were definitely attracted from the distance toward males displaying the brightest dewlaps, though they seemed unimpressed with the dewlaps at closer range.[28]

We were also able to demonstrate a clear case of sexual selection among those jewel fish that have taught us so many valuable lessons. Females were given the opportunity of laying their eggs on one of three inverted flowerpots, each placed close to a different side of an aquarium. On the other side of each pot, in separate aquaria, three males were placed. When one of the males had the erythrophores (pigment cells) of its ventral surface expanded by the injection of yohimbine (a drug) so that his appearance was more brilliant than usual, the females laid opposite him in 80 per cent of the trials. These injected males exhibited no courtship movements, hence the females were responding primarily to color. Further proof of this contention was found by placing two males, one made colorful by injection, in separate aquaria at either end of a tank containing a female ready to breed. The position of the two males was frequently changed. In a series of tests with different females it was found that they remained on the average twice as long in front of the more brightly colored male. In each case both males were of the same size and degree of sexual readiness.

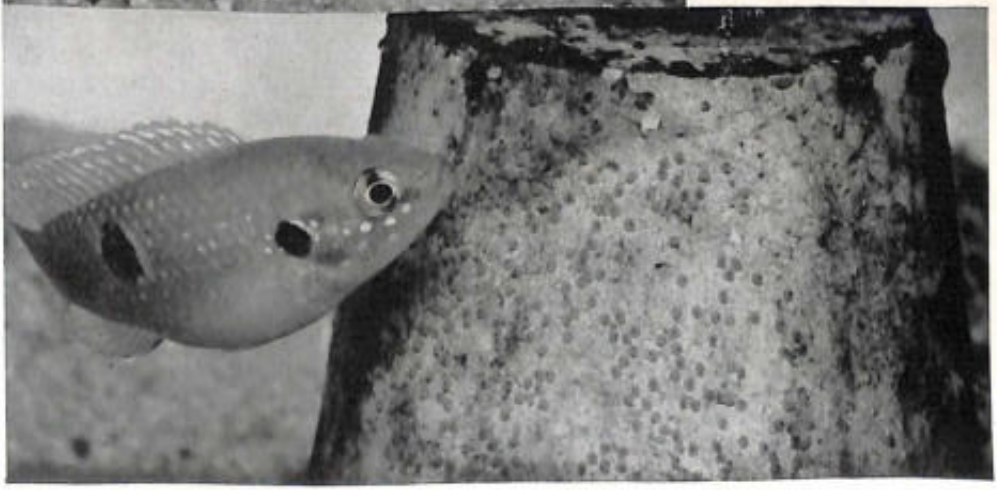
We have seen that the obverse holds true among the spotted turtles. Here it is the male that is attracted by the bright orange-yellow markings of the female's face. The brighter her face the more definitely is he attracted. Females with dull faces are consistently ignored. More-

COURTSHIP OF THE JEWEL FISH

The female jewel fish is attracted by territory-holding male. Courtship is mutual—symbolic of nest cleaning and egg laying.

After the female lays a few rows of eggs, the male swims by to fertilize them.

The parents take turns guarding the eggs and fanning them to keep them clean and oxygenated.



over, they fail to develop home ties, as do the brighter females, and become nomads or wanderers.

We may perhaps sum up a very complicated process by saying that male courtship display exerts a great influence upon pairing and thereby upon inheritance. This is accomplished by emphasizing sexual dominance and hastening receptivity in the female, by stimulating her emotions, by making territory available to her, by advertising, by driving off rivals, by maintaining social dominance, and by providing material advantages incidental to social position. All these factors have varying effects upon the female's physiology and nervous reactions, but they cannot be said to influence her in the sense of enabling her to make an intelligent or aesthetic choice.

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CHAPTER XIII

PARENTHOOD

THE YOUNG of many animals come into the world and begin separate lives without the slightest concern on the part of mother or father. The eggs are laid haphazardly, and it seems a matter entirely of chance that the young hatch and find food, protection, and an equable environment. This lack of care makes it essential that a vast number of eggs be laid, in order to insure the survival of a normal population.

The first glimmer of parental solicitude may be seen in those forms which seem to have a regard (unconscious, of course) for the future needs of the young by laying the eggs in specially favorable spots, usually provided with an appropriate food supply. Thus butterflies and other insects lay eggs on particular plants, and the ichneumon fly lays hers in caterpillars and beetles. This choice of environment does not involve foresight but is a mechanical reaction to certain sensory stimuli: carnivorous insects frequently lay eggs on the carrion flower, mistaking it for flesh because of its odor.

It is when animals remain with their eggs or their young and thus contribute in some way to their safety, health, or feeding that we find true parental care. More frequently it is the mother who stays by, less often the father. Occasionally both parents may be in attendance. The female crayfish carries her eggs about with her, attached to the swimmerets along her tail. Even after hatching, the young cling for some time to these small appendages. The giant water bug lays her eggs under the surface of the water, cementing them securely to the back of the male, who then has the responsibility of caring for them until they hatch.

Though parental devotion may reach sublime heights in the human race (on all too rare occasions), its origins are extremely humble and utilitarian in character. We have seen in the ants the mutual advantages which accrue to young and old alike in the establishment of the colony.

Amphibia

In the lower vertebrates we find many similar instances of quite effective parental care, however much that attention may be based upon purely selfish motives. The large and grotesque male hellbender salamander remains with the eggs after he has fertilized them and guards them zealously as his own food supply. Though, like the queen ant, he eats a few, incidentally he protects the others from far greedier enemies and thus contributes to the survival of his race.

The brooding of the mud puppy—another salamander—may have even less social significance. The mother remains in the "nest" even after the young have hatched and departed, an indication that her brooding may be owed merely to disinclination to leave a pleasant retreat. In most salamanders, where fertilization is accomplished, long before egg laying, by means of spermatophores, the male is not interested in the eggs, but the female is often found brooding them. The brooding mother probably contributes to the welfare of her offspring by assuring a supply of moisture from her damp body and by preventing the growth of fungus by secretions from her skin—advantages that would play a part through natural selection in developing the brooding instinct.[46]

In the marbled salamander brooding probably results from exhaustion of the female after egg laying; this is especially noticeable among species which deposit large-yolked eggs, a severe drain upon the mother's body. After laying her eggs in the fall and curling around them she will frequently remain with them, but if disturbed she shows no desire to return to brooding.

Other species of salamanders have developed a very strong bond between parent and eggs. Many mothers will return to the egg mass after being frightened away and some will move their eggs with them when disturbed or seek them out if they are hidden in unfamiliar places. Some salamanders, including the common dusky, will find and brood the eggs of another female of the same species, but not ordinarily the eggs of another species. However, if artificial eggs are placed at her original egg-laying site she will usually brood them, showing that her normal attachment is partly to the locality and partly to her eggs. Though a female cannot recognize her own eggs, she can discriminate between those of her own species and those of other species.[61]

Where the male salamander remains with the eggs it may be due to either of two factors: that the eggs accidentally were laid in his terri-

tory, or that they have become for him objects of sexual interest. In the few forms where fertilization takes place after egg laying it is essential that the male be attracted not so much by the female as by the eggs. The completion of fertilization is frequently delayed for some time; meanwhile the male exhibits an active interest in the eggs and even drives the female away in his struggle to gain sole possession of the clutch. The exhaustion of the male after his sexual frenzy may also contribute to his attendance upon the eggs. His jealousy in guarding the eggs, the protection of his mere presence, would again be of such incidental advantage that the instinct would naturally survive and become strengthened during the course of evolution.

Among certain frogs the tendency to brood the eggs has led to various modifications of the female's body, without, however, apparently establishing any emotional bonds to make possible the protection of the young after hatching. The eggs of Surinam toads are carried in individual sacs in the spongy skin of the mother's back until the young hatch fully formed, while marsupial frogs employ a single sac from which the young may escape as tadpoles or as metamorphosed frogs.[46]

When found guarding the eggs, the males of various species of frogs may not be truly brooding but merely exercising a tendency to remain near their calling stations. Occasionally, however, the male parent seems to be really attracted toward the eggs and in some forms actually transports the tadpoles from the place of egg laying to the pools. The carrying tendency may in turn have led to the remarkable habit of the male rhinoderma, a small Chilean frog, of carrying the fertilized eggs in its vocal pouch until the young are fully formed. A few species of fish also brood their eggs in the mouth of the parent, an instinct evidently traceable to their tendency to pick up the eggs in the mouth and convey them long distances to a safe retreat.

Blue-tailed Skink

Laboratory experiments on these lizards may further clarify the nature of the brooding instinct and demonstrate that parental care is more complex and advanced in many reptiles than is generally realized.[68] Though most reptiles provide their eggs with the necessary moisture and heat by burying them, and thus have little reason to brood them, the blue-tailed skink of the southern and central United States has a brooding behavior even more advanced than that of the salamanders just described.

A number of skinks, isolated in separate laboratory cages, were induced to lay in damp wood debris beneath a covering of bark. Usually the female remained with the eggs, curling her body protectingly around them; but at certain times of the day she would emerge and bask on top of the moss. It will be remembered that lizards are creatures of the sun, ill adapted to live long periods in the dampness and dark, as do most amphibia. A reptile's temperature is not constant like ours but varies according to that of the environment. The fact that the lizard leaves her eggs periodically in search of food and warmth is highly important. By warming herself in the sun and air she can so raise her body temperature as in turn to warm the eggs when she returns to brood them. One may imagine the difficulties of ascertaining the temperature of a lizard brooding eggs. Great care, infinite perseverance, and a special type of rectal thermometer were essential.

A second advance illustrated by the skink is in the handling of the eggs. Each time the mother returns to the nest she tests the eggs, turns them about a bit, and occasionally lifts one up gently in her mouth and changes its position. If the eggs have become uncovered or have been disturbed she invariably reassembles them into a compact group and covers them.

Like the dusky salamander, the blue-tailed skink adds to her clutch and broods eggs which, though not her own, belong to her species. This tolerance probably accounts for the fact, little understood before, that large clusters of lizard eggs are frequently found in the field, obviously the joint contribution of many different parents. The skink, however, rejected the egg of a foreign species and, when it was forced upon her a second time, bit the egg and broke the shell.

After her sorties in search of food and warmth she always returns to the nest. If the eggs have been removed she searches around until she finds them. By blindfolding her it was found that vision was not important in finding or in identifying them. As might have been expected from the way she nosed them and flicked them with her tongue, her sense of smell, functioning both through her nose and through her tongue–Jacobson's organ apparatus, brought her the necessary information. Obviously she was not at all interested in paraffin models or in shellacked eggs.

The female lizard surpasses the salamander in her protection of the eggs against enemies. Not only does she ward off interlopers by her passive presence but she can be most determined and ferocious in attacking and biting them—whether they be mice, snakes, or other lizards. The brooding skink will attack and drive off animals many times larger

than herself, boldly asserting her moral right to her territory and offspring. She touches intruders with her tongue, watching them closely while they stay away from the nest; should they come near the eggs she immediately bites them, chasing them and biting them again until they withdraw. She then returns to her nest, investigates all her eggs with her tongue, rolls them over with her snout, and settles down again to brood them.

Though the blue-tailed skink would never be considered a model parent from the human viewpoint, we have learned that she tends her offspring in many ways. She warms and defends her eggs, and promotes their health by turning them over and keeping them together. Some reptiles do a great deal more for their young; some do less, and some appear to do nothing at all. While most reptiles bury their eggs, many species, it is becoming increasingly clear, do not thereby abandon them entirely to the elements but continue to watch over them. Both male and female black snakes have been observed guarding (and evidently warming) eggs buried in a sawdust pile.

Alligators are extremely primitive in appearance, but their social relations are highly developed and bear out their close kinship to birds. Following a rain, the mother alligator places her eggs in a nest of saw grass, flag, or other vegetable material. As incubation continues the mass, baked in the sun, often becomes so hard that it cannot be torn apart with the hands. Remaining near the nest, the mother alligator digs out the young when she hears their cries as they are about to hatch. Perhaps it is the lack of voice in the young of lizards and snakes that fails to arouse interest in either parent for their offspring and prevents the establishment of mutual bonds.

At least in the Nile crocodile, the calling of hatching young will so affect the mother that she will dig under a stockade to get at them. When the young are free from the nest material the mother leads the way to the water, constantly uttering an attraction cry described as a "sucking-like *umph*." An additional distinctive grunt serves as a warning signal in case of danger. The young stay with the mother for periods ranging from four to twelve months. The parental bond probably ends when she leaves her nesting and wintering area to seek a mate. The *umph* cries of the young apparently act as a bond, holding the group together. Hunters imitate this call to lure the animals to the surface. This repertory of sound signals holding parents and young together, arising in the primitive alligator, expands enormously in birds.

Birds

In no field of natural history have sentiment and imagination run riot to a greater extent than in stories, poems, and songs about mother love in birds. Not only lullabies and nursery tales but even the traditional nature study are tinged by this romantic viewpoint. It is true that birds possess a remarkably well-adjusted set of parental instincts which in many ways suggest human tenderness, solicitude, and personal devotion. It is also true that bird parents can to a very slight degree adjust their instincts to meet unusual or changing situations, and can learn the barest elements of individual consideration for their young. But for the most part those so highly lauded activities cannot be attributed to love, ideals, or self-sacrifice, but are automatic responses to external stimuli and internal drives.

Parental behavior in birds may be said to begin with spring migration and with the claiming of territory by the father-to-be, thus assuring space and often feeding grounds for the growing young. After he has acquired a mate and the pair have had a chance to get acquainted, there is the determining of a nest site and the gathering of suitable nesting materials, sometimes including down from the parent's breast—as in the eider duck—or gummy secretions, as with our local chimney swifts or those Chinese birds who gave to the world "bird's-nest soup."

We have seen that all these activities are closely related to the physiological state of the parent, especially that of the mother, and that they are perfectly timed to the needs of the future progeny. The passion for nest building is largely burned out and gives way to the brooding urge just in comfortable time to insure the well-being of the eggs as they are laid. When the eggs hatch, the brooding instinct is supplemented by the feeding instinct.

The urge to sit long periods upon the nest and eggs is believed to be due to congestion of the skin capillaries of the breast, bringing about an uncomfortable heat which is relieved by the pressure of the nest and eggs and at the same time is indispensable to the development of the eggs. This congested condition of the skin is largely confined to certain *brooding spots* which, temporarily denuded of feathers, bring the eggs into direct contact with the moist skin, the surrounding soft feathers acting as insulators to hold in the heat. Part of the brooding activity is the turning of the eggs, thereby bringing a welcome coolness to the parent's breast and an equally desirable warming of all parts of the eggs. It has been observed that if the breast of an incubating bird is

immersed in cold water, thus counteracting the abnormal heat, the bird will no longer be interested in brooding.

Many ornithologists have been interested in determining the nature and strength of the bond that holds a parent bird to its eggs. Birds differ remarkably in the factors that call out their brooding responses. Adequate stimulus for incubation may emanate from the nesting site, the nest, the eggs, or a combination of these elements. At short distances broody laughing gulls appear to be attracted primarily by the eggs and in decreasing order by the nest site and the nest itself. In species which build more elaborate nests the attraction of the nest may be inferred to be greater.

Birds also differ greatly in ability to recognize their eggs.[67] Laughing gulls can distinguish their own eggs from artificial ones resembling them closely in form and color; but they cannot tell their own eggs from those of other laughing gulls, even if these are quite different in color tone or pattern. Incubating birds of this species will accept eggs of various colors when placed in the nest, though they may shy at blue or yellow and refuse to sit on red eggs. Roughening the surface of the eggs by gluing on them small pieces of straw disturbs but does not prevent the incubation behavior; yet a soft covering of rubber cement will inhibit incubation. Eggs of abnormal shape will be incubated, but not punctured or cracked eggs.

In general birds which build crude nests, like the laughing gull and the tern, are more readily disturbed by changes in their eggs than are birds which build well-formed nests protected by bushes or grass. Sensitivity to such differences reaches an extreme degree in the Atlantic murres, which build no nest but lay their single eggs on rocky ledges. The eggs of three individuals sitting close together were interchanged. Upon its return each bird rolled its own egg back to the original site and sat on it. Seemingly the lone egg means more to a murre than any single egg would mean to another bird.

Birds which have shallow nests on the ground will usually roll back displaced eggs into the nest if they have not been removed too far away. This is instinctive, not due to any personal concern for the safety of the eggs. A goose will laboriously push in an egg placed at the edge of her nest, but she will also push in a wooden cube or gayly decorated Easter egg. The strength of the brooding instinct is tremendous. If not interrupted by hatching, a hen may sit on her nest for months. She may remain on her eggs continuously, day and night, for four days, even when tempted away by food and drink. A penguin will brood her eggs even if they are frozen; she will also brood stones and cakes of ice.

PARENTAL CARE

Many female lizards brood and defend their eggs.

The Canada goose is one of the few birds in which monogamy and extended paternal care are found.

Mother zebra suckling young.

Though the mother usually has the greater responsibility in incubating the eggs, the father often takes his turn at brooding the young and especially at feeding them once they have hatched. The mother marsh hawk feeds the young; but the father kills four fifths of the prey and while on the wing gives it to the mother for the nestlings. Though the mother bird continues to cuddle the young ones under her breast and to warm them as she did the eggs, the new activity of feeding the young now seems to be set into motion by the begging cries of the young, reinforced by the search movements of the young birds' heads.

The young birds soon learn, or perhaps know innately, that a certain vibration of the nest means a mother returning with food. Instantly the begging starts and mouths open wide. If the nest is built in a hole or a hollow, as with woodpeckers, a sudden darkening due to the entrance of the mother will likewise start the begging. The mother, usually guided by the brilliant colors inside the open mouths, drops in her tidbit. Each species has its own mouth color pattern, to which alone the parent normally responds. In the American robin the mouth is a bright orange yellow.

The mother bird cannot judge which of her young is in most need of food and attention. The youngster who cries loudest, lifts his head highest, opens his mouth widest, gets the most food. In fact a young bird may be so weak from hunger that he fails to react normally to the mother bird who, no longer recognizing in him one of her own brood, may shove him out of the nest as she would a foreign body. The babe of a captive warbler, though strong and healthy, was tossed from the nest by its mother because, sated, it did not conform to the usual pattern of begging.

The European cuckoo and the American cowbird are known as parasitic birds, in that the mothers lay their eggs in the nests of other, usually smaller, species, leaving the foster parents to feed and care for their greedy young. Usually larger, noisier, and stronger than his nest mates, the young cuckoo or cowbird can often get far more than his share of the food, eventually forcing the rightful occupants to the edge of the nest, where they frequently fall out or are thrust out by their own uncomprehending parents.

The mother who cares for young in the nest must be not only a good provider but a good housekeeper. In a fairly shallow nest with few occupants the young usually retire to the edge to perform their toilet functions. Otherwise the removal of excrement devolves upon the parent. In many species feeding is promptly followed by evacuation; the mother, guided by the conspicuous anal ring of light feathers, waits for

the packet to appear and promptly removes it from the nest. Every time she feeds her young she seems impelled to carry something away; if there is no excrement she may pick up any bits of waste material or even part of the nest. It may be due to this house-cleaning ardor that the mother pushes her young from the nest if the usual recognition cues break down.

On their part, the young may show an equal lack of discrimination and adaptability. Young herons, normally fed on regurgitated food from the parent's beak, naturally do not question the suitability of the food offered them but automatically try to swallow anything which is put in their mouths: pieces of wood, the hand of the observer, et cetera. Often two young herons will attempt to swallow the wings, neck, or feet of a third. These greedy youngsters gorge themselves until the food is actually protruding from their mouths and even then the sight of more food elicits renewed feeding movements.

The young of some species, such as hens, ducks, geese, and wading and diving birds are not fed in the nest by the parents but as soon as hatched are more or less able to feed and run around by themselves. Quite naturally the bird most carefully studied in this respect has been the common domestic hen.[9] When her brood is first hatched the mother hen strives to keep them close about her. The youngsters soon show signs of independence but always come running back to their mother's cluck. In the hen world mothers do not have to worry much about children obeying them; the young are bound instinctively to react to the mother's call. A young chick peeps in his shell even before he is hatched, but if the mother utters her warning call the chick—with no experience whatever—automatically stops peeping. Later on the chicks go farther afield, but they still respond to her danger cry by running and hiding behind her.

Though the chicks soon learn to recognize their mother by her call, there is little evidence that she recognizes them individually. The mother, of course, means more to the young than vice versa. If a number of chicks are taken from the brood she does not seem to know the difference provided a few are left. If one of her chicks is put under glass, so that its cry cannot be heard, she will show no signs of recognizing or even noticing it.

The mother hen also has a leading cry by which she directs her brood about the yard in search of food particles. Instinctively she goes slowly but does not look behind to see how they are faring. If, however, she hears the abandonment cry of a chick she will stop or go back. The sudden cry of pain or alarm on the part of the chick is answered im-

mediately by the mother and also by the father, whose sole function now seems to be that of defense.

As the young become increasingly self-reliant the care of the mother diminishes and she begins to show renewed interest in the rooster and in nesting materials. The time comes when she refuses to have the chicks beneath her and pecks them when they feed near her. Forsaken by their mother, the young brothers and sisters remain for a time together, seemingly united by personal recognition and family ties.

Geese are said to be monogamous and to mate for life. The gander remains with the female and shares with her the responsibilities of raising each successive brood. Though the female does the incubating and most of the leading about for food, the male is constantly alert to any danger threatening them and is a fierce adversary if it comes to actual defense. On excursions by land or water the adults are apt to keep the young between them. For almost a year the young geese thrive on their unusual family life, but as mating season again approaches, the male's interest centers upon the female and he gradually drives the young away.

Mammals

It is in the development of adaptability—adaptability in parental care as well as in other activities—that mammals as a class surpass the animals beneath them. Even the humble laboratory rat can meet emergencies with some evidence of resourcefulness.[8] Though the mother's care is normally a matter of instinct, she is often called upon to make adjustments to unforeseen situations. If her nest is damaged or threatened the mother rat moves her young and constructs a new nest for them. If her young are removed from the nest she will search for them and bring them back. She may also learn to improve her instinctive care through experience. The rat who gives birth to young for the first time does all the necessary duties but is uncertain and clumsy about it. Later on she becomes much more adept and even displays a limited amount of gentleness in handling her young. This increased ability in mammals to adjust behavior to unexpected circumstances and to profit from learning is associated with the possession of a cortex. When that is removed these special skills are lost, though the essential innate activities may remain.

The safe and often prolonged development of the embryo inside the mother's body (instead of its incubation in an egg), plus the assurance of a perfect food supply, milk, give the young mammal a great advan-

tage over birds and reptiles. The mammal mother usually assists in the delivery of the young, if only by biting the umbilical cord. For the most part she remains passive while the newborn instinctively make their way to the mammary glands, attracted and guided by odor and warmth. Nursing is evidently a great satisfaction to the mother in that it relieves the pressure of the milk within her glands.

We saw in the chapter on learning that the mammal mother soon introduces her cubs to new and more substantial food, that she leads them very gradually into new realms and new responsibilities. She protects them not only from enemies but also from the elements. In spite of her discipline, however, the young ones occasionally wander off and come to grief. In spite of her watchfulness they become exposed to winds and rain and develop coughs and colds or more serious ailments. The life of a young animal in its nest or hole is not the serene, carefree existence we imagine childhood to be. In fact those days are probably the most precarious and instructive in its life. Early in the season foresters and game wardens frequently chance upon mothers escorting a retinue of several young. Later in the season the families are noticeably reduced, often only one or two cubs with their dam.

Many mammals develop through association a strong attachment to their young and learn to recognize them even in the midst of large groups. Mammals, like birds, are sensitive to sounds and much of their parental behavior seems to be activated by sounds. A mother sheep or mother fur seal will call for her young and wait for the answering bleat, which tells her surely which one of the herd is hers. The importance of odors has been repeatedly stressed. A ewe that has lost its lamb may adopt another, provided it is first presented to her with the skin of her own lamb thrown over its back so that it has the right odor. A mother cow who seemed unreconciled to the loss of her calf was given its stuffed hide for consolation. Comforted by the familiar odor, she licked it and rubbed against it fondly until she discovered that it was stuffed with straw. Then her one impulse was to eat it.

Similarly the young may recognize their mother by odor. Seton[83] relates rather unhappy observations of black bear cubs who had been with their mother but who had escaped when she was shot. The hunters had skinned the body, taking the hide back to camp but leaving the carcass, in hopes that the young would come back to it. After keeping their distance for two weeks the cubs finally returned and began eating the carcass. Two of them were caught and taken—frightened and crying—back to camp and placed near four bear hides. They immediately identified (undoubtedly by odor) the skin of their mother, snuggled up

to it, and appeared perfectly content. Thus we see that although mammals have the ability to combine many different sensations into complex perceptions and are seldom dependent upon any one sense a single cue *may* suffice in many instances.

Only a few mammals are fortunate enough to have the companionship and protection of both mother and father. The clumsy rhinoceros seems to be one of the few monogamous animals in which the family integrity of father, mother, and offspring is maintained over a period of years. In elephants as in most herd animals the males associate with the females only during the rutting season; the mother and her young alone carry on as a family. Often the males of such species are highly polygamous, their entire attention being focused on keeping their harems together and their rivals at a distance. Male offspring, far from being beloved by their fathers, often become hated rivals, objects of intense sexual jealousy. Theodore Roosevelt observed that the male deer and elk not only deserted mother and young but in emergencies even tried to divert attention from themselves to the mother and young. Some carnivore fathers have to be kept away from their young, lest they attack and eat them. However, male wolves, foxes, and many representatives of the cat family (such as cougars) will bring food to the lactating mother and later on share with her the duty of feeding the cubs. They warn the family of danger, come to their rescue if attacked, and care for the cubs if the mother is killed. The weasel father is said to be an excellent provider for his family. Among polygamous monkeys and apes the male overlord remains with his harem and bravely defends all members of the family. Nissen tells of a male chimpanzee who, defying his presence, ran back to rescue a young chimp and held it protectingly between his legs while facing the intruder fearlessly. In general, however, the acts of altruism which the primate father displays toward his young are only those which he might display toward any other member of his social group.[43]

In the maternal care of chimpanzees learning seems not only helpful but indispensable. The inexperienced mother often seems completely bewildered by her newborn babe and at a loss what to do with it. Having learned to take care of the first, however, she never seems dismayed by further additions. The chimpanzee infant is helpless at birth and for the first three to six months clings persistently to the fur of its mother's abdomen. With her assistance it begins to walk and climb, and before it is a year old can ride on her back. Besides nursing it for many months the mother devotes constant attention to it, skillfully feeding, grooming, and protecting it, and teaching or training it in the ways of the world.

CHAPTER XIV

ANIMALS AT PLAY

LONG BEFORE animal psychologists came upon the scene philosophers were asking themselves why animals play. The poet Schiller said that the animal *works* if a lack is the mainspring of its activity, and *plays* if a superabundance of life incites it to activity. After long years of speculation and the trying out of many theories most psychologists have gone back to Schiller's concept, bringing it up to date as the *surplus energy* theory. Young animals are characteristically vivacious; they have to be doing something. Their play activities, though not directly purposeful, are based on inherited nerve structures and naturally assume the form of instincts which have survived because of their usefulness.

Play has been explained by some authors as the outpouring of an imitative instinct. As early as 1825, Magendie called attention to the fact that the play of all young animals simulates the activities of adults of their species. Baby chimpanzees swing in the treetops as they have seen their elders do. Leopard and lion cubs worry sticks and stones in a manner resembling their mothers' treatment of live prey. The little boy imitates the fireman and the policeman. The little girl dresses up in her mother's discarded finery. Herbert Spencer, while agreeing with Schiller that play stems from a surplus of strength, believed that the instinct to imitate accounts for the form this activity assumes. We have seen, however, that imitation is not an important learning process in any but the highest species. In general animals do not imitate activities that are not natural to them. A kitten taken from the litter and reared in isolation will disport itself in the same manner as those cared for by the mother cat.

In his book on the play of animals Groos[24] has stressed the usefulness of play. To him play is no chance occurrence but an important aspect of instinctive behavior with definite practical value. It is the trying out of instincts, the making of adjustments, the learning of patterns that

will later be essential to the creature's survival. Groos looks upon play as an apprenticeship to the work of animals. Often, too, it is as strenuous as work. The young animal hard at play is not so much having a good time aping his elders as he is training himself for his adult activities—for fighting, for hunting, and for mating.

Only those animals which possess the highest potentiality for learning are accustomed to play. Certain important instincts appear early in the life cycle before they are seriously needed; as they mature they may be practiced and modified to meet life's real experiences. In the light of Groos's theory the real meaning of infancy is that is provides time for play. ". . . Youth probably exists for the sake of play. Animals cannot be said to play because they are young and frolicsome, but rather *they have a period of youth in order to play,* for only by so doing can they supplement the insufficient hereditary endowment with individual experience, in view of the coming tasks of life."

Some authors, while agreeing with Groos that the playful activities of childhood are part of the whole instinct picture, believe that most of those activities should be classified as *instincts;* that *play* should be regarded only as activity pursued for its sake alone, "for the fun of it." Portielje gives as an illustration a young hippopotamus born in the Amsterdam Zoo. Finding a withered maple leaf floating on the water, this "water horse" would dive under it, blow it up into the air, and plunge in pursuit of it once more. Since the hippo cannot be said to "hunt" for its food, such antics may not be regarded as a symbolic expression of the hunting instinct but as exuberant play. Lorenz stresses the lack of emotional drive and the maintenance of social inhibitions in true play. Biting to a dog is instinctive; biting gently, without anger, is true play resulting from social inhibition of the instinct to bite. The young rabbit which suddenly begins to cut capers in the meadow, then scampers for cover and hides there, Lorenz believes, is acting purely from instinct—just as afraid as though a hawk were after it. The young goat plays at fleeing quite differently. After cavorting madly over the ground it suddenly stands still and eggs its brothers and sisters on to continue the chase, obviously for the fun of it.

The modern surplus energy theory has the task of reconciling all these views. It is based, as we have said, on the fact that young organisms in general tend to be restless, to have a supply of energy more than ample for childish needs. They also have an untapped store of behavior patterns which will enable them in adult life to satisfy hunger, to mate, to care for their young. In the absence of need and an appropriate stimulus these instinctive reactions may be called out by anything re-

sembling the normal releasing object (or often by no observable cue whatever). The blowing leaf is now as provocative as a scurrying rodent; twigs are as engrossing as nest building later becomes. The practical advantages of play were perhaps not exaggerated by Groos; but they should be considered as incidental rather than causal factors.

Just why play is fun no one really knows. In high-strung, pent-up humans, however, activity in itself produces relaxation, a relief of tension which is distinctly satisfying. In active play the glow of excitement and the sense of physical well-being that come from vigorous muscular exercise contribute much to the joy of the game. Perhaps our most thrilling human play is in the nature of highly organized games where the social excitement and the spirit of competition are almost as strong among the spectators as among the players. Animals indulge only lightly in this type of sport, but they do have games in which the social and competitive factors seem to be highly exhilarating. And on occasion the participants have mildly interested spectators. From all appearances those higher animals who play derive a satisfaction akin to man's "fun." Just as a sleepy child will become alert at the sight of a new toy, so will an exhausted dog rouse himself to torment a new burlap fish or a rubber mouse with an irresistible squeak. In experiments with young chimpanzees the most effective reward that could be given was granting the young animal the privilege of getting back to his play.

Play as Exercise

By stretching and flexing its muscles, seizing and clawing, tasting and gnawing, pulling and tearing, uttering little sounds, pushing and kicking, a baby animal first tries out its muscles and organs and gradually gains mastery over them. We have all been amused by the ludicrous antics of a puppy in its first play. It yawns voluminously, wobbles, and tumbles over as it ventures upon all fours, bites its paws, finds its tail, and barks to hear itself bark.

In their youth the familiar animals of the barnyard—calves and colts and squealing, frisking little pigs—practice their characteristic methods of locomotion. Lambs and kids amusingly come to an abrupt stop as they cavort about and spring straight up in the air—practicing the direct high jump that was necessary for their species when they were mountain dwellers.

In the zoo, bears, honey badgers, and pandas amuse visitors for hours on end with their tumbling and somersaults. Mills[88] tells of a semitame

black bear cub who made itself at home around the cabin of a prospector. One day the bear, upon seeing Mills approach the cabin, went through a variety of pranks, evidently impelled only by the desire to show off. Eventually it leaped into an uncovered barrel, deliberately overturned it on the steep slope, and went merrily rolling down the hill, skillfully controlling both speed and direction with its forepaws. This would hardly seem a natural method of locomotion, yet many hunters have reported that bears, when injured or frightened, will attempt to elude their enemies by rolling or somersaulting downhill. Grizzly bears have been observed to *slide* downhill in the snow.

Young birds in the nest stretch not only their necks (for food) but also their legs and their wings. Later on they may playfully jump about, flap their wings, and rush at each other. Evidently all birds do not play. Watson, who made a careful study of sooty terns, claims that the young did little all day long but just stand still. In other species, however, even the adults seem to find fun in flight. Flocks will rise and float in circles ever higher and higher, then swoop down and rise and wheel again. A falcon, even though carefully trained, occasionally cannot resist the temptation to ignore the call of the master and play with its fellows as they soar into the clouds.

Because escape and flight are so essential to the survival of an animal it is natural that play should at an early age develop speed in running, flying, or swimming. Let off his leash, the cocker spaniel streaks across the park, his long ears streaming behind him; deer peacefully browsing at the edge of the woods break into flight and race madly as far as eye can see, though nothing has happened to startle them. Their running is evidently incited by an internal drive rather than an external stimulus; they act in accordance with an upsurging impulse, the prompting of the instinct to flee.

As we see a group of animals dashing over the countryside it is easy to attribute to their activity a strong element of competition such as we have in human racing. Competition is probably not an important factor, however. The racing animal does not try to beat his comrade to a goal; his desire seems to be to put as much space as possible, in as short a time as possible, between himself and his starting point. In the horse racing and the hound racing sponsored by humans the animals probably share less in the spirit of competition than we imagine them to. Hounds are beasts of prey; their chief incentive for running is the pursuit of a victim. Thus the fleeing rabbit is an essential part of the hound race. Horses, on the other hand, do not pursue prey; they just run. There are no rabbits at a horse race.

Play Fighting

Puppies romping together are training their minds and their muscles for future fighting. Sham battles are typical of the play of young wolves, lions, tigers, hyenas, foxes, and ocelots. Among those species which hunt in packs, like wolves and dogs, we find a certain amount of co-operative play as well as individual combat.

The wrestling matches of bears have always held a fascination for humans. Clumsy young cubs try to stand upright as they tussle. Hugging each other, they roll about, dealing cuffs to left and right. Usually it is all in good nature, but occasionally, as with children, real quarrels arise, the blows assume a deadly earnestness, and mother or caretaker has to step into the fray. Chimpanzees and gorillas love to wrestle with each other or with their caretaker and sometimes will act quite peeved if the desired partner does not feel like playing. Spider and howler monkeys in the wild have wrestling matches while hanging by their tails from the branches of trees. Bear cubs, too, have startled human observers by wrestling together far out on branches.

It is hard to imagine two porcupines wrestling, but they do. Sometimes they expend their energy upon a pole, rolling with it onto their backs, clutching it with their paws, biting and struggling with it. Defensive as well as offensive activities have been noted in play. A young female in her play would scramble up and down her perch, rush madly about her cage, dodge, and then—with quills erect and tail striking ominously—threaten her non-existent foe.

Similarly the play of many young birds includes both offensive and defensive movements. Young songbirds may chase each other, lower their heads and rush at each other, spar and squabble apparently without malice. Certain water birds will dodge and dive and thrust their bills into the air as if defending themselves against an imaginary bird of prey. Pet cockatoos and parrots often invite playful bouts with their human caretakers.

Play Hunting

The way of a puppy with a dangled toy is the way of a carnivore with prey. If the puppy cannot pull down the rope or the sock he seizes it with his teeth and tugs at it with all his might. With menacing growls he yanks it from side to side. Such behavior naturally serves as a re-

hearsal for the role of a hunter. By shaking a rabbit or a rat as he now shakes the sock he will deepen the hold of his teeth and stun his quarry.

The kitten, as soon as one eye is open, toys with any rolling or fluttering object within reach. Later she stealthily approaches a ball of wool, springs upon it, clutches it with her teeth from above and with her claws at the sides. She drops it for a moment, pounces upon it again. Sometimes, motionless and intent, she lies in wait, even appearing to ignore her prey. Her actions are prototypes of those she will use when she grows up to catching mice.

Young badgers, foxes, martens, and weasels play in a similar manner with pieces of wood or sod—poking, tossing, stalking, and pouncing upon the symbolic victim as does the kitten. As young animals become expert in handling inanimate objects the parent may bring them live prey, or they may of their own accord learn to extend their activities into more fruitful channels. Repeatedly they may pounce upon a mouse, drop it, and pounce upon it once more. Such torture is not sheer cruelty or perverted dominance; it has a very real survival value in affording them opportunity to learn the ways of their victims and to acquire stealth and accuracy of movement.

Young birds of prey—even when they are old enough to catch live mice—will playfully attack and seize sticks, roots, and pine cones, investigating them minutely with claws and beak. In captivity they may playfully attack their perch, the hand of their feeder, or any conspicuous target whatever. Bastian Schmid tells of his tame horned owl, who would catch a ball of paper thrown into the air, carry it to the floor, and there tear it to bits. For more than an hour this owl amused itself with the contents of a sewing basket, unrolling ribbons, pulling out the tape measure, and again and again dropping the thimble and a bunch of keys noisily to the floor. When he killed his first mouse he tore open the body and pulled out the intestines exactly as he had pulled the ribbons and the tape measure.[81]

Exploration

Curiosity is a striking attribute of many higher animals. The unfamiliar seems to have an uncanny fascination for them, arousing at once an apprehension and an urge to investigate. Young animals, like young people, are more interested than their parents in exploring novel situations.

The earliest field of exploration is the animal's own body. We have

watched delightedly as a baby discovers its hands, then its toes, and amuses itself by trying to bring them together. In the polar bear group at the Museum the little white cub likewise lies on its back and plays with its paws. The puma toys with its tail in the early days of life before he begins the specialized play of chasing it. In its early stages the sexual play of higher animals should be regarded largely as a phase of this exploratory behavior. Even at a very early age animals tend to examine and manipulate their reproductive organs and to manifest a curiosity toward those of their fellow creatures. This seems to be a natural playful instinct and consequently should not be considered a sign of depravity when it appears in young children.

In nature the young animal soon turns to exploring his home territory and to becoming acquainted with his companions. Raccoons and otters, adopted as household pets, inspected minutely all the household furnishings: curtains, rugs, cushions, as well as the contents of cupboards, drawers, and closets. Schmid's spotted woodpecker, as well as his owl, took a great interest in the sewing basket. His young magpie was also a skilled investigator. By inserting its beak in the slit it would lift the lids and examine the contents of an inkwell or a cigarette box. It would carry away small bright or glittering objects—a glass bead, a bit of tinsel, a silver spoon, and a metallic pot cleaner—hide them and recover them, only to hide them again and again.

Portielje[79] describes the behavior of a crested seriema (primitive South American bird) to whom he held out a crank handle. The bird first treated it as prey, knocking it to the ground. But after it happened several times to fall upon an iron well cover, so that a bell-like sound rang out, the seriema took the handle and deliberately ran with it to the metal cover in order to drop it where it would produce the enjoyable sound. Portielje also tells how Mani, a brown bear, sportively pushed a wooden block all about his cage and how capuchin monkeys clicked hazel nuts or pebbles together or against the wall.

Such playful activity, involving apparatus or "toys" (used primarily as playthings and not as prey), is considered by some naturalists to foreshadow the use of tools and likewise to indicate high mental development. An old otter in the Washington Zoo would play for hours with a flat stone, tossing it into the air, diving after it in the water, swimming with it skillfully balanced on her forehead. A pair of otters used to play contentedly with a silver dollar; another pair with a sardine can. In Africa, Akeley watched a group of baby elephants playing with a great ball of baked dirt over two feet in diameter. They rolled it along for over half a mile.

We have seen that many monkeys and apes appear to have a certain understanding of tools. Undoubtedly they pick up much of their knowledge in their youth while playing with a wide variety of toys and implements. A baby gorilla in the Washington Zoo amused and no doubt instructed himself by playing long hours with pieces of rope, a boiler large enough to fit on his head, balloons, gym apparatus, and dumbbells. Other apes have been observed to play ingeniously with sticks, string, nails, saws, and so on. Gorillas took a great liking to the garden hose and loved to slide on all fours over the wet floor of their cage.

Sometimes the animal's playful curiosity leads to destruction and mischief. Many animals pull things apart, perhaps to see what they are made of, perhaps to test their own strength and ability. Or they tease other animals to see how they will respond. While trying out new teeth little monkeys mutilate their wooden feeding troughs and—sad to relate—puppies gnaw on table legs and rugs. A dog tinkers with a low cupboard latch until he can open it and then enjoys the clatter as he slides the pots and pans about. Parrots mischievously throw the water cup out of their cage; cockatoos seem to delight in upsetting their feed trays. Monkeys upset tables, dexterously slipping out from beneath the falling objects to avoid being hurt. A certain orangutan practiced taking out knots and then untied the shoes of all who came near. Inconvenient and unpleasant though animal mischief and teasing may be to humans, we must give the devil his due and admit that such propensities involve a certain primitive "sense of humor," a quality long held to be one of man's most cherished attributes.

Moreover, tearing things apart may be a necessary forerunner to putting them together again. Synthesis is a process normally preceded by analysis. Many higher animals will destroy things primarily to examine them; a few display a desire and a certain ability to reconstruct them. Crude toy wagons were given to four macaques and four chimpanzees. The macaques rudely tore theirs to pieces and then abandoned them. The chimpanzees took theirs apart, also very rudely, but evinced a certain interest in the parts and soon endeavored—with only mild success—to reassemble the contraptions. In another way chimpanzees show a bent toward constructive play. One of their favorite pastimes is to build up a pile of blocks, then knock them down and build them up again.[85]

Social Play

Social animals play with one another. Animals which are solitary in later life are more likely to play alone, even though in their youthful days they are closely associated with mother, brothers, and sisters. Social play may assume many of the forms we have mentioned: pursuit, combat, flight. But in addition it produces the more intelligent, co-operative type of play we know as *games,* though of course these are loosely organized. In the field of human athletics we think it important for boys to play football and baseball because it teaches them teamwork. Similarly in the animal world social play may teach the animals to live together, to hunt in packs, to unite for common defense.

"Follow-the-leader" is popular with young lambs and sheep. The leader makes the game as difficult as possible. If he leaps onto a stone the others try to push him off. One of the plays is to nose out the leader. If, as he frolics across the meadow, he is overtaken by one of his playmates, this lamb takes his place. Seals play a similar game, making a loud commotion by lunging and splashing in the water as they chase one another. In Asia the anthropoid gibbons swing their way through the treetops, following their youthful leader. According to William James, the boy that romps with others "can no more help running after a boy who runs provokingly near him than a kitten can help running after a ball."

"Hide-and-seek" was played by Congo, the gorilla, and is said to be a favorite among otter cubs who may hide behind their mother, behind logs or stones, or even under the water. Young otters also have "tugs of war," each youngster pulling frantically at opposite ends of a stick.

Darling[17] has described minutely the games of the red deer. "Tag" is played frequently, but of course the rules are not observed as carefully as among human children. However, one animal actually does tag the other with its forefoot, and the one tagged is "it." The players do not keep at their game presistently; at any moment the sport may cease and the fawns suddenly run to their mother for a drink.

"King-o'-the-castle" is played by young red deer only up to the age of three months. Each youngster tries to attain and occupy the summit of a hillock, which is recognized and worn smooth as a playground, just as a boys' playground may be—or the meeting place of rollicking dogs. Rivalry is strong, but there is no actual combat as the young deer run up the hill and try shoving the others off. The game is started by

one energetic fawn making for the hill. This serves as a stimulus for the others to leave their mothers and push him off. This British game is said to be played also by British badgers, young and old together. At dusk they assemble at a traditional log or stump; for an hour or more they indulge in the sport of trying to climb the stump or pull the others down.

"Tag-around-a-hillock" may be played by the mother red deer and her young. The hillock provides an obstacle for doubling, a strategy appearing only in the higher animals. Darling believes that doubling demands insight—an intelligent grasping of relationships.

Social activities bring competition as well as co-operation. Even in animal games the spirit of rivalry seems to give zest to play. Among animals sufficiently advanced to play games prestige in itself seems to be a worthy goal of endeavor. In certain experiments, where the subject was supposed to be working for a material reward, it was sometimes found that the animal would perform admirably but ignore the reward, evidently satisfied with its own accomplishment and the approval of the experimenter.

In the social group success and failure in play may gradually build up a dominance scale in the young which will persist for years. Though howler monkeys are not an aggressive species, the young, by testing out their strength and wits in playful activities, soon develop a social order that is quite consistently recognized and held to among them.

Many animals tease each other. This is supposed to be due partly to an urge to experiment, partly to aggressive tendencies. By teasing, the animal may assert his dominance over another in a manner that is socially acceptable and that involves him in no actual danger. Seton[83] tells of a black bear cub who liked to play tricks on his dog companion. Often when the dog was peacefully sleeping under a tree the cub would climb high above him and leap down on all fours, not injuring the dog but knocking out his breath and giving him a big scare. Akeley's baby elephants would playfully tease the babies of a herd of buffalo until the cow buffaloes impatiently chased them away.[1]

Köhler reported that his chimpanzees loved mischief and teasing, and tended to adopt fads or "crazes" in the line of amusement. One of their favorite sports was teasing a hen with a stick. They would place a piece of bread just outside their cage to attract a hen. Then they would pull it inside as she was about to peck at it, or at that moment push her away with the stick. They repeated this prank time and time again, appearing to derive the greatest satisfaction from the hen's discomfiture.

It is not always a case of the strong teasing the weak. Troelstra's magpie teased a cat by darting past an opening in a hedgerow. The cat, of course, ran through the opening in a vain effort to catch it. Then the magpie repeated the prank on the other side of the hedge. Schmid's jackdaw could not bear to see his tame wolf stretched comfortably out before his feet. Again and again it would sneak up to the wolf, give it a resounding slap, and fly away—returning soon to administer another slap. A playful porpoise, in captivity at the Marineland aquarium, took to teasing the keeper who descended in a diving helmet to feed the other denizens of the enormous tank. The porpoise would gently grip the keeper by his clothes from behind, lift him bodily, and transport him to another spot in the tank.

Adult Play

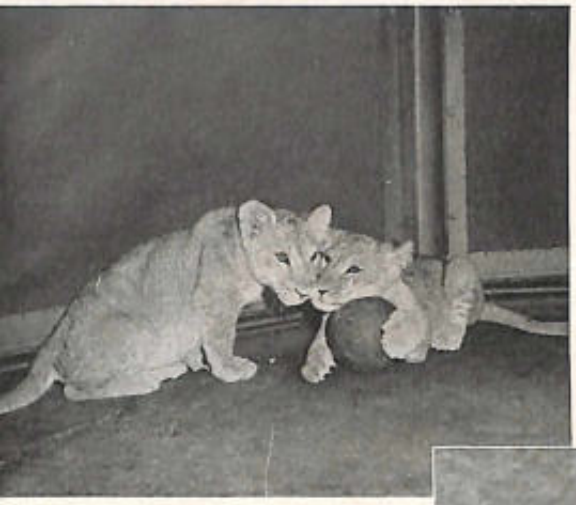
Though many animals frisk and frolic when young, their playful traits tend to disappear with growing self-reliance. However, mature play does occur in the lives of some animals, such as woodchucks, squirrels, seals, whales, apes, and monkeys. Sometimes it may be associated with the mother's habit of playing with successive litters of young. Then, too, an animal which in its early life has discovered satisfaction in play tends to continue it later if life's exigencies permit.

Certain types of adult play should be attributed to reproductive functions. In most mammals playful rolling and rubbing is part of the courtship pattern. In birds there is mutual chase, dancing, screaming, exhibitionism, toying with nesting materials. This play is largely a device for cementing an attraction between the sexes and in some cases for building up emotional bonds for future family welfare.

Other phenomena, such as the group dances of gorillas, are little understood and may be either sexual or social in nature. The same may be said for the vast and deafening choruses of some wild birds, monkeys, and apes.

Yet there can be no doubt that some adult animals play from sheer exuberance—for the fun of it. Birds continue to sing after the courtship is past. Gray squirrels chase each other up and down the branches in mating season and out of it; flying squirrels glide at dusk with no apparent purpose. Cormorants and pelicans, after their hunger is satisfied, continue "fishing" for its own sake.

An Antarctic explorer, Levick, has described the diving and sailing game of a community of full-grown penguins. They climbed aboard



Cubs of the cat family play with objects as they would with prey.

Panda play is largely climbing and somersaulting.

The mother bear introduces her cubs to new feeding areas, prods them in early attempts at climbing, scolds them and cuffs them.

an ice floe until there was no more room and floated on it to the end of the rookery. There they dived off in such rapid succession that they had the appearance of a "lot of shot poured into the water." After the icy plunge they repeatedly swam back against the current to catch another ride.

Full-grown otters seem to slide for pure fun. They clear away obstructions from a steep bank of snow, clay, or mud and then the game begins. In the words of Seton: "Whether the otter slides from the top of a mere snowdrift into the adjoining hollow, or down a muddy bank into a stream, or, best of all, down a long, icy hill, to plunge into deep, cool water below, it is evidently done for sport, for the joy of feeling itself flying through space without labor and without violence; and with the very same exhilaration that such a thing would give to mankind. To this, the creature fails not to add the crowning charms of good company and of friendly rivalry, for, so far as I can learn, no one has ever yet seen an otter enjoying its slide alone."[83]

As in human society, so throughout the animal world adult play and play for mere pleasure are associated with leisure. The porpoise and the panda are two of the most playful animals—the one a denizen of the deep, the other at home in high mountaintops. Neither animal has to work hard for a living, neither has many dangerous enemies. Keen competition is uncalled for; they can afford to be friendly and unafraid. Both are easily tamed, good-natured, affectionate, inventive in their play, and always appreciative of an audience. Thus on an ocean voyage we may see schools of air-breathing porpoises rolling over and over as they accompany the ship on its course. Sometimes they keep at a distance but more often frolic in the splashing spray. In captivity porpoises will play with balls, chase each other furiously around the tank, then suddenly slow down and approach each other caressingly. The panda is the world's champion somersaulter, rolling now from side to side, now headfirst, now taking a backward turn. It will climb and prance around with grossly exaggerated movements, seemingly in a deliberate attempt to produce a burst of applause or mirth from its human audience.

CHAPTER XV

HORMONES AND BEHAVIOR

WE HAVE SEEN that behavior depends not only upon an animal's structure and environment but also upon its internal conditions. Flowing ceaselessly through the organs, muscles, and nerves of the body is an ever-renewed stream of chemical substances. Seemingly unimportant glands and tissues pour into the blood an amazing flood of secretions or *hormones,* many of them so potent that an infinitesimal portion may radically affect the growth, structure, or behavior of the individual.

There are few human families in which someone is not taking thyroid or pituitary extract, insulin or adrenalin; and many persons, with superficial information, talk at length of endocrines and monkey glands. Yet endocrinology—the study of the glands of internal secretion—remains one of the most baffling and controversial of sciences. To the difficulties of determining the chemical analysis of these complex secretions is added the bewildering tangle of their interactions upon one another and upon the nervous system.

The endocrine organs and the nervous system are often closely interrelated in their functions, both frequently producing similar reactions in the body. In general the nervous system provides a more rapid and precise means of regulation, required, for instance, in effecting color changes in certain tree frogs. Chemical control through endocrine secretions is slower and more diffused but has decided advantages where continuous activity is called for, as in digestion, circulation of the blood, and metabolism.

However much remains to be known in endocrinology, a good deal that is important and extremely useful to mankind has been discovered. Psychiatrists have long realized that people are not altogether responsible for their eccentric acts, that often their mental aberrations or shortcomings are due to glandular upsets or other physical deficiencies over which they have little control. Numerous diseases, abnormal growths, and distorted structures are likewise the products of over- or

underactivity of the glands. The dwarf, the giant, and the bearded lady of the circus owe their freakishness to the malfunction of certain glands in their bodies. Many human sufferers have been greatly helped through glandular treatment; and individuals considered "peculiar" have been relieved and encouraged through understanding—rudimentary though it is—of endocrine disturbances.

The greater part of this knowledge has come through experiments upon animals, for the chemical secretions of man and beast seem to be very similar. Though most of the preparations used in clinical treatment of human ailments are now synthetic, many of them are derived from sheep, cattle, or other slaughterhouse animals; naturally not from human sources. The standard measure of male hormone is in "bird units," the amount of hormone necessary to make a capon comb grow by 20 per cent. Most vertebrates, like humans, have thyroid and parathyroid, thymus, adrenal, pituitary, and sex glands. For our present purpose it will suffice to mention a few examples of how glands can affect the *behavior* of animals, disregarding for the most part glandular effects on structure and development. And even here we shall confine our discussion largely to observations in the Museum laboratory.

Thyroid

The endocrine gland probably most familiar to the layman is the thyroid, the secretion from which has been produced synthetically under the name of thyroxin. This substance controls our metabolism—i.e., regulates the rate at which we consume energy. Sheep without their thyroids remain stunted in growth and mentally backward; children become cretins. Tadpoles deprived of their thyroid can never metamorphose into frogs. Conversely bullfrog tadpoles (which normally do not metamorphose for two or three years) may, by receiving one dose of thyroxin, change within a month into small but perfect frogs, their behavior as well as their structure being transformed from that of a purely aquatic, fishlike creature to an individual at home on land or in the water. In the "goiter belt" of our Western states a lack of iodine frequently causes enlarged thyroids and high excitability in cattle, hogs, and sheep as well as in humans. The discovery that a small amount of iodine given in food or water will prevent such conditions has meant the saving of millions of dollars to stock breeders.

Adrenals

Two very important though tiny glands lie close to the kidneys and thus receive the name of adrenals. Structurally these glands consist of two distinct parts, each with its characteristic secretion. In mammals there is an outer layer known as the adrenal *cortex* (or peel) and an inner layer or *medulla*. Certain cells in the adrenal cortex appear to secrete a substance which is either the equivalent of or which activates the sex hormones, especially those characteristic of the male reproductive organs. Women with abnormal masculine traits can sometimes be restored to normality by removal of one adrenal gland. The experimental administration of adrenal tissue to female guinea pigs brings about an unnatural masculinization.

The adrenal medulla secretes the well-known substance adrenalin, one of the most powerful chemicals known. One part in 330,000,000 parts of water can be detected in the laboratory. Tadpoles fed with adrenal tissue speed up their growth rate but do not metamorphose as they do with thyroid feeding. Adrenalin seems to be produced chiefly in fright and evidently serves to muster the body resources for defense or attack. In jewel fish injections of this hormone cause a contraction of the pigment cells and a consequent paling of the skin as in frightened fish; in either case the affected fish may lose his prestige and often his territory and mate.

Pituitary

At the base of the brain lies a small gland known as the *pituitary* or hypophysis. Though not much larger in man than a good-sized pea, its powers are many and mighty. It has been called a key gland in that it regulates other glands, including the thyroid and sex glands, and through them touches upon almost all the processes of the body.

Like the adrenals, the pituitary gland consists of more than one part. Moreover, each part probably secretes several different chemicals. The *anterior lobe* gives off a substance which greatly stimulates growth, especially of the long bones; if overactive, either in man or beast, it may produce gigantism. Giant tiger salamanders have been produced through feeding anterior pituitary. Injected tadpoles develop to twice their natural size. In the larger dinosaurs the pituitary was one fourth the size of the brain. The anterior lobe seems to have a hormone whose

particular duty is to stimulate the thyroid. Still other substances, by regulating the sex glands, stimulate sexual activity and in general control the breeding cycle.

The *pars intermedia* of the pituitary secretes a hormone known as *intermedin,* which expands the black pigment cells of the skin and thereby darkens the coloring. The frequent color changes of amphibia are probably caused by the interplay between intermedin and adrenalin, which we have seen brings about contraction of pigment cells. Lizards from which the pituitary has been entirely removed turn a pale gray and remain this color permanently under varying environmental conditions. If fragments of the pars intermedia remain, however, the lizards will change their colors to some extent but not as noticeably as control specimens. This reaction in animals also has its clinical application. A virulent type of cancer known as melanoma is associated with too much intermedin in the blood. In searching for a test for this condition in humans, geckos were found to be of value. When serum from a melanoma patient is injected into these small nocturnal lizards their skin immediately becomes blackened.

The *posterior lobe* produces a variety of secretions which apparently have important effects on many body functions, as water regulation, the contraction of smooth muscles, kidney activity, and fat metabolism.

Prolactin, one of the hormones secreted by the anterior lobe of the pituitary, has been used extensively in experiments on animal behavior. It has been called the parental hormone. If injected into fish, pigeons, rats, or humans it tends to induce parental behavior and to some extent parental emotions. If jewel fish have spawned once prolactin (and also other substances) may bring on the full pattern of brooding behavior: guarding eggs and young, eating young of foreign species, summoning young by means of rapid fin movements. Prolactin stimulates egg laying not only in hens but in frogs and salamanders. In animals which have recently laid it builds up the spent ovaries.[71] This hormone has proved of great value to the laboratory investigator, for by inducing mating and egg laying it furnishes, almost upon call, important observations and embryological material which might be most difficult to find in the field.

Both parental and sex behavior depend primarily, it is believed, upon instinctive patterns laid down by inheritance in the nervous system. The function of the hormones is not to determine but to activate these innate patterns. Parental behavior has been induced in fish and mice without hormonal stimulation. Moreover, when the nervous

mechanisms controlling parental behavior are destroyed by removing certain areas of the forebrain, hormones are entirely ineffectual in producing the response.

There is, however, a continuous interplay between hormones and nervous system. The pituitary, resting so closely against the brain, seems to have an especially intimate relation to the nervous impressions and reactions of the animal. This relationship is apparent in the secretion of "pigeon milk" by the pigeon. Both parents produce as food for their young a fatty substance which is the sloughed-off lining of the crop. This fatty condition of the crop is brought on normally by anterior pituitary secretions and may be induced artificially by injection with prolactin. The normal secretion of the pituitary, however, is dependent upon sight stimuli. If a normal father pigeon is removed from his family his crop loses its swelling and no "milk" is given off. But if allowed to see his mate brooding he maintains the functional crop. The psychic effect of seeing an industrious mate permeates his entire physiology. Hearing her will not suffice, even though he be in the same cage with only a board between them.

Sex Glands

Though we think of the sex glands as producing eggs or sperm, they are in addition very important and versatile organs of internal secretion. Hormones produced by the ovary and testis and their associated tissues vastly influence the activities and mental processes of all vertebrates. The sex glands are in turn activated, as we have seen, by the pituitary hormones.

We are accustomed to regarding an animal as distinctly a male or a female, yet this difference is not as absolute as may seem on the surface. In the early stages of embryology both male and female organs are identical; only in the later stages do they assume their distinctive forms. In many adult animals there are evidences of both sexes and indeed both are found together in man—e.g., the breasts of males.

As with structure, so with behavior and nervous machinery. It is probable that patterns for both male and female behavior are inherent in both male and female animals, and that hormones and environmental conditions call forth the appropriate reactions. Typical masculine behavior has been frequently observed in normal female cattle and rats. It was observed once at least in the laboratory herons.

Though human hermaphrodites are rare, masculine behavior and physical traits are commonly recognized in women, and feminine characters in men.

It should, therefore, not be surprising that both males and females have varying quantities of the hormones which we have been wont to think of as distinctly male or female products. The so-called "male hormone," testosterone, is evidently produced not only by the male testis but also by the female ovary, and perhaps by the adrenal glands and other tissues. Female hormones are likewise found in the male, even in the testis. In fact the richest known source is said to be the urine of stallions.

Though the sex of an animal presumably is determined at the time of fertilization by factors in the chromosomes, it may often be altered or reversed by the hormones of the opposite sex. Salamanders have had their sex changed in both directions by hormones from the more mature gonads of the opposite sex transplanted into their bodies. Many amphibia may pass through a prolonged neutral stage before the gonad develops into an ovary or testis, and during this stage hormonal or even temperature factors may bring sex reversal. When a female fighting fish, Betta, has been spayed (ovaries removed), she loses all normal phases of her reproductive behavior and, incidentally, her attractiveness to the male. These may be returned, however, by administration of ovarian extracts. If the spayed female is not interfered with she may regenerate a testis and assume the characteristic fins and behavior of the male, even to normal mating with a female. In the fighting fish sex reversal seems to take place only in the direction indicated. Neither a castrated male nor a spayed female has been known to regenerate an ovary.[66]

Male Hormones

Years ago mothers used to warn their daughters that "whistling girls and crowing hens always come to some bad end." Today the whistling girl is a delight instead of a disgrace, and even crowing hens have won acclaim. Hens are particularly susceptible to sex reversal. There are several records of hens which after living a useful life rearing a number of broods of their own chicks have changed spontaneously into roosters. In all birds only one ovary, the left, is functional. If this is removed or diseased the right rudimentary ovary will frequently develop into a testis. If male hormone is injected into a hen she may

develop a larger comb, take to crowing, and in general become more aggressive.

In the laboratory adult male behavior has been similarly induced in young chicks.[76] Normally attempts at mating do not occur until chicks are about five months old. In one experiment ten two-day-old male chicks received daily injections of testosterone. On the fourth day the tiny youngsters began to stretch themselves and crow with all the gusto of roosters. After six injections the chicks exhibited the vicious cocklike fighting and wing flapping. After eight injections they made definite attempts to mate with females and showed their sexual interest in other ways such as raising their neck feathers when approaching a female, pecking her head aggressively or—more gallantly—calling her to food before eating. Sometimes the precocious male chicks would scratch the ground to find food and hold it in their beaks while calling to the female. They also developed the treading activity, the large heavy combs, and the deep red wattles normally distinctive of the mature rooster. So strong was their prematurely induced sex urge that they would try to mate with anesthetized birds and even with the human hand.

Among the Museum black-crowned night herons male behavior was also induced in females and in the young of both sexes by the injection of male hormone.[78] Even in month-old chicks testosterone made the voice more guttural and induced territory defense, nest building, all male courtship ceremonies, copulation, and later, brooding. So realistic was the guttural sex voice of the treated chick that it acted as a parental "signal," calling forth instinctive food-begging behavior even in incubator chicks who had never heard a parent's voice. Though female herons are normally interested in sticks they do not play with them in a formalized manner as do the males. Nevertheless, by treating a female with this male hormone her interest was gradually increased until the full male pattern was developed. Puzzling enough, in these herons female hormones were found to have absolutely no effect upon the behavior of either male or female. Differences in the sexual behavior of the male and the female seem regulated only by variations in the amount of testosterone normally present in the birds.

Among dusky salamanders spayed females in which a testis has been implanted will shortly develop typical male teeth—elongated and daggerlike—rudiments of male behavior, and also the typical male glands, certain of which are supposed to secrete an odorous substance attractive to the females. Among some varieties castration of normal males brings about the loss of male teeth and their replacement by

female teeth.[70] Female toads, masculinized, develop the nuptial pads with which the courting male usually holds the female in embrace. Female jewel fish, treated with testosterone, often try to copulate even without an organ; though the organ grows later, it is interesting that the "mind" should respond to these hormones before the body.

Administration of male hormone will not only make hens crow and female canaries sing like males but will also raise their rank in the social hierarchy. In female swordtail fishes it will induce masculine behavior, the growth of a masculine "sword," and added prestige in the group.[54] Similarly social poise and self-assurance in women has been attributed to the male hormones in the blood stream. Bearded ladies and women with masculine voices, physique, and manners are the result of an overproduction of male hormone. Men clinically treated with testosterone have testified to a renewed energy and increased sexual emotions.

Experiments on Anolis lizards have demonstrated the anomaly that male hormones may sometimes induce—in both males and females—not only male behavior (bobbing up and down, displaying his dewlap, strutting, biting the female's neck) but typically female behavior too (identified by submission to mating and display of an inviting neck bend). They increase the aggressiveness of both male and female. In experiments with males alone testosterone-treated individuals fought much more actively than controls and the assumption of male or female behavior was apparently related to position as dominant or subordinate in fights among the group.[68]

Female Hormones

As might be expected, the endocrine products of the ovaries are primarily responsible for structures and behavior characteristically feminine: the breasts, rounded contours, soft voice of women; the subdued coloration of many birds; and probably the larger size of many female frogs and the brood pouch of kangeroos and opossums.

The fact has been repeatedly stressed that in all classes of vertebrates successful mating cannot take place unless the female is in oestrus—i.e., in a state of sexual readiness. By and large the physiological changes involved in this receptivity are initiated by ovarian hormones. Experiments with many animals have shown that removal of the ovaries eliminates (in all but the highest forms) oestrous behavior. Moreover, sexual receptivity may be induced in immature animals by treatment

with ovarian hormones, or in castrates by the implantation of mature ovaries. In mammals and probably in snakes ovarian hormones are responsible for the release of odorous secretions which attract the male during the reproductive period.

In general the reactions of the female hormones are not as clear-cut, as conspicuous, or as easily produced in the laboratory as are those of the male hormones. Castrated or immature males are not as readily feminized by ovarian hormones as the females are masculinized by male hormones. A male rat, castrated when young and later treated with ovarian hormones, will display feminine receptivity when courted by a male; but he will assume the normal masculine role when placed in the company of an oestrous female. Male chickens when treated with female hormones develop a rivalry with other females and accept food from a rooster in a quite feminine manner.

During the breeding season both sexes of the laughing gull develop special nuptial coloring: black head feathers and red beaks, red eye margins and red legs. The sexual behavior includes calls and postures also common to both sexes, but in addition other behavior distinctive of each sex. It has been found that the male hormone induces those calls and postures common to both sexes and also those characteristic of the breeding male. Female hormones, however, injected into either sex, will stimulate the subordinate behavior essential for successful mating and normally confined to the female—i.e., the food begging with lowered head and also the response to the "sex call" of a male.

The intricate changes accompanying pregnancy, such as the conditioning of the uterus and the mammary glands, are evidently controlled by a complex interplay of hormones from the ovaries, the placenta, and the many other tissues involved. In black-crowned night herons female hormones were proved to have important functions in preparing the oviducts for passage of the eggs.

One of the pregnancy hormones either activates the anterior pituitary or is itself the equivalent of anterior pituitary hormones. At any rate pregnant animals are found to have in their blood stream and to excrete in their urine large quantities of "anterior pituitary-like" substances, definitely associated with maternal physiology and behavior. Such substances, injected into a non-pregnant female rabbit, will cause her to pull out bits of fur from her breast and to shape a soft nest, as if she were preparing for a normal litter.

The abundance of this hormone in the urine has made possible the many "pregnancy tests" which appear recurrently in the news. In diagnosing internal disorders of women it is often important to ascer-

tain whether the patient is pregnant. Doubtful cases are most frequently tested by injecting mice, rats, or rabbits with extracts derived from the patient's urine. The pregnancy hormones, if present, immediately react upon the animal, producing within a hundred hours well-recognized physiological changes. Other animals, too, have been utilized in this type of diagnosis. Xenopus, a primitive aquatic toad, does not ordinarily breed in captivity; but if injected with pregnancy urine, ovulation and breeding activities soon result. The European bitterling is a fish whose eggs are laid and fertilized in fresh-water mussels. An extraordinary wormlike egg-laying tube is developed in the ripe female, enabling her to deposit the eggs accurately in the gills of the mussel. If pregnancy urine is injected into an unripe female bitterling she, too, will develop the long egg-laying tube.

In concluding this brief review of an ever-widening and interesting subject it may be well to point out that all too often in the field of endocrinology experimental results seem hopelessly confusing and conflicting. Yet to the zealous scientist such results are only more exacting challenges to further clarification of the problem.

CHAPTER XVI

ABNORMAL BEHAVIOR

The best laid schemes o' mice and men
Gang aft a-gley.

THINGS GO WRONG. The mental machinery clogs or breaks down or explodes. The human being becomes a problem to his family and friends, and all too frequently needs hospital treatment or confinement. The wild animal, when no longer able to compete with his associates, is killed or, like the rogue elephant, roams in solitude, an outcast from the herd. On the farm mad dogs, anti-social horses and cows, cannibal sheep and pigs have for generations perplexed their owners. In the laboratory certain types of abnormal behavior can be induced at will. Dogs, chickens, and lobsters—in fact an almost endless variety of vertebrates and invertebrates—have been hypnotized. To rats and mice, the usual laboratory subjects, have been given such disorders as fear complexes and epileptic fits. Especially in an artificial environment, where normal instincts and desires are thwarted and conflicts develop, the minds of mice and men "gang aft a-gley."

Hypnosis

Pavlov,[18] the great Russian physiologist, while studying inhibitions and conditioned responses, found that a dog would occasionally exhibit a state of rigidity comparable to that of human hypnosis. In some dogs this condition could be readily induced by a cessation of normal stimuli, a repetition of dull, meaningless stimuli, a sudden sharp stimulus, or a conflict of stimuli. It was attributed by Pavlov to an inhibition, disassociation, or sleep of certain higher centers of the brain during which other, presumably lower, centers remained awake and active. It was considered closely allied to both human hypnotism and the cataleptic condition or tonic immobility frequently found in animals.

Many animals—frogs and salamanders, for instance—if held firmly between the hands and suddenly turned on their backs, will remain

rigid for several minutes, then gradually "come to" and make off. Sales clerks in live-poultry markets sometimes weigh the struggling birds by quickly turning them on their backs, a position they retain as if frozen, at least for a few moments. Though the condition normally wears off in due time it may be terminated at once by a strong stimulus, as a loud noise or a flash of light.

The keeper at a Florida alligator farm is accustomed to "hypnotizing" a young alligator for the entertainment of his patrons. Holding the animal by its shoulders, he firmly rolls it over on its back, makes a few mystic gestures and utters a number of incantations, as a hypnotist might, then withdraws to talk to the spectators while the alligator lies on the ground as if dead. A few moments later the keeper saunters back to the beast, making more magical passes. The alligator twitches, stretches its legs, rolls over, and ambles off while the keeper bows to the applause.

Manifestations of tonic immobility are not necessarily "abnormal behavior"; they frequently occur in nature and have become more or less characteristic of some animals, as the cottontail's "freezing." Though undoubtedly they are related to hypnotism, their exact nature and the immediate stimuli which cause them are as yet unknown. Often, as in the monkey "scared stiff" of its superior, the condition is an individual reaction brought about by intense emotional shock. Many young birds, when approached by an enemy or warned by the mother's danger call, will "freeze" and thus avoid disclosing their presence by conspicuous movements. Whether it is fright that "petrifies" the nestlings we cannot say; perhaps the reaction which originally occurred as an emotional block, having proved useful, was adopted by the species and exploited for its protective value. Animals which "freeze" are usually those protectively colored; with their statuesque pose, their identity is readily lost against the background.

Death feigning is a more specialized protective device. Though it has become largely instinctive, it appears at times (probably falsely) to be deliberate, as in the opossum, which is said to "keep one eye open" to watch the maneuvers of its enemy. Animals that feign death are usually those that are preyed upon by species which react only to live moving victims. They are protected not so much by the fact that their pattern blends with the background as that they appear dead and hence are no longer attractive. A condition known as "benign stupor" has been occasionally found in humans and is regarded by psychiatrists as a protective device comparable to the death feint of animals. Usually it occurs as a result of shock or intense fear, the subject assuming—in-

voluntarily and unconsciously—the attitude and rigidity of death, sometimes for days.

One of the champion death feigners among animals is the hog-nosed snake, frequently found along the south shore of Long Island. When disturbed, he rolls over on his back and gives every appearance of being dead. When lifted up, his body hangs limp like a rope. That such inertness is due to blind instinct and not to emotional helplessness or intelligent contriving is shown by the fact that if turned over on his belly he will immediately shatter the illusion of death by persistently rolling back.

Among many birds the mother will divert threatened danger from her young by "injury feigning." Leaving the nest or eggs, she will go off in another direction, limping or dragging a wing, as if severely injured. The precise nature of this response to danger is unknown, but it is generally agreed to be automatic and instinctive, not the product of reason or strategy. Some explain it as an inhibition in certain parts of the brain, producing a limited motor paralysis.

Convulsive Disorders

"Cat fits" have been observed so long and by so many persons that the term has become a byword in the language, comparable and probably contributory to the notion that a cat has nine lives. Fits are by no means confined to cats, however. They probably occur in almost all species of animals, and for centuries have been the misfortune of some human beings and the object of much unnecessary horror and dread on the part of others. Epileptic fits, or convulsive seizures as many neurologists prefer to call them, are now known to be associated with disturbances in the electrical rhythm of the brain waves, and these in turn are probably due to a chemical unbalance the exact nature of which is still a mystery.

Spontaneous convulsions have been reported in virtually all kinds of domestic animals and in many of the animals at the zoo. Pandora, the panda at the New York World's Fair, had violent periodic seizures from which she finally died. Many neurologists and doctors examined and treated her but were thoroughly at a loss to account for the disorder. She had always seemed in excellent health and spirits, and autopsy revealed no signs of injury or infection.

Convulsive seizures have been artificially induced in many laboratories devoted to the study of nervous disorders and the relief of human

suffering. They have been brought on in rabbits by the use of certain drugs, and in rats by noises and by dietary deficiencies. Large doses of X ray will produce epilepsy in dogs; direct electrical stimulation of the cortex will do the same thing in monkeys. Cats and dogs, whose individual susceptibility to convulsions has been determined, have been used to demonstrate the beneficial or aggravating effects of different drugs. Treatment by electrical shock has been found to inhibit seizures in rats.

Mental Disorders Due to Infections and Injuries

Animal minds as well as human frequently break down from purely physical factors. We have seen that chemical changes in the body, often brought about by secretions from the endocrine glands, may radically distort behavior. Similar distortions may result from bacterial infections, parasites, senility, brain tumors or other nervous injuries, faulty diet, or food poisons.

The mad dog is a fearful spectacle familiar to all. He runs wildly about, barking and biting at imaginary objects, and finally becomes totally disorganized. Such a deranged animal has been the victim of rabies, a virus infection that affects the nervous system and produces intense discomfort and excitability. Rabies attacks not only the dog, but also the fox, wolf, hyena, jackal, raccoon, badger, skunk, many birds, and man. Sheep may develop the "staggers" from the cyst of a tapeworm in the brain; fowls may fall into a type of sleeping sickness as a result of a blood parasite.

One of the most puzzling phenomena of nature is the mad mass migration of lemmings. These small rodents inhabiting the mountains of Norway are subject periodically to enormous increases in population. Ordinarily they live close to the timber line, feeding on grass and roots, but at the height of their productivity vast hordes start on a frenzied migration to the coast and even out into the sea, where enormous masses are drowned. Many attribute this extraordinary suicidal behavior to an infection brought on by their abnormal numbers. Others explain it in terms of territory, claiming that, as the strongest take possession of all available space in the usual habitat, the weaker are driven onward and outward, trying vainly to gain a foothold.

A number of pitiable persons are born with defective brains and "just never have a chance." Many animals come into the world with similar insurmountable handicaps, the underlying causes of which may

be legion, subtle and complex. Mr. Lee Crandall, curator of birds at the Bronx Zoo, has had among his charges many "silly birds." A favorite pet was a mentally deficient pigeon named Eagle Beak, a "born moron" as they called him—undeveloped physically and with an abnormally down-curved beak which gave him his name. Supposedly a racing pigeon, he was too stupid to start flying himself and was often used as a "dropper" to get the other flying pigeons down. Eagle Beak never seemed to know what to do or where to go. He would eat if food was placed in front of him but probably would have starved rather than seek his own food or protect it from the others. He never had a proper mate and though he performed sporadic courtship maneuvers they never were appropriately directed or, from all appearances, favorably received.

Brain and nerve injuries may produce distortions of behavior similar to those caused by congenital malformations. Even an ant was found upon autopsy to have been the victim of a brain tumor! In nature, animals with damaged nervous systems seldom survive and are almost never available for study. To some extent their conditions may be reproduced through surgery in the laboratory, where they can be carefully studied and compared with normal animals. Experiments of this type have contributed much to our knowledge of human as well as animal psychiatry and brain surgery.

Birds with injured cerebellum (the organ of balance) can no longer fly. Monkeys, cats, and rats with frontal lobes removed forfeit most of their learned behavior but not the ability to learn new things. A fish with his forebrain excised loses his urge to explore and investigate. Though such a fish may be a quite effective individual, he loses his ability to get along with others; his courtship and parental behavior become totally disorganized, for he can no longer integrate his actions with those of other individuals.

Faulty Diet and Food Poisons

Behavior may be distorted into many strange channels solely because of faulty diet. Hens lacking calcium will eat their own eggs and peck furiously at the fingernails or buttons of their keeper. Sheep lacking vitamins and mineral salts eat the wool from each other's back. Cows occasionally develop an incurable habit of milking themselves and drinking their own milk. Among many animals, mothers deficient in manganese will not take care of their young.

Examples are numerous of the effect of food intoxication upon the nature of the beast. Countless cattle, sheep, and horses of our Western plains have contracted vicious nervous disorders from feeding on the well-known loco weed, "loco" being Spanish for "crazy." Once discovered, the taste for this plant may develop into a serious addiction which often leads to death. Cattle of our Eastern states may acquire the "trembles" from eating the white snakeroot, and may even pass on the disease, through their milk, to human beings. Sheep and goats in the pastures of Ethiopia, it is said, often get quite drunk and strangely aggressive from eating the beans of the coffee plant. Sapsuckers become intoxicated from drinking fermented sap. European thrushes occasionally develop a craving for certain berries which eventually cause paralysis and death. Katz speaks of ants which become intoxicated by eating the exudations of certain beetles, growing so delirious that they even offer their broods to the beetles as food. Veterinarians have often reported psychotic reactions in dogs following the administration of certain vermifuges. In less serious vein, all of us have been entertained by the crazy antics of a cat nibbling and playing with a spray of catnip.

In the last two sections we have considered the serious psychological derangements due primarily to organic defects and generally known in human psychiatry as *psychoses*. Less serious but far more prevalent are the *neuroses* brought about by maladjustment of the individual to his environment and his associates. A conflict or suppression of natural instincts is the usual precursor of neuroses.

Development Difficulties

Like humans, animals come into the world with an assortment of innate cravings that demand satisfaction. Lacking natural outlets, these feelings may distort the activities and personality of the individual through life. The newborn human must suck and be given warmth and physical contacts and manipulation. A few years ago the medical dictum was for mothers to leave their babies alone, to spare them the pampering of doting relatives and the excitement of proud uncles tossing them in the air. Now an almost opposite view is held: that babies thrive best on petting; that children brought up mechanically in large institutions tend to become neurotic and sickly. It is now good form in maternity hospitals for the nurses to play with the babies, even shortly after birth.

The newborn monkey is minutely inspected, poked, licked, and groomed by its mother. Young calves, kittens, seals, camels are diligently licked by the mother and by each other. Stockard, who made so many enlightening experiments on dogs, found that the puppies in his laboratory could not eliminate properly until they had been licked all over by their mother. Similar difficulties have been experienced with lions in zoos. Lion cubs not properly licked by their mother failed to eliminate and became physically and emotionally upset. The keeper was able to remedy the condition by rubbing a wet sponge over the abdomen of the cubs.

The process of growing up is a difficult one for any organism. Especially hazardous are the periods of transition from one stage to another, as from babyhood to childhood or childhood to maturity. Parents are well acquainted with the difficulties of adolescence, and naturalists know that many tadpoles die in the process of becoming frogs and many pupae in their struggle to become butterflies. Such changes seem to demand a supreme effort of body and mind, and any added strain may cause the animal to relax his efforts and revert psychologically to the earlier, easier stage.

The dissatisfied child will take to thumb-sucking, the adult to chewing gum, smoking, or biting pencils—all harking back to the oral stage of infancy. Young chimpanzees suck their toes as well as their thumbs. The older bear cub may likewise start sucking his toes; the monkey child may run back to its mother's breasts. Under the stress of emotion, babies and puppies, after attaining the walking stage, often go back to crawling.

These distorted activities are regarded by many psychologists as *infantile regressions*. Similar psychic atavisms (the going back to an earlier stage) involve other periods than infancy. When conflicts occur during mating time there usually is a reversion to a former phase in the cycle. Among birds, if a conflict develops during nest building, the bird will often revert to courtship activities. When things go wrong with the young bride her impulse is to go home to mother.

Emotional Shock

All these manifestations may be caused by shock as well as by emotional conflict. In addition many other neuroses, including anti-social behavior and fear reactions akin to inferiority complexes, may be produced by shock. The gun-shy dog would be placed in this category, as well as the dog who has been excessively punished. A sheep dog, in-

clined to attack and kill other dogs, was severely beaten by its master. From that time on the dog had no courage whatever, and though given a new home retained a constant fear of all human beings, barking at and running away from them.

A severe flood in Petrograd (Leningrad) led to unexpected observations in regard to the effects of shock upon Pavlov's famous dogs. The kennels were submerged and the dogs had to be taken, swimming, to the laboratory a quarter of a mile away. Loud claps of thunder, sharp lightning, falling trees terrified them. When finally they reached the laboratory and were huddled together they did not fight among themselves as was their wont but remained strangely impassive. Their normal reflexes had been completely blocked. After two months' patient retraining Pavlov succeeded in re-establishing the normal reactions. When, however, a trickle of water beneath the door was shown to one dog its neurosis reappeared. Though the animal's behavior was normal under ordinary circumstances, the shock had left an indelible mark upon its personality.

Shock may produce another type of neurosis occurring frequently in humans. While a hen was feeding in a room a guinea pig was placed in front of her. The hen at once stopped eating and fluttered about wildly. Though the guinea pig was promptly removed, the hen remained greatly perturbed and refused to eat. From then on she could not be coaxed to take food in that room, which seemingly had become to her haunted by the ghost of the guinea pig. Similarly it has been observed that a song sparrow frightened by an owl will fear the place where the owl has been. This attaching of emotion to a neutral object is the basis of many of our superstitions.

Sexual Difficulties

Few modern psychologists would go as far as Freud in attributing mental aberrations to sexual conflicts or frustrations. They agree, however, that the sexual drive is a very potent one and may, lacking normal outlet, express itself in most unexpected forms and places. In the chapters on sex recognition and courtship it was indicated that, owing primarily to lack of discrimination, animals may develop homosexual relations or attempt to mate with dead animals, sleeping companions, or inanimate objects. Pathological conditions comparable to masochism and sadism in humans also occur as exaggerations of the subordination or dominance instincts in animals. We have seen that reversed sexual

behavior may be the result of abnormal amounts of male hormone secreted by endocrine glands.

Sexual activities often appear not as part of a normal reproductive cycle but as a general emotional outlet in times of stress or excitement. It has been frequently observed in zoos that apes, baboons, and many other of the larger mammals, when enraged by the animals in an adjoining cage or by teasing visitors, will explode in a burst of sexual activity.

Conversely, when a genuine sexual drive is frustrated the animal may relieve its emotional tension by activities not at all sexual in character. Frustrated males or females may seek relief by fighting other animals toward whom they have not the slightest animosity. A frustrated male bird may relieve himself by exhibitionism, by nest building, or by fighting. This type of behavior, whereby relief is obtained not by the discharge of the normal drive but by another activity, is referred to as *substitute* or *irrelevant behavior.*

Again, we may have *symbolic behavior,* in which the normal activities are performed but with the object symbolized. Male birds have been known to direct their courtship appeals at a cabbage leaf and a beer jug. Such widely separated forms as the silvery gull and the ocelot have been observed to carry out complete courting and mating activities with a tree trunk.

Conflicts of Conditioning

Animals and humans may be taught in youth that one type of behavior is suitable for one situation, an entirely different type for another situation. This is all good training for the normal events of life, but circumstances occasionally arise when it is impossible to decide between two courses. The resulting emotional conflict is far harder on the individual's nervous machinery than the most strenuous work or severe deprivation. Serious neuroses have been experimentally induced in animals, neuroses that reproduce amazingly the conditions found in humans subject to worry, indecision, conflict.

Pavlov was probably the first to demonstrate this in the laboratory. Certain of his dogs were trained to expect food when a circle was projected on a screen, no food when an ellipse was so projected. Gradually the ellipse was modified until it approached the circle in shape. When the ellipse was eight ninths as broad as it was long most of the dogs broke down, unable to decide upon the proper course of action. Some

dogs became excited and irritable, others melancholic and unresponsive. In this and similar experiments a few stolid creatures always "refused to worry" and evidently were not seriously affected by the conflict.

Liddell and his associates at Cornell have induced neuroses in pigs, goats, and sheep. Primates have been known to break down as a result of conflicting loyalties to their mates. Cupid, a young rhesus monkey (already mentioned in connection with intelligence tests) at the University of California, became attached to a female named Psyche. After about three years of normal mated life Psyche was taken away and another female named Topsy was given to Cupid. At first he disliked her, but eventually he made the adjustment to his new mate and seemed quite contented. One day, however, he was led past the cage of his first mate, Psyche, now shrieking and excited. He looked back at Topsy, then at Psyche. Suddenly he began to bite himself, tearing long jagged gashes in his legs. The story has a happy ending. After Cupid's wounds were dressed Psyche was returned to him; she nursed him devotedly and in general had a quieting influence upon his distraught nerves. Yet it was fourteen months before his neurosis was pronounced cured.

Maladjustment to Environment

Animals are so perfectly attuned to their environment that any change in it or removal to a new environment will inevitably cause some degree of nervous disruption. Examples of neurotic animals may be seen in zoo, circus, and laboratory, despite every effort of directors to make the surroundings as congenial as possible. Environment is more than a landscape; it is a combination of sight and sounds, smells and contacts, food and companions, temperature and humidity, and possibly a host of other factors—each factor woven inextricably into the animal's instincts and experience.

The two lacks which the large captive animals probably feel most keenly are want of exercise and of companions. Because their energy cannot be expended in exercise and in the normal pursuits of everyday life it is often expressed in irrational emotional outbursts and in certain motor peculiarities comparable to tics in humans. Everyone is familiar with the mechanical pacing back and forth, or round and round, of animals in close confinement. Sometimes they execute an endless figure eight.

Especially during the mating season, when spirits normally run high

and excitement is to be expected, are the difficulties of restricted movement serious. The great majority of animals in captivity are females. In the first place the males are probably stronger in resisting capture, and in the second place, if captured, are likely to become so mean as they mature that they have to be disposed of. The males of many species, though amiable in their youth, become wild and actually dangerous when they reach sexual maturity. The male white-tailed gnus at the Bronx Zoo are almost all ugly in disposition and especially resent large groups of young visitors. There are few male elephants in captivity; Gunda and Runga, two males at the Bronx Zoo, though great favorites in their youth, became so vicious that they had to be shot. Khartum, though dangerous to men, seemed to develop a sentimental attachment to a nest of young robins in his enclosure and often caressed them gently with his trunk.

Among social animals members of the group form an intrinsic part of the environment. Such animals, if kept in solitary captivity, may develop neuroses which other animals, by nature more solitary, will escape. This is a common observance among the herd animals in the zoo—such as bison—and has been worked out experimentally, as with Brückner's studies with chickens.[9]

Brückner placed in isolation from one another a number of chicks who had just hatched from their shells in the incubator. Appropriate food, light, and warmth were furnished in such way that the keeper could not be observed. Even during the first week the isolated chicks were much noisier than normal ones. After the first week they became excessively and increasingly active, chasing flies madly, scratching aimlessly in their food dishes, dispersing the grain about wildly. One developed a ticlike movement, pacing back and forth and bumping himself from one side of the box to the other. When finally placed with a normal brood, these neurotic chicks were frightened and bewildered, and sought to escape from their new companions, though more often than not colliding with them in helpless confusion. From such observations fond human parents can see at least one reason why it is now against the law in many states to sell single chicks as Easter pets.

In many cases an animal of another species or even an inanimate object may symbolize the natural companion. A well-known example is cited by Lorenz of a budgereegah (parrot) raised in isolation which adopted a blue-and-white celluloid ball as its companion.[38] The bird would not come to rest except beside the swinging ball, which it caressed and groomed as solicitously as if the ball had had feathers. Then it would in turn place its head in position to have it stroked by

the swinging sphere. Stressing again the precise nature of many of these social reactions, Lorenz notes that the bird treated the ball in the same way as if it were the head of a fellow parrot, and showered upon it all the attention normally lavished upon the head of another member of the species. Endeavoring to keep the ball always level with its own head, the bird distinctly showed discomfort when the ball was fastened below head position. Whenever the ball was dropped on the floor of the cage the bird became silent at once and cowered in a corner precisely as budgereegahs react if one of their fellows dies in the cage with them.

Frustration of Normal Drives

Many factors besides change of environment bring about a frustration of normal instincts and satisfactions, and many instincts must be satisfied to insure the mental health of the animal. We have mentioned the necessity for social contacts among social animals, and the strong sexual drive so essential for the continuance of the race. Equally essential for race survival is the maternal drive in higher animals. If a mother animal cannot perform her duties toward her young in her usual instinctive manner she may suffer a nervous breakdown.

In the course of Brückner's experiments with domestic fowl a mother hen was given four hundred chicks to lead, brood, and care for. It was natural that the task should have proved too much for her. Unable to carry out her accustomed family duties or to treat each chick as her normal instincts dictated, she became highly excited and finally gave up the task entirely.

Even among jewel fish in the Museum aquarium abnormal behavior has often been noted.[58] Parent cichlids, if disturbed while spawning or brooding, are likely to eat the eggs and attack one another ferociously. During experiments precautions must be taken to avoid repeated handling of the fish, an annoyance many parents are unable to withstand. One female that had acted normally in recognizing her mate and brooding the eggs broke down after three and one half hours of disturbing experimentation and permitted a strange male whom she had previously dominated to drive her from her eggs. She even made no defense when the other fish in the tank pounced upon her eggs. Such breakdowns sometimes lead a parent fish to skip a step in the cycle of parental behavior. Thus a female who had become distraught after protracted tests picked up her half-developed eggs, churned them in her mouth for a few seconds, and spat them out on the floor of the tank.

She was treating the eggs as if they were young just hatched; and since at this stage there were no pits in the sand to receive the newborn, the embryos failed to live.

Such assaults are not confined to the laboratory but undoubtedly occur frequently in nature. Kirkman, in field studies of black-headed gulls of England, reports a "rogue gull" which habitually kidnapped young nestlings from under the beaks of their parents. A certain few parent birds were constantly persecuted and driven from the nest by their neighbors for no apparent reason. Abnormal behavior resulting from the thwarting of the brooding instinct was also observed. In these gulls both sexes brood the eggs and young, and it often happens that one mate is unwilling to relinquish its post when the other comes to take over. Kirkman noted that such distraught newcomers, unable to satisfy their intense craving for brooding, often gave vent to their feelings by collecting grasses and sticks and poking them into the already completed nest; a practice that in some cases resulted in nests several times their normal size.[84]

Instincts of aggression must necessarily be curbed in a restricted environment, and many peculiar manifestations may be laid to the distorting or turning inward of the desire to fight. A chimpanzee, when annoyed at the taunts of visitors, habitually climbed up a pole and bumped his head soundly against the ceiling. Frustrated rats bite their nails. Portielje alludes to the common attempts of puppies to bite their own tails, whirling round excitedly and growling fiercely as they try to catch the elusive "enemy." He also observed a striped hyena carrying on a sham battle with its own paw so realistically that it had bitten that member quite seriously; and tells of lions biting at their hind paws and rolling on the ground as though locked in mortal combat.

Therapy

Fortunately the appearance of abnormal behavior in either human or captive animal does not mean that the individual is destined to a life of irresponsibility or derangement. Thanks to the increasing knowledge of psychiatrists and the common sense and sympathetic understanding of friends, much can be done to relieve and even cure these mental illnesses.

Katz[88] mentions an observation by R. and R. Menzel illustrating how simple sometimes can be the remedy. A bitch, extremely timid and lacking in self-assertion, was constantly in difficulties in her pack

and suffered actual tyranny. Sensing where the trouble lay, a dog lover formed a new pack around her in which she stood in high esteem, and she soon responded by gaining noticeably in spirit.

Acute lack of confidence may also occur and be relieved in birds. New York State, which raises a large proportion of all the ruffed grouse reared in captivity, loses nearly one third of its stock each year from the development, it is asserted, of "inferiority complexes." Allen[8] too is of the opinion that male birds defeated in combat may be prevented by their upset from normal mating, and may actually die, so extreme is their degradation. In the laboratory such birds, treated with male hormone, have shown renewed self-confidence.

The black bass is by nature anti-social, a stern individualist who prefers to hide off by himself among the thickest weeds of the pond, ready to seize and devour smaller bass as they swim by. But even he can be reformed. Fish experts have learned that if young bass are raised in open water without weeds, so that they have opportunity to become acquainted with their fellow fish, they develop social attitudes, no longer prey upon one another, and thus leave a bigger crop for the sportsman.[87]

Though instinctive behavior is exquisitely attuned to normal living, though experience may assist in solving many difficulties, though conflicts are far less common in nature than they are in civilization, nevertheless mental aberrations undoubtedly occur in the wild. For animals as well as humans, life may be very trying at times and companions very irritating. If we seldom hear of deranged animals in nature it is largely because they are so soon eliminated.

CHAPTER XVII

BEHAVIOR AND EVOLUTION

Thus by the animal's form is its manner of living determined;
Likewise the manner of life affecteth every creature,
Molding its form.

Metamorphose der Tiere

THUS DID the poet Goethe—forty years before Darwin's *Origin of Species*—express in immortal literature the essential harmony of form, function, and environment. As long as men have studied nature they have undoubtedly been impressed by the extraordinary adaptation of animals to the surroundings in which they live—adaptation of *behavior* as well as of physical structure. Wading birds not only have long legs, long necks, and probing beaks adapted to shore feeding, but also strong instincts to poke into soft ground and to stamp in the mud, thereby detecting their prey. So impelling is this trampling-probing impulse that it often expresses itself in emotional behavior or in situations totally unrelated to feeding.

To some degree this harmony between animal and surroundings is evident to all, but only the technical scientist can fully appreciate the perfection of this relationship, involving not only gross structure and behavior but the most minute adjustments of nerves, glands, bones, muscles, reflexes to one another and to temperature, humidity, atmospheric pressure, food, refuge, and associates. Not only must the animal be attuned to the world about him, but each organ must work in harmony with the others, each cell in harmony with its neighboring cells. This does not mean that disharmonies never exist. Useless and often deleterious structures and instincts are frequently observed in present-day forms, and in the past untold individuals and races have arisen and been wiped from the face of the earth because they were less fitted than others for the life they were called upon to live.

These harmonious relationships have not come about—as often claimed—through special creation, nor through a predetermined and purposive course of evolution, nor through the inheritance of characters especially acquired by individuals because they were useful.

Rather they have arisen through mutations and have persisted through natural selection—an endless "struggle for existence," a "survival of the fittest" among innumerable individuals variously endowed with good, bad, and indifferent traits. The same evolutionary processes which mold the form of a species are likewise responsible for evoking its characteristic behavior.

Though mutations have been defined as *changes in the germ plasm,* their fundamental causes are unknown. They have been produced experimentally in the laboratory by chemicals, X ray, and radium and by radical changes in temperature; but it is not known to what extent these forces operate in nature. Mutations are believed to be chemical or physiological in character. Though inconceivably small in themselves, and often in their effects, they may sometimes bring about conspicuous alterations in either structure or behavior.

Change of Environment

Though mutations are said to be the "raw material" out of which evolution is made, and natural selection the most important agency in bringing it about, the accumulation and refinement of *adaptations* are greatly hastened by changes in environmental conditions. Winds or flood or ocean currents may carry large groups of animals away, or forest fires or volcanic eruptions may alter physical features more or less permanently. An earthquake in Guadalupe in 1847 tore off the whole side of a cliff and deposited it in the valley below. Black-capped petrels, nesting on top of the cliffs, never returned to the vicinity of their ancestral breeding grounds. There were undoubtedly many population shifts and adjustments during the ice ages and the extensive tropical eras.

In such times of stress *adaptive* evolution progresses rapidly. Those individuals which happen to have useful mutations and which happen to mate with other individuals equally well endowed are the only ones to pull through such cataclysms of nature; all others are destroyed. On the other hand, in times of ease and good fortune both useful and useless mutations flourish; *diversity,* rather than adaptation, is the result.

Animals which succeed in one locality may be unfortunate misfits in another. For instance certain individual animals, experimentally removed to higher altitudes, suffered interference in their sleep, their recognition of sounds, and ability to change their course of direction. Were this to occur in the course of evolution over many generations the

vast majority of individuals would die without progeny, and only the exceptional strains would survive.

In general species do not so much adapt their behavior and their structure to suit the environment as they find over a long period of time the environment best suited to their needs and limitations. Climate and geography are continually changing and animal populations continually shifting about. If the marbles in a puzzle box are shaken long enough most of them will eventually roll into their proper niches.

The so-called "blind salamander" (*Typhlotriton*) inhabits the caves of the Ozark Mountains, not because it is blind but probably because it prefers cool water. In fact its eyes develop normally under the stimulation of light. The Ozarks, like other limestone formations, have been subject to unusually rapid erosion. Many caves and sinkholes have appeared, the ground has become extremely porous, and most small streams dry up completely during the hot summers. The average temperature of what little surface water remains has undoubtedly risen considerably within recent times, geologically speaking. Field studies proved that *Typhlotriton* had far less tolerance for warm water than had other salamanders living outside the caves. Temperature preferences and a change in the environment itself, rather than failing eyesight, had undoubtedly led to cave existence.[19]

Learned habits, though not in themselves inherited, nevertheless may lead an animal into new environments and steer evolution along new channels. For instance squirrels may have arisen from a group of rodents driven by superior enemies from their terrestrial habitat to seek shelter in trees. For long generations those with poor climbing ability would fall prey to their hypothetical enemies. As mutations occurred those features which aided climbing would be retained, until eventually squirrels emerged.[20]

Learning is not always advantageous; sometimes it can react tragically against the success of a species. An example may be found in New Zealand, where the keas (omnivorous parrots) suddenly acquired a taste for sheep's kidneys with the result that farmers nearly exterminated them.

Origin of Species

One of the most intriguing problems in the study of evolution has been the origin of species. Why should life be made up of so many absolutely different types of animals and plants instead of being one

amorphous whole varying only imperceptibly from one form to another?

Many outstanding naturalists have recently accepted the views of Mayr[41] that the formation of new species is impossible without geographic or other spatial isolation and the consequent restriction of random mating. If groups of individuals are isolated from the remainder of the species, gene flow between these isolated populations is inhibited and mutational changes can become fixed and integrated into new patterns. New species arise which differ radically from the parent group and are usually more specialized in form and behavior and less generally adaptable.

It is now considered that the final criterion of a separate species is that it does not breed with its near relatives. The differences which prevent this interbreeding, always arising as mutations and becoming fixed through geographic isolation, may become manifest either in behavior or in structure. Slight hereditary changes in food or habitat preference, in breeding habits or parental care, may act as secondary isolating factors which pull the two groups even further apart.

The common Japanese tree frog may be mentioned as a form in which behavior changes have become evident before changes in gross structure. One variant of this frog lays its eggs in frothy masses on leaves over water instead of in holes in the banks of rice fields. The differences in head form and body size between the two are so slight that the variant has not yet been recognized in literature as a separate species. Since, however, the two forms are apparently isolated during the breeding season, they will continue to accumulate mutational differences and to widen the gap between them.

Again the distinguishing factor may be a matter of voice. It was noted in the course of field studies in Maryland that two slightly differing calls were given by the common tree toads.[84] One call apparently was characteristic of the Northern toads, while the other call was confined to the Southern ones; the two groups evidently overlapped in this section. In each case, however, the females probably were attuned to the call of their own groups and thus interbreeding did not generally occur. If this is proven to be true the two groups should be recognized —according to strict definition—as two separate species.

Similarly differences in call have led to the division of a large group of crickets into several distinct species. Though seemingly identical in appearance, they were found to differ consistently in physiology, behavior, and habitat.

Behavior May Indicate Relationships

Activity seems so plastic and voluntary with humans that we find it difficult to think of it as a rigid fundamental character of the animal. Yet behavior is a definite product of the animal's inheritance and is sometimes more stable than structure.[44] Often we find that similar movements and reactions indicate relationships and origins which might not be suspected from external appearances alone. Heinroth noted that a certain co-ordination of the movements of scratching the head with the hind leg was a valuable cue in classifying animals. In both fishes and birds it is well known that distinctive nesting patterns may run through a family or a group of related genera. Familiar examples are found in the sticklebacks and the sunfishes, the orioles and the hornbills. Certain groups of weaverbirds construct one kind of nest, other groups another kind of nest. The common English sparrow has been shown by its nest form, as well as by its anatomy, to be a weaverbird, unrelated to our American "sparrows," which are actually buntings. *Pipa* and *Protopipa,* two South American aquatic toads, are not only closely related anatomically, but are also the only amphibia known to carry their eggs in individual sacs on the back of the female until the young hatch.

Similar patterns of reproductive behavior in salamanders indicate definite evolutionary relationships.[46] Our common hellbender has as its nearest relatives several primitive species all confined to Asia. In all these forms the males remain with the eggs for varying periods of time after they have been laid.

Clear-cut patterns of courtship behavior often run through other large groups of salamanders as consistently as patterns of spots or stripes appear in species. In one group courtship is a communal affair in which males and females come together in a *Liebesspiel.* In the closely related newts one phase of this performance is developed: the courting male slips under the female, lifts her up by her front legs, and gives her a piggyback ride. In a third group, specializing in scents and hedonic glands, the male noses the female constantly, and both walk around together in a grotesque "tail walk."

The persistence of such instincts was demonstrated in the laboratory.[45] In the coastal plain of Southeastern United States the two-lined salamander lays its eggs singly or in small clumps attached to weeds or debris in small streams. The Northern race of the same species holds to the more primitive method of attaching its eggs singly to the under-

side of a flat stone. In the region where the former race occurs there are no flat stones, and the question arose: Might not the egg-cluster method be a makeshift arrangement which would be abandoned if the salamander lived in a more favorable environment? When several Southern salamanders were given their choice of laying their eggs among water weeds or attached to rocks they reverted to the primitive ancestral method. The behavior pattern had remained intact, though it probably had been suppressed for innumerable generations.

Unity of Whole

Philosophers and scientists with depth of knowledge and breadth of vision unite in a common conviction that all life and all matter are parts of one great whole; that the same physical laws that apply to the most remote star seem to operate in the tiniest cells of the body. Just as many persons look forward to a time when the simple Golden Rule may replace the endless volumes of civil law in governing human society, so these scientific thinkers look forward to a distant future when a few great laws will be found to explain all nature—universal principles that will replace the numberless formulas and theories with which we seek to explain the things about us.

Likewise, in the individual animal, psychology, anatomy, physics, chemistry, ecology are integral parts of the entire organism: factors that may be logically distinguished from one another but never isolated. As knowledge increases, the dividing lines between these sciences will gradually fade. That scientist to whom is revealed most clearly the nature of man and beast will not be a narrow specialist but a worker who, like the plainsman, has his feet firmly on the ground yet is aware of the far horizons stretching all around him.

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The following general reference books were of great help to the author and should prove of interest and value to readers who wish to study the more technical aspects of animal behavior:

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