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Chapter 13 Is There Purpose in Nature? The Evidence of Evolution

THERE ARE THREE distinct themes in biological evolution:
l. *Progression*: the more complex forms of life appeared later than the simpler ones.
3. *Transformation*: later forms of life descended from earlier ones.
4. *Variation and natural selection*.

Darwinism

It is the theme of variation and natural selection which is Darwin's essential contribution to modern thought. Before him, **Herder** had argued for progression but not transformation, whereas **Robert Hooke** maintained there was transformation but not progression, that is, later forms descended from earlier forms that were not necessarily simpler. **Linnaeus** and **Buffon** in the eighteenth century believed that the species now alive have

descended from ancestors equally complex and developed; simple organisms could not give rise to more complex ones; species are fixed, and any variation is within the species. The last paragraph of Darwin's *Origin of Species* states that all forms of life have been produced by the laws of

> Growth with Reproduction; Inheritance; ... Variability from the indirect and direct action of the conditions of life, and from use and disuse; a Ratio of Increase so high as to lead to a Struggle for Life, and as a consequence to Natural Selection, entailing Divergence of Character and the Extinction of less- improved forms.

Darwin did not discover any of these factors (although he coined the term "natural selection" by analogy to the artificial selection practiced by agricultural stockbreeders). What he did was to see these well-known phenomena in a new way. Previously it had been supposed that when God created the world, He created "to the limit of His capacity"; that is, that the whole

order of nature had emerged at the moment of creation. Would a perfect and omnipotent God create less than a complete world? Therefore, whatever kinds of being can exist, do exist. (This is the pervasive philosophical *theme of plenitude*, or the *Great Chain of Being*.) Moreover, no living species can ever disappear. **Thomas Jefferson** wrote, in 1782:

> Such is the economy of nature that no instance can be produced of her having permitted anyone race of her animals to become extinct; of her having formed any link in her great work so weak as to be broken.

For a species not to survive would reflect poorly on God; and it would open up the possibility that even man might become extinct. But other views were very much in the air: **Benjamin Franklin** and **Malthus**, for example, were aware of the factors Darwin mentioned; and *Tennyson*'s poem *"In Memoriam*" in , 1850 (eight years before Darwin's *Origin of Species*) refers to the natural selection of species. *What Darwin saw for the first time was an open-ended natural selection, without purpose or balance or plan, in which anything might happen*.

Evolutionary theory has changed since Darwin. His "use and disuse" of parts of the body are now known to have no effect on evol ution. **Lamarck** had supposed (erroneously) that you could

transmit to your offspring characteristics which you acquired during your life; but nothing you do and nothing that happens to you (short of the damage or destruction of your genes) can make any change in the genotype you inherited from your parents and will pass on to your descendants. *On the contrary, natural selection only speeds up or slows down a process which is genetically determined.* **Thomson and Geddes** make this point:

> [Natural selection] furnishes the brake rather than the steam or the rails for the journey of life; ... instead of guiding the ramifications of the tree of life, it would . do little more than apply the pruning knife to them.

There are no characteristics at all-not size, nor strength, nor speed, nor longevity-which by themselves make for fitness, or favor survival. **G. G. Simpson** explains, in *This View of Life*:

> What natural selection favors is simply the genetic characteristics of the parents who have more children. If genetically red- haired parents have ... a larger proportion of children than blondes or brunettes, then evolution will be in the direction of red hair . . . . The characteristics themselves do not directly matter at all. All that matters is who leaves more descendants.

Be fruitful, then, and multiply! *But the crucial aspect of this process is that the gene combinations that turn up, and their interaction with the environment, is opportunistic, blind, and purposeless*. That is the cream of the cosmic jest.

Genetic Mutations

Darwin, unacquainted with genetics, was puzzled by the mechanism of natural selection. If the children of a tall father and a short mother are of medium height (that is, if inheritance blends the constitution of the two parents) then the species will eventu.-ally reach a uniform intermediate height: what then does natural selection work on? (Darwin did not inquire into why there should be variation at all; he took it as a brute £act; just so, Newton did not see any point in asking for the cause of gravitauon, or of the solar system.) *It is now established that mutations-random changes in the genes, "errors in the DNA coding," caused*

by unknown factors, perhaps cosmic rays--and not Darwin's postulated "insensible variations"--provide the raw material for natural selection. *Most mutations are in fact unfavorable to the survival of the species; many are fatal*. It is disturbing, perhaps, to face this "paradox of advance through mischance, of ascent through accident" (Hans Jonas) ; but that is not the only reason for doubting that this world was made for us.

Nature's Ingenuity

What nature may be said to do is to try, in every possible way, to solve the problems of survival. She shuffles the genes so thoroughly that in the course of time (and if the entropy laws permit) any combination that can occur, may occur (just as any combination of numbers may eventually turn up on a well-balanced roulette wheel) . The varieties of methods of reproduction, for example, include hermaphroditic species; species in which a pair of individuals fertilizes each other; species in which the individual self-fertilizes; a tapeworm species in which the individual changes from male to female as it grows older; species in which sperm and egg cells float off to live lives of their own, and species in which this process alternates with more familiar sexual intercourse; an Australian fish species (the wrasse) in which, when the dominant male dies, the chief female in his harem becomes a male and assumes the dominant role; and species that are non-

sexual but are descended from sexually reproducing species! Again, in the behavior of a parent toward its progeny, one finds endless variations, from utter devotion to cannibalism; in "married life," every arrangement, from monogamy to reciprocal violence to the absence of any arrangement. But about this lavish and restless prodigality and inventiveness of nature *we must make the sobering comment that over 99% of all the species that ever came into being have failed to survive!* What a departure from the principle of plenitude and the cheerfulness of Jefferson!

When we examine the intricate and complex mechanism of the human eye, we marvel that it should have come about "by chance"; but nature has "experimented" with almost every possible type of photoreceptor, ranging from single-celled spots of pig-

ment that are sensitive to light, up to wonderfully complex light-receiving structures. The ones which are now functioning are the very few successes. In fact, it is the scallop *Pecten* which probably has the most remarkable optical apparatus in the animal kingdom; it has some fifty to one hundred eyes, each with a double retina; each retina is served by a separate optic nerve. Since there is a finite number of ways in which to solve a biological problem (e.g., to devise a photoreceptor or, say, an organ to control the salt content of the blood) and since nature's failures are extinct, there seem to be *"convergent lines" in evolution*. All species that have survived are adapted to their environment. In David Berlinski's phrase: "The whole gigantic panorama of life in its various forms is a matter merely of a system that misfires randomly if regularly and then manages to trap its usable mistakes." *The variety of living creatures is no more evidence of nature's purpose than are the survivors of modern warfare evidence of the merciful aspects of war: in both instances we must first look at the population of the graveyard.*

Purposive Adaptation and Functional Explanation

Opponents of this position will point to many striking examples of apparently purposive adaptation: the dolphin is born tail first, since it is an air-breathing mammal, and would otherwise drown. The ostrich has callosities on its undercarriage where it touches the hot desert sand when it sits down. Lemmings can barely survive the rigors of an arctic winter; they therefore multiply with extraordinary rapidity-they can breed at the age of three weeks; their gestation period is twenty days; and there may be as many

as thirteen young in a litter. Fireflies have a special rhythmic code whereby some forty different species of males and females can find. each other; a certain male, for example, will flash exactly twelve pulses in a third of a second. Some moths have colored spots on their wings that look like eyes (*ocelli*); this pigmentation confu ses predators. In the gypsy moth, the male antenna has some fifty thousand different odor sensors, each one sensitive to one type of

molecule; moreover, he can spot his mate a mile away. Survival of a species often depends on remarkable perceptual adaptations: the butterfly selects his mate by responding to an unimaginably minute amount of a chemical; the bee senses ultraviolet rays; some hunting birds have astonishingly sharp sight. Forsythia is yellow; if it weren't, bees (which are allegedly red-green color-blind) would never find it. Human beings also have various intricate sensory devices: for depth perception; for filtering out stimuli; for perceiving a gestalt out of only a few clues. The human body has a delicate and fragile system of nerves to maintain a steady internal state despite extensive changes in the outside world. Compensatory activities demonstrate "the wisdom of the body": an over-heated animal drinks to provide sufficient fluid to sweat, and sweating is a means of cooling. Shivering generates heat in the muscles. Goose flesh is an attempt to keep warm by fluffing out what used to be hair.

These frequently hair-raising examples, however, have been adroitly selected, and are ambiguous. The wisdom of the body can be matched by its stupidity: the same compensatory activities also form scar tissue, which produces cirrhosis of the liver as well as asphyxia; the appendix is apparently useless; cancer is the body's supreme folly. *Homo sapiens* is one of the few species unable to synthesize within his own body vitamin C (ascorbic acid); it is essential to life. Only man and the other primates are plagued by kidney stones; all other species produce the enzyme uricase, which oxidizes uric acid into a compound that can be dissolved and excreted. The human sinus drains poorly (and gives us trouble) because our four-footed ancestors held their heads down, not up. Child birth is painful and hazardous. Senility is degrading. No intelligent designer of a human body would ever do so poor a job! And, let us place that flashing firefly in appropriate perspective: there is a predatory cannibalistic female firefly that has learned to imitate the mating signals of other species; thereby she lures the unsuspecting amorous male to his death!

More significant than the examples offered on both sides of the

debate about selection is how they are employed. The paradigm way for science to explain is to subsume the fact in question under a general law (Chapter 10). But it is sometimes claimed tha t this method may not suffice to explain the activities of living

creatures; unlike rocks, they act purposefully. Thus, it is important to realize that any reference to purpose (we shiver "in order to get warm") may be replaced by a general law about function (shivering generates heat; if we don't shiver, then we don't get warm). The question "Why do human beings have kidneys?" need not be answered: "for the purpose of regulating the blood's salt content." Rather, it can be answered: "Kidneys contribute to life by regulating the blood's salt content; if that function were not accomplished, the species would suffer." This answer does not just shift emphasis (not like "your relatives will all die before you" versus "you will outlive all your relatives"). The purposive, or *teleological*, explanation introduces anthropomorphic (or theistic) elements which distort the situation, as it would if you were to say that a chain hangs in a catenary in order to reach its lowest center of gravity, or that the sun moves southward in the winter for the purpose of escaping the cold. If it were not for certain expedients, a species would become extinct: if dolphins were born head first, they would drown; fireflies without a built-in metronome would leave no offspring; moths lacking ocelli would be eaten; red forsythia would not catch the bee's eye. But the overwhelming majority of species has in fact vanished. Nature is the great destroyer.

If a living system maintains a specific property (e.g., internal temperature or blood salinity) *despite changes in the outside environment; or if it has compensatory mechanisms or "governors" for negative feedback; or if it acts with apparent purposefulness for an end contained within the system, then it may be called teleonomic*. (Note that this is not Aristotle's teleology, or final cause, which disappeared from the natural world with Darwin.) A teleonomic system is the result of natural selection, as much as a disposition to learn, or the ability of the hand to grasp, of the eye to see, of the spider to spin a web, of the bird to build a nest, or of the salmon to smell its way upstream. *To explain why birds migrate southward in the autumn, one might suggest four teleonomic frameworks*:

1. *Ecological*. Since birds eat insects, they would starve in the northern winter.

2. *Genetic*. Birds are "programmed" to do so by their genetic constitution, acquired during their evolutionary past.
3. Intrinsic physiological. Birds respond to the decrease in the hours of daylight-photoperiodism.
4. *Extrinsic physiological*. Birds respond to cold air, winds, ete.
None of these teleonomic descriptions requires any deviation from the paradigm of scientific explanation.

Nature's Successes

Let me illustrate adaptation in another way. One of nature's successes is the fluke-worm, *Redia*. **Charles Sherrington**, in *Man on His Nature*, describes its life cycle:

> It starts from the ripe egg as a little thing with two eye-spots and between them a tiny tongue-shaped bud. It travels about the meadow-pool ... it bores into the lung of the water-snail. There it turns into a bag and grows at the expense of the snail's blood ... they wander about the body of the snail. They live on the body of the snail, on its less- vital parts, for so it lasts the longer . . . . They breed and produce young. The young wander within the sick snail. After a time they bore their way out of the dying snail and make their way to the wet grass they encyst themselves and wait. A browsing sheep or ox comes The cyst is eaten. The stomach of the sheep dissolves the cyst and sets free the fluke-worms within it. The worm is now within the body of its second prey. It swims from the stomach to the liver. There it sucks blood and grows, causing the disease called "sheep-rot." ... The worms inside the sheep's liver mature in three months and produce eggs. These travel down the sheep's liver-duct and escape to the wet pasture. Thence as free larvae they reach the meadow-pond to look for another water-snail. So the implacable cycle rebegins.

It remains to add that sheep-rot caused the death of half the sheep in Ireland in 1862, and over a million sheep in Argentina in 1882, and that the related human disease *Bilharziasis* ("snail-fever" or "blood-flukes") today affects more than a hundred million persons annually-it is (after malaria) the second most

common human disease. It seems to me a reasonable bet that the tiny worm called *Redia* will be happily proliferating long after *Homo sapiens* is extinct.

(In discussing the concept of disease in Chapter 17, I stress the

importance of the point of view from which biologists and physicians structure and classify diseases. Malaria is not a disease from the viewpoint of the *anopheles* mosquito; if the preceding paragraph had been written by an intelligent worm, there would have been no irony about "nature's successes". It is for anthropocentric reasons that we favor sheep over worms. *There are no diseases in nature; nature is as indifferent to "disease" as to "dirt."* It is we who eat potatoes and corn who refer to a "blight" when they are infested by parasites: why don't we call it "the foddering of the parasite"?)

Can Evolution Be Predicted?

We have seen that one of the criteria for a good scientific hypothesis is that it be falsifiable (Chapter 9). If nothing whatever can possibly disprove it, then it is not very useful as an explanation. *Can the theory of evolution make predictions, so that it could be verified or falsified?* It asserts that genes, which are subject to mutation, are shuffled at random, so that an enormous number of gene combinations, or genotypes, are possible. (10^{963} is one estimate for human beings, who have at least 100,000 genes.) Relatively few of these possibilities are ever realized. Whatever combination does result is subjected to the pressures of whatever environment it happens to find: climatic changes? new predators? food shortages? geologic upheavals? Anyone genotype may produce a range of different mature individuals, or phenotypes, depending upon interaction with the environment. Even identical twins are not exactly alike at birth. Conversely, different genotypes may be represented in similar phenotypes. Moreover, organisms can adapt to the same environment in different ways. In the Arizona desert, plants and animals have managed to surmount the lack of water by means of quite different expedients. *It is the phenotype that is exposed to natural selection.* The environment of any one organism includes other organisms, which it may or

may not eat, and which may or may not eat it. Any change in an organism alters the environment of all other organisms with which it interacts. "An evolving population," says the biologist C. H. Waddington, "is, as it were, playing a game in which it has some choice as to which card it puts down for any given trick. It hasn't much choice as to which card it is dealt." *The initial conditions that must be considered in making a prediction of evolution are of an order of magnitude and complexity which over-*

whelms our finite resources. Yet no scientific theory can ever be used to make a prediction unless the initial conditions are specified; and all theories require the elimination of irrelevant factors (ceteris paribus, "other things being equal"); this constraint presents enormous practical difficulties to the biologist. The astronomer would find it quite impossible to predict eclipses if comets the size of the sun came tearing through our solar system every minute or two, randomly and from all directions.

In any event, *both evolution and genetics are concerned not with individual living creatures, but with classes, in particular, species.* (Similarly, the temperature and pressure of a gas are properties of a class of molecules; the physicist finds it meaningless to refer to the temperature of a single gas molecule.) *The species is now defined as a "gene pool" that has become reproductively isolated*; a species is a group of living creatures that does not interbreed with other groups. This is a more dependable approach to defining species than grouping according to physical properties, or appearances, since no property which can be used to distinguish one species from others is in fact possessed by all the members of the species. A species can maintain its genetic integrity in many ways: by an elaborate ritualized courtship; by high specificity in the time or place of reproduction; by a narrow range of responses to different sounds, smells, or colors. All of these peculiarities act as barriers to unproductive mating. Some biologists believe species tend to branch only when there occurs a geographical or ecological barrier that prevents genetic exchange. And gradualism or continuity seems to be the rule: at no single point, for example, does a tissue become a kidney or one species branch and become another. *Since evolution considers not the single organisi n, but only the species, the difficulties in prediction are practically insurmountable.*

There are problems with the explanatory adequacy of contemporary evolutionary theory. *If survival value alone is to account for the attributes of living creatures, why is it that so many of these attributes do not seem to be relevant to survival?* What is the value of the tuft on the breast of the wild turkey? Why are there so many different shapes of antelope horn? Why does the cow have a multiple stomach, whereas the horse, which is about the same size and is also a vegetarian, does well with a simple stomach? Why are there different human blood groups-why

hasn't the fittest blood group been naturally selected by now? On the other hand, why should a species ever lose organs once useful, the eyes of the mole, for example, or the toes in the flipper of the whale? Perhaps these apparent exceptions to the criterion of survival value can be explained by the interrelation of genetic characteristics, so that features that are neutral vis-a-vis survival are genetically linked with others that have survival value.

Another sort of issue is posed by parallel evolution: why is the skull of the Siberian wolf so very similar to that of the Tasmanian wolf? These species have been subjected to different environmental pressures for all the millions of years, ever since Australia became separated from the Eurasian continent-a sufficiently long time for the evolution of the Australian kangaroo. Is it because there is only a limited number of ways in which an organism can "make a living"? or must one postulate some other factor? perhaps some sort of "archetypal grooves" or constraints? (The biologist O. H. Schindewolf holds that a *taxon* -a classified group of organisms-comes into actual existence when its first species appears; and also that *taxa* exist objectively. Thus, according to Schindewolf, the class of birds originated in one step with *Archaeopteryx*, the first animal to fly by means of feathers.)

Does Evolution Have Any Direction?

Can any overall trend or direction be discerned in the open-en ied evolutionary process? Nothing is clearly established. To say tnat

it moves toward better adaptation is analytic, since whatever species do survive at any given time are adapted to survive at that time. Is the size of the organism a factor? But the bacterium is tiny. Is individuality a factor? But blades of grass, like bacteria, are as much the results of evolution as are human beings. Everything alive today is the culmination of a long chain of mutations and adaptations. Have animals evolved toward greater complexity? But the hoof of today's horse is surely less complex than the four toes of *Eohippus*, its remote ancestor. In what direction do birds evolve, if the ostrich has lost the ability to fly, but can run faster than other birds? Why should the evolutionary process ever have gone further than, say, the rabbit? or the ant? Why have plants not evolved toward greater complexity or higher organization?

The list of questions is virtually endless. The rate at which evolutionary changes occur seems to vary enormously. Some species have not changed at all within vast time spans: the *coela-*

canth is apparently identical to its most ancient ancestors; algae found in rocks over three billion years old closely resemble their descendants today. Could a time possibly arrive when both the environment and the genetic code would become perfectly stable, and evolution cease*? Can we be sure that evolution is going on now?* Is the increased human life span a mutation? or resistance to TB? Could evolution ever reverse or repeat itself? The ancestors of the whale left the sea and then returned. Could dinosaurs reappear? Any species alive today is what it is because of a particular history or sequence of events that spans billions of years. *The residual influence of the past is never entirely lost*. There is a connectedness to all life: you yourself would be different now if some reptile in the Paleozoic era had wandered north instead of south. Is evolution a universal law of nature (like gravitation, for example) which would apply wherever living creatures appear, or does it hold on this planet only? Nothing, as I said, is clearly established.

Two distinguished biologists disagree flatly on the course of evolution. **Julian Huxley** believes that "the biological process culminating for the evolutionary moment in the dominance of *Homo Sapiens* ... could apparently have pursued no other general course than that which it has historically followed." But **G. G. Simpson** asserts that "the assumption . . . that once life gets started anywhere, humanoids will eventually and inevitably

appear is plainly false." Human beings have greater power over their environment than other animals have, and they are more independent of their surroundings; but still man is, for Haldane, "a worse animal than the monkey."

(A parenthesis on sex and death: primitive animals [e.g., *Paramecium*] reproduce by fission; that is, the mature creature divides into two, each half becoming a new young adult. If there are no mutations, the genetic material remains the same. The new animal thus does not have the advantage of the diversity provided by the sexual mingling of parental genes and might not therefore have the variety of reserves which opportunistic evolution favors. On the other hand, unlike the creature born of parents, which grows old and dies, the animal which reproduces by fission can keep on dividing and live on as long as its food supply holds out. In a sense, then, sex and death [*Eros* and *Thanatosl*] may be said to have come into the world together. And, in another, odd sense, they may go out of the world together: as the human life span increases indefinitely and the planet gets more and more

crowded, there is likely to be pressure to reduce-perhaps eliminate-not sex, of course, but births.)

What Is Life?

Modern biochemistry has established that all genes of all living creatures are made up of the same substances (DNA, RNA, and proteins) . A man's genes differ from a dog's, say, only in the way they are arranged. The same contractile protein produces the streaming motion of the amoeba and the moving finger muscles of the pianist. Heredity operates in the same way in plants, bacteria, and human beings. This chemical unity of all life makes it conceivable that life originated only once. Darwin tried to avoid the problem of the origin of life, but he was pressured into adding, in the second edition of *The Origin of Species* (published six weeks after the first) , this passing reference: "Life having been originally breathed (by the Creator) into a few forms or into one .... " There is nothing chemically unique about the structure or functioning of living materials; many have by now been synthesized in test tubes.

Biologists now define a living organism as

> an entity that can utilize chemicals and energy £rom the environment to reproduce itself, can undergo a permanent change (mutation) which is transmitted to succeeding generations, and . . . can evolve into a distinctly new species.

The emphasis in this definition is on self-duplication and mutation; many time-honored "characteristics of life" are not included: organic unity, self-regulation, regeneration of parts, ability to react to stimuli, spontaneity, goal-directed or purposive behavior, and memory or learning. (And what a far cry from Henry James' definition of life as "that predicament which precedes death!") *There are, inevitably, borderline entities such as the virus, which have features of both living and nonliving matter* -how to classify them seems to be a matter of convention. *Can the living cell itself be synthesized in the test tube*? The task is enormously complex; and the probabilities-presently, at least-are against it; *but there is no logical or theoretical reason why it cannot be done*. Similarly, no reason is known why there should not be living creatures elsewhere in the universe-the incredible complexity of the living cell may be matched by the incredible vastness of space. There are over a million galaxies within reach of our telescopes; our own Milky Way galaxy con-

tains a hundred billion stars similar to our sun; if each of these "suns" had one planet physically similar to our earth, there would be a hundred thousand trillion planets on which some sort of life might be possible. These numbers stagger the imagination; but *speculation should be tempered by the sober fact that no slightest bit of evidence exists*. Furthermore, we must remember the intimate functional relation between life as we understand it and the physical attributes of our earth. When the solar system was formed, if the earth had been about 10% .closer to the sun, some four-fifths of our planet would have been too hot to support life. If the earth had accumulated more than its present mass, birds might never have evolved, since the ability tel fiy requires a delicate balance of gravity, air density, and the amount of bone needed for support. And if the earth's axis had not been inclined to the plane of its orbit around the sun, we would have had no seasons.

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Our Moral Responsibility

The moral for philosophy is clear: if there is any purpose in nature, we have put it there; it is no longer a figure of speech that man can make himself. The biologist now asks: what are your standards for admission to membership in the human race? The unborn fetus may now be diagnosed by amniocentesis; a decision may be made (based on its strength? brain size? freedom from disease?) as to whether this potential person should become an actual person (Plato's selective breeding!). We may in the foreseeable future become parents by ordering from genetic engineers just the baby we want, and adopting it prenatally. We are about to direct and transform the human species irreversibly. We shrink from this terrifying responsibility.

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