PALEONTOLOGY: OVERVIEW

Paleontology is the study of prehistoric life through its fossilized remains or the traces of its history in sediments. Fossils, the remains or traces of once-living organisms that are preserved in the sediments of the Earth's crust, provide the only direct evidence of life in the past.

As a scientific discipline, paleontology is the study of biological objects (fossils) in a geological context (the sediments in which they are preserved). Consequently, paleontology borders on, and draws from, two major branches of science. Paleontologists must be interdisciplinary in their interests and competent in both geology and biology. Some paleontologists find employment teaching geology in colleges or universities or working in geological jobs (such as in the oil or coal industries, or in governmental geological agencies), while others teach biology in colleges and universities, or anatomy in medical schools. Paleontological research is published in a wide variety of geological and biological journals, as well as in many specialized and interdisciplinary publications, so the relevant literature is often scattered among many books and journals.

Specialization

Most paleontologists specialize in a particular subdiscipline. Some subdisciplines are defined by the group of organisms that are studied. Vertebrate paleontologists study the remains of extinct backboned animals (vertebrates), including fishes, amphibians, reptiles, birds, and mammals. Invertebrate paleontologists study the remains of animals without backbones (such as arthropods, molluscs, echinoderms, brachiopods, bryozoans, corals, and sponges). Paleobotanists study the remains of ancient plants. Micropaleontologists specialize in a wide variety of different groups of organisms that are so tiny that they can only be studied with a microscope. These include microscopic plants (pollen, diatoms, calcareous algae), animals (ostracodes, conodonts, pteropods), and single-celled organisms that are neither plants nor animals (foraminifera, radiolaria, and many other protistans). Because micropaleontology is very useful in finding oil, the majority of micropaleontologists are employed by the petroleum industry. Paleontologists who study megascopic fossils, on the other hand, tend to be employed by colleges and universities because the benefits of their research are more academic in interest.

Paleontologists also may define themselves by areas of theoretical interest. Paleobiology describes any application of biological principles to the fossil record, and many paleobiologists study biological phenomena across many taxonomic groups (classifications). Paleobiogeography is the study of the past distribution of organisms in an attempt to understand their origin and dispersal around the world and sometimes to decipher the motions of continents and land bridges. Paleoecology is the study of ecological principles as they apply to the fossil record. Paleoecologists try to reconstruct ancient environments and the ecology of extinct organisms. Paleoclimatology is the study and reconstruction of ancient climates, a discipline that not only uses fossils as indicators of past environments but also uses information from geochemistry, climatic modeling, and many other fields. Biostratigraphy uses the distribution of fossils in stratified layers of rocks to correlate and date those rocks. Most paleontologists who are employed by oil and coal companies as economic paleontologists use their knowledge of the fossil record (especially biostratigraphy) to predict the location and the quality and quantity of future oil and coal resources.

The profession of paleontology itself has evolved and changed over last the century. The first people to study fossils were scholars who made their living in other professions. The Danish biologist Nicholaus Steno (also known as Niels Stenson) was a doctor, as was the American anatomist Joseph Leidy. Many eighteenth- and nineteenth-century paleontologists were professors of anatomy or mineralogy or were independently wealthy gentlemen who could study fossils as a hobby. Not until the mid-nineteenth century did it become possible for a scientist to earn a living as a paleontologist. A few were professional fossil collectors, but most were professors in universities or were employed by governmental geological surveys or museums. This employment pattern continued through much of the twentieth century, but by the 1920s and 1930s the explosive growth of the petroleum industry created an enormous demand for micropaleontologists, who were critical participants in the search for oil and gas. In the 1960s and 1970s the expansion of colleges and universities to cope with the "baby boom" generation meant that many more college geology and biology departments could employ paleontologists. Since the mid-1980s, however, the contraction of the oil industry, the decline in federal funding for science, and the change in priorities within academic departments have meant that employment opportunities for paleontologists are much worse than they were in the heyday of the 1960s. Paleontology now may be contracting to the smaller number of professional positions that it sustained before the oil and baby boom.

While many paleontologists study fossils because they are fascinated with prehistoric organisms and want to understand ancient life, there are also many practical reasons for studying paleontology.

Biostratigraphy

Fossils are the only practical means of telling time in geology. Radioisotopic decay methods, such as potassium-argon or uranium/lead dating, work only in rocks that have cooled down from a very hot state, such as igneous or metamorphic rocks. Most geological history is contained in sedimentary rocks, which cannot be dated by radioisotopes. Consequently, fossil studies are the only practical method of determining the age of rocks in most geological settings. For a long time, the major employers of paleontologists were oil companies, who relied heavily on biostratigraphers to tell them where to find oil. Modern civilization would have been impossible without these specialists. No matter what fads come and go in geology, there will always be a demand for paleontologists who can answer the basic question, "How old is it?"

Evolution

Fossils are the only direct record of the history of life. Although evolutionary biology has made enormous strides studying living organisms such as bacteria, fruit flies, and lab rats, these studies focus on evolution only within the thin slice of time known as the Recent epoch. Fossils provide the only direct evidence of 3.5 billion years of the history of life, and in many cases, they suggest processes that might not be explained by what is known from living organisms. Fossils provide a fourth dimension (time) to the biology of many living organisms. Many groups of organisms, such as conodonts (minute tooth-like fossils) and graptolites (widespread, floating, colonied animals), are extinct and are known only from the fossil record.

Paleoecology

Fossils can provide direct evidence of ancient environments. Although many sedimentary rocks deposited in different environments look very similar, the fossils and trace fossils found within them are often their most distinctive characteristic and provide a way to analyze conditions at the time sediments were deposited. (This process is called "diagnosis.") Fossils can be used to define the depositional environment more precisely than any other property of the sedimentary rock.

Paleogeography

Fossils can be critical to determining ancient continental positions and connections. Some of the earliest evidence for continental drift came from the similarities of fossils on different continents, and paleontological evidence is critical to any understanding of biogeography.

The Value of the Paleontological Perspective

Despite all these important reasons for understanding fossils, most paleontologists enter the profession because fossils and the extinct organisms they represent are fascinating, in and of themselves. The fossil record offers us a unique perspective on life that could never be appreciated from what is alive today. Without the fossil record, who would have imagined that the land was once ruled by such immense creatures as the dinosaurs and that the seas were ruled by equally impressive marine reptiles? Who would have dreamed of some of the bizarre creatures that are now extinct, from the trilobites (marine arthropods) and ammonites (shelled animals related to nautiluses) that once dominated the seas, to the incredible plants and animals of the land and air that once existed? Without the fossil record, who would have guessed that through 85 percent of life's history three billion years there were no organisms on this planet more sophisticated than bacteria, and no organic structures larger than algal mats?

Ecologists assume that the modern complexities of the food web and other principles of ecology are the norm, but the fossil record teaches us that such complex ecological relationships are a relatively recent innovation of life. Through most of life's history, much simpler ecological patterns prevailed. At one time, the land was not dominated by flowering plants, insects, mammals, and birds (which are all relatively late arrivals on this planet), but by simple plants and (if there were land animals at all) millipedes, spiders, and scorpions, and eventually by amphibians and reptiles. Today, the sea is the realm of fishes, clams, snails, and crustaceans, but in the past it was dominated by groups that are either extinct, or still alive but relatively rare in the modern ocean: trilobites, nautiloids, brachiopods, bryozoans, and crinoids. The air was inhabited by flying insects hundreds of millions of years before the first birds or bats, and even flying reptiles preceded the first birds. Without the fossil record, none of these insights into life of the past would have been possible, or would even have been predicted from our knowledge of life today.

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See also Micropaleontology, Vertebrate; Molecular Paleontology; Paleobiogeography; Paleoclimatology; Paleoecology; Paleoethology; Paleomagnetism; Paleontology: Careers for Paleontologists; Paleontology: History of Paleontology

Further Reading

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PALEONTOLOGY: HISTORY OF PALEONTOLOGY

Although the term "paleontology" (or palaeontology, from the Greek meaning the "study or science of ancient life") dates only to 1838, when it first was coined by the British geologist Sir Charles Lyell, the science of ancient life has much earlier roots. The fundamental objects of paleontological study are fossils, a term now used to denote the remains, impressions, or evidences of ancient life-forms preserved in rocks. The word "fossil," used long before there was a true science of paleontology, is derived from the Latin