1. *The Foundations of Tropical Splendor*

I look over a wide green landscape flooded with brilliant tropical sunshine, from the clamorous mountain torrent below me to distant craggy summits. Amid the lush verdure glittering hummingbirds and painted butterflies sip nectar from bright flowers, lovely tanagers and great-billed toucans seek colorful fruits, while overhead a flock of green, red, and blue parrots flies noisily against an intensely azure sky. Light brings me awareness of all this splendor, uniting me with it as nothing else can. It reports without delay any visible movement within the wide circle of my vision, for at a velocity of 186,000 miles, or 300,000 kilometers, per second it traverses almost instantaneously the few miles that separate me from the most distant summit.

No less wonderful than light's unique velocity is its ability to travel in straight lines for immense distances. The valley over which I gaze is filled with billions or trillions of rays as closely packed as molecules in the air, crossing one another at every possible angle. At every point of its journey to my eyes, a beam from a leaf across the river intersects with innumerable others; the number of such encounters in a traverse of a hundred yards is inconceivably great. Nevertheless, each ray preserves its individuality amid the throng, contributing to a clear image of its distant source. This capacity of a beam of light to preserve its integrity in a medium densely threaded with other beams, to me one of the most marvelous facts about light, is hardly mentioned in textbooks of physics, which for simplicity treat light rays as though they sped through space without encounters.

The thought of innumerable beams passing from every direction through a point in space without loss of identity makes us ponder what light can be. Although we are told by physicists that it combines properties of particles and waves, it can hardly consist of solid or mutually impervious particles however small, for they would certainly collide and knock each other out of their courses.

There is small probability that a single particle could pass in an undeviating line through a wide space saturated with light, and we should see nothing clearly, if we saw it at all.

The theory that light is propagated in the form of minute waves, or transverse vibrations, of measurable length and frequency neatly explains, by geometrical constructions, the common optical phenomena. Undulatory motion is conceivable only in a medium—solid, liquid, gaseous, or other—capable of vibration. Since light is propagated through a vacuum, whether artificially produced in a bell jar or in outer space, it is obvious that none of the three familiar media is involved. To supply the deficiency, an earlier generation of physicists postulated the luminiferous ether, imponderable and invisible, filling all the space within the Universe. Since it is impossible to separate the ether from space or to find any space through which light cannot pass, they before long recognized that the ether is nothing other than space itself and discarded it as a superfluous entity. Space is the medium that transmits light.

To recognize that space transmits light, which can hardly consist of solid particles, is to be convinced of the untenability of the doctrine, propounded in ancient times by Leucippus and Democritus and widely held in early modern times, that space is simply void extension, the interval between bodies, a container devoid of intrinsic properties. As Plato, Aristotle, and the Stoic philosophers recognized long ago, space is certainly more than that; at the very least, it must have the qualities once ascribed to the ether. But when we consider what is happening continuously at every point of light-filled space, such as that over the valley filled with bright sunshine that I survey, we are perplexed. At any point you choose, innumerable light waves of different frequencies are passing in every direction without losing their identities. Moreover, this same point of intersection is simultaneously traversed by ultraviolet rays, infrared rays, radio waves—almost the whole range of electromagnetic waves. Add to this the magnetic and gravitational fields that permeate it. What kind of medium can at the same instant vibrate in so many different rhythms at a single point, can transmit so many different motions and forces without scrambling them?

To be sure, other media can undulate simultaneously in various frequencies. We can distinguish one voice amid several, hear different sounds at the same time; but the number of sound waves that can pass through the atmosphere without losing identity appears to be limited. The clamor of the mountain torrent, compounded of many different noises made by water rushing over rocks, falls upon my ears as a confused roaring in which, as in the rumble of a great city, I can distinguish no note clearly. But a vastly greater number of light waves, from every visible point in the wide landscape, reaches me with so little loss of identity that, with unaided vision or my binocular, I can distinguish fine details at a great distance.

Nothing is more familiar to us than the space in which we live. It permits us to move freely over a horizontal surface; it accepts whatever we place in it; it is so transparent that it seems to hide no secrets; it is the one thing under the Sun that appears perfectly simple and uncomplicated, easy to understand. We determine its dimensions, whether in a box, a room, the solar system, or the Universe, in whatever units of measurement we choose and are satisfied that we know all that is to be said about it, although actually we do not begin to understand it. So tenuous that it does not resist the movement of a feather, space is nevertheless so strong that it holds Earth in its orbit around the Sun and the Moon in its course around Earth. Binding all things together by means of its unexplained

property that we call gravitation, transmitting electromagnetic waves and other influences over vast distances, it makes a coherent Universe of bodies which, if space were no more than void extension, would be a loose collection of unrelated objects. If we knew the intimate nature of space, we might understand everything that it contains. Contemplation of the enigma of space should dispel all dogmatism, assertive or negative, and make us duly humble while we are filled with gratitude for the privilege of living in a medium that almost instantaneously and with no loss of identity can transmit the light waves which so enrich our lives.

Electromagnetic waves within the range of visible light transmit most of the energy that the Sun sends to Earth and the other planets, yet for this the capacity of light waves to preserve their individual identity amid innumerable others hardly seems necessary. A massive influx of mingled waves that had lost their original directions might convey much energy and serve for photosynthesis. Some of the properties of light waves—their stubborn preservation of individuality, the capacity of each to indicate the exact direction of its source—seem to become significant only when they fall upon eyes that report to receptive minds, to which they reveal in detail the forms of objects near and far, to which they bring beauty and knowledge and a sense of intimacy with the larger surrounding world. Nevertheless, for long ages after the Sun began to lavish its rays upon Earth, eyes equipped with lenses and sensitive retinas were nowhere to be found, save possibly in inhabitants of planets beyond the solar system who viewed our Sun as one among a multitude of stars.

A world thickly laced with light waves yet devoid of beings able to see would be incomplete, lacking something necessary for its perfection. High values that it potentially contained would remain unrealized. Such a world would be like a stage set for a splendid drama that is never performed. Evidently the Universe does not rest like an unfinished house but is ever striving to complete itself by the full realization of its potentialities for joyous, satisfying existence. The difficulties are immense, the hazards great, but its resources are vast and its time unlimited.

The preparation of our planet for the more advanced forms of life was an immensely long process, the details of which are still being revealed by scientists in many fields. Concentrating attention upon the material aspects of this preparation (temperature, properties of soil and atmosphere, the living environment necessary to support large, air-breathing animals), we often neglect another aspect equally important to man. Conceivably, the planet might supply everything necessary for the physiological processes of a large animal while offering little for its spiritual or intellectual development, as a vat of syrup provides all that yeast cells need for their growth and multiplication but nothing, as far as we can tell, to nourish a spiritual being. On our planet it has been otherwise; while developing an environment fit to support man's body, it has simultaneously prepared itself to nourish his spirit most generously, with the beauty of the heavens, the grandeur of mountains, and countless lovely or stately vegetable and animal forms that foster aesthetic appreciation and challenge his intellect to learn about them. The effectiveness of much of this preparation depended upon the ability of light waves to intersect at all angles without losing their identity or deviating from straight paths. More than all else, light prepared the world to become a fit abode for spiritual beings. Coeval with the Universe, the world had to wait an enormously long age for life to arise and avail itself of the precious benefits offered.

The human eye, like the eyes of many other vertebrate animals, is an excellent optical instrument whose evolution by

the natural selection of random variations required countless generations. Eyes are far from being the whole of our visual apparatus, which includes nerves and brain. It is useful to distinguish between the optical image and the visual image. The former is a pattern of vibrations of diverse frequencies focused by the lens on the rods and cones of the retina. It is a greatly reduced, inverted, intrinsically colorless replica of the visual field—a landscape, building, or person. If we saw the world as it is represented in our eyes, it would appear to be very small, upside down, and severely plain. By a marvelous transformation that we are far from understanding, this drab optical image becomes the often richly colored visual image that illuminates our consciousness, showing us in the wide landscape instead of the landscape in us and with everything right side up.

This visual inversion, whereby we see ourselves in the world instead of the world in us, has far-reaching spiritual as well as practical consequences. If the visual image were the same as the optical image, it would be a poor guide to action, possibly making us try to thread a needle or plant a garden that appeared to be inside our heads, and doubtless it was to promote effective action that the visual inversion evolved. Moreover, we might be far more egocentric and aloof from the world if we saw it on a greatly reduced scale inside us instead of projected outward in three-dimensional space, reduced in size only by perspective and arrayed in attractive colors.

A human being might be described as an expansive spirit enclosed in an insulated body. Like any warm-blooded animal, we need insulation, as in skin and clothing, to preserve our body's heat and vital fluids and exclude injurious organisms and substances that may touch us. Our senses save us from the insulation that would oppress our spirits while it safeguards our tissues. Of our five senses, that which most helps our spirits to reach outward and expand is sight. As light waves stream into our eyes, bringing visions of fair and friendly things, our spirits appear to retrace the beams back to their sources in loving communion. Nothing so attaches us to the surrounding world or reconciles us to our precarious human situation as the visions of beauty and grandeur that light conveys to us. We love beauty because it makes Earth appear friendly to us.

Meditation upon light and its counterpart, vision, reconciles us to nature, or the Universe, in a more profound and philosophic sense. Ages before life arose, before even stars and planets condensed from the cosmic dust, the ability of space to transmit light waves in straight lines, undistorted by all the other waves that cross their paths, offered a means of enhancing existence by serving as a vehicle of communication between bodies and creating visual beauty. To realize the high values that light was capable of generating required optical apparatus of good quality reporting to receptive minds. In the absence of a Supreme Intelligence able to create advanced forms of life directly from the elements, eyes and minds could arise only by the blundering methods of organic evolution, a slow, harsh process involving the replacement of more primitive creatures by more advanced creatures. Nevertheless, persisting through inconceivably long ages, nature produced animals whose lives are immeasurably enriched by the values that refined vision—especially color vision—can bring to grateful, appreciative minds.

The world process moves toward the enhancement of existence by the realization of potentialities present in the primal Universe. Nature does not rest so long as attainable values remain unrealized. Ceaselessly recombining the elements in patterns of ever-increasing amplitude, complexity, and coherence, nature advances by a devious course until it produces the structures neces-

sary for the actualization of these values. Without foreseeing guidance, nature's progress is inevitably slow and often painful; but with growing intelligence, insight, and self-control, we should be able to accelerate the progress while we mitigate it. Knowledge that our unquenchable thirst for a happier, more richly rewarding existence is a more pointed expression of a movement that stirred in the primal depths of the Universe, of which we are parts, should encourage us to persevere in our efforts to overcome all the doubts and difficulties that assail us in an overcrowded, overexploited world while it increases our devoted attachment to a planet made beautiful by light.

The splendors that light brings to us are nowhere more profusely and continuously displayed than in the more humid regions of the tropics, where plants grow and bloom and birds wear their brightest plumage throughout the year. Here, too, are the richest still unrealized opportunities to explore nature's secrets. While we delight in the beauty around us or eagerly add to our wealth of knowledge, we may forget that we owe our enjoyment of beauty, no less than our ability to observe and study natural phenomena, to the mysterious medium in which we live and move, to space which can transmit a thousand rays of light through a single point without distorting the least of them.

23. *The Lonely Vanguard*

From ancient times, the beauty of the nocturnal sky, the precision and constancy of the movements of the Sun and stars, have inspired thoughtful men with wonder and admiration. Beings that endured unchanged for long ages, that moved across the firmament without collision or strife with neighbors, were revered as immortal gods by ancient sages. Only the planets, appearing to move now forward and now backward among the constellations, troubled certain Greek philosophers by their ungentlemanly inconstancy. Modern thinkers, aware that the stars are but huge masses of incandescent matter, that the planets and their satellites shine with borrowed light, may still believe, with Sir James Jeans, that the Universe was set in motion with mathematical precision by a master Intellect, that the order of the cosmos implies a divine Orderer, a God who is above all a cosmic planner or astrophysical engineer. Our very term "cosmos," from the Greek word for order or harmony, commemorates the ancient belief that the Universe is a beautifully ordered system.

When we turn from the greatest bodies to the least, we discover similar orderliness and durability. The smallest particles of matter, protons, neutrons, and electrons, appear to be even more enduring, more "immortal," than the stars which, in their inconceivable myriads, they compose; there is now evidence that the latter are born, grow old, and decay while their constituent matter surges through the Universe forever unless, perhaps, it is imprisoned in one of the astronomers' black holes. The chemist can predict the interaction of two substances with hardly less precision than the astronomer foretells the positions of the heavenly bodies. Although the same atom may in turn enter a variety of molecules and one chemical often disintegrates another, at the atomic level no destruction occurs in ordinary chemical reactions—the atoms simply change partners, like dancers. In the inorganic

world, the so-called cosmic strife may be no more than a merry dance in which the inconceivably minute dancers restlessly alter their formations with never a pang or a regret and, perhaps, with gleams of pleasure for all concerned. Or, if these diminutive beings line up in crystals, they may repose unaltered for long ages in apparent bliss. It is as easy to believe in a God who is the Supreme Chemist as in a God who is the Master Astrophysicist.

About midway in size between the world of protons, electrons, and atoms and that of stars and galaxies stands a third realm, that of living beings, where a very different picture greets us. Regarded in isolation, a healthy organism is a supreme achievement of biological engineering. In it, compounds of great complexity are present in greater variety, interacting in more subtle ways and preserving a more self-sustained stability than one finds in any inorganic system of comparable size. If the existence of anything in the known Universe seems to point to an omniscient and omnipotent Creator, it is a living plant or animal.

But when, instead of focusing attention upon single organisms, we contemplate the whole realm of life, doubts assail us. The living world is, preeminently, the realm of strife. Daily myriad living things are torn piecemeal or devoured whole by other living things. Not only do the more advanced organisms exploit and consume those lower on the scale, which the former may suppose to have been made to serve them, but very often the lesser creatures afflict and destroy the greater, frequently in the form of multicellular parasites or microscopic pathogenes. The flow of materials and energy through the living world, the so-called food chains, cannot, like the permutations of elements in chemical reactions, be regarded as a merry dance, devoid of pain and fear and possibly with pleasurable sensations for all the invisible participants. As we know only too well, the strife in the living world is accompanied by vast amounts of fear and pain, of hatred, anger, fury, and all the other violent passions that oppress us. Here is no neat exchange of partners, as when two compounds exchange atoms, but beautiful creatures are suddenly reduced to bloody messes from which we avert our offended vision. The living world is the realm of paradox, in which creatures that above all strive to preserve their integrity are inexorably doomed to disintegrate, if not by violence then by slow decay.

Although it is not too difficult to imagine a Divine Astrophysicist who rounded the celestial bodies and set them on their courses, or a Divine Chemist who formed the smallest particles and regulated their interactions, it is hard to conceive a Divine Biologist who has guided the evolution of life. Or if such a Being exist, he must be all power and cleverness, unleavened by compassion, who with infinite skill has formed a vast diversity of creatures that he does not lovingly protect from pain and horror. Such a God might be worshipped by those who admire unlimited power, but he would be repudiated by those who demand benevolence and love in the Deity they adore.

Perhaps it is a question of importance. All the matter in the Universe appears to be involved in physical and chemical processes, and a large proportion of it is aggregated into stars, planets, and other celestial objects. But, on the most liberal estimate, only an infinitesimal fraction of the stuff of the Universe is contained in living organisms; even on our planet, which seems to be more richly endowed with life than most, it occupies only a thin skin surrounding a huge, lifeless mass. Such a negligible quantity of matter may well be neglected by the ruling Power.

Life apparently arose from the strong tendency of the elements to combine in

ever more complex aggregations wherever, as on the surface of a planet provided with water and an atmosphere and energized by radiation from a central Sun, they found themselves in an environment favorable for such developments. Eventually, some of the large molecules so resulting acquired the power to duplicate themselves by controlling the behavior of simpler substances that came within their sphere of influence, much as, on a more primitive level, a crystalline particle governs the alignment of atoms or molecules like that of which it is composed. With the acquisition by complex molecules of the power of reproducing themselves, life embarked upon its long, adventurous course.

The evolution of life depended, in the first place, upon chance alterations in the structure of the central or governing molecules of each aggregate of living substance—molecules which, in more advanced organisms, are situated in the chromosomes of the nuclei. Such alterations or mutations are caused by the incidence of radiation of high frequency, although chemical reactions are responsible for some of them. Evolution received a great impetus with the development of sexual reproduction. Itself no doubt a result of random changes in the living substance, sex greatly increased the element of chance in biological development. The union of two gametes, or sexual cells, is like shuffling together two more or less different decks of playing cards which are then dealt to the future progeny. The resulting "hand" which each receives may differ from that borne by any of its ancestors; it may give the progeny a substantial advantage in the game of life or, on the contrary, it may so handicap the creature that it succumbs. Sexual reproduction is essentially a form of gambling. Life may be said to have gambled its way upward from the primitive poverty of the most rudimentary organisms to the opulence of the higher plants and animals. But, as in all forms of gambling, the winners grow rich at the expense of the unfortunate losers. Albert Einstein, a mathematical physicist, could not believe that "God plays dice with the world," but chance enters into genic mutation and recombination hardly less than into a throw of dice. Life has had to advance by this crude and hazardous method because, without guidance, no better way was available to it.

The complement of mutation is selection, without which variation might have populated Earth with a multitude of inefficient, barely viable organisms. The idea of natural selection and its decisive role in the evolution of life grew out of observation of the results of artificial selection as practiced by breeders of plants and animals. But natural selection and selection by man operate by exactly opposite methods. The breeder of animals or plants works with an ideal of beauty or utility; selecting those individuals that show some advance in the direction of his ideal, he gives them special care and fosters their multiplication. Natural selection operates with no ideal or goal; it consists not so much in giving special advantages to superior individuals as in penalizing the inferior—inferior, above all, in ability to procure nourishment, escape enemies, resist environmental stress, or reproduce. Artificial selection is positive selection—choosing the best for protection and propagation. Natural selection is negative selection—picking out the weakest or least efficient for destruction. As has often been observed, the fitness implied by the phrase "survival of the fittest" means nothing more than fitness to survive and reproduce; it indicates no other excellent qualities. Since innumerable kinds of pestilent organisms and noxious parasites as well as fierce predators have proved their ability to survive at the expense and to the detriment of more amiable creatures, evolution by

random mutations, sexual shuffling of genes, and natural selection has filled the world with organisms that perpetually harass and oppress other living things while contributing little to the beauty and joy of life.

In the tropics, the immense profusion of creatures that bite, sting, or otherwise irritate, that ruin one's possessions or destroy one's dwelling, repels many visitors from higher latitudes, while others are so captivated by the splendor and interest of tropical nature that they willingly endure all this and more. The wonder is that by such rude methods evolution has produced so much that is fine and lovable while it continues to fill with life every part of the planet, however harsh and forbidding, that is capable of supporting vital processes on however reduced a scale. Only a very strong impulsion to raise existence to higher levels by whatever means are available can account for this.

When one surveys the living world broadly, observing what treasures of beauty, what marvels of perceptiveness, what heights of love and devotion the stuff of the Universe is capable of generating when molded into organic forms, one reflects with a pang what life might have become if its formation had been guided by some great and beneficent Power instead of being left to the rough, groping methods of organic evolution, gambling with destruction of the losers. Such a Creator might have covered our planet with loveliness and joy and sympathetic understanding, with beings of a magnificence, physical and spiritual, that we can hardly imagine, with none of the mean and loathsome and pestilent creatures that swarm upon it today. Above all, such a benevolent and skillful Creator would have avoided the horror of predation by making it unnecessary for any animal to strike down another to satisfy its hunger, and he would likewise have so regulated the reproduction of organisms that no species would have exceeded the ability of Earth to support it, with resulting deprivation and misery.

These two major evils, predation and overpopulation, are more closely associated than is generally recognized. Probably some animalcules began to devour others after they had become so numerous that primary sources of nourishment, such as nutrients dissolved in the primeval seas or algae capable of photosynthesis, no longer sufficed to support them. Species subject to heavy predation must reproduce abundantly to avoid extinction, as must those afflicted with fatal diseases or other causes of high mortality. If for any reason the predators diminish in numbers or efficiency, the rate of reproduction that they have forced upon their prey proves to be too high, with the result that the species relieved of this drain multiplies until it begins to exhaust its food supply and the surplus population succumbs to starvation. This situation has led ecologists to view predation as a blessing in disguise because it prevents the miseries that follow upon overpopulation. However, they overlook the probability that in the absence of predation the species preyed upon would not have developed such a high rate of reproduction. Animals show considerable ability to adjust their reproductive rate to their mortality, but such adjustment is achieved so slowly that any sudden increase or decrease in the death rate is likely to have disastrous consequences, the former perhaps leading to extinction, the latter to overcrowding with its attendant evils—to both of which man, no less than other animals, has been subject.

Man's religions are proof of the manifold evils that afflict a living world that has groped its way forward without guidance or regulation by some beneficent Power. We do not have these religions because gods or a God exists. It is precisely because there is no God, or at least none who cares lovingly for living creatures, that we have religions such as most of

those that we know. For what are the majority of these religions but pleas for supernatural succor wrenched from the perplexed soul of a humanity tortured by pain and fear, from a humanity living precariously under the shadow of inevitable death? Whether we examine some primitive cult that strives to placate an angry or envious god by bloody sacrifices; or Buddhism, with its program for extinguishing an existence that it declares to be fundamentally painful; or Christianity, whose symbol, the cross, at the summit of every church proclaims to all the world that salvation is won through suffering, the conclusion is the same: we have these religions because no Deity at once powerful and benevolent cares about the living world.

I would not infer from this that a race ignorant of suffering, fear, and death would be devoid of religion. Every spiritual intelligence tries to relate itself ideally and in practice to the Whole of which it conceives itself to be a part, and such relatedness, devoutly cultivated, is the essence of religion. But in the happier world, religion would be a paean of joy rather than a cry of distress. Instead of fostering hope that death will be followed by some more blessed existence for which it can offer no convincing proof, it would promote the appreciation and loving care of a world that offers much to delight us. It would be a religion of thanksgiving rather than of salvation.

Although life has evolved without guidance by anything more ancient than itself, it is far from being unrelated to earlier phases of cosmic development. On the contrary, it represents a later or higher stage of a process that has pervaded the Universe at least from the beginning of the present cosmic era. Throughout visible space, we detect a movement of organization or harmonization which, acting on a grand scale, has rounded off the stars and set the planets revolving around them with majestic regularity. On a small scale, it has joined the ultimate particles—electrons, protons, and neutrons—into atoms which are sometimes pictured as miniature solar systems; it has joined these atoms into molecules of varying degrees of complexity; and it has lined up atoms and molecules in crystals that are often of great beauty and capable of enduring unchanged for long ages.

Carried to a higher level of complication and integration, the organizing tendency that forms atoms, molecules, and crystals brings forth living substance. It is hardly an exaggeration to say that life is the goal of matter, for wherever conditions are favorable to the delicately balanced vital processes, as on the surface of a planet neither too hot nor too cold, with abundant water and nutrient salts and an atmosphere that stabilizes temperature and supplies oxygen and carbon, matter enters the living state with a rush. The resulting superabundance of life is one of its chief troubles. If there were fewer living things to bump against, compete with, prey upon, or parasitize, life would be far more pleasant for all creatures. Like a developing child, life in its onward march has needed not only guidance and encouragement but likewise restraint and the moderation of its often excessive exuberance. Both the guidance and the restraint have been conspicuously lacking.

If the older constituents of the Universe from which life arose have failed to provide helpful guidance, they have at least supplied the impetus that carries it forward. If they have not beckoned it from above, they have pushed it upward from below, and this is the source of life's creative energy. They continue daily to give it substance and energy and a place to stand. Without the inorganic Universe, life could not exist in any form that we know. With this impetus from below, this lateral support, life continues, lonely and unguided, to grope its way forward into the unknown.

As is natural, man, who in certain ways marches at the van, seems more alone than any other creature. Despite his teeming billions and his dominant position on his planet, in his more thoughtful moods he sometimes feels devastatingly solitary. The gods to whom his ancestors looked for guidance and succor in times of distress, who when angry could be placated by gifts and expressions of submission and adulation, turned out to be but figments of their fertile imagination. With telescopes, huge radio antennae, and space probes he searches the Universe for indications of intelligent life beyond his own planet, thus far always in vain. Receiving no answers to his anguished pleas for assurance that some higher Power is cognizant of him, that he is not the only advanced intelligence to be found anywhere, he may conclude with Bertrand Russell that he lives precariously in a hostile Universe. As though he could exist in a hostile Universe! As though he were less a product of a universal creative process than the plants and animals around him and the stars above him!

Man's loneliness is largely the fault of himself and, ultimately, of the harsh conditions in which he, like other forms of life, evolved. Although primitive tribes often cultivated brotherly feelings toward nonhuman animals and even plants, more recent man, especially in the West, has fiercely resented the assertion that he belongs to the natural world—an attitude that has happily been changing in the present century. If a quite different animal of approximately equal intelligence and power, an animal with whom he could communicate freely and gain fresh knowledge and insights, shared Earth with man, he would probably try to exterminate it. If *Homo sapiens* had been less intolerant and belligerent, Neanderthal man and other less closely related tool-using primates might well be with us today.

Coexistence with other articulately intelligent animals, no matter how harmonious, or enlightening communication with extraterrestrial beings would not necessarily alleviate our loneliness, for they might be subject to all the doubts and hazards that oppress us. What man has long sought is some higher Being to whom he could look for help, guidance, and the assurance that he is not an accident of evolution but of transcendent importance. But, if we are at the forefront of the advance, how can we expect to find a guide or leader ahead of us? The time has arrived to outgrow the childlike need of a father, in heaven or elsewhere, and, at last maturing, make the best of our own great sources of strength. We must cultivate acute awareness of the power within us and its continuity with forces and processes pervading the Universe. Just as the topmost twig of a lofty tree, exposed to Sun and wind and rain with no shelter from surrounding foliage, might, if it could reflect upon its situation, feel lonely and abandoned unless it remembered that through roots and massive trunk the whole tree supported it, so, until we recognize our intimate connection with universal forces, we shall continue to feel abandoned and bewildered.

One continuous organizing movement sweeps in successive phases through the Universe, from the earliest unions of the smallest particles to form atoms and molecules to the highest levels of conscious life. The significance of this movement of harmonization—might we say its purpose?—is that it increases the worth of existence, making it more precious and desirable, by intensifying consciousness and enriching it with ever higher values of beauty, understanding, and love. Indeed, I cannot imagine any other significance that the cosmic process might have, for what would be the worth of a Universe of billions of stars thinly scattered through vast stretches of space, with nothing in all this immensity

to enjoy existence? All the restless permutations of the cosmic stuff, from the formation of stars to the evolution of life, become meaningful when interpreted as stages in a sustained striving to avoid the utter barrenness of a Universe devoid of creatures that enjoy their existence in it. We are a partial fulfillment of this immensely prolonged effort, its chief beneficiaries in the solar system.

Recognition of our intimate relation to the universal constructive process should make us feel less alone. But intellectual acquiescence in the fact is not enough; we must accustom ourselves to feel, pulsing through our bodies, activating our minds, sustaining us from day to day, the same creative energy that formed the solar system and fashioned all the living beings around us. This vivid sense of our close relationship to all organized beings should make us feel less aloof from them. We are their elder, and perhaps wiser, brothers who must often resist or combat them, but always with the restraint that comes from the thought that they, like ourselves, are products of the process that raises existence to greater awareness and enjoyment, although they appear to have been less fortunate in the outcome.

Understanding our relatedness to the creatures around us, to the whole natural world, should increase our capacity for loving, which is the most effective cure for loneliness. The more widely we can love and, above all, lovingly care for, the less solitary we shall feel amid the immensity of space. While we march at the forefront of the living world, too often lonesome and fearful, with nothing but our own ideals before us, the immense forces behind impel us forward. As we become more sensitive to their direction and intensity, more interested in and careful of the multitudinous creations of these same forces, we shall advance with greater confidence in our future.

Epilogue

I began this book with reflections on light and space; the last chapter considered an aspect of consciousness. The choice of subjects was not accidental, for space and consciousness appear to be the alpha and omega of existence. Space is the container and matrix of all that exists, the continuum that binds all things together and makes this a Universe rather than a loose collection of unrelated things. Consciousness appears to be the end and goal of the Universe, which it strives to increase and intensify, because without feeling and awareness it would exist barrenly, devoid of value. Although space and consciousness seem to stand at opposite poles they are probably much more closely linked than we realize.

Nothing is more familiar to us than space and consciousness. In space we live and act and keep our possessions. Consciousness declares its presence in us all our waking hours and even while we dream. The skeptic who questions the reality of everything external to his mind cannot doubt that he is conscious. Nevertheless, paradoxical as it may seem, these two familiar things are the least understood, the greatest of the mysteries that surround us. In the first chapter, I did not attempt to explain how space conveys light waves over vast distances or how it draws all things together. Although now we measure with great accuracy the strength of the gravitational field and the velocity of falling bodies, how gravitation works—its mechanism—is as great a mystery to us as it was to the ancients who first tried to explain why some things fall and others rise. In the last chapter, I could not prove that birds are emotionally attached to their nests and feel strongly about their young; I could only present my reasons for believing that they do.

Mind—consciousness—is revealed directly to us only in our individual selves; its presence anywhere else, even in the people closest to us, is only an inference or an intuition. The distribution and intensity of feeling in our planet, or even in the living world, have never been mapped

as we map its magnetic fields. Even in ourselves we do not know how it is related to the body; introspection hardly reveals where it is. The ancients, including one of the greatest of all thinkers, Aristotle himself, regarded the chest rather than the head as the seat of feeling and thought. If now we are certain that we think with our heads, it is probably because anatomy points to this conclusion and we are taught from childhood that this is true, rather than a spontaneous revelation.

Compared with the vast bulk of our information about matter, its composition and behavior in the most varied conditions, what we can say about space is meager indeed. Although psychologists tell us much about the human psyche, they have not probed it to its prime foundations, and, after all, man's mind appears to be only a small province in the whole realm of consciousness. Ethologists describe in great detail how animals behave but they do not reveal what they feel and think. To understand this perplexing Universe, we need to know far more than we do about space and consciousness, its alpha and omega.

These limitations of our understanding should challenge rather than oppress us, make us humble but not despondent. Between these two enigmas lies an infinity of things to delight and exercise our minds, in all parts of Earth where life abounds but nowhere more than amid tropical profusion. As, year after year and generation after generation, we sharpen our minds and deepen our insights, we should come closer to understanding the ultimate mysteries. This, at least, is the faith of one who, in a contemporary world that contains much to oppress us, has been sustained by the fascination and splendor of tropical nature.

Agouti