plunging ahead to reform the field. There is a difficulty, however. Paint is cheap, and to construct a masterpiece one has merely to arrange paint properly on a flat surface. Stories are made partly of ideas, partly of characters, partly of an interesting sequence of events (plot), and wholly of the right words in the right order. It is pleasant to talk or to write about clever, well-thought-out and well-written stories which scientists might write around sound or diverting ideas, but it is much more difficult to write such stories than to talk or to write about them. How many will spend real effort in this dubious direction?

There is another possible remedy for the state of science in fiction. The lack of science in science-fiction merely reflects the lack of science in the public mind. One gets the impression elsewhere, as well, that the general knowledge of science—and in fairly respectable circles, too—is a mystical wash of relativity and uncertainty over a lack of pre-Newtonian physics. It is hard to explain the success of Velikovsky's *Worlds in Collision* in any other manner. Perhaps the easiest way to get good writers to write sensibly about science, and to get readers to ask something sensible of writers is to teach people about science.

Perhaps scientists should write popular articles rather than science-fiction. But here, too, the way is difficult. It is no good for men to be told about the new if they do not understand the old. And who will read an article about Newton's laws of motion, when an article about unified field theory seems fresher and more glamorous? Some humanists recommend old books for teaching old matter. But there is something ephemeral about the best of science writing, fact or fiction, for science continually sheds new light on old truths and continually binds old truths together. I think that most scientists would shudder at the idea of learning science from old books, beautifully petrified though they may be. Science is live and growing; the solid trunk, as well as the fresh shoots, is a part of today.

In the present, we know merely that people are increasingly interested in science. Science-fiction, science in stories and novels, show this, but they also show people's ignorance. The interest is flattering and good. Although there are many happy instances to the contrary, the ignorance is sometimes appalling. We wish people were better informed, but who will make them so?

# The Cosmic Cinema[1]

Herbert W. Rand

*Department of Biology, Harvard University, Cambridge, Massachusetts*

William K. Gregory is generally known as a paleontologist. A dictionary defines paleontology as "the science dealing with . . . the fossil remains of animals and plants." Nothing is more dead than a fossil. It is thrice dead. An animal that lived perhaps a hundred million years ago ceased to exist as a going concern. Its carcass suffered complete dissolution. The materials handled by a paleontologist are the more or less distorted mineral replicas of fragments of the carcass. But any fossils that have the good fortune to come into Dr. Gregory's possession do not long stay dead. At his hands they experience the miracle of the resurrection of the body. He assembles the skeletal fragments and restores the complete skeleton. Viewing the skeleton as a three-dimensional diagram of the mechanical stresses sustained by its several parts, he restores the animal's motor mechanism, the musculature, in its proper relation to the skeletal structures. Peculiarities of the teeth and jaws and of the locomotor appendages reveal the nature of the animal's food, the manner of getting it, and the animal's general mode of living. The relative size and the form of the cranial cavity tell something about the nervous mechanism. All available data having been evaluated, the animal, even if not alive "in the flesh," confronts us with a scientific reality not possessed by any mere ghost.

Gregory's *Evolution Emerging* is as far as possible from being a dull description of fossils. It is a story of Life in process of creation. It presents to the reader a marvelous pageant of ever-changing, living creatures ranging upward from the earliest, smallest, and simplest and culminating (in orthodox anthropocentric fashion!) in the human mammal. The pageant is presented not in words only, but by use of a lavish profusion of remarkably fine illustrations.

In *Who's Who in America* William K. Gregory is described as "paleontologist, morphologist." But in course of his story of "emerging evolution" he discusses the essential unity of the astronomic cosmos, the structure of the atom, the nature of time, and other subjects that are indefinitely remote from fossils and biological morphology. The behavior of animals leads him into psychology. The first paragraph of his Introduction, beginning with a reference to the philosopher Hobbes and his concept of a "leviathan state," concludes with these words: "The present work . . . deals with a complex pattern made up of innumerable pieces, the whole, nevertheless, being greater than the sum of its parts." The description in *Who's Who* is obviously a glaring understatement of

[1] *Evolution Emerging.* 2 vols. William K. Gregory. New York: Macmillan, 1951. 1,748 pp. Illus. $20.00. (Reviewed in galley.)

the breadth of interests and the range of knowledge possessed by the author of *Evolution Emerging.*

The reader of the book will be immediately impressed by the imposing magnitude of the work—two volumes, the first containing 704 large two-column pages of solid print, with no illustrations, the second containing 1,013 pages occupied exclusively by illustrations and their descriptive legends which, with few exceptions, are very brief. A bibliography fills 144 pages of Volume I. Based on a count of the references on five pages, the total number of citations (books or papers) must be approximately 5,000.

Volume I is arranged in six parts, the first of which consists of an Introduction and three chapters. Chapter I deals with protozoans, sponges, coelenterates, and worms; Chapter II, with mollusks; Chapter III, with arthropods. In the Introduction, entitled "The Cosmic Cinema," evolution is defined as "the natural history of the universe and its parts." Thus defined, evolution is announced as "The Master Key" to such understanding of the universe as may be possible for us. The author, discreetly avoiding probing too deeply into the dark past of the cosmos, begins with the origin of the solar system and the structure of the atom ("building-blocks of matter"). Passing then to a statement of his concept of "Polyisomeres and Anisomeres: the Role of Repetition and Emphasis," the Introduction concludes with the author's "Argument," which is set forth in 19 stanzas of what may be described as informal unrhymed verse. The stanzas range in length from four to eleven lines. An especially significant stanza, XII, may be quoted:

> Of earlier forms the habitus, or mask,
> That fits them for a special way of life,
> To all their seed becomes prerequisite,
> The basic portion of their heritage—
> ''Preadaption'' but not predestination.

This "Argument" is reminiscent of Erasmus Darwin's "Temple of Nature," in which his idea of evolution was expressed in rhymed verse.

Chapters I–III present an excellent survey of the several groups of invertebrates, with special reference to the features that are most significant as to evolutionary relationships.

Part II includes Chapters IV–IX, beginning with the "Coelomate Food-Sifters" (IV, brachiopods, polyzoans, and echinoderms), then passing on to the prochordates (V), ostracoderms (VI), placoderms (VII), sharks (VIII), and bony fishes (IX). In Chapter V the several theories of the origin of vertebrates are very ably discussed. Patten's arachnid theory receives especially lengthy and serious consideration but, for valid reasons, is rejected.

Part III (Chaps. X–XV) begins with "The Air-Breathers—Struggle for Life" (crossopterygians, dipnoans, early amphibians) and continues with the later amphibians, the reptiles, and the birds.

The seven chapters of Part IV cover the several orders of mammals, exclusive of primates. In Part V, Chapter XXIII considers the "Origin, Rise and Deployment of the Primates," and Chapter XXIV is headed "Man's Debt to the Past." This chapter is essentially a review of all the preceding chapters, but with special emphasis on those structural features that may be traced in a continuous and progressive series from the earliest living things to the present. In Part VI (Chap. XXV), entitled "Retrospect and Prospect," the author summarizes his ideas as to the mechanism of evolutionary emergence and clinches his introductory "Argument."

The gist of Part VI may be best presented by a series of quotations. Beginning with a slightly apologetic statement that he himself is "a sort of educational hybrid between Science and Philosophy," the author notes that "the concept of evolution must take into account the relatively unchanging side of nature as well as its measurable or describable transformations; that we should study the relatively fixed background as well as the moving or changing object." A conspicuous feature common to objects in the mineral, plant, and animal kingdom is the basic similarity of numerous "adjacent individuals of the same general derivation." To any such group or series of repetitive units the author applies the name "polyisomeres." As examples of polyisomeres are mentioned "a row of graptolites, all the leaves on a tree, or other biologic units; they may be a row of cog-teeth on a zipper, the pebbles in a stratum of conglomerate, or a string of musical notes or drum beats;" and elsewhere are added "daisies, flies, sand grains, chocolate bars, votes, vertebrae and mosquitos." Polyisomerism is commonly exhibited both by *things* and by *events,* and "in nature" and in "the works of mankind." "Differentiated polyisomeres" are called "anisomeres" or "polyanisomeres"—e.g., sacral vertebrae, in which certain basic features of a typical vertebra are either emphasized or reduced.

> How did the world come to be so full of polyisomeres and polyanisomeres? . . . As soon as we realize that any sort of recurrences are in themselves polyisomeres, it follows that the latter must be abundant in a world in which every sunrise starts and every sunset stops or slows down the basal process of photosynthesis in plants; that at every low tide billions of limpets, barnacles and other creatures clamp down on the rocks and remain quiet, without new food until the next tide reaches them. . . . In such a world of both simple and complex recurrences and unexpected conjunctions and emphases it is small wonder that animals, if they are to exist at all, must have various ways of adjusting themselves to recurrent changes in their environment. . . .
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> *E pluribus unum* is the principle of progressive increase, organization and integration. During the course of evolution, as well as of individual development, new characters and units of structure appear at given levels and these units are subsequently combined and made to work together either in further extensions of old organs and functions or in entirely new forms and functions. Undoubtedly the individual animal receives through the interaction of heredity and environment some sort of regulating or adjusting system whereby the dangers which its kind have been accustomed to meet are usually rendered nugatory. From such facts and considerations has arisen the doctrine of holism, . . . which stresses the wholeness, the self-defensive, self-perpetuating reactions

of organic beings. The . . . whole is in one sense really greater than the sum of its parts. . . .

A discussion of changes in anatomic pattern and corresponding changes in function concludes that "by the extremely slow effects of Natural Selection upon chance mutations, the locomotor patterns of the fast-moving terrestrial carnivores were gradually overlaid and replaced by the later swimming patterns of the ancestors of the sea-lion. Thus the habitus of the remote ancestor becomes a diminishing part of the successive heritages of its highly modified descendants." The "divergent pressure of Natural Selection, acting through competition and the environment, upon each animal . . . took part in opening the paths leading from primitive land mammal respectively to dog and sea-lion."

"Through the age-long sifting action of Natural Selection many animals inherit such a configuration of the nervous system that they instinctively prepare far in advance for the oncoming winter, certainly without knowing why they do it; they are merely 'wound up' to do it." Is this apparent foresight truly an instance of "design," or is it merely "preadaptation"? The author regards both man-made designs and "natural designs" as "parallel or convergent results, (a) of the preadaptive nervous system of man, and (b) of the cumulatively adaptive patterns of nature."

As affording a suitable basis for a discussion of "Law *versus* Chance," the author offers this incident:

> An incautious human bather stepping on a sting-ray concealed in the muddy sand may receive an extremely painful wound. . . . The evolution of the sting-ray's weapon was probably well under way in Cretaceous times, when the ancestors of man were arboreal, insectivorous tree shrews, living in the forests well away from the bays in which the sting-rays lurked. . . . Thus the present poisonous effects on man are due to the then long distant and unpredictable intersection or coincidence in later time and space of a then non-existent human foot and a then incomplete sting-ray's sting. . . . No doubt a practically infinite number of prerequisite events and conditions took place in geologic time, leading respectively on one side to the evolution of sting-rays and their stings, and on the other to the evolution of early man and of modern incautious bipedal bathers. [The evolution of the sting and of the bather's foot have alike been] preconditioned by the cumulative effect of repetitive or polyisomerous situations, which have developed more or less rhythmically, as in events determined by recurring sunlight and darkness, by winter and summer, by seasonal times for breeding and not breeding, or for growth and arrest of growth, or for seeking this type of environment or that, and by thousands of others. . . . In so far as similar events occur rhythmically, they increase their chances of meeting *similarly* rhythmical series with which they can cross or intersect. . . . The more often differently conditioned series exist near each other, the greater are the chances for meetings or combinations between them. This is a part of the ''kaleidoscope theory'' of evolution proposed . . . by the writer. . . . The net result of these considerations is to suggest that newly emergent or creative evolutionary events have not been foreordained but have been preconditioned. . . .
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> Natural ''laws'' . . . are recognized by man through their effect in causing repetitive, recurrent phenomena. ''Chance'' is the name for random or unexpected events, due to new or newly observed intersection or collision of different natural laws at a given time or space. Hence ''Law'' and ''Chance'' are not mutually exclusive but complementary aspects of natural events or phenomena. . . .
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> The changing patterns of a kaleidoscope afford various similes of the ways of evolution . . . and so the cosmic kaleidoscope keeps turning round and round, slowly but endlessly dissolving old combinations while creating new patterns, new values, new opportunities.

Volume II, containing a thousand large pages of illustrations, is in itself a monumental achievement. With few exceptions, each "illustration" consists of two or more (usually several or many) figures. The total number of constituent figures—not easily estimated—must run far into the thousands. Excepting a few reproductions of photographs, the figures are line cuts, drawn to a generously large scale. Names of parts are conveniently shown in each figure, and the work is of superior technical and artistic quality. These features combine to make the illustrations vividly intelligible. Especially important is the fact that a large proportion of the illustrations represent *series* of structures or of animals arranged in order of evolutionary relationship—e.g., from crossopterygian to labyrinthodont; pectoral girdle and right humerus from crossopterygian to man; skull from fish to man, etc. Most of the numerous "family trees" are pictorial—i.e., the relationships are shown not merely by branching lines but by a series of pictures of the successive related animals. These pictorial genealogies are vividly instructive. They are, in effect, strips of "movie" film enabling the observer to *see* the evolution in process, the moving being done by the eye instead of by the film. In fact, they are more instructive than an actual "movie" because the observer may, at will, linger at some one stage in the series, or repeat his viewing, or view in reverse. Nor are these series "silent movies." The constituent figures are so lifelike that they "speak for themselves."

The author's literary style ranges from severely conventional anatomic description to a somewhat informal or even "conversational" style in some of his discussions. Occasional passages suggest that his ideas sometimes flow with greater facility than his words, so that a listener would probably interrupt with a request that the sentence be repeated or clarified. A light touch is given to the text by such captions as "The Bivalves—Brainless but Successful" and "The Coelomate Food-Sifters." Among the headings in the chapter on bony fishes appear "Master Wrigglers (Apodes)," "Animated Stone-Crushers (Labroidea)," "Nibbling Angels," "Impetuous Swordfish," "Obese Lump-Sucker," and "Ogling Dragonets."

The reader is never allowed to forget "polyisomerism." The terms related to the concept are too frequently used in situations where the context requires the addition of an explanatory phrase specifying what the polyisomerous structures are, or indicating whether the anisomerism in question is an instance of differentiation, augmentation, reduction, or some other change. It would usually suffice to mention merely the specific structures or the nature of the modification, leaving it to the reader to recognize the "isomerism," and thereby avoiding making him feel that the concept is being overworked.

It is impossible nowadays for anyone to be an all-round zoologist. He can merely be an embryologist, geneticist, paleontologist, or any other one of many "-ists." If a paleontologic author introduces into his work some histologic, embryologic, or physiologic details, he does so at some risk. It is fair to say that a few of the author's statements about integumentary organs are open to question. Especially so is his oft-repeated statement that the scales of teleosts are horny (see pp. 104, 116, 151, 344). The brief account of the development of a feather (p. 314) leaves much to the imagination, or even puts imagination on the wrong track. The same comment, with increased emphasis, applies to the development of antlers, as described on page 438. The statement that "the velvet secretes the antler" is followed by "the antler-producing organs act somewhat like the large glands on the face in front of the orbit, but instead of secreting a waxy material, they deposit solid bone." Later the antler-producing organs are referred to as "antler glands." Is there any conceivable relation between antlers, constituted of dermal bone, and sebaceous glands, which are wholly epidermal? On page 247 it is stated that amphibian glands of various kinds are derived from the "deeper layers of the skin," and that some of them "secrete pigments." The glands are epidermal and do not secrete pigment. The statement (p. 345) that sebaceous glands tend to "conserve body heat" is open to question. On page 447 it is asserted that the whole "assemblage" of anatomic parts of a whale is "enclosed and held together by an extremely thick and strong streamlined integument, commonly known as blubber." "Held together" is not a function usually ascribed to skin. The interpretation of scales on a bird's foot as modified feathers (p. 315) raises the question as to whether they are not more likely a direct heritage from reptiles. Did early birds have feathers on their toes?

The description of the structure of the ear (pp. 265, 346) is somewhat sketchy. Otoliths are doubtless somehow concerned in the stimulation of the sensory cells of the ear, but they certainly are *not* "attached" to branches of the acoustic nerve.

The electric organs of *Torpedo* (p. 138) are asserted to have been derived from muscles and nerves of the pectoral fins. The innervation of the electric organs is correctly stated as coming from cranial nerves VII, IX, and X. If derived from pectoral muscles, the innervation should be spinal. The fact that the electric organs lie in close relation to the wall of the pharynx and have cranial innervation clearly indicates their origin from visceral muscles.

It would be of interest to know what ground the author has for proposing that osteoblasts may be produced in localized "centers" and carried thence by the blood or lymph to sites where bones are destined to develop, being somehow "attracted" to the appropriate locality. He seems to favor the idea (proposed by P. E. Raymond *et al.*) that the evolutionary origin of exoskeletons was incidental to a necessity for excreting excessive quantities of calcium and other waste substances at the outer surface of the body—converting a necessity into a virtue, so to speak. Would it not be equally reasonable to propose that animals devised endoskeletons as a profitable way of using excess waste material? The idea would seem to be discredited by the fact that numerous animals, large and small and of all sorts, are devoid of skeletons and yet seem to suffer no embarrassment in disposing of their waste materials.

The author's discussion of the evolutionary status of *Amphioxus* (p. 88) invites comment. He depicts *Amphioxus* as an unfortunately frustrated little creature which might have had a bigger and better brain had not the front end of the notochord been in the way. This calls to mind Wilhelm Roux and his *Kampf der Teile* (1881). But a half-century of experimental embryology teaches us that the conspicuous feature of embryonic development is not competition but cooperation or coordination. The fact that the brain of early reptiles was confined in a rigid bony case did not prevent their descendants from having progressively relatively larger brains, the increase being accompanied by coordinated changes in skull and form of head. If the brain of *Amphioxus* should somehow acquire several hundred thousand additional neurons, its size would not be greatly increased, and relatively small adjustments in neighboring parts would allow for it. *Amphioxus* is very highly specialized and beautifully adapted to a peculiar mode of life. Is it not likely to be "content" to stay where it is and become a "dead end" of evolution?

In the attempt to demonstrate the unity of nature, the author makes various comparisons between actions occurring in living and in nonliving things. In some instances he emphasizes a quite superficial similarity and ignores profound differences. Discussing "Brains as Organs of Futurity," he says (p. 540), "If the weight of mountains be pressing against the rock floor of a tunnel at the bottom of a deep mine, it may buckle up and be squeezed together until it is strong enough to resist the thrusts from the sides. Here is an example of an adjustment without benefit of a nervous system." He goes on to say that rocks, metals, etc., "react" to such "stimuli" as may be exerted upon them by impacts, heat, etc. He finds an analogous reaction in mammalian skin when local pressure or friction causes formation of a horny callus. There is no significant analogy here. The falling of a brick is not a response to a stimulus. When a man slips on ice and falls flat, the event is due to his *failure* to effect sufficiently prompt muscular reactions to the various stimuli caused by the slipping. Sustained local pressure or friction on mammalian skin causes great increase in epidermal activity in the affected area—

proliferation of cells, deposition of keratin, piling up of an abnormal number of layers of cornified cells resulting in a protective thickening of the stratum corneum. All this is truly response to stimulus. Nothing analogous to it occurs in the "squeezed" tunnel. The "adjustment" of the deformed tunnel is not achieved by the tunnel itself. The tunnel *can* do nothing because it *is* nothing, being merely a hole in the mountain. No *new* materials are brought to the scene of damage, whereas in the skin materials derived from food in the digestive tract are carried by the blood to the scene of repair to be used in the production of new cells and more keratin.

Another dubious analogy appears in a brief account of osteogenesis and the adaptive structural peculiarities of bone (p. 178). The account begins thus: "In a crude way the skeleton of any bony fish may be likened to a many-pieced ship made of concrete that has been poured into a mold and allowed to set." Turning then to the development of bone: "A . . . bony precipitate . . . has oozed out from the gland-like osteoblasts into a jelly-like matrix (. . . hyaline cartilage . . .)" which is "confined within limiting walls, such as the periosteal membranes . . . ," etc. Development of a bone could better be likened to the building of a brick wall. The bricklayers are the osteoblasts accurately laying course upon course (bone lamellae)—but the bricks do not "ooze out" from the bricklayers. If the "limiting walls" of the cartilage (perichondrium) are to be likened to the "mold" into which concrete is poured, it must be recognized that the perichondrium is a *living* "mold" which *produces its own "concrete"* in that it is the source of the osteoblasts that deposit calcareous material. As later pointed out by the author, it is a "mold" that spontaneously expands and changes its form as the bone grows. In striking contrast to the concrete mold, it persists as the living periosteum on the surface of the bone and, in event of injury to the bone, it repairs the damage. In short, there is *no significant* analogy between osteogenesis and the shaping of concrete in an inert mold.

The author has confessed to being an "educational hybrid" between Philosophy and Science. The reviewer's educational pedigree contains only a negligible taint of philosophy, and he should not undertake any serious discussion of the author's philosophic views. William James, in one of his informal lectures, said that human minds are of two types, "hard" and "soft." The hard-minded man is a materialist and mechanist; the soft-minded is an idealist and vitalist. The philosophy of *Evolution Emerging,* as set forth in the "Kaleidoscope Theory," should be acceptable to the hard-minded. It is clearly and effectively worked out and should be quite convincing to anyone who is willing to allow himself to be convinced. The soft-minded person will be like the woman in the old saying who, "convinced against her will, is of the same opinion still."

If there is any weak point in the Kaleidoscope Theory, it is in the high degree of efficacy attributed to natural selection. The difficulty which, since the time of Charles Darwin, has perpetually beset the concept of natural selection lies in the fact that, in so many instances, the incipient stages of a potentially "new" organ would seem to have no selective value—i.e., to offer nothing that natural selection could lay hold on. A good case in point is the electric organ of fishes. Could it have any selective value before it had attained such a stage of development as would make it at least slightly disagreeable, if not positively harmful, to potential enemies of its possessor? The transformation of muscle to electric tissue requires radical histologic and functional changes in the muscle. To assume sufficiently numerous successive mutations in the same direction is hardly justifiable.

The cleavage between the "hard" and the "soft" types of human mind is as ancient as philosophy itself and will doubtless persist for long ages to come. Scientific method and our thinking in general involve various assumptions. We have no assurance of their absolute validity. According to the Kaleidoscope Theory, consciousness and mind "emerge" from electrons. But it is perhaps as easy to derive electrons from mind as to derive mind from electrons. We do not really know whether mind is now engaged in *discovering* the universe or has *created* it. Hamlet, Prince of Denmark, may have been mentally askew, but he was both sane and wise when, to Horatio, he made a remark that is pertinent to all our philosophies, "hard" or "soft": "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy." Whether we regard its plot as likely or not, we are certainly deeply indebted to William K. Gregory for allowing us a view of his masterly production "The Cosmic Cinema."