A TROUBLED REALM

ESSAYS ON THE LIVING WORLD AND ITS CONSERVATION

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PREFACE

If I were asked to characterize the living world in one word, the word would be "paradoxical." A paradox is a conclusion which, although possibly true, appears not to follow logically from its premises, or a situation incompatible with its antecedents. Paradoxes are inconsistencies, contrarieties in the development of a doctrine or a system. The living world, incongruously replete with beauty and ugliness, delight and terror, love and hatred, cooperation and exploitation, life and death, is a fabric of paradoxes.

The most glaring of nature's incongruities is the internecine strife between organisms that, from the least to the greatest, have so much in common. The more intensively they are studied, the more similarities are disclosed, in genetic control and physiological processes, between creatures that vary immensely in form, habitat, and activities. The life and health of each are preserved by a high degree of internal harmony among diverse organs and functions, yet their external relations are frequently far from harmonious.

To understand this paradoxical situation, we must look deeply into the nature of the Universe, which, as I explained in Life Ascending (1985), is pervaded by an unremitting tendency to arrange its materials in patterns of increasing amplitude, complexity, and coherence - the process of harmonization that brings order out of chaos. On a vast scale it has condensed great quantities of matter, originally present as intergalactic clouds of gases and dust, into stars, planets, and their satellites. It has set the planets in orbits around the stars, the satellites in courses around the planets, in dynamic systems so balanced and stable that, as in our solar system, they endure for long ages.

On a small scale, the same process is evident in the union of atoms in molecules of innumerable kinds, and the alignment of atoms or molecules in enduring crystals that are often of scintillating splendor. In the living world, the tendency of matter to form patterns of increasing amplitude, complexity, and coherence is most clearly revealed in the growth of organisms, even the simpler of which are of greater complexity, and more closely integrated, than anything of comparable size we can find in inorganic nature. The same process is apparent in the moral endeavor to create harmoniously integrated societies, in the efforts of thinkers to form coherent systems of thought, and of artists to create beauty. We owe to harmonization all the values that enhance existence and make life worth living. It appears to be a universal striving to enrich the cosmos by actualizing potentialities, thereby transforming bare Being to full Being, replete with high values.

It is not difficult to understand how strife and suffering arose in a world pervaded by a process that is primarily creative and beneficent. Unguided creativity is unrestrained by moderation. It initiates so many organisms that they compete stubbornly for the space and materials that they need to complete and preserve themselves, with all the lamentable consequences that we have noticed. Not more creativity but more restraint is the world's great need, and this is nowhere more evident than in the human sphere.

In addition to this major paradox, the living world presents many minor ones, a few of which we examine in this book. Among them is the dual nature of animals, products of harmonious development, depending for their survival upon close adjustment to their environments, often dwelling in amity with other creatures, yet capable of such fierce rivalry and lethal violence - contrasts nowhere more glaring than in humankind. Is it not paradoxial that plants, sharply distinguished from animals by their ability to synthesize their own food from inorganic matter as no animal can do, should occasionally turn the tables and devour animals as, on an infinitely larger scale, animals devour plants as well as other animals?

Not the least of the incongruities that the living world presents are revealed by a survey of the growth of intelligence. We might expect reason - the ability to think, to compare, to foresee - to advance steadily from humblest rudimentsto full maturity, as a seedling grows into a tree, as daylight brightens from dawn's first glimmer to noontide brilliance, thereby becoming a luminous guide to peaceful living. On the contrary, as our final chapter tells, humans' fumbling efforts to use their inchoate rationality have yielded mountains of error and been a major source of absurd practices and widespread suffering.

It is not surprising that serious attempts to understand a confusing living world have led to fantastic interpretations widely accepted by biological orthodoxy. Prominent among those that claim our attention is the doctrine of the "selfish gene," with its corollary that individual animals and plants never act "for the good of the species." Presumably, survival is good; species continue to survive; and what keeps them extant if not the activities of the individuals that compose them? When we reflect that anatomical similarities among diverse animals, such as primates, ungulates, bats, and birds, provide strong evidence for evolution, fervently supported by orthodox biologists, it is puzzling to find them so vehemently rejecting suggestions of psychic resemblances between man and other creatures, which they condemn as anthropomorphism. Another scientific heresy is teleology, the ascription of ends or purpose to any part of nature except our very purposeful selves; as though, after a prolonged purposeless preparation for humanity and its manifold material and spiritual needs, purpose suddenly sprang up in the world without antecedents. Equally difficult to understand is the widespread insistence that natural selection acts exclusively upon individuals, never upon populations or groups, apart from which no sexually reproducing organism can propagate its kind.

A chapter compares the consequences of unilateral exploitation with those of cooperation among organisms, noticing the many benefits that we owe to the latter, whereas exploitation has been a major source of life's ills. Finally, we arrive at the paradox that humans, each separated from the surrounding world by a skin that protects his or her finely adjusted vital processes from disastrous intrusions and lethal losses, reach out beyond this insulating integument with love, sympathy, and thirst for understanding that know no bounds.

Finally, we look at conservation, which is the effort to halt, or at least to retard, the rapid deterioration of the paradoxical living world, rife with antagonisms and conflicts. This growing enterprise is supported, vocally and often materially, by people with contrasting temperaments and opposing interests. This lack of unanimity is not surprising in a movement that enlists such a diversity of people commited to the preservation of such a perplexing world; conservation is not devoid of its own internal conflicts. Hunters support conservation to ensure a continuing supply of targets for their guns, while friends of animals deplore their needless destruction. Many try to protect, and even increase, the raptors that prey heavily upon the birds, especially Neotropical migrants, whose decline others deplore. Some assign priority to the preservation of habitats, whereas others are more concerned about the fate of species on the verge of extinction. To avoid contrary efforts and waste of inadequate funds, conservations need to clarify their objectives and agree upon priorities. In the last chapter, I suggest a criterion for conservation that is objective in the sense of being independent of individuals' preference of this or that category of organisms. Widespread adoption of this criterion should greatly promote the ends of conservation.

I wrote this book because I was convinced that examination of some of nature's paradoxes could deepen our understanding of life. Each chapter is an independent essay, understandable without reference to the others. Together, they develop a view of the living world that is not despondent but cautiously optimistic.

For ready reference, the scientific names of organisms capitalized in the text are given in the Index.

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LIFE: A REALM OF PARADOXES

What is the most fundamental difference between a living organism - yourself, for example - and a lifeless object, such as a stone? You are self-moved, as the rock is not. You feel and think, as stones evidently cannot do. You are structurally much more complex than any mineral, and your parts are more closely integrated. You are capable of doing a hundred things that stones cannot do. We might continue for pages to enumerate all the ways in which people, and other living things, differ from lifeless things without hitting upon the most basic difference because it is perhaps the least obvious. I hope that you will not be offended if I suggest that the most fundamental difference between you and a stone is that you are covered by skin and the rock is not. All that the living world has achieved, all its glories and likewise its tragedies, may be traced to the unexciting and sometimes overlooked fact that organisms of all kinds are separated from their ambience by a semipermeable integument, a thin pellicle or a thick skin, such as inorganic objects commonly lack.

Insulation and its Consequences

The basic unit of life is the cell, with the protoplast that it encloses. This consists of the watery, somewhat viscous cytoplasm and the organelles within it, including a nucleus, mitochondria, and various other plastids. Even one-celled organisms, scarcely visible or invisible to our unaided eyes - the amoeba and the paramoecium - are vastly complex. To carry on their diverse functions, they must control their contents, retaining within themselves what they need, resisting the intrusion of superfluous or harmful substances from the surrounding water. They cannot completely insulate themselves from their milieu, for they depend upon it for indispensable materials, and they must return to it waste products of metabolism that would be injurious if permitted to acumulate. To control its exchanges with its surroundings, each minute organism encloses itself in a selectively permeable pellicle or membrane, which freely permits the inward or outward diffusion of certain substances but refuses passage to others. The creature's life depends upon the maintenance of this exceedingly thin and fragile barrier. To impair it is to kill the organism.

Plants and animals increase in complexity by adding cell to cell. Although they cooperate closely, the cells of a multicellular organism preserve a certain independence by retaining the semipermeable ectoplasm that regulates their exchanges with adjoining cells. This is most readily demonstrated in vegetable tissues with cells enclosed in more or less rigid walls of cellulose. Tender growing stems and leaves maintain their shapes while their cells are turgid with water; if they lose too much liquid they wilt and droop, like a balloon from which the air escapes. If one places a thin section of plant tissue in a concentrated solution, as of cane sugar, and watches through a microscope, he can see each protoplast shrink away from its enclosing wall of cellulose. The cell's semipermeable ectoplasm permits water to flow outward but retards or prohibits the inward diffusion of the solute. The cytoplast continues to lose water and contract until its osmotic pressure equals that of the solution in which it is immersed.

In addition to the defenses of their individual cells, multicellular organisms develop more obvious and resistant means of regulating their exchanges with their media. Trunks, branches, and roots of woody plants cover themselves with bark, which at least on younger branches is penetrated by lenticels more permeable to air. Leaves and herbaceous stems are covered with waxy cuticles, which are thicker and less permeable to water the more arid the environment. Penetrating the cuticle and epidermis of leaves and green stems are multitudes of minute pores, the stomata, which by opening and closing regulate the inward and outward passage of gases needed for respiration and photosynthesis, and the outward diffusion of water vapor in transpiration.

The integuments of animals are wonderfully diverse. Many aquatic and not a few terrestrial creatures enclose themselves in hard shells or carapaces, which may have evolved primarily for protection from predators but at the same time help to insulate them from the ambience. Insects are covered by their chitinous exoskeletons, penetrated by the tracheal openings through which they breathe. Among vertebrates, the primary integument is a flexible skin, resistant to most substances that are likely to moisten it in an animal's natural environment, constantly renewed as it wears away, in many animals equipped with sweat glands that help to regulate body temperatures, or with chromatophores that by changing its color assimilate it to its background and make it less conspicuous to enemies. The scales of fishes and reptiles, the hair of mammals, and the feathers of birds give additional protection. Although every organism, from algae and protozoa to trees and the largest vertebrates can regulate the entrance and exit of materials to and from its living cells, only fur and feathers, or subcutaneous fat in certain animals of cold climates, provide effective thermal insulation. Only animals covered with hair or feathers that enclose many minute air spaces can afford the luxury of constant body temperature; for others, the attempt to achieve homeothermy would cost too much energy. By growing a thicker coat of feathers or fur as the climate becomes colder, or depositing more fat beneath their skins, birds and mammals can remain warm and active in air so frigid that all other creatures become dormant or die. They have attained the maximum independence from climatic extremes that animals can achieve without shelters that can be heated or cooled.

Insulation is not only physical but also psychic. We do not doubt that other people feel, and sometimes think, much as we ourselves do; and the more intimately we study the lives of other animals, the more certain we become that they, too, are stirred by emotions and are not devoid of thought. But, with certain possible and debateable exceptions, we never have direct, unassailable evidence that other creatures of any kind feel or think; we infer their feelings and thoughts from the way they act, the sounds they emit, their facial expressions. Our psychic insulation is tighter than our physical insulation; the membranes that separate us from our physical environment are but semipermeable, permitting many substances to pass in and out; whatever it may be that shields our minds from direct awareness of the psychic states of other creatures is nearly, if not wholly, impermeable. This insulation makes it possible for one animal to harm another without feeling the consequences.

Although we seldom attribute sociality to lifeless things, they are in fact much more social than living organisms. They seldom enclose themselves in integuments that, like walls, effectively separate them from surrounding materials but freely intermingle when they meet. Rocks and crystals expose their unmodified substance, their naked bodies, to the disintegrative action of air, water, and soil. Gases of different kinds intermingle, or are absorbed by liquids, with usually no barrier to control the process. Drops of a liquid coalesce when they flow together, one losing its identity in the other. Even solids such as metals slowly diffuse through each other when tightly pressed together. Everywhere in inorganic nature we find readiness to meet and to mingle; no substance appears to be consistently averse to losing its distinctness by union with some other substance. Rarely do we find such aloofness, such stubborn clinging to a separate and insulated existence, as in living things. It is significant that when we wish to waterproof a fabric, or to cover metal or wood with a thin, impermeable pellicle that will shield it from rust or decay, we commonly choose for the protective coating some substance elaborated by living organisma. Waxes, resins, rubber, in their many varieties, are not fortuitous secretions of plants; they are elaborated for the protection of vegetable bodies.

With the exceptions of parasites and their hosts, only exceptionally do separate organisms unite as intimately as lifeless substances so frequently do, and these are nearly always members of the same species. Relatively simple animalcules, like corals and sponges, join in large numbers to form compound organisms. Roots of different trees of the same species, especially conifers, may fuse together when they meet in the soil, and the horticulturist's art may graft one variety of a tree or shrub upon the stock of another. The higher animals so stubbornly resist the intrusion into their own flesh of alien flesh, even of their own species, that only by the surgeon's utmost art can thay be induced to accept a foreign organ to replace a diseased one of their own.

Even in their manner of destruction, living beings demonstrate their essential difference from the nonliving. Barring violent impacts and such crushing forces as might reduce rocks and crystals to rubble or powder and living flesh to formless pulp, organic and inorganic bodies are destroyed in radically different ways. Rocks weather on their exposed surfaces and slowly dwindle; crystals dissolve from the surface inward; drops of a liquid evaporate from the outside. But living things are so well enclosed in protective membranes or integuments that their destruction, when not caused by violence or high temperatures, usually results from changes in the interior rather than at the surface. The deadly poison or fatal parasite must insinuate its way into the body, either through one of the natural openings normally under the control of the organism or through a break in its integument, before it can begin its work of destruction. Or, if it escape death in other forms, the organism runs down and becomes quiescent from senescence, a process wholly internal.

The other distinctive qualities of living organisms are ancillary to their ceaseless effort to preserve separate identity. Most significant of these are their capacity to assimilate and incorporate intimately into themselves materials different from their own substance, and to grow from within rather than at the surface— by intussusception rather than by apposition, as botanists say. Whereas crystals and other inorganic bodies that do not enclose themselves in insulating membranes may continue to grow by means of superficial deposits, this method of enlargement is not available to an insulated organic body.

Living things tend to avoid contact with substances and processes that would harm them: a protozoan swims away from the diffusing chemical that would kill it; a man snatches his hand away from a hot stove. Inorganic bodies show no comparable tendency to avoid other bodies that would injure them. But the living organism does not always passively await actual contact with the deleterious substance; it displays a sensitivity to influences playing upon it, from sources near or remote, such as is rarely found in inorganic matter, and frequently it succeeds in escaping from dangerous situations. And when contact with the injurious foreign object is inevitable, it exhibits an ability to adapt itself, to escape destruction by changing shape and endless stratagems, for which one looks in vain in lifeless bodies.

But in spite of all its defenses and its wiliness in confronting unfavorable situations, the more highly differentiated organism must sooner or later succumb, if not by external agency, then by internal decay. Yet even mortality cannot defeat it. If it cannot maintain its separateness in its own body, it will transmit this capacity for preserving separateness to others like itself — not only to one, but to several or many, to ensure the perpetuation of its kind against all contingencies. As though foreseeing its own eventual disintegration, it does this while still at the flood tide of vitality, while senescence and death seem remote. The capacity to reproduce itself in all its complexity, from a minute and seemingly simple particle of itself, is one of the most marvelous of all the properties of the living organism, and one which most strongly distinguishes organic from inorganic bodies. Although the latter sometimes display superficial resemblances to the life-processes, analysis shows that these seeming likenesses in inorganic substances are not close.

[illegible]. Toughness and Aggressiveness of Life

The greatest paradox of living substance is its combination of tenacity with extreme frailty. It is so easy to destroy by heat, by intense illumination, by chemicals of a thousand kinds, by mechanical violence; yet with incredible Protean cunning it outwits its destroyer and blossoms forth again with renewed vigor and fertility. A rock in your field is troublesome; you carry it away and see it no more. But pull up a weed, remove it, burn it, grind it into fragments, utterly obliterate it — and the chances are that within a few months seeds or fragments ~~particles~~ of it that escaped your notice will have produced a hundred weeds where you found one. To emphasize the evanescence of human life, moralists sometimes ask where are the hands that erected the Pyramids or built the Parthenon. Where are they, indeed? Those hands are multiplied a thousandfold; they are in Europe and America and Africa and Australia and on the farthest islands of the oceans; while the stones that they set in place daily dwindle under the action of wind, rain, and frost.

A fundamental property of life is its stubbornness, its opposition to the forces that would carry it away, reduce, or annihilate it. The swiftly flowing river bears downward, for yards or miles, a stick, a stone, or any other lifeless thing that may fall into it; but all its free-swimming living inhabitants, from the great fishes to the frail beetles and striders and other organisms so small that they escape the careless eye, set their heads resolutely against the current and resist its force. The fish in the mountain torrent is symbolic of all life, in the water, on the ground, or in the air: it resists the forces that would carry it along. Life seems to be pitted against the external world; struggle is its essence. And although against cataclysmic forces it is pathetically helpless, tossed like a feather by the tempest, burnt to cinders by a puff of volcanic vapor, for all its frailty it is the toughest thing under the Sun.

To add to the paradox, this thing at once so delicate and so resistant, so ephemeral and so enduring, tends ever to clothe itself in forms that present a greater challenge to all that is inimical in its environment, as though exulting in opposition to elemental forces and delighting to devise new ways of thwarting them. To the seaweed floating in still water, the maintenance of life is relatively simple. Constantly bathed in a liquid containing all that it needs for respiration and growth, it is hardly affected by the pull of gravitation; neither scorching sunshine nor drying winds are a threat to it; it has no occasion to send forth roots to gather essential elements thinly diffused through the soil, then transport them to distant organs.

Why did not vegetation remain for ever content with the security of the aquatic environment in which it arose; what stubborn perversity of the living substance goaded it into invading the land, into assuming forms whose continued existence is a miracle of audacity? In every respect in which life is simple and safe for the seaweed, it is complex and perilous for the tree. Whereas the alga vegetates in a caressing bath of nutrient fluid, the tree rears its lofty head as though to defy the gales and the lightning, the drying winds and the desiccating sunlight, the unremitting gravitational pull of the Earth. It is endlessly extracting water and solutes from the soil and, by a process that has been difficult to understand, raising them fifty or a hundred yards into the air. It ceaselessly resists the elemental forces that would dry up its sap, starve its living foliage, and flatten it on the ground. And yet, as though to testify to the toughness and enterprise of life, trees, not algae, are (or until recently were) the dominant vegetation on this planet.

In the animal kingdom, the course of evolution has paralleled that of plants. Life is simple for the amoeba and other blobs of protoplasm that live always immersed in the water that forms the greater part of their substance; it is, as we all know, very complicated for man in his multiform, constantly changing environment. The more we contemplate the transformation, the more incredible it appears that organisms forsook the ease and security (except from other organisms) of their primitive aquatic ambience to live unquietly amid all the stresses and perils of the less stable subaerial environment. Had they been forced by some external power to assume forms whose preservation demands ever-increasing effort, their metamorphosis would have been surprising enough. We marvel the more when we remember that the impulse that drove them from change to change has always come from within them.

It is not that the Universe, or that immediately effective part of it that we call the environment, is actively hostile to life, as Bertrand Russell (1917) believed. Save for an occasional hurricane, volcanic eruption, or flood, the environment is passive enough. In many regions, it is so favorable for vital processes that it almost seems to invite the presence of living things. Its fitness to support them has many aspects. Water is, of all known liquids, that which best serves as a medium for intricate processes which can go forward only within a narrow range of temperatures; and it is the only liquid abundantly present on the surface of our planet. Among the properties that make it a fit medium for life are its high specific heat, which retards changes in temperature; its abrupt change from contraction to expansion as, in cooling, it approaches the freezing point, which causes it to congeal from the surface downward rather than from the bottom upward and increases the thermal stability at low temperatures of deep lakes and seas, making their complete congelation improbable. Add to this its chemical stability combined with its versatility as a solvent, and its capacity to form, with carbon, compounds rich in latent energy. Likewise oxygen, hydrogen, nitrogen, the sunlight, and the soil, all have properties that make them peculiarly favorable for vital processes. The environment is friendly enough to life.

Life, on the other hand, often seems to challenge or defy the environment, like an aggressor invading a hostile land. Had it been content to remain in the warm seas where it began, in the humid tropical lands where today it flourishes most lushly, it might have existed in vast profusion yet remained in friendly inorganic surroundings. But not satisfied with these immense yet almost uniformly congenial domains, restless life, impelled by its own great capacity for multiplication, invaded the arid deserts, advanced far toward Earth's frigid poles, climbed ever higher up the rocky mountain slopes, battling against thin air and intense insolation and cruelly sudden changes in temperature. On every front, life armed itself to battle with the environment, which is not intentionally cold or arid or changeable - siezed it by the throat, so to speak, and by sheer force compelled it to yield what imperious life needed and demanded. When conflict arises between life and its milieu, life is usually the aggressor; the passive environment is what it must be.

In these uncongenial regions where intrusive life exists precariously, a slight intensification of the prevailing conditions, such as a more prolonged drought in an arid land or exceptionally intense cold in a frigid zone, causes great destruction of living things. We are then apt to remark upon the harshness or cruelty of nature. But if one will perversely sit too close to the fire, can he claim to be unfairly treated if he is now and then scorched?

It was once the habit to look upon all those features of Earth that make it a favorable home for living things as special provisions for this end. This interpretation provided a strong argument for natural theology, and writers of this school became eloquent as they contemplated the manifold arrangements that make this planet a congenial abode for mankind. Since the publication, in 1859, of <u>The Origin of Species</u>, an exactly contrary view has become current. It is now held that we must not regard any features of the physical world as adaptations to support life; but that life, the late-comer, has simply had to conform to the conditions that it found here, which it accomplished by a long course of trial and error. This interpretation is as wide of the mark as the earlier one. It would be true only if life owed its origin to a process wholly different from that which formed the lifeless world, or if it had somehow intruded into this world from beyond. But since it is a product of the same process - harmonization - that earlier prepared the stage for it, this modern view is obviously too extreme. Actually, the living world is related to the physical world as one phase of a continuous process to an earlier phase. Life is adapted to its inorganic setting because it emerged from that setting; the setting is adapted to life because it was formed by a preceding phase of the movement that gave rise to life. The adaptation is neither all on the side of the environment nor all on the side of life, but the conformity is that of the parts to the whole.

Life's stubborn intrusion into environments poorly fitted to support it reveals the intensity of harmonization's striving to build up patterns of higher integration, even in the face of the utmost obstacles. By far the greater part of the stuff of the Universe is prevented by physical conditions from attaining the level of organization found in living things. Only an infinitesimal proportion of the total quantity of matter can at one time participate in such complex formations. Yet the moment it encounters favorable circumstances, the stuff of the Universe rushes with unrestrained exuberance to arrange itself in elaborate patterns, exhibiting closer integration and greater beauty than we often detect in the lifeless world. A major portion of life's ills springs from just this almost explosive rush by the cosmic stuff to participate in a higher synthesis; if this urge did not result in such excessive numbers of organisms, life would certainly be more pleasant for those endowed with it.

Conflicts between Organisms

Just as they are often militant against the environment, living things are belligerent toward each other. One organism invades another, forcing it to yield the requesites of its own existence, to become a living environment for it. Nothing is sacred; no organ, tissue, or fluid, no matter how exquisitely delicate and admirably adapted to an intricate function, no matter how indispensable to the life of the host, is spared the pitiless invasion. Eyes and ears, heart and lungs, the very life-blood itself - all are at times forced to become the medium of aggressive foreign organisms. Myriads of creatures live parasitically at the expense of others, from viruses too minute to be detected by common microscopes to ticks and leeches that batten shamelessly in view of all the world.

A growing organism tends to perfect a form intimately related to its mode of life and the constants of its natural environment. Except where strong winds prevail, trees commonly form upright trunks surrounded by boughs arranged with radial symmetry. Encrusting lichens spread in expanding circles over the faces of rocks. The giant kelp assumes an elongate, flattened form that permits it to yield gracefully to the ceaseless surge and tug of the surf where it thrives. Not only the organism as a whole but each organ strives to express its innate form or pattern; each leaf, according to its position on the herb or tree, would if left to itself become an undistorted example of its hereditary type. Likewise, each animal tends to become a shapely representative of its kind, perfect of limb and organ, its garment of scales or fur or feathers comely and complete in every detail. Nevertheless, countless creatures fail to attain the full perfection of which they are capable.

When we investigate the causes of the failure of organisms to be whole and perfect examples of their kind, we usually find that other living things, rather than the inorganic setting, are to blame. As a rule, the environment cooperates with the organism, helping it to perfect the form that was evolved in relation to this same environment. But it is quite the contrary with other living things; they rarely modify their own innate tendencies to grow to full perfection so that neighboring organisms may do likewise. They crowd and push against each other until shapeliness is impossible; they twine around and constrict each other; they strive to live in such egregious numbers that none of the multitude can procure all that it needs for full development; they invade each other's vital tissues; they consume each other piecemeal of devour each other whole. So intense is the struggle that, in tropical forests, a botanist may often search through the whole crown of some great fallen tree without finding a single twig with perfect foliage for his collection — insects have gnawed into all of them even before they stopped growing. It is only exceptionally the environment that prevents organisms from attaining their ideal form; it is far more often the strife between the living things themselves.

Yet, except among morally underdeveloped ~~men,~~ people, we rarely find a suggestion that one living thing injures another just for the sake of hurting or destroying it. Each is striving to maintain and complete itself, to realize that particular perfection inherent in its own organization, but its circumstances are often such that it cannot procure all the materials or the space it needs for this purpose without opposing or injuring other living things. Life is always primarily constructive; destruction is all too often incidental to its activity, but hardly its primary goal. Thus, each living thing owes its being to an organizing movement and its continued existence to the maintenance of a harmoniously integrated pattern, yet it must ever be prepared to contend with or to resist other more or less similar entities. These opposing tendencies account for those contradictions in the character of animals that will claim our attention in chapter 3.

[illegible]. Real Strife Confined to the Living World

By the efforts of living things to occupy environments unfavorable to vital processes, and even more by the clash of organism with organism in a crowded world, harmonization, itself a definite, straightforward movement, becomes entangled in organic evolution, a labyrinth of complexities and contradictions that confuse the student of nature. We shall not succeed in understanding evolution unless we distinguish clearly between its driving force and true constructive principle, harmonization, and the dreadful embroilment into which it is plunged by the manifold interactions of its own products. Without this distinction, the living world appears to be a fantastic welter of competing forms, a maze of frenzied stirrings leading nowhere; only in its light can we hope to discover a path through the labyrinth (Skutch 1985).

Life has needed to be aggressive because it has had to make its own way, creating itself under the constant impulsion of harmonization working within it. Evolution is self-creation. The origin of species by gradual evolution implies their formation by their own efforts. External agents have dictated the forms that organisms must assume in order to survive, but they have not made these organisms. Beyond the primitive home of life in tepid seas and humid adjoining lands, external agents would have annihilated living things but for their stubborn will to exist. The environment has everywhere stipulated the conditions that organisms must accept if they would continue to live, but it has not itself altered them into conformity with these conditions. On the contrary, living things have molded themselves to their medium like some soft, plastic creature or tissue, an octopus or a growing root, forcing itself into a crevice in the rock, pressing itself home until it fits snugly into every cranny and around every projection. It is not the rock, but the octopus or the root, that has supplied the energy for this close adaptation.

The genesis of species by gradual changes promoted by interactions between themselves, surrounding organisms, and the physical environment provides a key to the understanding of evil. As long as people believed that each kind of living thing had been created in its finished form by an Agent at once omnipotent and beneficent, strife and evil remained inexplicable, or could be explained only by means of unconvincing myths. For a Creator of unlimited power and perfect benevolence might have established each species in all its perfection, adjusting the relations of each one to every other, and of every one to its environment, so harmoniously that strife and discord would never arise. Actually, however, they have been self-created, formed by this very attrition and interplay that special creation might have obviated.

Apart from life, the disharmony we behold in the Universe is more seeming than real. Matter flows ceaselessly from form to form; body collides with body; the smaller mass fuses with the greater and loses separate identity. Solar systems no less than molecules are constantly changing, dying, being born anew. No composite thing is eternal, nothing immutable, nothing fixed for all time. Strife has been called cosmic; but are the collisions and the often violent transformations that we witness in lifeless matter actually strife? Strife is essentially a conflict of wills, an attempt to alter or destroy that which stubbornly strives to preserve its present form. But in inorganic matter we detect no strong will to exist as a separate entity. Lifeless bodies rarely ensheathe themselves in an insulating integument as in a coat of armor; it appears to be indifferent to the crystal, the rock, the mountain, the planet, or the solar system whether it continue in its present form or be transmuted to something else. These compound bodies evidently lack the will to perpetuate themselves. Far from resisting the closest union with others, the micropsychic atoms of which they are composed readily seek such union to satisfy their social nature.

The "cosmic strife" would be more aptly characterized as a cosmic dance. The dancers are marshalled in companies of the most diverse sizes — in atoms, molecules, crystals, drops, oceans, continents, planets, solar systems, and galaxies. Each company is ceaselessly shifting its place, meeting others and uniting with them; or else great armies separate into smaller bands. And within each company the platoons, squads, and individuals are in constant happy agitation, following the immutable rules of the dance. In all the vast concourse, everyone appears to be in a tranquil mood; there are, as far as we can discern, no hatred, no anger, no jealousy, no vain strivings, no sighs, no regrets — no tragedy that is evident to our human eyes and minds. Strife springs from individuality, from the effort to preserve separate identity by beings that try to insulate themselves from the rest of the Universe and are not minutely guided by a single comprehensive Intelligence.

Contemplating the countless ills that arise directly from organisms' need to insulate themselves from their surroundings, one sometimes suspects that life represents a miscarriage of harmonization, which in producing living things somehow went astray. Yet the very intensity of the movement to create them and lift them to higher levels of organization suggests that they are indispensable for the fulfillment of the world process. It seems that only in a community of individuals can harmony, in its highest sense, prevail. If harmony were simply unruffled uniformity, such as is found in a body of pure, still water or among the pages of a closed book, the whole creative process is a mistake; for the longer it continues, the farther it carries the world from this condition. Harmony is unity in diversity, concord between differing entities. Whether in a work of art or a society, the more varied the entities that compose it, the richer and more precious their harmonious integration becomes.

For the higher modes of harmony, individuality appears to be indispensable; and the physiological foundation of individuality is the insulation of organisms. Spiritual community is superimposed on this biological separation; it owes its sweetness and poignancy to its persistent striving to overcome the very aloofness that is its foundation. Moreover, as far as we can tell, only individuals can experience happiness and high values, toward which the whole creative process appears to be directed.

6. Cooperation and Competition

Furthermore, we must be careful lest by over-emphasizing the strife of the living world we lose sight of its complementary aspect. Those who see in nature only battle and carnage are as shortsighted as those who find there only beauty and peace. Each of these interpretations results from one's need to discover in nature support for his own dominant mood; so that to the violent and bloodthirsty she is red in tooth and claw, while to the loving heart she is the tender universal mother. This capacity to give to each that which he seeks is proof of nature's vast diversity.

The outstanding feature of the relations between organisms, whether of the same or of diverse kinds, is neither their friendliness nor their hostility so much as their baffling complexity. On one hand, they must cooperate closely to create and stabilize the environment on which the prosperity of each of them depends. On the other hand, they are forced to compete for the materials, space, and energy which are rarely [redacted] abundant enough to fill the needs of all the individuals produced by life's prodigious powers of multiplication. Cooperation and competition, harmony and strife are equally prominent in life's paradoxical involvement. Those who blindly stress one of these contrasting aspects while forgetting the other have not understood life. Cooperation and competition are so intimately linked that it is hardly possible to separate them. Cooperators readily become competitors, and competitors may become cooperators before they are aware of it, both in natural communities and the commercial world of man. Stranger still, it often happens that the same creatures are simultaneously cooperators and competitors; as, by their very competition, the rule-abiding players of two opposing teams provide the cooperation that makes ~~the~~ a good game.

The more complex organisms, animal and even vegetable, can hardly survive in a lifeless milieu. The cooperation of many of them is needed to create a favorable environment. Yet these same organisms compete with, and often destroy, each other. A mature forest, for example, in large measure creates its own environment. Closely spaced trees are necessary to prepare and preserve the peculiar qualities of soil, humidity, and light requisite for the germination and prosperous growth of these same trees. Nevertheless, they compete keenly ~~with each other~~ for space, mineral nutrients, and sunlight. Many lose in this struggle and die. Swarming insects devour the foliage of the trees, yet some of these trees need some of the insects to pollinate their flowers. The saprophytic fungi that break down dead wood and foliage, returning mineral nutrients to the soil and enriching the mold necessary for the continued growth of the vegetation, readily mutate into parasitic strains that attack living plants. The birds roaming through the forest in mixed flocks help each other to detect and escape enemies and to find food but compete for the food thus encountered. If food becomes scarce, as in temperate-zone forests in winter, competition grows keen and some individuals may starve because their more competent companions capture the larger share. So delicate and so paradoxical is the balance between cooperation and competition! Nowhere is this paradox more striking than in the world of humans, who so need each other's support yet are so often hostile to each other.

There was a time when an intelligent observer of events on this planet might have suspected that the process of creation at multiple centers had reached an impasse, a point where cooperation and harmony could not be increased without at the same time intensifying competition and discord; and competition could not be diminished without at the same time reducing the number and quality of existing organisms. For the more highly organized the creature, the more it needs the cooperation and support of a complex environment, yet the more it preys on or competes with the very organisms that make life possible for it. Although nearly every living creature is in some respects a cooperator and in some respects a competitor with its neighbors, the latter is perhaps more evident in its behavior. Its instincts and appetites are directed primarily toward its own welfare, prompting it to seek what it needs without much consideration for its neighbors. Only toward its mate and dependent young, and more rarely toward other members of its flock or herd, is it explicitly altruistic. Yet by the secular interactions of species in living communities, the habits of each become compatible with the survival of associated species, in so far as this is necessary to preserve the biotic association in a thriving state. Species that cause the deterioration of their environment dig the ground from beneath their feet and prepare their own doom.

To break the impasse between cooperation and competition and turn the balance in favor of harmony, only one hope is at present discernible on this planet. Very recently, as cosmic and even terrestrial time is measured, beings gifted with free intelligence and morality arose upon it. At first, these faculties were dedicated exclusively to the welfare of the individual animals endowed with them and their close kin, but gradually they acquired a broader vision. When leavened with sympathy, intelligence can understand the way of life of other creatures, their needs and tendencies. Taking the external view, the intelligent being can often predict at what points others will come into conflict with itself, and sometimes it can also foresee how such conflicts might be avoided, or at least mitigated. It can guide the formation of patterns from two or more centers simultaneously toward eventual harmonious union, in a manner impossible to an immanent creative process that can work only from within.

Morality at its best is willingness to modify one's own life and reduce one's material needs so that other beings may fulfill themselves. As long as life can be sustained only by exploiting an environment that can never satisfy all the demands made upon it by teeming creatures, strife and conflict will never be wholly eliminated. But moral effort, inspired by love and directed by intelligence, can do much to diminish disorder and promote harmony. One becomes the more eager to dedicate his strength to this endeavor when he reflects that the contrast between himself and the beings that surround him is not nearly as sharp as it appears to minds that spontaneously exaggerate distinctions in the interest of effective action. Humans so endowed, who devote themselves to this cause, become voluntary workers in the cause of harmony, impelled to undertake this high endeavor by their sensitivity to the creative energy within them, their loyalty to the process that made them. At all levels of the world process we detect a tendency to overcome conflicts by the union of colliding patterns in a higher synthesis, but it is by means of moral agents of this high quality that harmonization most readily overcomes strife between physiologically and psychicly insulated organisms not directly sensible to the pain or distress that one too often inflicts upon another.

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2

THE INDIVIDUAL AND ITS SPECIES

Before we explore the relation of the individual to its species, we must clarify the nature of a species. The textbook that, early in this century, I studied in my first college course in general biology asserted that "a species is merely a concept of the human mind - the only reality in nature is the individual, and an understanding of the differences between individuals gives us a key to the differences between species." This nominalist position conforms to the definition of a species as a group of individuals "which differ less among themselves in the sum of their characters than they do from the members of any other group of individuals" (Woodruff 1922). One might make a similar statement about human artifacts; the word "chair," for example, denotes a group of objects which differ less among themselves than they do from other kinds of household furniture. But chairs are related to each other only ideally; they conform to a concept in our minds; one chair does not create another. If all the chairs in the world were to be destroyed tomorrow, furniture makers would be so busy that, after a few months, there would be no lack of chairs. When a biologic species is exterminated, it can never be replaced.

The definition of species in my college textbook is close to the original concept of a species as a class of objects that look alike, as, with due regard to age and sex, the members of a biologic species mostly do. Early systematists, including Linnaeus, regarding species as unchanging entities, each corresponding to a Platonic form, or an idea in the mind of God, depended largely upon their outward aspect, sometimes supplemented by a study of their anatomy, to delimit them. As is evident from the foregoing quotation, widespread acceptance of Darwin's theory of evolution did not immediately change this. More recently, the old morphological concept of species has been superseded by a more realistic, dynamic view. The biologic concept of a species, now widely used in classification, regards it as a group of individuals that freely breed together wherever they intermingle, producing fertile progeny. Spontaneous interbreeding is a more dependable indication of specific limits than the production of fertile offspring by artifical crossing. The former depends upon the appearance and behavior of animals; the latter, upon the compatibility of their genetic complexes, which is a quite different matter.

Extreme forms of a species may differ so conspicuously in appearance that they were formerly placed in separate species, as in the case of Baltimore and Bullock's orioles, recently lumped together as Northern Orioles; or that of Yellow-shafted and Red-shafted flickers, now united as Northern Flickers. On the other hand, forms too similar to be readily distinguished may be classified as different species if they fail to interbreed where they are in contact, as is true of a number of American flycatchers. Since nowadays we think so much about genes, we might define a species as a group of individuals who share a common pool of genes, a selection of which is present, in diverse combinations, in each of them. All members of a species are descended from the same ancestral stock; a species is monophyletic. When we view a species in this biologic rather than in the formalistic manner, it becomes clear that it is not merely a concept of the human mind but a self-perpetuating natural entity, no less real than the individuals that compose it. Indeed, if reality has degrees, and the longer something exists the more real it is, species have greater reality than individuals, which are to their species as leaves to a tree.

One may ask why animals and plants belong to species that are typically sharply delimited from other species instead of intergrading so that they might be arranged in series without discontinuities and we might, for example, find every possible gradation from ~~intermediate~~ between an Ostrich and a hummingbird, or an oak tree and a violet. Probably, if all the organisms that have become extinct through the ages were presently available, we might come close to doing this, but in no single era would this be feasible. In the geographical races of many species, we do indeed find a gradual transition between extreme forms which do not, however, transcend the limits of a species. Between species, especially those in the same region, gaps of some kind are always present. ¶ The discontinuities in the living world are closely related to biparental reproduction. To reproduce sexually, organisms must find partners whose genetic constitutions, called genomes, are compatible. This is the fundamental reason why plants and animals belong to species. In a world where asexual propagation predominated, instead of being subordinate to sexual reproduction as in our actual world, we might indeed find all transitions between the most extreme types, as on a small scale we do among cultivated plants. And how confusing this would be to everyone interested in nature, how frustrating to all attempts to classify and name! The biologic definition of a species as a group of individuals any two adults of which, of opposite sex and normally developed, might together beget fertile progeny, recognizes the intimate connection between biparental reproduction and the segregation of organisms into species. By this definition, cultivated plants that can be propagated only vegetatively, such as certain varieties of bananas and sugarcane and many ornamentals, are clones that do not properly belong in any species, although for convenience they are classified in the species from which they were apparently derived. With these exceptions, individuals and species are mutually dependent; neither can persist without the other.

The publication, two decades ago, of Richard Dawkins' book, _The Selfish Gene_ (1976) has helped to diffuse the idea, implicit in much contemporary thought about evolution, that the individual does nothing "for the good of its species." We need only to recall the interdependence of individual and species to recognize the logical absurdity of this perverse notion. If to exist is good, and if the existence of any composite entity, such as a species, depends upon its parts, then, simply by existing, individuals contribute to the good of their species. But living organisms commonly do more than contribute passively to the existence of their species, as parts of some lifeless object, a chair or a machine, contribute to its wholeness; by reproducing they perpetuate their species in a perilous world. Reproduction benefits the progeny, few or many, that will continue to compose the species, not the reproductive individual. Unless the parent finds satisfaction in rearing its young, as apparently some do, or unless when grown the offspring redounds to its comfort or safety, as is rare in the animal kingdom, the individual gains nothing by reproducing. It squanders vital resources, exposes itself to dangers that it might avoid if careful only of its own safety, often exhausts itself and shortens its life, to perpetuate its species, as does the salmon when, after struggling upstream against foaming rapids, she lays her eggs and expires.

Modern evolutionary thought is preoccupied with the competition among organisms of the same species to increase their fitness, measured by the number of their living progeny. Successful individuals often deprive others of mates or opportunities to reproduce, sometimes of their lives. Responsibility for this selfishness is frequently attributed to the organisms' genes. However, if an individual's genes increase its fitness, their multiplication, even if this entails the exclusion of the less efficient genes of competing organisms, benefits the species, which thereby becomes more firmly established in the living world. In competing with others of their kind for the means of reproduction, individuals appear to vie with one another to contribute to their species. The great majority of organisms can serve their species only by producing offspring; but more social animals can otherwise benefit their kind, as by mutual aid, joining in constructive enterprises, teaching, creating, inventing, or clarifying thoughts and ideals - these last, ofcourse, only in man. Paradoxically, by "selfishly" striving to increase the number of their progeny, individuals may benefit their species more than themselves. However, animals who contribute too many offspring to their species may harm it by overburdening the habitat and causing widespread starvation. Even in beneficial activities, moderation is needed.

Apart from any mutations that might arise in its reproductive tissues, the genes an organism bears are not peculiarly its own but were inherited from its forebears, which are seen to be more numerous the farther backward in time we trace its ancestry. The more these genes contribute to the quality of the individual and the survival of its race, the more their bearer serves its species by transmitting to posterity this endowment which, in a sense, it holds in trust for future generations.

An animal may serve its species without assisting its contemporaries, or it may aid them without benefit to its species, as is particularly evident in human society, where philanthropy or charity may have highly dysgenic consequences. Beneficence too often helps incompetent individuals with heritable defects not only to survive but to beget children who are likely to receive the undesirable traits of their parents, thereby deteriorating the human stock. We value the impulse to help the unfortunate, while we deplore consequences that might be avoided if those with genetic defects who are made comfortable by public or private assistance could be restrained from reproduction. Animals in a state of nature commonly lack the surplus of energy and resources to succor less fortunate or less well endowed individuals, nor can they afford to weaken their species by diluting its gene pool with inferior genes. Failure to distinguish behavior beneficial to the species from that which aids individuals most in need of support has led certain biologists to exaggerate the selfishness of animals, or of the genes which determine their behavior.

Some animals act in ways that are excessively brutal, as when male lions or langurs destroy the suckling of a female whom they have wrested from another male, so that the mother may the sooner become pregnant with the winner's progeny; or when a victorious human tribe massacres all the males and pregnant females among its captives, retaining the virgins to bear children for their captors, as happened when the Israelites, at the command of their leader, Moses, overcame the Midianites (Numbers 31). Such harshness has rarely been recorded in the animal world. More widespread is the mitigation of conflict by ritualization, especially among birds, whose disputes tend to be settled by posturing and calling rather than by fighting. At territorial boundaries, Howling Monkeys of tropical American forests confront their neighbors with stentorian voices that obviate physical clashes. Or if fighting becomes serious, the losing animal may save itself by assuming a submissive posture that pacifies its opponent, as happens among wolves, turkeys, and gulls. Natural selection should promote all behavior that abbreviates or avoids conflicts that needlessly squander the contestants' energy and exposes them to predation while they struggle, heedless of what is happening around them. Few species are so firmly established that they can afford to lose many members in intraspecific strife. Predation and parasitism, far more than competition between individuals of a species, make nature harsh and bloody.

Many animals increase their safety by joining in flocks and herds, composed of one or more species. Although mixed flocks of birds, foraging through tropical woodland, are conspicuous, many keen eyes and voices ready to sound the alarm make them difficult for a predator to approach undetected. By joining such flocks, a bird apparently feels, and is, safer than if it lurked obscurely amid dense vegetation. In the midst of a compact flock, foraging in trees or on the ground, birds spend more time eating, less looking around or up to avoid being surprised by predators, than do individuals on the outskirts of the crowd, or those foraging alone. In such aggregations, each individual tries primarily to protect itself and increase its intake of food; but by the combined action of all, all are safer and better nourished. Because no individual willingly exposes itself to save its companions, or deliberately helps ~~another~~ adult not its mate to food, these foraging groups are sometimes called "selfish herds." But is it not enough that by acting in concert the whole party benefits? Why should one individual court death to save another adult of its species? Large animals, well armed with horns, hoofs, or fangs - zebras, horned ungulates, baboons - may save companions or dependent young by confronting powerful predators; small, weak creatures could only sacrifice themselves.

Protection from predators is the most widespread mode of mutual aid among animals. The startled cries of a bird who spies a hawk alerts others within hearing, of the same or different species. These notes, frequently voiced by birds with or without dependent young, have puzzled evolutionists who believe that animals should consistently behave in ways that conduce to their individual survival and fitness. Why should a bird who first notices an approaching raptor draw attention to itself by its voice, when it might discreetly hide, leaving less alert companions exposed to attack? Perhaps among the birds warned by its cries are its mate or independent young, in which case its behavior is more readily explicable. But a bird may sound the alarm when no related individual is within hearing, and birds of other species may be saved by this timely warning. To be sure, the individual who has given the alarm call may on another occasion profit by that of some other bird; its service may be requited. Except in the context of parents with young, alarm cries have proved difficult for evolutionists to reconcile with their theories, but they obviously benefit the caller's species by promoting the safety of its members - and often those of other species.

The great majority of birds breed in monogamous pairs, of which the male feeds and guards the young, or frequently shares with his mate all the activities of the nest, including building, incubating, and brooding the nestlings. In a minority of species, females are so well able to rear their families without help that the males are released from all domestic chores. By staying aloof, they decrease activity that might reveal nests to hostile eyes. Instead of remaining alone, the emancipated males of a number of species gather in courtship assemblies which attract females whose developing eggs need to be fertilized. Among northern birds, this mating system is followed by certain sandpipers and grouse, including the Capercaillie, Black Grouse, and Ruff in northern Eurasia, the Sage Grouse and prairie chickens in North America. These are precocial birds whose chicks leave the nest soon after they hatch and pick up their own food under maternal protection and guidance. In the tropics, courtship assemblies are found chiefly among altricial birds, with broods of rarely more than two nestlings - in the New World, mainly hummingbirds and manakins; in the Australasian region, birds of paradise, larger birds with louder voices, who tend to be stationed farther apart, in expanded, or "exploded," leks.

A subtle balance of cooperation and competition prevails in a courtship assembly. Its members cooperate to establish a mating station that becomes well known and accessible to the females in the vicinity because, the habitat remaining favorable, it is in the same place year after year, while the calls or wing-sounds of the participants advertise its presence. At the same time, these males compete for females, whom they attract by vocalizations that, according to the species, may be melodious or raucous, and by visual displays that may be bizarre or enchantingly lovely. These gatherings benefit the species by providing for the females a situation in which they can readily compare males who vie for their attention, and freely choose the individuals who appear most likely to sire vigorous offspring.

Incidentally, the strong intersexual selection associated with this mating system has given us many of our most beautiful birds, from dainty, glittering hummingbirds and ornate manakins and cotingas to lavishly adorned birds of paradise. Moreover, males in these assemblies appear to be safer from predation than they would be if they courted in solitude. Although the groups of performing, calling birds certainly attract attention, in any case males would need to make themselves conspicuous to be noticed by females, and by displaying in assemblies they gain the advantage of many vigilant eyes, as in flocks of all kinds. In courtship assemblies, one or a few dominant males, probably most often senior birds, win most of the females, while the younger members on the outskirts practice displays that may take long to perfect, and become more successful as they grow older. Since only exceptionally do assembly members fight furiously together, they may live long.

Individuals also benefit their species by adopting young. Although not unknown among fishes, mammals, and altricial birds, adoption is most frequent and spectacular among precocial birds who pick up their own food while following an adult. A parent of nidifugous chicks, who need only guidance, protection, and brooding, can attend in this manner to many more young than it can hatch; whereas parents of altricial and semialtricial young, who must be given food brought from a distance and placed in their mouths, are often unable adequately to nourish additional dependents. As they lead their families to good foraging, birds so diverse as Ostriches, rheas, grouse, sandpipers, stilts, avocets, and plovers are often joined by lost, orphaned, or abandoned chicks unrelated to them. Similarly, parent geese accumulate goslings, ducks pick up ducklings, not their own. Such mixed flocks of dependents, guarded by one or a few faithful adults, can become very large, occasionally, as has been recorded of Ostriches and Shelducks, containing over one hundred young of different ages. Many nidifugous juveniles owe their lives to foster parents.

Semialtricial chicks, who leave their nests while still flightless - colonial-nesting penguins, pelicans, flamingos, and certain terns - gather in nurseries or crèches, guarded by a few adults, while their parents forage afar and bring their meals. By voice, appearance, or both, parents and young recognize each other individually; each of the former feeds its own offspring, an arrangement that ensures a more equitable distribution than would result if a returning adult delivered its food to the first claimant. By this system, weak or ailing chicks, who would be pushed aside by more vigorous young if feeding were indiscriminate, are assured meals. Among ~~passerine~~ nidicolous birds, a parent whose mate has died is sometimes joined by an unattached individual of the opposite sex, who helps the bereaved parent to feed its young. (Skutch 1987). [insert 1] p 43a

Finally, the individual dies for the good of its species. If successful in escaping all the hazards that prematurely destroy so many free animals, it grows feeble and expires from internal causes. When we recall the great recuperative power of organisms, their ability to heal wounds, recover from diseases, and restore wasted tissues, senile decay is the greatest of paradoxes. Why should animals not continue to live and reproduce indefinitely? Do they die to make room for their progeny and avoid overpopulation? It is widely held that natural selection favors the fittest or most prolific individuals; by living indefinitely, organisms might attain maximum fitness. Replacement, whether of artifacts like cars or adult organisms, is wasteful of resources; the problem of keeping a population within the limits set by the carrying capacity of its habitat might be more economically resolved by restraining the reproduction of long-lived, if not immortal, adults, who might gain experience of value to their species.

The most probable explanation of senescence and death is that it is an evolved character, programed by the genes. An animal is born with the seeds of its decay within it. Evolution depends upon the continuous replacement of individuals; only populations can evolve. The adaptability of individuals, limited by their heredity, may not be great enough to adjust them to changing environments. Perhaps, in the long history of the living world,

[insert 1]

Stepparents are too infrequent, or too seldom detected and reported, to importantly affect populations of abundant, strongly established species, but by even slightly increasing the reproduction of a declining species they may help save it from extinction.

Finally...

species composed of potentially immortal individuals arose, only to become extinct because they lacked the flexibility to adjust to changing conditions that death and mutability give to a species. Creatures die to give their species the adaptability to survive in a world of change, or to rise to higher levels of organization and mentality. After working hard to replenish its species, the individual, even in the absence of external causes, passes away, reducing by one the numerical strength of the species. Far from doing nothing for the good of its species, willingly or unwillingly the individual makes the supreme sacrifice for its species. It owes its life to the species; it relinquishes its life for the benefit of its species.

Contemporary biologists, who view all organisms as ceaselessly engaged in a relentless struggle to increase their individual fitness, as measured by the number of their progeny, use all their ingenuity to explain puzzling examples of animal behavior in ways that support their theories. They appear to delight in detecting trickery and deception in animal life. Thus, the much-discussed "beau geste" hypothesis holds that a bird sings a variety of songs in different parts of his territory to make it appear that several individuals are settled in it, thereby discouraging other males from trying to intrude. When a bird feeds nestlings or fledglings of a different species, this is a "mistake." In both of these situations, alternative explanations deserve consideration: the singer may repeat several songs because he enjoys hearing them, or because a varied repertoire, like bright plumage, makes him more attractive to females in search of a partner; the altruistic bird, well aware that the alien nestling is not its own, is moved by its pleas for food. Since we cannot read the mind of a bird, we cannot be sure which of the alternative explanations is correct; but consistently to choose the harsher interpretation makes life appear more sordid than it may actually be. Ought we not to welcome any indication among nonhuman creatures of the psychic or moral attributes that we admire in ourselves, and do our best to substantiate them? The more cooperation or kindness that we can detect in other branches of the animal kingdom, the more hopeful our own future becomes. Certainly the living world contains enough that is obviously repugnant or distressful to contemplate, without increasing its apparent amount by forced interpretations. Since, whether we like it or not, we belong to the living world, some of us wish to think well of it.

Because genes impel animals to increase their own fitness, **as measured by the number of their progeny,** often regardless of consequences to other members of their species or to other species, they have been called "selfish." But, as we have seen, creatures so motivated squander their strength, expose themselves to perils, and often debilitate themselves to perpetuate their species. Finally, if no accident befall them, they grow senile and die to give their species the flexibility to confront changing environments and perhaps rise to higher levels. With the reservation that we can apply moral attributes only metaphorically to mindless molecules, should we not call genes "altruistic" rather than "selfish"?

Some of the ways that animals benefit others of their kind perplex biologists who do not look widely enough. The lineage that tried to perpetuate itself by unions of brothers and sisters or other close relatives would probably fail because of the debilitating effects of continued inbreeding. Organisms need others to provide unrelated partners for their progeny. Among the conspecifics saved by a bird's alarm cries, as among the young that it adopts, may be mates for its own descendants, or parents of such partners. Since no lineage is likely to survive long apart from a well-established species, an individual does well to promote the prosperity of its species. Paradoxically, thoughtless genes appear sometimes to see farther than the clever mathematical biologists who try to interpret, in the light of their theories, behavior controlled by these genes.

3

THE TWOFOLD NATURE OF ANIMALS

Life is an intensification of harmonization. A living thing, of whatever kind, contains a greater variety of components than any coherent inorganic formation of equal size, each part is more closely dependent on the others, and together they perform more diverse activities than one will find in any lifeless body of comparable extent. Because of its complexity, an organism is highly vulnerable to extremes of all sorts, and its life depends on the maintenance of a delicate balance with its surroundings. Thus it thrives only by preserving a high degree of both internal and external harmony, and where there is harmony we recognize goodness. Yet when, in chapter 1, we surveyed life broadly, trying to discover its most distinctive features and its relation to the environment that supports it, we found it aggressive and responsible for bringing evil into the world. Although violent collisions are frequent in lifeless matter, we detect there no evidence of destructive passions, malice, nor the consequent frustration and suffering, which are the distinctive marks of evil as we feel it. Accordingly, it is above all in the realm of life that the universality of the impulsion toward order and harmony produces strife and evil as a secondary effect.

As products of a process that moves toward an ever more comprehensive harmony yet incidentally entangles itself in discord, living things could hardly have a perfectly consistent character. They inevitably bear the marks of the contradictions in which they are involved, displaying both good and evil qualities. We wish to know how these contrasting traits occur in them. Is there stratification, with one sort more superficial than the other, or do both penetrate to the core of their being? Although consideration of their mode of origin suggests that goodness is central to living things and destructiveness more peripheral, the subject is so important that we must investigate it from another angle, trying to discover from their behavior what is the primary fact about them, and how this can be distinguished from all the accretions that mingle with and often mask it. In

Contrasting Modes of Behavior

The question that now engages us will emerge in sharper outlines when we survey, even superficially, the temper and behavior of ourselves, our acquaintances, or the animals most familiar to us. All of us, man no less than other animals, are compounded of contrasting and even contradictory impulses, some so incompatible with others that, when we pause to reflect, as we too seldom do, we wonder how they could coexist in the same individual without incapaciting him or her for effective action; as two calves, tied together by a rope, each with its own notions about where the grass is sweetest, rarely wander far.

Once I had a colt who grew up in the same pasture with a gelding past his prime. From the first, the two were close companions, romping and racing together, playfully nipping each other's legs, rearing up on their hindlegs in mock battles. The old horse was always gentle with the youngster, enduring with admirable patience a surprising amount of nonsense. This friendship continued unbroken until the colt passed his fourth year and reached maturity. Then the young stallion turned against the old horse five times his age, trying to drive him from the pasture and the mares, viciously biting and kicking him if he resisted. It became necessary to keep the stallion and the gelding in separate fields, in order to preserve the peace of the farm. This altered relationship was caused wholly by changes in the stallion; the older horse remained the same and gave the younger no provocation. Which was more central to the stallion's nature, his early friendliness to the old horse or the enmity that replaced it? Or did his nature undergo a radical change as he matured, so that both the friendly and the belligerent attitudes were equally expressive of his inmost disposition at the time when each prevailed?

Among birds we witness many examples of these opposite modes of behavior. Some species that, through much of the year, associate in compact flocks lose their sociability at the approach of the nesting season, when each male establishes himself on a separate patch of land and will fight any of his erstwhile companions who dares to intrude upon it. And there is a limit to the gregariousness even of those species that not only flock when not engaged in reproduction but also nest in crowded colonies on cliffs, islands, or in treetops. Breeding penguins, albatrosses, and gulls repulse with their bills those of their neighbors who press too close to their nests, with the result that each pair maintains a small unoccupied space around its nest, and this ensures a rather uniform distribution of the breeding pairs over the available area. Swallows perching on wires seek each other's company yet resist too close crowding, so that neighboring individuals are separated by a distance that is determined by how far each can peck without budging from its chosen spot. Birds of many kinds feed the young of other parents, of their own or even of alien species (Skutch 1987). Yet some parent birds, including several kinds of jays and toucans, are not above snatching the young from nests of other species, perhaps bringing their mangled corpses to feed their own carefully attended families. Could we say that the social or the antagonistic instincts, the helpful or tyrannical attitudes toward neighbors, are more central to the character of a bird? Or are both equally expressive of its inmost nature?

Similar contrasts are found in the behavior of insects. Ants are among the most social of animals, dwelling in populous colonies that rival the cities of man in their teeming inhabitants and complex organization. The workers tenderly nurse and feed the helpless larvae, caress each other with their antennae, and pass food from mouth to mouth. Yet not only do they battle fiercely with ants of other species, they are almost equally hostile to other colonies of their own kind, and they may devour the off-spring of vanquished rivals. Like man at an early stage of moral development, they have one pattern of behavior for their family or clan and another for all outsiders. The two modes of behavior lie at opposite poles: treatment of members of the clan often evinces lack of respect for privacy and individuality that would be intolerable to cultured people; treatment of those beyond the narrow pale of immediate kinship reveals brutality that outrages finer feelings. Which of these two modes of behavior, that toward one's own tribe or that toward outsiders, is more central to the nature of ants and of men?

In trying to answer this question, we shall follow three lines of approach. First we shall see what light the study of animal behavior can shed upon our problem. Next we shall ask whether our understanding of evolution can help us to decide which kind of behavior is primitive and which derived. Finally, in chapter 22, we shall try to learn whether human experience agrees with the conclusions reached by the first two methods of investigation. Merely as terms indicative of overt behavior, and without reference to accompanying affective states, we shall call all those attitudes and activities that tend to draw animals together "friendly" or "integrative", all those that make them avoid or harm each other "hostile" or "disruptive".

. Hunger and Fear as Causes of Hostility

The chief causes of conflict among animals are hunger and sexual rivalry. The need or inclination of each individual or closely knit group, in many species, to preserve for itself, and keep free from others of its kind, a territory or area that provides food or shelter or both, is a secondary cause of conflict: the defended space would have little value if it failed to yield nourishment or to hold rivals aloof. On the whole, sexual rivalry is not a major cause of avoidance or fear among animals; ~~As we saw in chapter 17,~~ much of the so-called sexual fighting, especially in birds, is formal jousting that rarely results in injury to either of the contestants. As a rule, the victor in these duels has no incentive to pursue his fleeing antagonist beyond his own domain; and when the season of reproduction has passed, the former rivals may gather in friendly groups once more. This leaves hunger as the great disruptive force in the animal world, the chief cause of fear. Because some animals need others as food, these others must defend themselves desperately or else flee for their lives. Unlike an animal withdrawing from a sexual rival, who is usually satisfied by the departure of his antagonist, the creature fleeing from a predator can satisfy its pursuer only with its living flesh.

Aside from man and some of the social hymenoptera, animals rarely wage war or kill other animals except to fill their stomachs. When not hungry, predatory animals, including some of the fiercest, only exceptionally molest others, even of kinds on which they habitually prey. Antelopes and other herbivores are somehow able to recognize the moods or intentions of the carnivores that eat them, galloping away from hunting lions but continuing to graze peacefully in the vicinity of these hereditary enemies when the latter are not interested in prey. Similarly, ducks have been seen swimming about fearlessly while carnivorous otters played among them. Hawks that catch smaller birds often hunt chiefly at a distance from their nests, leaving unmolested the small songbirds who rear their broods near the eyrie. The birds learn which kinds of hawks are dangerous and which relatively innocuous, and they may sometimes be seen feeding calmly in the tree where one of the latter sort rests.

Some animals instinctively avoid predators that have for generations preyed upon their kind, but they lack an innate tendency to shun other animals in general; so that they may remain unconcerned near one so potentially dangerous as man, until disastrous encounters, over a long interval, have taught a sort of wisdom to their race. Thus, it is well known that birds and other creatures on uninhabited islands, or in other regions from which humans had long been absent, are fearless of man, with the lamentable consequence that mariners who encountered them in their pristine innocence exterminated whole species before they acquired wariness, as happened to the Great Auk of Labrador and the Dodo of Mauritius.

Moreover, even among the predators themselves, the habit of capturing and tearing the prey appears in some instances to be not innate but learned from the example of their parents or others of their kind. We learn from Lockwood Kipling's Beast and Man in India (1892) that the young Cheetah is not worth catching, for it has not learned to hunt and its human captors cannot teach it. Konrad Lorenz (1952), the famous student of animal behavior, owned a female Imperial Eagle, acquired after she was already mature, who even when hungry refused to harm a hair of the rabbit that was offered to her. Facts such as these, which might be multiplied, suggest that neither the predator's fierceness nor the timid hunted creature's shyness is an expression of its essential or inmost nature. These contrasting attitudes arose because they were needed for survival; when the need is satisfied or removed, the conduct and the accompanying emotions vanish. This conclusion was reached by the ancients: In his essay on abstinence from flesh, Porphyry quoted with approval Aristotle's statement that if all animals enjoyed abundant food, they would not act ferociously toward each other or toward man.

What remains in the animal when these disruptive tendencies have been neutralized or eradicated? Either indifference to creatures of other kinds or a measure of positive attraction. Social or gregarious animals are, as a rule, little drawn to animals of other species as long as they can find comrades of their own kind, but in the absence of these they may seek heterogenous companions. A solitary horse at pasture stays nearer his master than one with equine friends. Some kinds of birds that, even outside the nesting season, retain too much territorial exclusiveness to associate with others of their kind, nevertheless attach themselves to mixed parties of distinct species, one individual of the exclusive species in each flock, as though preferring some companionship to a wholly solitary life. The pretty Slate-throated Redstart of the Guatemalan highlands is a good example of such behavior. Under domestication, when man has brought together creatures of diverse sorts with little regard for their natural affinities, the most incongruous companionships may grow up between individuals deprived of access to others of their kind. Domestic horses have contracted friendships with a swan and a hen, and wild mustangs with bison. Dogs have accepted as comrades a variety of animals that they usually persecute, including a deer, a peccary, an otter, a lioness, rabbits, and squirrels. Crows can be trained to dwell peacefully with owls. These are a few of the strange companionships that naturalists have recorded (Dobie 1945).

Just as evolution has covered certain animals with hard carapaces or sharp quills to protect their tender flesh; so it has overlaid their basically pacific nature with fierceness, to help them to survive in a fiercely competitive world. But the fierce temper is as superficial as the protective integument. Hereditary enmity, the normal relationship between predator and prey, tends to disappear if individuals of both categories are reared together soon after birth, before one has learned to kill and the other to fear, and enough food is provided for both. Even animals as fierce and powerful as lions, leopards, bears, and wolves will grow up as affectionate friends of the person who attends them gently from an early age. Perhaps only animals of very low intelligence, which seize their prey by a reflex act little subject to inhibition by the higher nervous centers, are intrinsically incapable of becoming trustworthy companions. Without the ferocity fomented by hunger, and the timidity of victims of predation, the whole animal kingdom might become the pacific community that Isaiah envisioned.

3. Sexual Rivalry

The second great source of strife in the animal kingdom is sexual rivalry. Whereas hunger brings discord between different species and is far less a direct cause of conflict between animals of the same kind, the reverse is true of the enmity stirred up by the reproductive passions. This is displayed almost exclusively between individuals of the same species and sex, usually between males; although in a few kinds of birds in which the usual roles of the sexes in courtship and parental care are reversed, as in the phalaropes, jaçanas, and Spotted Sandpipers, the female is more aggressive than the male. Among vertebrates, sexual jealousy does not, as a rule, arise until the animal approaches reproductive maturity, and in nearly all species in a state of nature it is intermittent, occurring only in the season of rutting or mating. Gregarious birds and mammals of the male sex, who have grown up peacefully together in flocks or herds, become antagonistic to their former companions and playmates as they mature. At this stage the males of numerous monogamous species separate. Each claims a territory that he defends against others of his sex, while he uses all his arts to attract a mate. Polygamous males may fight stubbornly to drive away all competitors and become each the sole master of a harem. But after the close of the breeding season, these same rivals may reunite in a peaceful group.

This strenuous sexual rivalry is induced largely by hormones that the reproductive organs release into the blood stream at the period of their greatest development and activity. It has long been known that geldings and oxen graze pacifically together while stallions and bulls brook no rivals. Castrated pigeons and other birds remain tranquilly with their male companions at seasons when they would normally fight. Conversely, by injections of appropriate hormones, quails can be made pugnacious in the winter months when otherwise they would be foraging in amicable flocks. Here, too, the basic and primary state of the animal is pacific and sociable. Sexual jealousy, with all the exclusiveness and sometimes fierce belligerency that accompany it, results from the modification of this prevailing condition by a chemical poured into the blood stream and acting upon the nervous system, thereby inducing distinctive attitudes and modes of behavior. There are reasons for believing that this whole arrangement was brought about by natural selection, because of the advantages that accrue to a species in a world of conflict when the strongest males win more mates and leave more progeny than the weaker ones, or when the breeding individuals are scattered rather than crowded together.

In many species, the male reproductive apparatus is a Nessus' shirt that diffuses a subtle poison through the unfortunate animal, destroying his amiable tranquility and bringing on a sort of madness. The hormones it releases have much the same effect as a blow in the face of a peaceful man, who doubles up his fists to strike back almost before he is aware of what he is doing. The effects of anger, as of fear, are intensified by a hormone that quickens circulation, deepens breathing, and tenses muscles. But no special hormone is needed to make animals placid and sociable. This is their primary state, which may be masked by the goading of hunger or the disquieting secretions of the sexual glands, but can hardly be permanently altered without destroying their health or sanity. Yet even in this upsetting matter of sexual jealousy, life's integrative force has asserted itself, turning rivals into associates and making of competition a mode of cooperation, as in the courtship assemblies of male birds mentioned in chapter 4.

How Strife Entered the Living World

Our survey of some of the pertinent facts of animal behavior suggests that friendly or integrative attitudes are more fundamental or central, closer to the basic, unmodified character of animal life, than hostile or disruptive attitudes. When we reflect upon the origin of organisms, we see that it could hardly be otherwise. Life arose as a late phase in a long course of harmonization, which is, above all, the process of building up coherent patterns. Life could not flourish on this planet until cosmic and terrestrial developments had prepared a fairly stable, orderly environment for it. First, diffuse nebular material condensed into definite, widely separated bodies, moving rhythmically in dynamic equilibrium with distant neighbors. Then on the cooling surface of the Earth the mixed vapors separated out, forming the atmosphere and the oceans, with emergent areas of land. The peculiar properties of air and water, the regular diurnal rotation of the sphere, stabilized the temperature within limits compatible with vital processes. Only in such a moderate milieu, shielded alike from extremes of heat and cold, of radiation and chemical activity, could the integrative process that is life be carried forward. Then atoms could unite in molecules of extraordinary complexity, and these join in colloidal masses, which enclosed themselves in delicate membranes that regulated their exchanges of materials with the environing world.

As evolution proceeded, the primitive cells, instead of separating into independent halves after each fission induced by their increasing size, remained in contact and gave rise to multicellular organisms. As these aggregates of cells grew in bulk, those on the outside were exposed to conditions different from those near the center, and this diversity of situation induced differences in structure and function. Distinguishable tissues arose in these early organisms, and with continuing evolution diverse tissues were grouped into distinct organs. Eventually, animals and plants were equipped with a great diversity of organs, external and internal, each with its own marvelously complex structure and its particular function in the economy of the whole organism. To ensure the proper coordination of these separate organs and functions, each so necessary to the welfare of the whole body, integrative devices developed in the form of the nervous system and an array of chemical messengers which, released into the circulatory system by one organ, effected correlative modifications in others, often widely separated from the first. And while this internal development was proceeding, the whole cellular community remained sensitively responsive to modifications in its surroundings, for its prosperity depended, above all, on close adjustment to the environment that sustained it.

Thus, life could not appear until it found a fairly stable environment. From first to last, its evolution has depended upon harmonization, not only for the close integration of an increasing multiplicity of parts but likewise for adjusting this manifold to its ambience. Life arose out of harmony; it is a constant endeavor to preserve and increase harmony; it languishes or perishes with the failure of harmony, either in its internal arrangements or in its relations with its milieu. How, then, did this tender and delicate thing, this triumph of harmonization, ever become capable of violence?

Strife arose from the collision of patterns growing up at separate centers and incapable of coalescing into a single whole. Such fusion was impeded by the integument in which each living unit found it expedient to enclose itself in order to carry on its intricate processes without much interference from outside. Moreover, the complex molecules of the living substance, although exhibiting a fundamental similarity in chemical constitution, soon acquired different structures in diverse organisms, so that the simple fusion of distinct masses of protoplasm was no longer possible. The great profusion of life, the tendency to initiate these patterns of superior complexity and integration everywhere on the Earth's surface that they could exist, inevitably resulted in the clash of living things, which is but a special instance of the general truth that the ~~very universality~~ excessive intensity of the impulsion toward harmony gives birth to disharmony.

Increase in the number of organisms not only resulted in more frequent physical contacts between them; so many living things absorbing nutrients from their ambient impoverished the medium and made the maintenance of life more difficult. Conditions were approaching an impasse that might have blocked the evolution of life had it not been broken. Finally, some of the primitive organisms developed the capacity to break down the substance of other organisms, take it into their bodies, and incorporate it into their own protoplasm. Possibly at first they ~~utilized~~ used only dead organisms in this way; but since many of the protista multiply by simple fission and probably never die of old age, lifeless protoplasm might have been available only where the excessive heat or insolation of some exposed pool had destroyed its inhabitants; or where overcrowding of these minute creatures potentially endowed with immortality caused many to perish from malnutrition, thereby releasing for the hardiest and most adaptable survivors the materials they needed to preserve life.

Whether or not the earliest organisms that nourished themselves on other organisms consumed only dead ones, it is certain that eventually living things began to prey on each other. This prepared the way for a tremendously long and intricate evolution in two complementary directions. In the first place, the organisms most helpless in the face of the primitive predators would be devoured in greatest numbers; while those that could move away, or were protected by a resistant envelope or a peculiar chemical composition that made them unacceptable to their enemies, survived and multiplied ~~in larger numbers~~. Every character that increased the security of victims of predation acquired survival value; mutations improving such features had still greater survival value; and lineages whose existence depended upon swift retreat, or concealment, or protective incrustations, or a fecundity able to compensate for high mortality, started down the long evolutionary road. As the victims of predation became more adept at avoiding capture, the predators simultaneously increased their speed or craft or strength for overcoming their prey, for those best endowed in any of these ways were most adequately nourished and, on the whole, left more descendants. Another category of animals, specialized for predation, began to evolve, producing by adaptive radiation an ever-increasing array of types, and keeping pace with the prey, which by developing fresh modes of defense or escape fled them down the geologic ages.

. Strife Intrudes into Reproductive Activities

At first, simple reactions sufficed the predatory animals for capturing victims that possessed only equally stereotyped reactions for escaping. But with the increasing size and structural complexity of both predators and prey, more complex innate patterns of behavior were impressed upon their nervous systems, on the one hand promoting the capture of victims, on the other, escape from the pursuing predator. Concomitant with the evolution of the nervous system was an intensification of psychic life, which necessarily corresponded with each animal's mode of existence. Predators became bold and fierce, especially when pricked by the pangs of hunger; creatures whose safety lay in flight or concealment became timid and secretive. Intelligence, slowly increasing to give greater plasticity to the behavior of certain gifted animals, was at first almost wholly under the dominance of those appetites and emotions essential to the survival of the individual and its race, so that its mind was swayed by greed, rage, and anger, or by fear, hatred, and suspicion.

With the growth of the carnivorous habit among animals, death crept over the Earth in countless guises, and to compensate for its ravages, the multiplication of individuals became urgent. Animals with many diverse parts could not, like their most primitive ancestors, multiply by simple fission, and more complex modes of reproduction became indispensable. Instead of giving its whole self to produce two replicas of itself, in the manner of the humblest organisms, the multicellular creature set apart a fraction of its body to generate several or many offspring at first wholly different in appearance from itself. Instead of a single individual's sufficing to propagate its kind, the cooperation of two individuals became necessary throughout the metazoa, the reason for this complex arrangement being that, by mingling the traits of individuals, a greater variety of offspring is produced, some displaying new characters or combinations of characters that bring advantages in the increasingly intense struggle to survive.

The cooperation of two individuals in reproduction demands a high degree of harmony between them. Their external genitalia be must be complementary; their physiological cycles must be so adjusted that they are simultaneously ready to mate; their patterns of behavior must be coordinated; their germinal cells must have mutual affinity so that they fuse; and their genetic constitutions must be such that when combined they produce a well-integrated organism. If the two parents remain together after the fertilization of the ova and cooperate to rear the young, their interactions with each other and with their developing progeny must be closely adjusted. At least at higher psychic levels, this intricate process is colored by appropriate emotions, the chief of which, love, is the most powerful agent of concord among individuals. The whole reproductive process, in its physical no less than in its psychic aspects, is a masterpiece of harmonization in the living world.

The intrusion of disruptive, hostile passions and behavior into this realm of subtle and delicate adjustments is one of the great paradoxes of animal life, explicable only when we understand how sexual rivalry is related to the deadlier conflict between predator and prey. The strife stirred up by the carnivorous habit finally insinuated itself into the intimate internal relations of each affected species, whether of predatory animals or their victims. Among the former, any system that would make the strongest and most pugnacious males most successful in winning mates and fathering offspring, would help the race to attain maximum efficiency in running down and overpowering its prey. Among the latter, the selection of the hardiest and boldest males as sires would result in progeny better able to escape their pursuers by sustained flight, or even to confront them when the presence of defenseless young made retreat inexpedient.

Accordingly, natural selection promoted the fierce competition among the males of many mammals and other animals that tends to deprive the weaker or less enduring individuals of a share in reproducing their kind, while the more powerful ones pass on their size and vigor to the next generation. And this fighting, as Darwin recognized, led indirectly to the origination or further development of horns, antlers, tusks, claws, spurs, and other offensive weapons on the one hand, of tough skin, ~~callous pads~~ carapaces, capes of feathers, manes, and other protective coverings on the other hand, no less than to the increase of sheer bulk, strength, and endurance in the contestants. Much of this offensive and defensive armament helps the animals that wear it, in their encounters with hereditary enemies as well as in duels with rivals of their own kind. But perhaps the energy and determination needed for the effective use of this equipment in intrasexual struggles is, in the long run, of greater value to the species than the often clumsy and bizarre excrescences themselves. Thus, the strife between predator and prey abetted sexual fighting, which by selecting the victors to become parents made this strife ever more savage.

By so long and devious a path has the impulsion toward harmony of which life is a product become entangled in antagonistic habits and attitudes, been armed with a vast array of aggressive and protective devices; until, regarding the living world superficially, one might suppose that discord rather than concord, war rather than peace, is its fundamental character and prime necessity. But an intimate study of its origin and nature reveals that this conclusion is false. Disharmony can never be more than froth upon the deep current of life. A system of relations so extensive and intricate remains intact solely by virtue of the harmony that pervades it; to saturate it with strife is to ensure its dissolution. In structures, in functions, in emotions, harmony is the pulsating heart of life; discord, the armor it puts on to confront the world. And from this discord, growing out of the physical problems of life, moral evil at last arose when, after millions of years of slow evolution, man became capable of foreseeing the future and choosing between alternative courses of action.

A Diagram of Animal Nature

For clarity and brevity, the conclusions reached in this chapter are summarized in the accompanying diagram, which includes man, who shares so many attributes with his brother animals, and in whom some of the tendencies of animal life reach their most revealing expressions. At the center of our diagram we place the primary nature of organisms, which in man has been called the central self. A product of life's formative agent, harmonization, whose expression in living things is growth, it is the same in all of them, plants as well as animals, and is everywhere creative and pacific. This is most clearly evident in green plants able to synthesize their own food from elements present in air, water, and soil, an achievement that exempts them from the necessity to exploit other creatures. The primary nature of the higher animals is expressed by friendly or loving attitudes, cooperation, caring, and creating.

Animals start with a handicap. Unable to synthesize their own food, they must exploit other living things and often struggle stubbornly with them to survive. This conflict has developed their secondary nature, which surrounds their primary nature like an armature, and is represented by a ring around the central circle. Their secondary nature is, in varying degrees in different species and individuals, aggressive-defensive, belligerent, suspicious, selfish, irascible, fearful, and lustful.

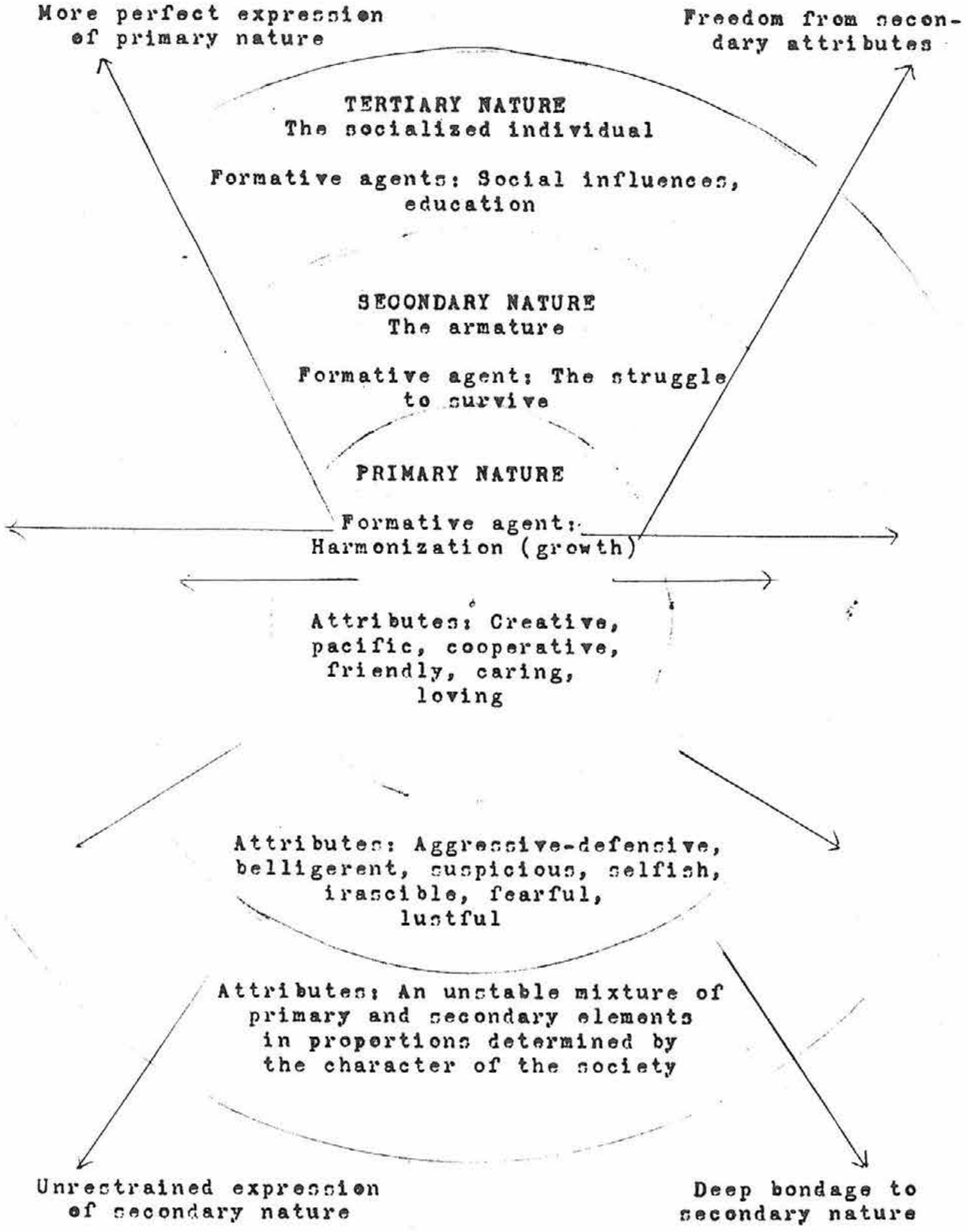
Animals in which the secondary nature is highly developed and untamed are unfit for social life. To live in societies, this rude secondary nature must be mitigated, suppressed, or somehow controlled, so that elements of the primary nature may break through it — the process of socialization. Many animals appear to have become innately socialized as their societies evolved, but a measure of training or the example of their elders may be needed to finish the process. Ornithologists have noticed that Florida Scrub Jays, Arabian Babblers, and Jungle Babblers of India, often disorderly and quarrelsome when young, become as they mature well-behaved members of their pacific cooperatively-breeding groups. Young humans are socialized by discipline, example, and education during their prolonged immaturity. The result of this process is the tertiary nature of social animals, which we represent by a ring around the secondary nature. The attributes of this tertiary nature are an unstable mixture of primary and secondary elements, in proportions determined by the innate quality of the individual and the character of its society.

The rings around the primary nature are not impenetrable barriers. In socialization, attributes of the primary nature penetrate the secondary nature to become manifest in the tertiary nature, as is indicated by arrows extending from the central circle to the outer ring. Occasionally in other social animals, and all too frequently in man, attributes of the secondary nature break through the social restraints, as is suggested by arrows passing from the armature to below the outermost circle. When this happens, animals become aggressive and destructive members of their societies, humans become dangerous criminals, often of the blackest cast, or dominating their society, cruel, oppressive tyrants.

As we know only too well, our actual societies are not the harmonious associations of friendly, cooperative people that we long for them to be. Our treatment of the natural world that supports us threatens to wreck it; we abuse and needlessly slaughter beautiful, harmless animals that deserve our protection. People whose primary nature burns strongly within them, perhaps thinly overlaid by their secondary nature, yearn to transcend the narrowness of their societies. They wish to live in harmony with all creatures, not only their fellow citizens. In their efforts to achieve this more inclusive harmony, they may adopt habits that cause them to be mocked, avoided, or persecuted. They rise above the conventional level of their society, often to lonely heights, as we indicate by arrows passing from the central circle through both enclosing rings to rise above the outermost.

Our diagram corroborates the judgment of philosophers who long ago proclaimed that human nature, despite its manifold blemishes, is intrinsically good. The Socratic doctrine that people naturally seek the good but mistake it, hence can be made virtuous by teaching them to judge correctly, is recognition of man's basic goodness. Far away in China, the sage Mencius (1942), who can hardly have been influenced by the Athenian philosopher, compared human nature to a mountain that had been wooded with beautiful trees, which were ruthlessly felled to supply timber to a neisgboring city, leaving desolate slopes where every aspiring shoot was cropped by cows and goats. Similarly, the benevolence and moral rectitude that are man's natural endowment are weakened by his daily toil. Mencius could not have known for how long an age, under what harsh conditions, evolution had been weaving an aggressive-defensive armature that tends to mask the central goodness of man and other animals.

As sages have long recognized, obsession by the disturbing passions of this armature is human bondage, emancipation from their oppressive dominance is freedom and mental tranquility. When the motivation of one's acts springs from his primary nature, uninfluenced by secondary accretions, he consistently chooses the course that best promotes harmony, as far as he can foresee the consequences of his actions. His will is free, not by virtue of some nebulous indeterminacy, but because it is an expression of his true and inmost self; and who can be freer than one whose course is determined by the process that formed and sustains his body, gives coherence to his thoughts, and benevolence to his will.



A DIAGRAM OF ANIMAL NATURE
(including man)

CAPTION FOR DIAGRAM

The central circle represents the primary nature of all animals, including man. This is surrounded by a ring representing their secondary nature, which in turn is enclosed by a ring representing their tertiary, or socialized nature. At the bottom of the circle and each of the rings are some of the attributes corresponding to each nature, most of which will be manifest only at higher psychic levels. Arrows pointing outward indicate that elements from one sphere enter enclosing spheres, modifying their character; or they transcend the external ring, as when the pacific primary nature rises above a belligerent society, or when, at the opposite extreme, the aggressiveness of the secondary nature escapes social restraints to make outlaws. For a fuller explanation, see text.

Diagram
legend

4

MUTUAL AID AND SOCIAL RELATIONS

To emphasize the vast disproportion between the number of plants and animals of all kinds that nature produces and the number that can survive to reproduce, and the resulting severe competition between individuals of the same species no less than between those of different species, was essential to the argument of Darwin's The Origin of Species by Means of Natural Selection. Evolutionary change depended upon the survival, in this ceaseless struggle, of those best fitted to survive. To Darwinists of the latter part of the nineteenth century, nature was "red in tooth and claw," a monster who proclaimed "I care for nothing, all shall go," But it would be unjust to hold Darwin solely responsible for the prevalence of this attitude. The famous phrases just quoted were written by Tennyson between 1833 and 1849 and published in 1850, nine years before the appearance of Darwin's great work.

Obsessed by the idea that relentless struggle is indispensable for evolutionary advance, the Social Darwinists advocated a competitive society, with few props for the weak and the faltering. They seemed to forget that the attributes which most promote survival and reproduction in a fiercely competitive system are not those which raise man above the level of the shark and the tiger. Fitness to survive and fitness to live in a society of which spiritually awakened people can be proud are two quite different things.

Although from Darwin's later writings, especially The

Descent of Man and Selection in Relation to Sex, it is clear that he recognized that cooperation no less than competition influences the course of evolution, particularly in man; it remained for others to demonstrate how widespread is cooperation in the living world. Perhaps no one did more to promote a more balanced attitude toward evolution, at least among English-speaking people, than Prince Piotr Alexeivich Kropotkin, a Russian nobleman and anarchist long resident in England, who in 1902 published a book on Mutual Aid: a Factor in Evolution, the chapters of which had appeared in the preceding decade in the Nineteenth Century.

Kropotkin's work has been condemned as uncritical. At the time he wrote, scarcely any of the patient, systematic, critical field studies of free animals that are now available in increasing numbers had been made; he had, perforce, to select most of his examples of mutual aid in the animal world from incidental observations, especially those of travelers and huntsmen. But his approach was essentially sound; and no one can justly accuse him of a one-sided attitude, or failure to recognize the prevalence of conflict in nature. "Rousseau," he wrote, "had committed the error of excluding the beak-and-claw fight from his thoughts; and Huxley committed the opposite error; but neither Rousseau's optimism nor Huxley's pessimism can be accepted as an impartial interpretation of nature." Kropotkin believed that animals associate together not only for the security that numbers give but to increase their enjoyment of life; he surmised that birds often fly in flocks "for the mere pleasure of the flight".

Modern biologists are inclined to scorn such notions as unscientific, and to account for all animal associations by their purely utilitarian function of promoting survival and reproduction; but unless creatures find some satisfaction or joy in living, and this increases along with advancing organization, evolution, which multiplies their kinds and elevates their organization, is futility on a stupendous scale, signifying nothing.

More recently, W. C. Allee (1951), long of the University of Chicago, explored cooperation in nature, performing with his students many carefully controlled laboratory experiments to demonstrate that organisms in groups help each other to survive. He proved that animals, such as goldfish in a tank poisoned with colloidal silver, planarian worms exposed to ultra-violet radiation, marine worms transferred to fresh water, buffer each other from adverse effects and survive longer if exposed to them in groups than singly. Sea-urchin eggs develop more rapidly when crowded than when scattered; and certain bacteria fail to multiply if too few are inoculated into the culture medium. Accordingly, Allee recognized an "unconscious proto-cooperation" among organisms low in the evolutionary scale, and traced its growth into the more advanced cooperation of higher animals. He recognized that for many organisms there is an optimum concentration, neither too sparse nor too crowded, which most promotes vital processes.

In the natural, as in the human, world, cooperation and competition are so intimately intertwined that it is often difficult to disentangle them. I am impressed with this truth as, through my study window, I gaze out upon the forest dripping from October's torrential rains. The dominant trees in this rain forest compete intensely for a place in the sunlit canopy, where alone some species can flower and set seed freely. Probably not one in ten thousand seedlings succeeds, after many years of patient growth, in thrusting itself up into this privileged position, for which it must often wait until the giant beneath which it germinated dies of old age or falls in a windstorm. Yet these trees, bewildering in variety, that compete so strenuously with each other, create the conditions indispensable for each other's growth.

One might suppose that trees which find competition in the forest so severe would be the first to take advantage of a clearing that men had made in or adjoining the forest and abandoned after taking off a crop or two; their seeds are often carried to such clearings by birds, bats, terrestrial animals, or wind. But nothing of the sort happens; the trees that invade the new clearings are nearly all of different, quick-growing species that are rare in the forest, where they occur chiefly in openings made by the fall of a great tree. Only after the second-growth trees have profoundly changed conditions in the clearing do the true forest trees invade it; many years, probably centuries, must pass before the original forest is reconstituted. The forest trees not only compete with each other; they cooperate with each other to create a favorable environment for themselves and all the lesser creatures that depend on them.

About the edges of this same forest over which I look, I find the courtship assemblies of ~~the~~ male Orange-collared Manakins, ~~of which I shall tell more in the following chapter~~. These tiny, brisk birds compete pacifically for the females of their kind, who come to have their developing eggs fertilized. One might assume that each manakin's chances of winning a temporary partner would be better if he established his courtship station at a distance from his rivals, instead of within hearing, and often also within sight, of a number of them. But apparently this is not true, for perhaps the majority of the avian species that follow this mating system display in groups or assemblies rather than in isolation. They cooperate to establish an assembly that persists in the same locality year after year, and is large and conspicuous enough to be easily found by the females, at the same time that they vie intensely with each other to attract the females who visit the assembly (Skutch 1992).

Examples of a similar mixture of cooperation and competition among humans are not hard to find. In a big city, shops that sell similar goods are often located close together on the same street or in the same section. Although they compete with each other for customers, they likewise help each other by making it widely known that this is the part of the town where shoes, or jewelry, or whatever one wants, is to be found. In both nature and human society, opposites such as cooperation and competition, good and evil, beauty and ugliness, are so intricately intermixed that we must be wary of all sweeping generalizations.

. Mutual Protection

One of the most widespread forms of mutual aid in the animal kingdom is cooperation in escaping enemies. Everywhere the milder birds and mammals appear to have formed a defensive alliance to protect each other from the fierce predators. When they espy an approaching hawk, birds give special cries, often loud and sharp, that cause others to fall silent and dive into the nearest available cover — not only other individuals of their own species, but likewise birds of other kinds, so that a hush falls over fields and groves as the raptor sails by.

Mammals and birds reciprocally warn each other of perils. While intensively studying Mule Deer in the Sierra Nevada of California, Thane Riney (1951) often saw the deer alerted to the approach of a man or some other dangerous animal by the alarm notes of birds that had noticed the animal first. The birds, of several kinds, not only warned the quadrupeds of peril; by resuming their songs or other activities, they reassured the deer that the danger had passed, so that the latter returned to their grazing or undisturbed repose. By imitating appropriate notes of the birds, Riney could not only alert the deer but also allay their fears.

On the African savannas, Ostriches often associate with antelopes and other herbivorous animals. Because they are taller than most of the associated quadrupeds and have sharper eyesight, they often warn their four-footed companions of impending danger. It is probable, too, that they profit by the mammals' keener sense of smell, when the approaching predator is not in sight, or tries to steal up under cover of darkness. Once, while I stood watching a covey of Marbled Wood-Quails in a banana plantation, a squirrel in the crown of a neighboring banana plant noticed me and scolded sharply. Although the birds could not have been unaware that I had been standing close to them; on hearing the rodent, four of them instantly squatted down on the ground in plain view, while the fifth ran behind a clump of bananas. I remained motionless, and soon the quails resumed feeding close in front of me.

At the sight of a flying hawk, the gregarious California Ground Squirrel utters a loud cheesk, which is repeated by neighboring squirrels as each slips into its hole. A series of different notes warns the community of the presence of a snake; and yet another call advises neighbors that a man, a dog, or a coyote is approaching (Bourlière 1954).

Many kinds of animals find safety in numbers. At the approach of a Peregrine Falcon, European Starlings flying in a flock bunch more compactly and make sudden, closely coordinated turns. A falcon dashing into such a dense flock at tremendous speed would injure itself by colliding with some of the starlings, hence will try to seize only an isolated individual (Tinbergen 1951). Similarly, a flock of Cedar Waxwings, repeatedly menaced by a Cooper's Hawk, contracted into a dense mass and veered aside in unison each time the raptor tried to seize one of them, always failing (Meyerriecks 1957). As I was finishing this book, I received the National Geographic for November 1988, with an underwater photograph by David Doubilet of a school of Crevalle Jackfish swimming in close contact while they chased a great barracuda that they had thwarted when it attacked them. On the ground, in the air, and under the water, gregarious animals employ similar methods to baffle their enemies.

The caterpillars of several kinds of butterflies live in clusters, sometimes dozens of hundreds of them forming a conspicuous, compact sheet on the bark of a tree. Since at least some kinds of these gregarious caterpillars are palatable to birds, one might suppose that to make themselves so visible would be disastrous. But it has been demonstrated in the case of the Small Tortoiseshell and the Peacock that certain birds, such as redstarts, hesitate to attack the caterpillars while clustering, although they devour one of the same kind if they find it alone. Why the birds avoid clustered harmless caterpillars remains unexplained (Tinbergen 1958).

In other ways, too, the massing together of small creatures may give them a measure of safety. Midges flitting back and forth in a dense aggregation, crowded tiny animals darting at random in the water, may be harder to catch than if they were more thinly dispersed. A predator closely pursuing one of them seems to be thrown off the track by another suddenly crossing its path. Allee, who noticed that goldfish ate fewer, rather than more, Daphnia when these small crustaceans were very crowded in the water, called this the "confusion effect".

From ancient times, it has been known that an owl drowsing on an exposed perch in the daytime is often surrounded by a crowd of small birds of the most varied kinds, all flitting closely around the sleepy raptor and calling in a medley of voices. The Greeks, as we learn from a remark in the Olympian discourse of Dio Chrysostom, supposed that the birds were admiring the owl; but the modern explanation is different. Similar behavior, known as "mobbing", is elicited by a perching hawk, a snake, a cat, and indeed any animal dangerous to small birds or their nests. Attracted by the hubbub, I have sometimes found nothing more formidable than a very large, moribund moth at the center of the crowd of excited birds. The birds scarcely ever touch the creature that they mob; but I have known Riverside Wrens and Rufous-fronted Thornbirds to peck snakes a dozen times their own length, always being careful to keep away from the serpent's head. Mobbing serves to warn every small animal in the vicinity that a potential enemy is present. It is always a great advantage to know exactly where one's enemies are; not the snake that is seen, but the snake that escapes detection, sinks its venomous fangs into the unwary pedestrian's leg. Moreover, by joining a group of mobbers, young birds learn which animals are dangerous.

Some animals give a warning sound, or flash a warning signal, as they flee from an actual or potential enemy. Pigeons sometimes clap their wings loudly as they take flight, thereby alerting other pigeons. Hares thump the ground with their feet. The Agouti, a large, nearly tailless terrestrial rodent of tropical American forests, emits a startlingly loud note, like a harsh sneeze, as it bounds away from an approaching man. Although the Agouti is a solitary animal, the only evident function of this revealing cry is to warn other Agoutis in the surrounding woodland; if it fled silently, the animal would more often escape detection and death.

The white caudal flags that White-tailed Deer and Cottontail Rabbits flaunt so conspicuously as they bound away seem also to serve as warning signals to others of their kind; the animals' own safety might be better served in they held their tails down, rather than up, as they flee. More complex is the warning behavior of the African Springbuck. Along the posterior half of the back of this antelope is a double fold of skin forming a narrow pouch lined with pure white hairs from four to six inches long. When alarmed, the antelopes leap high into the air with body curved, legs close together, and head down. At the same time, the pouch is everted, displaying the long white hairs like a fan over the rump.

3. Social Hierarchies

Since the Norwegian T. Schjelderup-Ebbe published his study of the social psychology of the domestic hen in 1922, much has been written, in "popular" no less than scientific publications, about social dominance and despotism among animals, including man. In certain flocks and herds, all or most of the individuals are arranged in a hierarchy of power or privilege. In hens, social rank is revealed by the peck order. The top hen pecks all the others, but is pecked by none. The second hen is pecked only by the first, and she pecks all the others except the first. The third hen pecks all except the first and second, and so on, down to the most subordinate hen, who is liable to be pecked by all her associates in the flock but is too timid to retaliate. As anyone knows who has tried to put a hand beneath one of the more peppery hens while she incubates or broods her young, a hen's peck can be painful. At times a triangle develops somewhere in such a series, A pecking B, who pecks C, who in turn pecks A.

The situation among hens is known as "peck right". In domestic pigeons it is more complex and known as "peck dominance". The pigeon that is pecked does not always tamely submit to this aggression but often returns what it receives. To discover the hierarchy in a flock of pigeons requires long, patient watching and counting of the pecks delivered in all directions. A bird who pecks another more than it is pecked by that other is considered to be dominant over the other.

Social hierarchies have been demonstrated in animals the most diverse, including fishes and lizards, gregarious quadrupeds, monkeys, and man. Among cows, the dominant animal butts her subordinates with her horns; among ~~men,~~ humans, as everyone knows, social dominance is shown in the most varied ways, blunt or subtle, and often no less hurtful than a hen's peck or a cow's butt.

The position of an animal in a social hierarchy depends on various factors, some of which are obscure. Age and experience are certainly of the greatest importance; the youngest members of any group generally stand at the bottom of the ladder and must gradually work their way upward, suffering many harsh rebuffs on the way. Strength and vigor count for much, but temperament is equally decisive; a large but mild animal may yield to a smaller, more aggressive companion. Intelligence may also help to win a high rank. A high-ranking animal who becomes sick or suffers an injury may fall from the top to the bottom of the hierarchy. A newcomer in a flock or herd, timid amid strange companions and unfamiliar surroundings, usually enters it with a low rank; but if a strong or aggressive bird or mammal, it may soon fight or bluff its way upward.

Sex also influences social rank, but in no invariable fashion. In Budgerigars, or Shell Parakeets, females are dominant over males when they are not nesting; but while breeding is in progress, the males dominate their mates and are said to drive them back to their eggs when they attempt to leave. In the European Jay and the Canary, however, the situation is just the reverse: the male of a pair is dominant over his mate in the off season; but as nesting begins, she assumes the ascendancy (Shoemaker 1939). In some birds, such as the Jackdaws that Konrad Lorenz (1952) kept at Altenberg, the female, whatever her original rank, acquires that of the daw with whom she mates; so that a low-ranking female may suddenly find herself at the top, if she wins the leading male ~~(Lorenz 1952)~~. The diligent reader of history will doubtless recall parallel cases among people.

Some naturalists have contended that for successful coition the male must win dominance over the female, but this fallacy appears to result from the confusion of spatial position with personality or social standing. It would be as logical to maintain that the motorcar is dominant over the mechanic who crawls beneath to repair it. Not infrequently, as I have seen in woodpeckers and has been reported in other birds, male and female alternately mount each other. Sometimes the male of a pair is the stronger character, sometimes the female; and I have watched many a pair of birds build and attend their nests without any indication that either lorded it over the other.

Dominance in a flock or herd confers several advantages. The dominant animal has the first choice of food; if the source is spatially limited, as at a feeding table for birds, it may eat first, while the others follow in the order of their rank. In times of scarcity, social standing may determine survival; the lowest-ranking individuals, pushed to the outskirts of the feeding flock, watchful to avoid the pecks or nips of their superiors, as well as predators, may not manage to eat enough to keep alive. Low social ranking appears to be one of the reasons why the juveniles of certain birds, such as Wood Pigeons in England, suffer a much higher winter mortality than their elders. Dominant birds can occupy the most coveted places in a communal roost; and among polygamous animals of all kinds, the high-ranking males most often win females.

On its own territory, a bird is usually dominant, no matter how low it may rank on neutral territory — a fact that led Edwin Willis (1967) to define territory as "a space in which one animal or group generally dominates others which become dominant elsewhere". A number of jays, titmice, thrushes, and other birds fall lower in social rank, or perhaps it would be more correct to say that they become more timid and submissive, the farther from their own territory they wander in search of food. Animals of nearly every kind feel more confident on their own home ground.

Although not absent from free animals in their natural environment, peck orders and similar manifestations of social rank are most conspicuous in domestic animals, animals in confinement, animals at feeding stations, and in other more or less artificial situations. In such situations social hierarchies have been chiefly studied. Certainly the kind of despotism that has been observed among penned chickens is rare among wild birds, which are free to go elsewhere if too greatly harassed by their companions in the flock.

In many social animals in their natural state, the high-ranking individual is not the despot but the leader, the vigilant guardian, the protector of the group who occupies the post of danger, the peace-maker when disputes arise, like the patriarch among gorillas, the matriarch among Red Deer, the senior male ~~as will be told~~ in a group of cooperatively breeding Jungle Babblers. ~~beyond.~~ The true leader does not push his followers away from food and water but sees that they have what they need. Alexander of Macedonia, for all his faults, showed his true greatness as a leader when, marching on foot over sandy wastes under a blazing sun at the head of his army, tormented by thirst like all his men and barely able to stagger onward, he was given a helmet full of water, all that his scouts could find. Since it was impossible to divide so little water among so great a multitude, after thanking the scouts, Alexander poured it on the ground in full view of his troops, thereby raising their spirits as much as if each had received a drink — one of the finest things Alexander ever did, remarked his biographer, Arrian.

Much has been made of peck orders and other manifestations of dominance hierarchies as a method of social integration. But animals do not associate with others of their kind in order to be pecked, nipped, butted, or otherwise mistreated and made to feel inferior. Perhaps, however, their need to keep close company with others — for protection, for help in finding food, or just for companionship — is so great that they are willing to endure such treatment rather than remain solitary. Peck orders and the like appear to be ~~a~~ compromise developments whereby animals that are imperfectly social manage to remain together without too much discord. If such animals must compete for precedence, vent their irritation with each other, and otherwise display unfriendly attitudes, it is ~~far~~ better that they promptly decide who comes first, who has the power to domineer the others, and that they preserve this order, than that they bicker continually over food, sleeping places, and other benefits. In some animals, we notice great disparity between the need for social cooperation and adaptation to social life. In man, this disparity is tragic: we yearn to love and to be loved; yet so great are our asperities and imperfections of character that our attempts to cultivate intimate, enduring relations with others often end in bitterness.

Of all animals, the termites and social Hymenoptera seem most perfectly fitted for social life; yet the price of this adaptation appears to have been loss of individuality. In the most highly social birds that I have studied, not dominance but perfect amity and equality appeared to prevail. Let us now examine the true bonds that hold animal societies together.

4. The Social Bonds

The life of many animals is a compromise between social and antisocial tendencies. Even when they associate in large companies, these imperfectly social animals hold each other more or less aloof, each surrounding itself with a space within which it does not willingly permit its companions to intrude. This "individual distance", as it has been called, is a sort of mobile territory with invisible boundaries that envelops the animal wherever it goes. P. J. Conder (1949) noticed that resting Black-headed Gulls maintain an individual distance of about one body-length; but when searching for food, their separation becomes greater. Tufted Ducks on a lake in St. James' Park in London stayed two or three body-lengths from each other. Swallows resting on a wire seldom perch in contact but are often strung out at short and rather even intervals. Frequently the individual distance is the reach of a perching bird's bill.

The most social birds, however, show no such coolness toward their companions. While studying Groove-billed Anis, I noticed no antagonism between the members of a group, no attempt of one to dominate another. These highly social, communal-nesting, black cuckoos widespread in tropical America rest during the day, and roost at night, perching in a row and pressing as close together as they can. If a bird in the middle flies away, the remaining ones promptly sidle together and close the gap. Several species of wood-swallows studied by K. Immelmann (1966) in Australia perched in equally compact rows. In Kenya, V. G. L. van Someren (1956) found from two to six White-cheeked Colies, known also as mousebirds, clinging upright to a leafy branch, abdomen pressed against abdomen. Among other birds that bunch together in groups containing more than a single pair, at least when roosting at night, are Splendid Blue Wrens, Ornate Bee-eaters, Long-tailed Titmice, and hanging parakeets. Cold weather often induces clustering by birds that ordinarily avoid contact with each other.

Among the bonds that hold social animals together, not the least important is reciprocal preening or grooming. Probably the majority of birds preen only themselves. Others, including pigeons, parrots, toucans, and many others, preen their mates, especially about the head and neck, where the feathers are inaccessible to a bird's own bill. But in the most sociable of all, members of a flock appear to preen each other indiscriminately. When anis perch in a row, any one may nibble the feathers of any other. In the days when this valley was still wild, Marbled Wood-Quails, now so rare and shy that they are seldom seen, were so tame that I could sometimes watch them for long intervals while standing unconcealed only a few yards away. They were especially easy to observe when they foraged at the woodland's edge. After scratching for food among fallen leaves, to the accompaniment of soft, melodious, contented notes, a covey of six began to put their feathers in order. Three rested close together on a low branch, alternately billing each other's plumage, chiefly on the head and abdomen. The one in the center performed this service for its companions on either side, who reciprocated the favor; and sometimes an outside bird reached past the central one to bill the plumage or legs of the quail on the other end.

Presently a fourth bird jumped up to join the preening party on the branch, while the remaining two were similarly engaged on the ground. None tried to dominate another. (Skutch 1983).

Among primates, mutual grooming is a prominent activity that probably helps to counteract the disruptive aggressiveness of some species, particularly the baboons. So important is mutual grooming to lemurs that their dentition has been highly modified to facilitate this activity: the front teeth of the lower jaw project forward as a sort of comb, which appears so poorly fitted for biting or chewing that it puzzled naturalists until they discovered that it serves excellently for grooming (Jolly 1967). The true monkeys and apes work over each other's pelage with their fingers rather than their teeth, removing dirt and external parasites. This widespread primate habit persists among humans with inadequate facilities for washing. In the highlands of Guatemala, where cold air and rarity of large streams discourage bathing, I used to see Indian women sitting in the doorways of their huts, diligently searching their children's hair for lice or whatever infested it, putting to their mouths what they found. Horses, although imperfectly social, nibble each other simultaneously, mostly on the withers at the posterior end of the mane. My stallion and mare regularly exchanged this courtesy after their evening meal; yet, far from being a perfect gentleman, he would drive her from her bananas if he finished before she did.

Not only does help in body maintenance bind social animals more closely together, it may even draw animals of diverse kinds together. A number of birds regularly pluck parasites from the bodies of large mammals. In Africa, two species of sharp-toed ox-peckers, belonging to the starling family, persistently climb over the bodies of rhinoceroses, zebras, domestic cattle, and other herbivores, relieving them of the ticks and other pests that supply most of these birds' food. In the Americas, cowbirds of several species perform the same service for cattle, ~~Similarly,~~ and for free animals such as capybaras and tapirs. Similarly the Egyptian Plover plucks parasites from the thick hides of crocodiles and even, if Herodotus and Pliny were well informed, enter their huge mouths to clean between their teeth. Although all these great animals are amazingly tolerant of their feathered attendants, none seems to go out of its way to secure their services (Howell 1979).

The situation among certain fishes is quite different. According to a ~~recent~~ review by W. Wickler (1968), the warmer waters of the oceans contain no less than forty-two species of fishes, belonging to fourteen families, known as "cleaners". These fishes specialize in removing from the bodies of fishes of different kinds the bacteria and external parasites that adhere to them, as well as loose or dead skin and particles of food. The clients, which are often very much larger than their attendants, even open their mouths and raise their gill-covers to permit the cleaners to enter and search through the gills. The cleaners profit by eating what they remove from their clients, while the latter are benefitted by this cleansing of their bodies, so that this is an excellent example of mutually beneficial symbiosis. The client fishes make a practice of visiting the coral reefs where the cleaners dwell, for a periodic grooming. The latter fearlessly approach fishes that could easily swallow them and gently work over their bodies, removing foreign matter. Occasionally, perhaps in consequence of a misunderstanding, a cleaner is devoured by its client.

As too often happens when a pleasant community of interests grows up in the natural world or among people, strangers butt in to take a base advantage of the situation. One of the cleaner fishes *Labroides dimidiatus*, is mimicked by a quite different fish, *Aspidontus taeniatus*, of the same size and similarly marked with wide, longitudinal black bands on a light ground. Advancing under false colors, the sharp-toothed *Aspidontus*, instead of grooming the client, bites pieces from its caudal fin. Despite the close resemblance of the imitator to the cleaner in appearance and mannerisms, the clients learn to distinguish them; young, inexperienced fishes appear to be the chief victims of the deception.

Another social bond is cooperation in feeding. Probably most flocking birds, from pelicans that dive for fishes in the ocean to swifts that catch flying insects high in the air, help each other to find the richest concentrations of their appropriate food. Oceanic birds, which are often dazzling white, or black and white, can see each other from afar, and when they notice a few of their kind repeatedly plunging upon a school of small fishes or a concentration of squids, hasten to join the feast. Similarly, swifts coursing over a wide area can watch each other flying above the treetops and converge on the spot where continued circling reveals the presence of many small volitant creatures. Much closer cooperation in foraging was exhibited by the Marbled Wood-Quails already mentioned. Standing almost above them, I noticed not the slightest resentment when one picked food from a space that another had just cleared by scratching, sometimes removing it almost from beneath the scratcher's body. If one found something too large to swallow all at once, it did not run away with its prize, as domestic chickens do, but amicably permitted its companions to share it. Yet all these quails appeared equally mature and able to forage for themselves.

Many birds wander through the woodland in mixed flocks, which are especially large and diverse in tropical forests. The members of such flocks have different foraging habits: some climb over the trunks of trees, plucking insects and spiders from crevices in the bark; others ransack dead leaves lodged in crotches and tangles of vines; others glean caterpillars and spiders from living foliage; still others dart into the air for flying insects. Although the birds in these motley flocks are predominantly insectivorous rather than frugivorous, and so take much the same food, the help that they incidentally give each other seems to outweigh competition. The insect put to flight by a bark-searcher or a leaf-gleaner is snatched up by a vigilant flycatcher. The continuous movements and varied calls of the birds in these parties make them so conspicuous that raptors should have no difficulty finding them; but, doubtless the advantage of having many sharp eyes to detect an approaching enemy outweighs the hazard of conspicuousness, so that the birds are safer in the motley flocks than they would be alone. Probably a feeling of greater security and a desire for companionship, as well as greater ease in finding food, induce these birds to forage in the mixed associations.

By placing food in each other's mouths, animals establish a still closer bond. Birds of many kinds feed their mates, most frequently as the breeding season approaches and while incubation is in progress. Usually the male gives food to the female; but occasionally she passes a morsel to him, as I have seen in the White-flanked Antwren and the Tawny-bellied Euphonia and Mrs. Lawrence (1968) in the Evening Grosbeak. By repeatedly feeding the male Andean Hillstar who has entered her territory in the high Peruvian Andes to court her, the female overcomes his timidity in a strange situation, without known parallel in the hummingbird family (Dorst 1962). More rarely, birds feed companions other than their mates: A group of Cedar Waxwings may pass a berry back and forth, until finally one swallows or drops it. Scattered through the literature are instances of adult birds, including a blind American White Pelican, a blind Indian Crow, a Brown Booby with only one wing, a Magnificent Frigatebird in similar plight, a Fiery-billed Aracari with a badly deformed beak, an ailing Gray Wood-Swallow, and a wounded Fijian White-breasted Wood-Swallow, all of whom remained alive and in fair condition, apparently supplied by their companions with all the food they needed. It is not evident that all these crippled or sick birds were actually seen to receive food from others; but in British Columbia N. A. M. Verbeek and R. W. Butler (1981) repeatedly saw a male Northwestern Crow feed a female, not his mate, who had a blind eye and a deformed bill.

The importance of food as a social bond reaches its climax among the most highly social of all animals, the termites and the social Hymenoptera. W. M. Wheeler (1928) applied the name "trophallaxis" to the continual exchange of food, or at least of gustatory satisfactions, which he regarded as the most compelling attraction between all the members of an insect community. Termites are constantly feeding each other, with nourishment extruded either from the mouth or the opposite end of the body, a practice that led Maeterlinck (1927) to characterize a termitary as a "collective coprophagy". By these exchanges, they infect each other with the intestinal protozoa without which many species of termites cannot assimilate their ligneous meals. In certain termites, the queen of a colony, whose huge swollen abdomen has become a factory for turning out endless eggs, exudes from her skin a substance so highly relished by the workers who feed her that sometimes, in their eagerness for more, they tear little strips from her cuticle to reach the underlying source. Small brown scars mark the spots where she has been wounded by her progeny.

The larvae of certain ants and wasps secrete from their salivary glands, or from relatively enormous glandular growths surrounding the mouth, substances that their nurses greedily lick up after feeding them. Naturally, the quantity of nourishment given by the attendants to the larvae far exceeds what they receive from them; otherwise, the young insects could not grow. But the larval secretions are so highly attractive that the workers will relinquish much food to obtain them; as a farmer will sometimes sell ~~many~~ pounds of his produce in order to buy a few ounces of some delicacy. Adult ants of the same colony habitually feed each other with nutriment regurgitated from their "social stomachs". Wheeler held that neither affection nor cleanliness is the motive for the mutual licking in which ants indulge; they do so to enjoy the fatty exudates and other secretions of each other's bodies. If Wheeler's interpretation is correct, gustatory and olfactory pleasure — or, more technically, the stimulation of their chemoreceptors — is the reward for which the workers among the social insects lead their strenuous lives, cooperate closely with each other, and faithfully attend the helpless members of their community, including the egg-producing females, the larvae, and sometimes also the males. And who would begrudge them such small delights?

Among the attractions that bring animals together, we must not overlook the communal roost, which as night approaches draws to a central point, often in tremendous numbers, birds that during the day have been widely scattered in smaller groups or singly. The roosts of such birds as starlings, pigeons, swallows, crows, and others are too well known to need description here. Often birds of a number of species sleep close together in a clump of tall bamboos or a high stand of grass or reeds. In inclement weather, many individuals of a species that is usually less gregarious may crowd into a cavity that offers some protection. In western United States, O. A. Knorr (1957) found as many as a hundred and fifty Pygmy Nuthatches lodging in an old pine trunk that contained several holes, at least one hundred of them in the same cavity. In the Costa Rican mountains, during the season of chilling rainstorms, I once, to my great delight, watched sixteen Prong-billed Barbets enter a hole in a tree so small that they must have slept in layers. Yet, when nesting, these barbets are highly territorial (Skutch 1989).

Finally, we cannot lightly dismiss the desire for companionship, divorced from any purely utilitarian motive, as a factor that draws individuals together, at least among the higher animals. Deprived of companions of their own species, animals sometimes become closely attached to an individual of some very different species. W. H. Hudson (1919) told of a lone swan that sought the company of a horse. Such incongruous partnerships as that of a dog and a deer, a cat and a rabbit, or a crow and an owl, have been so frequently recorded in the annals of natural history that it seems superfluous to elaborate the point. (Dobie 1945).

It will be noticed that in the foregoing discussion of the social bonds nothing was said about sex. The omission is deliberate. Sex itself is not a cohesive but a disruptive factor in animal life. Gregarious mammals and birds, which through the long annual interval of sexual quiescence have lived together amicably, become mutually antagonistic as their reproductive urges awaken. The sexual hormones, coursing through their veins like some subtle venom, make implacable enemies of erstwhile companions. Sex, in itself, forges no lasting bonds even between individuals of opposite sexes. Unless sexual partners are held together by some shared occupation or interest, such as caring for their offspring, or by personal liking or attachment not dependent upon primary sexual activity, male and female separate and go their own ways after the exhaustion of their erotic ardor. This applies to man no less than to the rest of the animal kingdom, the chief exceptions being those species in which a degenerate male lives permanently attached to the female in parasitic dependence, as in angler fishes. Failure to recognize these truths has led certain anthropologists to attribute to the absence of an annual interval of sexual quiescence in man a role in human social development that does not belong to it. Only indirectly, as the necessary prelude to the generation of offspring whose care unites the two parents in a shared activity, has sex contributed importantly to sociality in man and other animals. This will become increasingly clear in the course of this book.

Cooperation in Nesting and Attending Young

Sea birds of many kinds may be constrained to nest colonially by the paucity of islets or forbidding cliffs where alone they find adequate protection for their eggs and young. The massing of nests of gulls, terns, gannets, boobies, penguins, and other marine birds does not necessarily imply cooperation between them, although sometimes, as among murres, or guillemots, they minister to their neighbors' young.

Colonial nesting has a different aspect when several or many nests are contained in a single massive structure built by the occupants themselves. Among the conspicuous features of Hispaniola are the nests of the Palm-Chats, distant relatives of the waxwings, nearly always situated in the crown of one of the stately Royal Palms so abundant on that large Caribbean island. One such nest was a mass of interlaced twigs that we estimated to be ten feet high by four in diameter (3 by 1.2 meters). At a much smaller nest, I counted about twenty-five of the starling-sized brown birds with streaked white breasts flying back and forth, bringing more sticks. These great nests are avian apartment houses, containing many chambers that do not communicate internally with each other. Each chamber appears to be occupied by a single breeding pair, whose domestic activities remain to be thoroughly studied. The same palm that upholds the Palm-Chats' massive structure may contain in its columnar trunk numerous holes of the Hispaniolan Woodpecker, one of the few members of this great family that nests colonially. In one trunk with twenty-four holes, we found four pairs of woodpeckers nesting simultaneously, and others seemed to be preparing to do so.

Nests of similar size are made by the Monk Parakeet, or Cotorra, of Argentina, one of the few parrots that builds instead of nesting in a cavity in tree or cliff. Strongly constructed of interlaced thorny twigs, the nests may hang from outer branches of trees or even a large palm frond. They may attain a height of seven feet (2.1 meters), weigh a quarter of a ton, and provide separate, unconnected chambers for up to a dozen pairs of the parakeets, each of which lays four to eight dull white eggs in an unlined compartment that is approached through a porch or vestibule from a downwardly directed entrance (Conway 1965).

Of quite different construction, and even more ponderous, are the apartment houses of the Sociable Weaver. In one of the scattered trees in arid Southwest Africa, Herbert Friedmann (1930) found an edifice that measured about twenty-five by fifteen feet at the base by five in height (7.6 by 4.6 by 1.5 meters). To start such a construction, the whole flock of sparrow-sized birds, working together, builds a spreading roof by interlacing coarse dry grasses and small twigs. Beneath this general covering each pair attaches its own nest made of similar materials, until the lower surface of the mass is perforated by small, circular openings — nearly a hundred in the very large structure found by Friedmann. Each year the birds attach new nests below the old ones, until finally the overladen branch breaks beneath the weight of the huge edifice. Like the Palm-Chats and the Monk Parakeets, the weaver birds sleep in their nests even when they are not breeding, thereby saving much energy on chilly desert nights and decreasing their need of food.

Still closer cooperation in breeding is practiced by the lanky black anis with high-arched bills, that we have already had occasion to mention. Although a pair will often nest alone, frequently two, three, or even more pairs join forces to build a simple, open nest of coarse sticks, which they line with green leaves that are brought daily until the young hatch. In this broad, open bowl the females lay their chalky white eggs in a common heap. All the participating anis of both sexes take turns incubating, one at a time, and later all feed the nestlings, making no distinction between their own offspring and those of their coworkers. Each night a single male takes charge of the eggs or nestlings. Bold in the defense of their families, Groove-billed Anis have often buffeted the back of my head while I looked into their nest (Skutch 1983) ~~1987)~~.

Although Palm-Chats, Monk Parakeets, and Sociable Weavers build compound nests in which each pair occupies a separate chamber, and anis make a simple nest in which several pairs raise a compound family, another mode of cooperation is much more widespread among birds: a single breeding pair is assisted by one or more nonbreeding helpers. At the bulky nests of sticks built by the big, raucous ~~White-tipped~~ Brown Jays in Caribbean Central

America, the mated pair are usually aided by younger birds that are readily distinguished by their bills colored black and yellow in the most diverse patterns. Once I watched seven grown jays, including the parents and five helpers, feed and guard a brood of three nestlings; and every nest that I studied had at least one young assistant. These helpers sometimes fed the incubating female. In a population of Florida Scrub Jays, Glen E. Woolfenden (1975) learned that nearly all the yearlings helped their parents to feed and defend nestlings and fledglings, and about half the two-year-old jays did so. Breeding pairs assisted by their older, nonbreeding offspring produced substantially more young than did pairs without helpers.

In the Caribbean lowlands of Costa Rica, long burrows in the ground beneath heavy rain forest, which in one case sheltered a brood of three nestlings, were attended by three or four White-fronted Nunbirds, all bringing food in their vivid orange-red bills. In England, a cosy nest of Long-tailed Tits is often attended by one or two adults in addition to the parents, all bringing food in perfect harmony. In the highlands of Guatemala, the beautiful, lichen encrusted, downy pouches of [illegible] Bush-Tits attract from one to three unmated birds who wear the black facial masks of the males. These helpers sometimes brood as well as feed the four nestlings. As a reward for their services, they are permitted to sleep with the parents and young in the swinging pouch, during the cold nights of high altitudes.

In Australia, breeding pairs of Superb Blue Wrens are often assisted by extra males, who are usually their offspring of earlier years. Ian Rowley's (1965) careful studies showed that pairs with helpers raised nearly twice as many nestlings per nest as unassisted pairs, and about 50 percent more nestlings for each attendant adult. In many other resident birds of warmer regions, similar breeding groups, consisting of a mated pair with one or several unmated helpers, have been discovered; and the list of avian species that practice such cooperation continues to grow as tropical birds are more extensively studied ~~(Skutch 1987)~~. (Brown 1987, Skutch 1987, Stacey and Koenig 1990).

Among the many modes of mutual aid among birds, none is more surprising than that practiced by the unhatched chicks of certain nidifugous species. The slight sounds made by quail chicks, as they break out of the eggshell, stimulate somewhat younger chicks in other eggs in the same nest to pip their shells sooner than they would otherwise do, with the result that all hatch more or less simultaneously, and can be more promptly led off to the feeding ground by their parents. This doubtless unconscious cooperation contrasts strongly with the behavior of the young of certain raptorial birds which, sometimes when only a few days old, murder, and perhaps afterward devour, their slightly younger or weaker nest-mates, thereby removing competition for food. (Johnson 1969).

Sometimes a lactating female mammal will suckle an orphaned young, of her own or even another species; as when a Blue Wildebeest who had lost her calf gave milk to a motherless Burchell's Zebra. But helpers do not fit into the mammalian system of reproduction as readily as they do into the avian system and, with the exception of a few cases reported for jackals and wolves, cooperation in rearing the young is largely limited to protecting the mother and her offspring. Among elephants, zebras, wild horses, and horned quadrupeds of various kinds, the males defend the females and young. When threatened by wolves or other predators, Musk Oxen of the Arctic tundra form a circle around the calves, present-ing their horns in unbroken array against the enemy. The Malayan Gaur, or Seladang, a wild relative of domestic cattle, travels through jungle and neighboring clearings in herds of a dozen or more individuals, led by a large, wary cow. From a crow's nest high in a treetop, L. Weigum (1970) enjoyed the rare experience of watching such a herd when a marauding Tiger approached. Hearing the carnivore's rumbling, the old cows advanced toward it, while the master bull guarded the calves. After the cows had located the marauder, the bull, bellowing and snorting, rushed toward it with lowered horns and put it to flight.

On the African savannas, baboons travel in large companies, with the females and infants surrounded by the adult males. About twice the size of the females, the latter have much bigger canine teeth, useful for defending the troop from Leopards and other enemies. Policemen of the society, the dominant males stop fights among their subordinates, often simply by means of a masterful stare. Other monkeys also travel in troops, in which childless females eagerly fondle infants not their own. Occasionally, even a male will carry an orphaned baby, as C. R. Carpenter (1934) noticed in the Howling Monkey of tropical America. Living in trees through which they can flee more rapidly than pursuing mammals, monkeys are less exposed to danger than are the largely terrestrial baboons, and their troops are less tightly organized.

The foregoing examples of cooperation in the living world are only a small selection from the vast body of similar facts that naturalists have gathered, chiefly in the present century; but they amply confirm what Kropotkin tried to prove with the more meager data available when he wrote, that mutual aid is widespread among animals and has powerfully influenced their evolution.

Harmonization is active not only within organisms, in their growth and functioning, but likewise between them, joining members of a species in cooperative societies and even bringing diverse species together in mutually beneficial associations. This harmonization or pacification of the living world has still not progressed very far; the cooperating groups exist precariously in the midst of strife, and even within them concord is often far from perfect. Yet cooperation no less than competition is widespread in ~~undeniable facts of~~ nature, and must receive serious consideration by any evolutionary philosophy.

5

EXPLOITATION AND COOPERATION

As this book has shown, the living world is full of inconsistencies, or situations that one would not expect to follow from their antecedents. Among its many paradoxes is the fact that organisms ~~that,~~ which, to the best of their ability, insulate themselves from everything around them nevertheless need surrounding things to support their lives; whereas lifeless objects, which do not separate themselves by special coverings from other things but mingle freely with them, have in general no need of ~~them.~~ insulation. Rocks, many metals, and the more stable crystals might continue indefinitely to exist in a vacuum; living organisms need constant support by their environment, and most of them are, in one way or another, dependent upon other organisms.

Dependence has degrees. Green plants, able to elaborate their own food by photosynthesis, are far more independent than animals. Their basic needs are sunlight, air, water, and elements dissolved in it or in the soil. Probably most of them could thrive as isolated individuals, as many do scattered through arid deserts, in rock crevices at the highest altitudes where vegetation grows, and in scattered spots almost everywhere. Even those that thrive amid others, like trees in a forest or grasses in a close stand, may grow in isolation, sometimes better when less closely crowded by competitors for sunlight and water. However, many plants are less independent of other organisms than they appear. The tree that stands so proudly all alone may need the mycorrhizal fungi that envelop its finer roots to absorb the water and solutes that it requires from the soil. Planta that are not self-fertile need pollen from others to set seeds. All whose pollen is not carried by wind or water are dependent upon animals - insects, birds, bats, and others - to bring it to them, and many employ animals to disperse their seeds. In the living world as a whole, the most widespread mode of dependence of one organism upon another is for reproduction. Even those that as individuals can live quite alone would cease to exist as species without other individuals to fecundate their reproductive cells.

Unable to synthesize their own food from inorganic materials, all animals are strictly dependent upon plants, either directly, or indirectly, as when they eat other animals, themselves nourished, often also indirectly, by vegetation. The dependence of one organism upon another may be unilateral or reciprocal, exploitative or cooperative, in both relationships often complicated by competition for resources. The effects of these two modes of interaction upon the creatures involved in them are among the greatest contrasts that the living world presents.

Interactions among organisms fall into the following broad categories:

Exploitation of plants by plants
Exploitation of animals by plants
Exploitation of plants by animals
Exploitation of animals by animals
Cooperation among plants
Cooperation between plants and animals
Cooperation among animals

Let us briefly survey these relationships in this order.

Exploitation of Plants by Plants

In the vegetable kingdom probably the most frequent, and certainly the most conspicuous, mode of unilateral exploitation is that practiced by vines of all sorts, from slender twiners like morning-glories to massive lianas of tropical forests, all of which, having lost the capacity to hold themselves erect, grasp other plants to raise themselves into the sunshine. Usually they reduce the amount of light that falls upon the supporting plants, decreasing their photosynthesis. The more aggressive of them spread a smothering blanket of foliage over the crowns of the highest trees of the forest. Their constricting coils may strangle the tree up whose trunk they spiral; but sometimes the trunk grows over them and embeds them in its wood.

In abandoned clearings in humid forests, a riotous growth of vines and creepers burdens young trees, weighing them down or breaking their branches or trunks, making it difficult for them to rise above the welter, and delaying for years the reestablishment of the forest. Certain trees that frequently start life in such clearings have developed special strategies to meet this situation: the young trunk bears no branches, but only big leaves that perform their photosynthetic task and fall, giving the creepers no permanent hold, until the slender tree rises above encumbering vegetation and forms a spreading crown, in the manner of cecropia and jacaranda trees in tropical America. Many vines flower beautifully on the roof of the forest or nearer the ground, often at the expense of the host's own bloom.

Instead of climbing from the ground up to the light, epiphytes germinate and grow on trunks and branches, above all in the humid tropics. They depend upon the host only for support, while they make their own food in green leaves, and derive their minerals from decaying bark and the vegetable debris that lodges among them. Some epiphytes send long roots to the ground, whence they draw water and minerals, while others catch and store rainwater in specially modified organs. In size, epiphytes range from trees that perch on other trees through a vast array of ferns, aroids, bromeliads, orchids large and small to tiny mosses and liverworts. A moderate load of epiphytes appears to have no ill effects upon the plant that supports them but, especially in cloud forests on tropical mountains, the burden of these air plants may become so heavy that it breaks large boughs. With a wonderful diversity of colorful flowers and floral bracts, bromeliads, orchids, and other epiphytes adorn the trees on which they perch, usually below the high canopy, in the shade where bloom is scarce.

Most aggressive of all are the strangling fig trees, which from seeds deposited by fig-eating birds and other animals on high limbs start life as epiphytes, but send roots to the ground along the trunk of the host tree. As they thicken, these roots meet and coalesce, until the supporting trunk is enveloped by a massive network. After the strangled trunk dies and decays, the fig tree remains standing on a high cylinder of fused roots, through the gaps in which one can look. Some of these usurping figs are among the giants of tropical forests.

The exploitation of plants by plants reaches a more advanced stage in the half-parasites or water-parasites, which might be described as green epiphytes that synthesize their own food but draw water and minerals from the host plant's vessels by means of haustoria that penetrate its tissues. Best-known and most abundant of the water-parasites are the mistletoes of the family Loranthaceae, with about 1,300 species distributed over most of Earth, chiefly in the tropics and subtropics. A few make colorful floral displays on high boughs, but a heavy infestation may kill the supporting tree. Their fruits are eaten by many birds and are a principal food of several species of both the Old World and the New. After digesting off the pulp, the birds void the seeds surrounded by mucilage that attaches them to branches on which they happen to fall, where they germinate and grow.

Among flowering plants, full parasites are rare. Some are inconspicuous plants of humid forests, where they grow upon roots of other plants in the dark undergrowth. Their leaves, reduced to scales, are devoid of chlorophyll, making them wholly dependent upon their hosts, or associated fungi, for nourishment. The parasite may be white, yellowish, purplish, brownish, or dark red. Their flowers may be small and inconspicuous or very big, like the yard-broad flower of <u>Rafflesia arnoldii</u> of Sumatra, reputed to be the largest in the world. Much more numerous than fully parasitic flowering plants are parasitic fungi, which attack agricultural plants of many kinds as well as forest trees, often causing heavy losses if not combatted with fungicides that help to pollute the environment. Parasitic fungi are apparently derived from saprophytic forms that play an indispensable role in nature's economy by decomposing dead vegetation of all kinds, returning its ~~their~~ mineral contents to the soil, where they are picked up by the roots of living plants. Without these saprophytes, woodlands would become impenetrable mazes of fallen trunks and branches, because ~~Without them,~~ termites and other insects would hardly suffice to reduce to humus all the debris of thriving forests.

A wide survey of exploitation in the vegetable kingdom reveals that it is caused chiefly by severe competition for living space and sunlight. Many plants, the vines and epiphytes, solve their problem by climbing over other plants or perching upon them. Those that grow upon others, often far above the ground, sometimes find it expedient to draw sap from their hosts; instead of sending roots down to the soil, they become half-parasites. A different set of plants, mostly growing in deep shade, have become full parasites, often on the roots of their hosts. None of these dependent plants has anything to gain by killing its host; the liana or epiphyte falls with the tree that supports it; the half-parasite or full parasite dies with the plant on which it grows. Aside from parasitic fungi, the chief vegetable enemies of trees are the lianas that weigh them down, smother them, or constrict their trunks. In contrast to the situation among animals, exploitation of plants by plants has no psychic effects upon them, or none detectable by us. It is so slow and silent that it hardly distresses the most sensitive onlooker. By greatly diversifying vegetable forms, it has made the vegetable world more interesting, and given us the beauty of orchids, most of the more spectacular of which grow as epiphytes.

<u>Exploitation of Animals by Plants</u>

Animals, which exploit plants on a vast scale, are rarely exploited by them. The carnivorous flowering plants, which by traps and pitfalls the most diverse capture and digest insects and other small invertebrates, occasionally a diminutive vertebrate, are every-
a very minor element of the flora that deserves a separate chapter. A family of fungi, the

Entomophthoraceae, contains numerous species that infest the tissues of flies, caterpillars, and other small creatures, killing and devouring them. Other fungi exploit larger animals, including humans, causing irritating skin infections and more serious diseases.

Exploitation of Plants by Animals

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Although plants rarely exploit animals, they are heavily exploited by them. The only animals that do not exploit plants directly are the carnivores or insectivores that do so indirectly, by devouring creatures directly nourished by plants; or sometimes, in long food chains, nutrients obtained directly from plants pass through diverse animal bodies before they reach the ultimate predator. Recent investigations of the upper levels of tropical rain forests suggest that the number of insect species may run into millions, and a large proportion of them devour the tissues of living plants. Most conspicuous is their damage to foliage; if they do not defoliate a whole tree, they may leave few intact leaves upon it. Swarms of locusts may devastate a wide area. Less noticeable but almost equally damaging to plants are the depredations of a host of small, seed-eating beetles that may ruin the seed crop of a tree. The relation of butterflies to plants is ambivalent: caterpillars devour much foliage; the winged adults into which they metamorphose make some amends by serving as pollinators, often not of the plants that nourished their larval stage, as would be just.

Vertebrate animals that exploit plants unilaterally include the grazers, the browsers, and the seed-eaters. Horses and their kin are most at home on wide, open grasslands, over which they roam in small or large herds. Over the ages, typical grazers and their food plants have coevolved, not in a direct, one species-to-one species pattern but in a more diffuse manner; many of the grazers involved in this secular interaction have disappeared from Earth, and perhaps some of the grasses that nourished them have also become extinct. By their basal growth, grasses are as well adapted to support grazing that is not excessive as, by dentition and digestive system, the grazers are to crop and digest them. By preventing the accumulation of dead blades that reduce photosynthesis and invite fires, moderate grazing appears to benefit well-adapted grasses.

Browsers gather foliage, often together with branches and flowers, above the ground. Probably the most highly specialized of extant browsers is the Giraffe, whose long neck, with associated modifications of the vascular system, permit it to reach green shoots too high for all its four-footed competitors. Although primarily grazers, hprses are often tempted to browse upon the foliage of shrubs or trees within their reach. Cows browse as readily as they graze, as do a number of antelopes and deers. At higher levels, sloths and monkeys browse upon the foliage of a variety of trees and vines, which for some species, like howler monkeys, is a principal food. Fairly large birds, such as grouse in northern woodlands and guans in tropical American forests, browse freely on foliage and buds, often high in trees. Among reptiles, iguana lizards eat leaves. Grazing and browsing mammals serve the plants among which they move by dispersing seeds that cling to their hair by means of hooks or sticky secretions. Many of these animals vary their diet of green herbage when they find tasty fruits, whose seeds may pass unharmed through their alimentary canals and thus be widely spread. The fragrant fruits of Guava trees are eagerly sought by horses, cattle, and other animals, who scatter the hard, undigestable little seeds through pastures and fields where many seedlings spring up.

Among the exploiters of plants are seed-eating birds and rodents. Although some members of the large parrot family are nectar-drinkers and pollinators, the majority are seed-predators, who with thick, doubly-hinged bills extract nutritious embryos from seed-coats that are often hard. With strong, crushing bills, grosbeaks and other finches remove embryos from hard-shelled seeds. Little goldfinches and the many seed-eaters that swarm in tropical grasslands prefer smaller seeds that they can swallow whole. Crossbills with overlapping mandibles pluck seeds from the scaly cones of pines and other coniferous trees. Squirrels, agoutis, rats, and other rodents devour many seeds. Seed-predators, both invertebrate, like many beetles, or vertebrate, like a number of birds and mammals, greatly reduce the reproductive potential of the plants that supply them with rich sources of energy. However, certain jays and nutcrackers among birds, agoutis and squirrels among rodents, compensate the sources of their seeds by burying a few or many for future use. The forehanded animal may die, or forget some of its hidden seeds, which germinating, perhaps at a distance from the parent tree or shrub, propagate the species.

Among grazers, browsers, and seed-eaters are many highly gregarious mammals and birds, who through much of the year live in peace with others of their own and of different species. In general, they neither fear one another nor are feared by animals of different habits. Mutual aid in avoiding or repelling predators is frequent among them, as told in chapter 14. Conflicts arise among the males of these vegetarians mainly in the mating season, when they contend for females, often fiercely. Unless their populations become excessive, they do no great harm to the plants that support them: grasses are well able to withstand grazing; seeds of many plants are produced in such abundance that the existence of their species is not jeopardized by the consumption of many of their embryos; vigorous trees and shrubs can replace lost foliage.

More harmful to vegetation appear to be the largely terrestrial mammals and birds that dig up and devour the subterranean storage organs, rich in starch and other nutrients, of many herbaceous and suffrutescent plants - their tubers, corms, bulbs, and thickened roots. On the whole less gregarious than grazers, browsers, and seed-predators, they tend to forage alone or in small groups, which is fortunate for the plants they eat. While humans were in the hunting and gathering stage, the storage organs that they extracted from the soil with digging sticks must have contributed substantially to their diets, but the extent of this injury to vegetation is now difficult to assess. Exceedingly harmful to plants are huge animals like elephants, who to supply the immense quantity of provender that each individual needs every day may, where numerous, destroy light woodlands by pushing over small trees.

The greatest, most destructive exploiter of vegetation, as of much else, is man himself. I refer not to agriculture, which is essentially a mode of cooperation between man and his cultivated plants (although its side effects upon the native flora are often disastrous), but to the widespread destruction of trees to provide grazing for beef cattle, for timber, pulpwood, charcoal, and other products. After destroying most broad-leaved forests in the North Temperate Zone of the Old World and the New, exploiters of trees and the lands on which they grow have been attacking tropical rain forests with such unrestrained greed that if this plundering cannot be halted they will disappear in the next century. So great is this destruction that whole species of animals and plants are becoming extinct, or have already vanished. The trees that man plants, as some slight compensation for the woods that he destroys, especially the all-too-common pines and eucalypts, can never form forests of the magnificence and productivity, for creatures of many kinds, of those that he levels.

Exploitation of Animals by Animals

The exploitation of animals by animals has many aspects. Frequently the animals that are eaten are so different from their eaters that we do not think of this act as predation. Although the robin that swallows earthworms and the warbler that catches insects are technically predators; we do not ordinarily place them in this category, to which we spontaneously assign the larger and fiercer carnivores - lions and wolves, eagles and falcons - which strike down, rend, and devour creatures whose blood is as red and warm as their own. The distinction that we make between animals that devour creatures very different from themselves and those that prey upon animals in the same zoological class, or as highly evolved, as themselves has a valid foundation in the effects of their activities upon the animals themselves and upon us who look on. Although many people delight in the spectacle of violence and bloodshed of every sort (so long as they are not themselves hurt by it), the sensitive onlooker is shocked and distressed by the sight of a hawk seizing a piteously crying bird or a Cheetah tearing the vitals from a living antelope; but he is not so affected by a bird devouring a caterpillar. His sympathy is not aroused by the insect or spider in the bill of a bird as it is by a song-bird in the talons of a falcon or a mammal eviscerated by the fangs of another mammal.

As far as we can tell, predation by animals upon others much lower in the evolutionary scale has not the same psychic effects upon either predator or prey as predation upon birds and mammals. It is above all such predation that has burdened animals with their secondary nature & and all the distressing attributes of the armature (chapter 36) — ferocity, anger, hatred, fear, suspicion, callousness, and similar psychic states. Although predation by warm-blooded animals upon warm-blooded animals appears to be the chief cause of this lamentable development, carnivorous reptiles - snakes, crocodilians, monitor lizards - have contributed substantially to it. Man, long a hunter of large animals and probably through a long ages a frequent victim of the larger predatory mammals and reptiles, has been heavily infected by these disturbing passions, possibly, because his mind is more active and his emotions stronger, more than any other animal. Only because he has had hands to wield weapons has man managed to survive without protruding fangs, claws, horns, or similar organic growths, offensive or defensive, which the struggle between predator and prey has imposed upon creatures involved in it; and without a thick hide or protective carapace.

Our rapid survey of the exploitation of animals by animals would be incomplete if we failed to mention the exploitation of females by males who fight among themselves for them but contribute nothing to their offspring beyond a minuscle sperm. The psychic effects of such fighting and uncaring fatherhood are in some animals almost as unfortunate as those arising from predation.

Even among men who in the present age mostly support and protect their children, an exploitative attitude toward the child-bearing sex persists in the guise of *machismo* or male chauvinism, which today is combatted by women seeking emancipation.

The exploitation of animals by a great variety of small parasites, internal and external, has been a major cause of suffering and death, but its psychic effects have been very different from that caused by large predators. One cannot fear or hate a protozoon or fluke that he has never seen (and probably does not know about) as he can fear and hate a man-eating tiger or a shark. Fear of disease tends to be more persistent but less paralyzingly intense than terror in the imminent presence of a huge ravening beast.

Cooperation among Plants

Turning now to the cooperative interactions of organisms, we find that among plants they are chiefly passive. By growing close together, plants may maintain an environment favorable to each other, as among the trees of tropical rain forests. The mycorrhiza that envelop the feeding roots of many of these trees, helping them to absorb indispensable elements from the soil, are nourished by carbohydrates supplied by the trees in a mutually advantageous association. A similar symbiosis occurs between leguminous plants and the bacteria that form nodules on their roots, absorbing free nitrogen from the air that permeates the soil and supplying their hosts with nitrates in return for carbohydrates.

Cooperation between Plants and Animals

Plants, which for long ages have suffered uncomplainingly from the depredations of animals, respond magnificently when animals cooperate with them. The flowers that brighten woods and meadows, adorn our festive occasions, express our sympathy with the sick and the bereaved, and provide the motifs for so many paintings and household decorations are displayed by plants to advertise the availability of nectar to the bees, butterflies, other insects, birds, and other creatures that convey their pollen from the anthers of one to the stigmas of another. Fragrance makes them more attractive to insects as well as to the people who delight in them. Sweet nectar is sometimes enriched with vitamins and amino acids; while for bees pollen, produced in excess of the plant's needs for fertilization, offers a nutritious food for the many kinds of bees that busily collect it in special baskets on their hindlegs, then carry it back to their hives and mix it with nectar to make "beebread."

Wind pollination is a wasteful but adequate method for plants that grow in almost pure stands, as in grasslands and northern woods. In rich tropical forests where trees of one kind tend to grow scattered among many other kinds, only insects or birds that, at least temporarily, confine their visits to a single species can efficiently pollinate them. We owe such forests to cooperation between animals and plants. We, who enjoy the colors and fragrance of flowers, the beauty, interest, and diverse products of tropical woodlands, are incidental beneficiaries of a mode of cooperation between animals and plants highly advantageous to both of them.

Although by hooks or other means of attaching inedible fruits to fur or clothing many plants exploit animals unilaterally to disperse their seeds, a great number of them reward the dispersers with food. Frugivorous birds - in contrast to seed-predators like parrots - are by virtue of their numbers and mobility, the chief disseminators of seeds, especially in tropical woodlands where dispersal by wind plays a subordinate role. After swallowing a many-seeded berry or a small, one-seeded drupe like a cherry, a bird rapidly digests the soft pulp. Small frugivores like tropical American euphonias and manakins may void the seeds in their droppings ten minutes or less after swallowing the fruit; larger species, like Eurasian Blackbirds, within half an hour. If, instead of passing the seeds through the length of the alimentary canal, the bird regurgitates them from its crop, it eliminates them much more rapidly. Such brief residence inside the bird does not injure seeds adapted for avian dispersal, which germinate where they fall, often at a distance from the plant that bears them (Snow and Snow 1988). We owe the colors, aroma, and nutritive value of a great diversity of fruits to a tacit compact between fructiferous plants and frugivorous birds. By selection, man has increased the size and flavor of fruits originally adapted for dispersal by birds, among which we might include cherries, currants, and strawberries. The wild ancestors of certain larger fruits improved and esteemed by man - avocados in the New World, mangos in the Old - were probably disseminated by mammals. Again, we have benefitted greatly from a mutually beneficial arrangement between plants and animals.

No mode of cooperation between animals and plants has had more momentous consequences, not only for man but for the whole living world and the planet that supports it, than agriculture. It would be superfluous to expatiate here upon the advantages, economic and aesthetic, moral and intellectual, that man has derived from cultivating plants in fields, orchards, and gardens. If we measure the success of a species by the number of its individuals and the extent of their dispersion over Earth, cultivars that man has improved and carefully tended for many centuries include some of the most successful of all plants. The association has been highly advantageous to both parties. Even the campfollowers of cultivation, the unwanted plants that we call weeds, have profited greatly and spread widely over the world. Regrettably, agriculture has expanded at the expense of vast areas of splendid forests and the creatures they sheltered. By supporting excessively dense human populations, it has created many problems that never troubled peoples who lived as hunters and gatherers on the bounty of wild nature. Plants have responded generously to the care that man has bestowed upon them. It seems to be our turn to show our appreciation of the advantages plants have given us by using them with greater wisdom and moderation, restricting agriculture to soils best suited for it, and showing more concern for all the vegetable and animal species that thrive on uncultivated land without our help but often with mutually beneficial associations of their own.

Cooperation among Animals

Man's association with domesticated animals has been less unequivocally commendable than that with cultivated plants. As with plants, some domestic animals are much more numerous and widespread than they might have become in the wild state, and by this criterion they are highly successful species; but with animals that enjoy and suffer, the relationship has other aspects that hardly apply to plants, which are less highly organized. Plutarch, defender of animals, held that it is not wrong to domesticate them so that we may be kind to them. When an animal who is gently treated, well fed, and cured when sick or injured pays for all this laborious attention by working for his master, we might regard this as a fair and mutually beneficial arrangement. But the animal who bears our burdens or hauls our vehicles - the horse, the ox, the camel - does not understand why he is compelled to work; for him it is forced labor. Moreover, the situation has all the perils inseparable from arbitrary power. Too often the poor beast is underfed, overworked, his sores neglected. Plants cannot be cudgeled or goaded to increase their yield, as beasts of burden too often are to make them pull or bear loads too heavy for them. Animals raised for their flesh are cruelly slaughtered, often after being abominably treated during their short lives. Only exceptionally, or in an indulgent mood, can we regard man's association with his domestic animals as mutually beneficial cooperation. At best, many generations of compulsion have distorted the animals' hereditary patterns of behavior; they have in most cases been selected for docility rather than intelligence; their spontaneous impulses are thwarted, with the result that people who know only domestic animals tend to underestimate their minds - an assessment that might be corrected by wider familiarity with free ones.

Many examples of cooperation among animals were given in preceding chapters, especially chapter 6. The first step in the formation of a cooperative society is the association of a male and female in attending their young, which is much more common in birds than in mammals. In many birds the association is very close, the two partners sharing rather equally all the tasks of rearing and protecting their offspring. When the pair remain together throughout the year and their young stay with them after becoming self-supporting, sociality takes a long step forward. This is the origin of cooperative breeding, which in its advanced stages is the highest development of family life among nonhuman vertebrates, equaled only by the most harmonious human households. A cooperating group may consist of from three to, rarely, thirty-five individuals, as in the Chestnut-bellied Starling of Nigeria (Wilkinson 1982). Group members are usually closely related, most commonly offspring of the breeding pair, but outsiders may join the family and help with its chores. The arrangement has advantages for all participants. The parental task of rearing a brood is lightened by the help given by other group members in feeding nestlings and fledglings, protecting them, and, in species that sleep in dormitory nests or cavities, putting the youngsters to bed. Parents with helpers may live longer and raise more young than those without them. The nonbreeding helpers benefit by being permitted to reside in relative safety on the parental domain instead of being expelled to confront an unfamiliar and perilous world soon after they can support themselves, as many young birds are. While assisting the breeding pair to rear nestlings who are usually their younger siblings, they gain experience that will be valuable to them when, at the age of about two or more years, they emigrate, mate, and rear families of their own - or, in some species, they may set up housekeeping on the group territory, which then contains several breeding pairs that reciprocally help one another, while receiving more aid from the younger, nonbreeding members of the association.

All who have carefully watched cooperatively breeding birds have commented upon the amity that prevails among group members, the rareness of conflict among them. Moreover, boundary disputes with adjoining groups tend to be settled by vocal and visual displays instead of crude fighting - peace conferences that actually keep the peace! Although probably no animal can exist in this competitive world with no vestige of its secondary nature, in these cooperative birds the armature has been attenuated. Their pacific character might be a direct expression of a primary nature that was never heavily loaded with secondary attributes, or, ~~or,~~ since many of them are probably descended from ancestors that were less social and pacific, it might be a result of socialization, as is evident in the young of certain cooperative breeders who become more disciplined as they mature in the midst of their families (chapter ~~12~~ 7).

Unhappily, the small cooperative groups in which humans long lived did not settle their differences with neighboring groups by singing and dancing on opposite sides of a territorial boundary but resorted to more violent measures. These people, like many of us today, were laden with such an incredible hodgepodge of primary secondary, and tertiary attributes that we wonder how they kept their sanity. Nevertheless, developments within these clans had far-reaching consequences for the future of mankind. When man's remote ancestors abandoned the trees to live on the ground, they had grasping hands evolved for climbing. As these ancestors became able to walk erect, their hands, no longer needed for locomotion, became the most versatile manipulatory organs in the animal kingdom. The uses to which hands could be put gave to intelligence survival value beyond what it could attain in animals whose lack of such flexible executive organs severely limits the practical value of whatever bright ideas they might have. Brains grew larger and intelligence increased to make the best use of these facile hands.

Despite much theorizing, the origin of language from the inarticulate cries of animals remains obscure. But, however language began, we can hardly doubt that the need to communicate while planning and executing constructive undertakings that required many hands accelerated its growth. A developed language is intimately related to constructive cooperation by primates equipped with efficient hands. Animals that join in activities no more constructive than running down and tearing prey, like wolves and hyenas, do not need articulate speech and, accordingly, never developed it.

The ability to speak and exchange ideas with others stimulates thought and speculation. For a long while, man's notions about himself and nature were~~, as we saw in chapter 11 ,~~ crude and confused. With the development of agriculture and a settled instead of a nomadic life, a small minority enjoyed leisure to put their minds in order and think more deeply. They began to grope toward wider horizons and, with growing wisdom, their sympathies expanded. The Stoics taught that all good people everywhere are friends; Christians proclaimed the brotherhood of mankind; oriental religions ~~taught~~ inculcated harmlessness to all creatures. Whatever their religion or philosophy - or lack of either - generous, sensitive spirits reach out with love and grateful appreciation toward an inclusive whole. That an animal who, to safeguard the delicately balanced physiological processes that support its life, insulates itself in a flexible skin, should expand spiritually and intellectually so far beyond its enclosing integument is the most unpredictable development, the greatest paradox, in the whole paradoxical realm of life. But perhaps, if our insight were deeper, we might recognize that man's expansive spirit is a flowering of tendencies present in the materials of which we all are made, a partial fulfillment of the universal movement to give value to Being by ordering its contents in patterns of increasing amplitude, complexity, and coherence.

26

PARADOXICAL PLANTS

Plants are independent, self-supporting organisms; animals are dependent upon them; from this fundamental difference most other far-reaching differences between plants and animals may be traced. A typical vascular plant is rooted in the ground, from which it draws the water and salts that it needs to maintain its independent life. Anchored in one spot, it is unable to change its location and, accordingly, it lacks both locomotor organs and sensory organs to guide them. Without such organs, a brain and central nervous system to receive information through the senses and direct its course would be superfluous. Its movements are limited to alterations in the arrangement of its parts, especially foliage, by growth or changes in the turgor of its tissues, which may be slow or swift. A typical flowering plant stands erect with its roots in the soil, spreading its leaves in the sunlight. Less often it creeps over the ground, preserving its independence if not its upright posture.

A minority of plants compromise their independence for certain economies or other advantages. Most numerous in this category are the vines that save the expense of forming self-supporting stems and rise more swiftly into the sunshine by twining around or clinging to other plants. Some plants become half-parasites, drawing sap from their hosts but retaining their green leaves and capacity for photosynthesis, like mistletoes. A few flowering plants loose their chlorophyll and become full parasites. Most surprising of all are the insectivorous or, more correctly, carnivorous plants, which in traps the most diverse catch and digest a great variety of small insects and other creatures, including an occasional vertebrate such as a tiny tadpole or hatchling fish, thereby obtaining nitrogenous compounds, phosphates, and other salts rare or lacking in the swamps, sphagnum bogs, or poor soil where many of them grow. Worldwide, about 450 species of dicotyledonous flowering plants, belonging to fifteen genera in six families, have adopted the carnivorous habit. Since all these plants retain their chlorophyll and capacity to synthesize carbohydrates, none is as completely dependent upon other organisms for food as animals are; but by feeding like animals many of them increase their growth.

Pitcher Plants or Pitfall Traps

The traps are all modified leaves, or parts of leaves. They may be passive, waiting motionless for victims to enter them, or active, moving to seize their prey or to hold it more securely. Among the former are the pitfall traps, shaped like pitchers or trumpets. Of these the best-known family is the Sarraceniaceae, or pitcher-plant family, with nine species confined to eastern North America, from Labrador to Florida and westward to Iowa and Kentucky, with most species in the southeast. The pitcher may stand more or less upright, bearing above its mouth an expanded projection or arching hood, sometimes miscalled a lid; it does not close the pitcher but may diminish the amount of rain that falls into it. Or it may lie recumbent on the ground, like *Sarracenia psittacina*, with a recurved, cowled end that directs the narrow mouth horizontally toward the base of the tube. The slender upright pitcher of *S. flava* is often ~~two~~ three feet (90 cm.) high by two or three inches (5 or 7.5cm.) wide. All these pitchers have a broad or narrow wing along the front. They tend to be brightly decorated, with white, red, purple, or yellowish spots or stripes on a generally green ground. These colors not only attract insects but, together with the large, inverted purple or yellow flowers raised above the rosette of pitchers on long stalks, they have induced horticulturists to grow them in cool greenhouses, making many hybrids.

A feature common to all carnivorous plants is an abundance of glands of diverse forms and functions, some of which lure visitors with their nectar or sweetish mucilage, while others secrete enzymes to digest them or to absorb the products of their dissolution. Drawn to a pitcher of Sarracenia purpurea, the Side-saddle Flower of Huntsman's Cup, by its colors, an insect finds nectar glands scattered over its outer surface among abundant hairs. If, creeping over the exterior, it reaches the pitcher's mouth, it enters an insidious pitfall in which four zones are distinguished. The first is the cordate, emarginate hood, where the hairs amid the nectar glands point strongly downward, directing the creature inward to the second zone, which is a narrow collar of velvety aspect, covered with fine, downwardly directed ridges and many more glands. Sliding still farther inward while it enjoys the nectar, the deluded insect reaches zone 3, which covers half of the pitcher's interior with a smooth, glassy, gland-dotted surface that precipitates it into the fourth zone. This pit is surrounded by long, slender, downward-pointing, glassy hairs, that impede the victim's escape. Here are no more nectar glands to solace it while it drowns or otherwise succumbs. Absence of a cuticle over much of this zone facilitates absorption.

Species of Sarracenia differ in the amount of water their pitchers contain before they open or which is secreted into them after opening. The liquid in young, unopened pitchers appears always to be sterile, but that into which animals have fallen contains bacteria, as is to be expected. In Sarracenia, as in other carnivorous plants, the possibility of decomposition by bacterial action has persistently plagued the interpretation of the many experiments designed to demonstrate the presence, and test the potency, of digestive enzymes elaborated by the plants, some of which, as we shall see, also secrete antibacterial acids. It appears that protein-digesting enzymes are present in the pitcher fluid of all species of Sarracenia, and in most it acts best in an alkaline medium, but in some acid is more favorable, as in the human stomach. Often it was found necessary to add an alkali (or an acid) to the pitcher fluid to obtain positive results. In any case, the several species differed greatly in the rapidity of digestion; in some it was swift but in others it required many days. Water and nitrogenous compounds released by digestion or decay are absorbed by the tissues at the bottom of the pitchers. Birds occasionally drink from them.

Also in the pitcher-plant family is Darlingtonia, with a single species, californica, in the north of that state and in adjacent southern Oregon, where it grows in swamps and on wet soil in open woodland glades. Springing from a perennial rootstock, the slender tubes, sometimes standing a yard high, are twisted over much of their length until the hooded top faces outward from the clump. From the downwardly directed mouth of the hood hangs a broad, forked, "fishtail" appendage, whose inner face secretes much nectar to lure insects who crawl over it to the orifice. The green tube is veined with red; the hood and top of the tube are thickly dotted with whitish, translucent windows through which trapped insects might vainly try to escape until, exhausted, they fell into the depths. The absence of glands indicates that enzymes are not secreted to digest the many small creatures that die there. Substances released by bacterial decay are absorbed by the inner surface of the tube and help to nourish the pale green-and-reddish yellow flowers that rise above it on long scapes.

The third genus in the pitcher-plant family, Heliamphora, was unknown until about 1840, when the explorer R. H. Schomburgk found H. nutans growing in a marshy savanna at an elevation of about 6,000 feet (1,830 m.) on Mt. Roraima in southern British Guiana (now Guyana). In the wettest spots on the cliffs and summit of the mountain, rosettes of foot-high (30 cm.) red-veined tubes with flaring mouths spring from stout rootstocks, in wide, dense stands. Along the front of each tube are two wings, and from the summit rises a little appendage, called the spoon, much too narrow to keep out the frequent rains. As in the foregoing pitcher plants, nectar glands at the top attract insects, downwardly pointing hairs direct them inward to a smooth and shining zone over which they slip to the depths of the vessel, where more such hairs impede their escape. As in Darlingtonia, digestive glands are absent here. The white or pale rose, petal-less flowers are displayed high above the tubes on red-tinted stalks. Other species of Heliamphora grow on the tepuis, isolated table-mountains that rise into the clouds from the savannas of southern Venezuela. Some are shrubby plants up to four feet (1.2 m.) tall, with pitchers up to two feet (60 cm.) high. A peculiar feature of some of these pitchers is a pore about halfway up the front, which permits excess rainwater to flow out.

EPILOGUE: THE FAILURE OF SUCCESS?

Whether in the mind's eye we survey the solar system, its nine planets floating majestically around the Sun, satellites orbiting around most of them, every celestial body remaining in its own space in a system so balanced and orderly that it has endured for ages; or through a lens we admire the filigree tracery of a snow crystal; or we reflect how our brains spontaneously integrate in meaningful figures the myriad discrete vibrations that excite the retinas of our eyes - when we contemplate all this, and many similar facts, we become convinced that, from its physical foundations to its highest developments in the realm of mind and spirit the Universe is pervaded by a movement that arranges its constituents in patterns of increasing amplitude, complexity, and coherence - the cosmic process of harmonization. While bringing order out of chaos, harmonization enriches the cosmos with values, raising bare, meaningless existence to full, significant existence. Most notably, it has covered Earth with graceful forms and bright colors, and equipped certain animals to see and enjoy all this beauty. We owe to this tireless process, the true constructive factor in the evolution of life, all that makes living precious to us. It is the source of our moral nature, the foundation of our felicity.

The growth of an organism of whatever kind is an excellent example of harmonization. By adding molecule to molecule, cell to cell, organ to organ, a plant or animal grows into an organism of great complexity. Its survival from day to day depends upon the integration of all its parts and functions into a coherent system of mutually supporting organs. Even a protozoon hardly visible to the naked eye is a very complex creature, with a nucleus and plastids performing diverse functions and, on the scale of the atoms of which it is composed, an organism of great amplitude. Large animals containing trillions of atoms and billions of cells, a great diversity of organs, all united by circulatory and nervous systems, are marvels of coherent, self-regulated complexity, such as man has not yet achieved in his most intricate machines. When we reflect upon the vast variety of organisms, the multitude of species and the incalculable billions of individuals that cover our hospitable planet, each a product of harmonization, each a harmoniously integrated system, as it must be to remain alive and active, we recognize that on Earth harmonization has been a highly successful process.

We might expect that organisms made by the same constructive process, alike in so many ways that biologists have recognized, would, whatever their outward shape, form a harmonious community of living creatures; that the relations between all members of the immense assemblage would be as harmonious as the internal organization of each of them. Why does the process that has brought order and stability to the solar system, that aligns atoms and molecules in glittering crystals, that is active in the growth of every least organism, fail so dismally to bring concord into the relations of all these organisms? Why does the world process, instead of continuing steadily onward in the same direction, adding harmony to harmony at an ever higher level of integration, abruptly falter or reverse its course when it passes beyond the individual organism? Why does a cosmic movement whose only goal or purpose, as far as we can tell, is to enrich Being with high values, produce so strange a mixture of values and disvalues, of good and evil? When we contemplate all the strife, carnage, and disease that afflict the living world; the fear, hatred, rage, pain, and frustration that distress us and, apparently, other animals, we sometimes suspect that pain and sorrow outweigh joy, that the farther life advances, the more it suffers. Success in covering Earth with myriad living forms fails to bring harmony among these forms, to make the living world what, in view of the process that pervades it, we might expect it to become.

The causes of this failure are not far to seek. The primary cause is the insulation of organisms. The integuments indispensable for the protection of all the delicately balanced physiological processes that preserve life make of each ~~of them~~ organism an almost closed system, independent of other similar systems. Their insulation is not only physiological but psychic: just as the malfunction or disease of one does not directly affect the health of another; so the joys and sufferings of one creature are not felt by another; one animal can agonize and die without causing the least discomfort to another of the same or a different kind. Even humans with a developed language and other means of communication often feel remote from those closest to them. Difficulty of communication often seems to separate us by interplanetary distances not only from animals of other species, including the domestic mammals and birds most intimately associated with us, but frequently from other humans - all without the admirable arrangement that keeps every planet in its course, never clashing with another.

Thus, physiological and psychic insulation makes it possible for one creature to exploit, maim, torture, or kill another without physical or mental consequences distressful to itself. Add to this the excessive abundance of organisms, which throws them into relentless competition for almost everything they need to sustain life and to reproduce, and we have the stage set for all the miseries that creatures inflict upon one another day after day and everywhere, which in aggregate far exceed all that the living world suffers from the intermittent and local excesses of lifeless nature, such as earthquakes, volcanic eruptions, hurricanes, and floods. Life's great misfortune is that evolution, dependent upon random genetic mutations that are more often harmful than beneficial, is a process in which quality too frequently wages a losing battle against quantity. Although the growth of an organism is a mode of harmonization, the organism's form and function are determined by its genetic endowment. Harmonization arranges the genes in the most coherent pattern they are capable of assuming, but it can operate only with the materials available to it.

The failure of harmonization's success in covering Earth with abundant life is not absolute, as everyone who has experienced happiness and true values should bear witness. In the foregoing chapters we noticed some of the ways in which animals cooperate to increase the safety or enhance the quality of their lives. Noteworthy are the foraging flocks of mixed species of birds, the relations between cleaner fishes and their clients, the adoption of lost or orphaned young by birds and mammals, and the concord that prevails in groups of cooperatively breeding birds. Especially significant are the mutually beneficial interactions of plants and the animals that pollinate their flowers or disperse their seeds in return for food in the form of nectar or fruits. Harmonious associations can arise among individuals of the same species, of different genera or orders, of different zoological classes of animals, and even between animals and plants.

In our more optimistic moods, we may take peaceful associations as indicative of the direction in which the living world is moving, to make them more common in future ages, perhaps, if all goes well, to the virtual elimination of strife. Nevertheless, it remains true that in the present age competition and merciless exploitation are much more frequent in the animal kingdom than harmonious cooperation. Conflict and predatory violence are so widespread and conspicuous that people have long been familiar with this harsh aspect of nature; many of the cooperative associations were unknown until, in recent times, the patient observations of naturalists disclosed them - which makes it appear probable that many more remain to be discovered.

In many ways, the most successful product of evolution and harmonization is man. In an exceptionally well-endowed and enduring body, well equipped with sensory organs, he has a large brain and an active mind. These advantages, coupled with hands that are the most versatile executive organs in the animal kingdom, enable him to fill his needs and modify his environment to his own advantage as no other animal can; to spread over every habitable region of

Earth and to become by far the most abundant large terrestrial animal. Despite all these advantages, it appears that man is rushing headlong to the failure of his success, which will not be far distant if he does not promptly reverse his course. By his soaring billions, he is overexploiting the planet's productivity, devastating the environment, polluting air and soil and water. And as humans become too abundant, their average quality decreases, as is evident from the mounting crime rate, the increasing addiction to stupefying drugs, and the greater fecundity of the least competent and responsible moiety of the population.

The addition of man to the long list of extinct animals would be lamentable because he brings to the living world qualities otherwise rare or lacking: ability to appreciate its beauty; to seek knowledge and understanding; to care devotedly and unselfishly for Earth and everything good and lovable that it contains; to feel compassion for fellow creatures of all kinds; and to be grateful for manifold blessings - all of which are attributes very unequally developed among humans.

What is needed to save mankind from self-destruction is common knowledge: population must be stabilized or, preferably, reduced by restricting the birthrate; the environment must be protected. The burning question is whether an organism psysiologically and psychically insulated from all others can transcend its limiting integument to feel itself part of an encompassing whole on which its own prosperity depends; to recognize its responsibility to this whole; to feel instinctive or imaginative sympathy for other creatures; to restrain its appetites and dominate its passions in order to live more harmoniously with others. We know that some individuals are capable of cultivating this wider vision and living in its light. If a larger proportion of humanity could attain this spiritual level and the generosity that corresponds to it, success might follow success, directly for mankind, indirectly for a large segment of the living world.

An augury for success is found in the history of human intellectual development. Over the ages, humans have learned not only to use their facile hands for ever more complex creative tasks but also to employ their restless minds for deeper understanding of nature. The superstitions that filled, and too often oppressed, the minds of our ancestors have, with the growth of philosophy and science, been largely dispelled from the thoughts of the more enlightened of our contemporaries, although unfortunately they linger stubbornly in a large part of humanity. Our success in clarifyung our thoughts and combatting many of the diseases that afflicted our progenitors should encourage us to tackle more resolutely the immense and yearly growing problems that confront humanity but are not intrinsically insoluble. What is lacking is the foresight and the will to make Earth a fit abode for the children that we beget in excessive numbers, for their remote descendants, and for the many creatures that might dwell compatibly with them.

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ILLUSTRATIONS