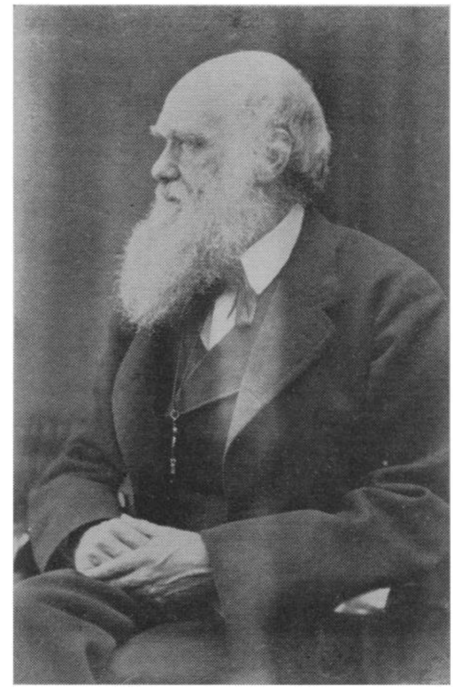
Evolution



Charles Darwin [Smithsonian Institution]

For centuries man has theorized on the origin of the world and the development of man. Thales, a Greek philosopher (640?–546 B.C.), was perhaps the first thinker who applied scientific rather than mythological interpretations to the study of natural phenomena. He believed that water was "the mother from which all things arose and out of which they exist." Aristotle (384–322 B.C.), Greek naturalist and philosopher, made the first attempt to classify animals on the basis of their anatomy by emphasizing the main animal divisions—vertebrate and invertebrate. His theory on the origin of life was the theory of spontaneous generation, according to which even complicated forms of life might arise spontaneously from nonliving matter. Many centuries later, in the early 1790's, Jean-Baptiste Lamarck, a French naturalist, developed a theory that species are not constant, but rather are derived from preexisting species. Evolutionary change came about by use and disuse of parts; the change acquired in the lifetime of one individual by use or disuse would be inherited in the next. However, the greatest advancement in the theory of evolution occurred when Charles Darwin (1809–1882) published his treatise, *The Origin of Species by Means of Natural Selection.* Darwin recognized two causes of evolution: (i) the inheritance of characters acquired by the ancestors and (ii) natural selection. Darwin stressed the second of these causes; his explanation of the process of evolution by means of natural selection was the triumph of his work.

Scientists are continuing the search for answers to the secrets of life. Some think that the past may hold the answers, and they will discuss their findings at a symposium entitled "Reconstructions of Past Biological Environments" at the 132nd AAAS Annual Meeting, Berkeley, California (27 December 1965). The discussions will cover what has been learned regarding the past environment of life, from the origin of life on earth to the environment under which early man lived. Modern tools of science which have been used to gather such information will be discussed. The symposium will be sponsored by the American Society of Naturalists; the program chairman is Carl L. Hubbs (University of California, San Diego).

In order to understand the evolution of man, it is important to know more about the origin of the earth. One theory will be discussed by Harold C. Urey and Bartholomew Nagy (University of California, San Diego). "One possibility is that life evolved on one planetary object, and that it was transferred to another planetary object of primitive composition. Of course the example of this in the solar system that immediately comes to mind is the earth and the moon, which may have a composition consistent with the carbonaceous chondrites. It is an old suggestion that the meteorites have been coming from the moon, but the recent evidence, though not conclusive, is suggestive at least.

"If the moon escaped from earth it is not unreasonable to believe that it could have been contaminated temporarily with terrestrial water. If the moon was captured by the earth, the process may have been a very complicated and violent one because such a capture hypothesis almost surely implies that many moon-like objects were present and that they and fragments of them were accumulated into the earth, a hypothesis put forward by Urey some time ago. If indeed the surface of the moon carries a residue of the ancient oceans of the earth at about the time that life was evolving, it means that the Apollo Program should bring back to earth fascinating samples."

The earth itself holds answers to many questions about early life. T. C. Hoering and P. H. Abelson (Geophysical Laboratory, Carnegie Institution of Washington) will discuss "Organic geochemistry and the record of ancient life." They will tell how geochemical methods record ancient life through the recognizable chemical molecules found in sedimentary rocks.

The method is especially important in the study of the pre-Cambrian era, where fossil records are very limited. Fractionation of stable isotopes occurs during photosynthesis, and the record of the carbon isotopes in stromatolites is consistent with the occurrence of photosynthesis for at least 2.7 billion years.

Chemical processes in living organisms possess the unique ability to synthesize compounds with long, straight chains of carbon atoms in preference to the thermodynamically more stable branched chains. Normal alkane has been isolated from some of the earth's oldest sedimentary rocks, of age greater than 3 billion years. Chlorophyll is altered to metallo-porphyrins in the sediments. The porphyrins are readily recognized through their optical spectra and have been found in very ancient rocks. Living matter synthesizes asymmetric compounds that display optical activity. The search for such compounds will be described. All signs point to the existence of life on earth for at least as long as there have been rocks to record events.

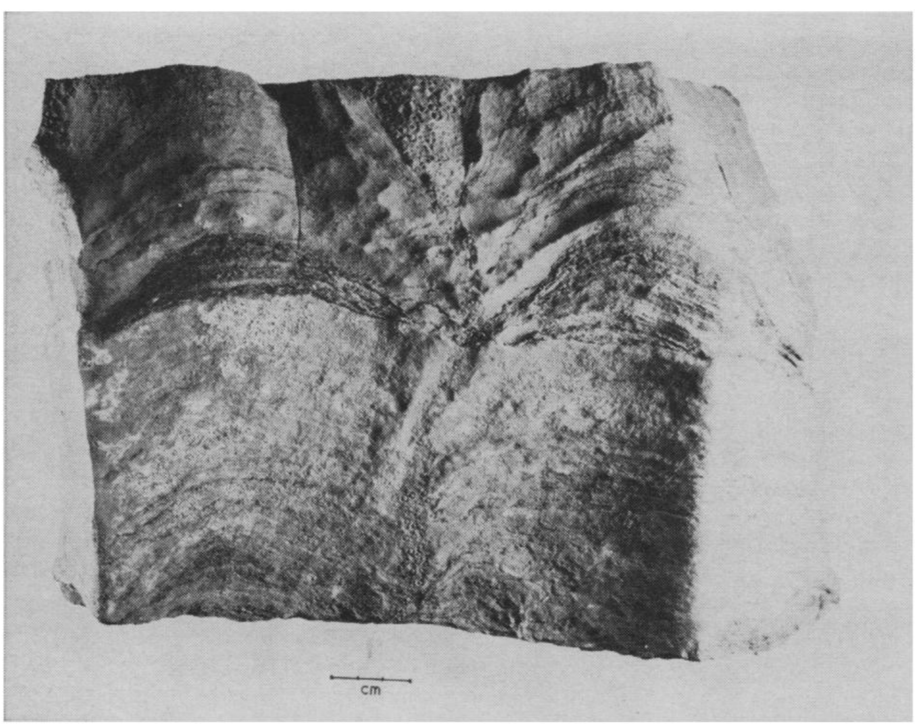
Among the methods used to discover the ancient topography of our planet centuries ago is one used by Daniel I. Axelrod (University of California, Los Angeles). Axelrod, in his talk entitled "Tertiary floras and ancient topography," will discuss how the concepts of effective temperature and temperateness can be used to estimate altitude and hence ancient topography. Effective temperature is a measure of the warmth and duration of summer; temperateness refers to the departure of mean temperature from 57°F and to the mean monthly fluctuation in temperature.

The effective temperature at lowland stations can be used to determine accurately the altitude of the effective temperature at stations in upland forests today. The effective temperature of a Tertiary flora near sea level appears to provide a reliable basis for determining the altitude indicated by the temperature of a contemporaneous upland flora because there was a more regular vertical distribution to zones of effective temperature in the Tertiary. This resulted from climates which were more broadly zoned and less diverse in type; from relief which was lower and which had less influence on the local distribution of temperature; and from temperateness which was high over wide regions.

Since Tertiary climate was characterized by pronounced temperateness, the effective temperature of a Tertiary flora can be determined most accurately if inferences are drawn from analogous modern forests in areas of high temperateness (temperateness over 60°F), the regions where forests have persisted with least change since the Tertiary.

The method devised to determine altitudes of stations in modern upland forests has been applied to Tertiary floras with the following results: (i) A late Eocene subalpine forest (Bull Run flora) in northeastern Nevada probably lived near 4500 feet, contemporaneously with broadleafed, evergreen forest near sea level to the west (Moonlight, Comstock floras). Mixed deciduous, hardwood forest, inferred by botanists to have occupied the ancestral Great Smoky Mountains during Eocene time, probably had its lower margin near 2500 feet, situated above the warm, temperate, broadleafed evergreen forest that dominated the lowlands. Other data about floras from the middle Miocene and Oligocene eras will also be discussed by Axelrod.

The data support the principles that (i) altitudinal zonation of Tertiary climate exerted a primary control on the distribution and composition of forests much as it does today; (ii) a rise in altitude during the Tertiary corresponds to time transgression because floras of younger aspect lived in the cooler uplands; and (iii) owing to altitudinal zonation of climate, analysis of the secular trend of Tertiary climate should be based on sequences of floras in local areas at or close to sea level.



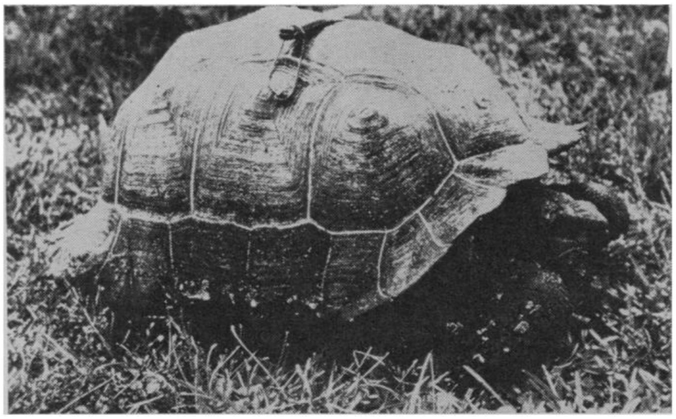
Two-billion-year-old stromatolite from the Transvaal system of South Africa. These layered structures in carbonate rocks are believed to have been formed by layers of blue-green algae (scale, 3 cm). [T. C. Hoering]

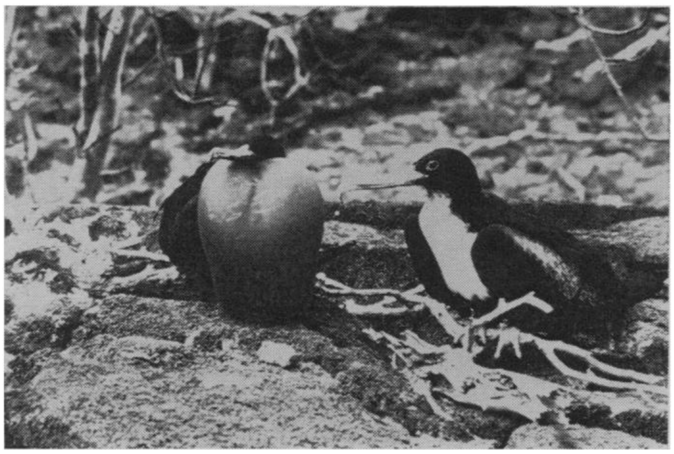
One technique employed in finding out about past environments is by studying lake sediments. D. A. Livingstone (Duke University) started 15 years ago to study lake sediments; he wanted to find out about the history of lakes as ecological systems. Initially, he expected that lakes would display general trends of development, analogous to the increase in size and complexity of a growing organism. His expectations have not been borne out. Lakes are extremely sensitive to changes in their external environment, particularly to changes in climate. Lake sediments are therefore a valuable key to the general conditions of the past. For the past 5 or 6 years a major part of Livingstone's attention has been directed to the lakes of tropical Africa, particularly in and around the Great African Rift. Results of his studies indicate that climatic changes during the past 15,000 years on the mountains of equatorial Africa have been similar in some respects to changes in the temperate zone. The lower lands of tropical Africa seem to show a different pattern, with a dry climate prevailing when the temperate zone was moist and cool enough to support widespread continental glaciers.

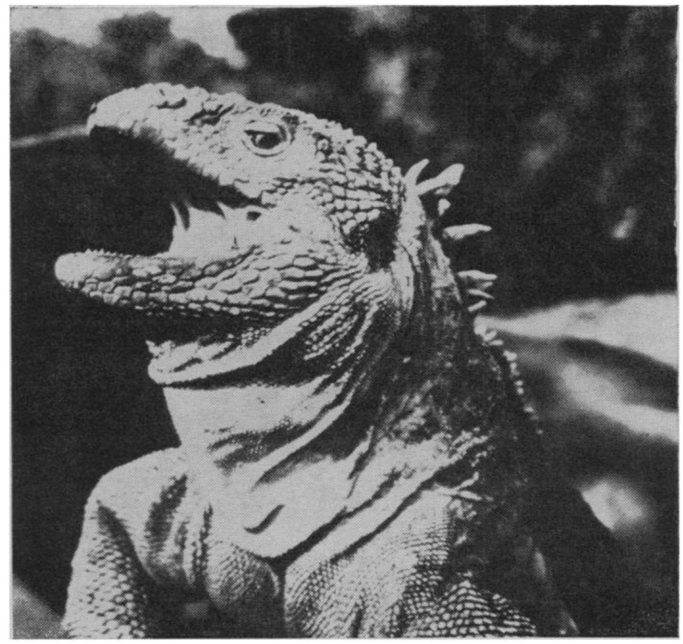
In his discussion, "Paleolimnology," Livingstone reports on his work and mentions its relevance to the biogeography and human history of Africa. He deals more generally with the things that can be discovered by studying lake sediments chemically, biologically, and geologically.

The amount of information preserved in lake sediments is overwhelming. The number of fossils in a cubic centimeter of lake mud is commonly of the order of 1 million. Under favorable circumstances even the fine cytoplasmic details of these fossils are preserved for millions of years. In addition to pollen grains, diatoms, sponge spicules, desmids, and other organisms, lake mud commonly contains appreciable quantities of chemical fossils, including substances such as photosynthetic pigments and free sugars that would be decomposed very readily in most environments.

A valuable indicator of past en-







Animals inhabiting the Galápagos Islands. (Top left) The most remarkable island reptile is the giant tortoise which gave its Spanish name, galdapago, to the islands. [J. Wyatt Durham, University of California, Berkeley] (Bottom left) The male frigate displays its bright gular pouch to attract females during courtship and nest-building. [J. Wyatt Durham] (Above) The land iguana lives on leaves and cactus plants and climbs trees. [R. N. Mariscal, University of California, Berkeley]

vironmental conditions is freshwater fish. These fish, with a long history of restriction to inland waters, now constitute important indices of the past hydrologic history of arid regions. Detailed knowledge of their distribution and relationships often provides clues to drainage history that may supplement and reinforce evidence worked out by earth scientists.

In his paper, "Quaternary hydrography and fish life of the now arid American west," Robert Rush Miller (University of Michigan) will discuss the distribution of fish in the west. His maps give unmistakable evidence that the region was well watered during the last glaciation, approximately 10,000 to 40,000 years ago. His conclusions agree closely with those of geologists and other earth scientists. The present fish fauna consists of relict populations whose relationships clearly show the integrity of major and minor drainage systems and of their hydrologic relation to surrounding river basins.

Fossil fish, chiefly of Quaternary age, provide evidence for hypothetical drainages that were of Pleistocene or Pliocene age, dating back from 1 to 5 million years. On the premise that habits, preferred habitats, and environmental tolerances have not changed significantly during the past million years or so, deductions are drawn regarding past climates and paleoecology. The data reinforce the interpretations that have been made heretofore chiefly by students of warm-blooded fossil vertebrates and of fossil mollusks. The paleoichthyological studies have only recently been initiated, and though the record is still meager, some significant finds have been made. For example, certain living genera of lacustrine channel fish are now seen to be relicts of groups that were formerly much more widespread and included a greater number of species. Shrinkage in number of species and areal abundance are traced to the progressive desiccation of the past million years.

The study of spores and pollen grains is important in paleontological research. Because of their chemical nature, the walls of spores and pollen grains are resistant to decay; both are consequently preserved in most sedimentary environments and rocks. Other factors which make spores and pollen signficant are: (i) they are small and are produced in large numbers; (ii) they are disseminated widely by wind and water; (iii) they possess structures which make them identifiable into groups and species; (iv) they are restricted within short geological time divisions; (v) they are useful indicators of paleoecology; (vi) they occur in continental and in marine deposits; (vii) they are indicators of paleogeographic conditions; and (viii) they can be treated statistically to reveal the degree of correlation.

Peter J. Mehringer, Jr. (University of Arizona), has been engaged in research on spores and pollen grains and will discuss "Palynological inferences and Quaternary environments in arid lands." He attempts to relate the pollen record from cave deposits, playa lake cores, archeological sites, alluvial sequences, and coprolites to possible changes in Quaternary vegetation in the arid and semi-arid western United States. He does not reconstruct a chronology of vegetation change. Instead, he uses specific pollen localities of various ages to illustrate the problems, procedures, and potential of reconstructing past vegetation from the fossil pollen record.

Paleoecology is becoming popular, almost fashionable, but its popularity is greater among geologists and anthropologists than among biologists. Late-

Pleistocene paleoecology has obvious bearing on modern vegetation and present-day biogeography and is therefore being actively pursued by environmental biologists. However, the environments of the remoter past are still of interest mainly to geologists. The view of ecology that nonbiologists have acquired, without much help from professional ecologists, tends to be a 19th century view, dominated by autecological thinking—why does this species of animal or plant live where it does? The principal preoccupations of 20th century ecologists—productivity, community structure, population dynamics, the ecosystems—have made little headway in paleoecology.

Edward S. Deevey, Jr. (Yale University), will present in his paper, "Population dynamics and communities in the past," the argument that these synecological considerations have much to contribute to the reconstruction of all past environments, not just to those of the late Pleistocene. Conversely, ancient populations, communities, and ecosystems can be seen changing through time and are profoundly relevant to present-day ecology. Illustrations of his population-ecosystem approach to the geologic past are drawn from several published and unpublished investigations—dynamics of Pleistocene cave-bear populations (Kurtén), analyses of interspecific competition in ostracods (Deevey), specific diversity in cladoceran assemblages (Goulden), and quantitative reconstruction of forest communities from pollen assemblages (M. B. Davis).

Important in the evolution of man is how he has reacted to environmental changes. Fred Wendorf (Southern Methodist University) and James J. Hester (National Institutes of Health) will discuss Pleistocene environmental changes and how they have affected man both biologically and culturally. They are primarily concerned with the New World but will consider some evidence for the Old World. One of their major points is concerned with man's response to the climatic changes at the end of the Ice Age. Wendorf thinks it is significant that the same type of response occurred both in the Old World and the New World and at about the same time. Hester is concerned more specifically with the South American area. He will show how a combination of the South American geography and climate affected early human occupation of South America.

More on Evolution . . .

Scientific Advances in Human Evolutionary Studies

One of the "Moving Frontiers of Science" lectures will be presented by F. Clark Howell (University of Chicago) on the evolution of man (26 December 1965).

Paleoanthropology had its genesis somewhat over a century ago with the discovery of an extinct form of mankind (Neanderthal), the recovery of successive occurrence of Stone Age artifacts in geologically ancient deposits in association with extinct vertebrate species, and the demonstration of species mutability and of evolutionary change. The multidisciplinary study of the evolution of man and cultural paleoanthropology has now gained maturity as a scientific discipline. Discoveries in recent years have revolutionized former conceptions of human physical and behavioral evolution.

Hominid skeletal remains are now known, though very unequally, throughout the range of Pleistocene time from Africa and (subsequently) Eurasia. The fossil record of the Hominidae reveals the existence during the Pleistocene epoch of at least two distinct higher taxa (genera *Australopitheus* and *Homo*), each with two or more successive species; an early taxon of *Homo* was coexistent, at least in Africa, with one form of the other higher taxon. At least some of the oldest known Pleistocene hominids were habitual toolmakers, were predaceous, and carnivorous. Some scant fossil evidence from southern Asia and eastern Africa suggests the existence of the family Hominidae at least 12 to 15 million years ago.

Evidences of hominid cultural capabilities are also known nearly throughout the Pleistocene, and most adequately and abundantly from later time ranges and from closed occupation sites which are still well preserved. However, in recent years the discovery (or rediscovery), systematic excavation, and recovery and analysis of cultural and related occupational residues and datable contents, often with rich associations from more ancient situations, afford at last a real measure of cultural adjustment and change over a span of nearly two million years.

Studies of early man have derived much from modern advances in other investigations of late Cenozoic time—notably stratigraphic geology, sedimentary petrology, paleopedology, paleomagnetism, methods of isotopic age determination (especially C^{14} and K/Ar), palynology, and vertebrate paleontology. Howell will discuss some of the more recent joint investigations by paleoanthropologists and colleagues from these and other specialties which are advancing our understanding of human origins and development.

Laboratory of Evolution

The Galápagos Islands are located in the Pacific Ocean 650 miles west of Ecuador and are literally a "living laboratory of evolution." For centuries life on the islands has evolved in a world of its own with only rare contact with the mainland.

The islands are best known for their unusual animals, the most dramatic being the large spiny marine and land iguanas. The archipelago is named after the enormous land tortoises (galdapago, old Spanish name for "tortoise"), considered among the oldest living creatures on earth. Other unusual specimens include a four-eyed fish, distinct species of penguin, flightless cormorant, and 13 species of very tame finches. Charles Darwin visited Galápagos in 1835 as a naturalist aboard the H.M.S. *Beagle* and was so impressed with the inter-island variations in the shape of the tortoise shells and of the finch bills that they inspired many of his views on natural selection.

Because of the uniqueness of the Galápagos biota and because of the great interest in the area, a symposium, "Systematic Studies of Collections Made on the Galápagos International Scientific Project," is planned as the program of the Society of Systematic Zoology (27–28 December 1965 at the AAAS annual meeting. The program officer is Jerome G. Rozen, Jr. (American Museum of Natural History, New York City).

Practically every aspect of the Galápagos islands will be reported on —animals, plants, insects, geological features, meteorological features, and others. The expedition included over 50 scientists from several countries. Almost every discipline of science was represented. Probably no expedition organized for a similar purpose ever had so many specialists in such a wide variety of subjects.