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The word paleontology is taken from the Greek words 'palaios' meaning old, 'ontos' a being, and 'logos' to study (Hamlyn, 1968). It is usually loosely translated to mean 'the study of past life', or 'the study of fossils'. Though the word itself has been used only in recent times, an interest in fossils (as interesting objects literally "dug out of the earth") is probably as old as humankind.

The subject of this paper is the development of ideas that deal with the significance and origin of fossils. The explanations range from ancient times up to the nineteenth century when fossils became generally accepted as evidences of past life, and paleontology became recognized as an area of scientific inquiry.

Ancient Cultures

Any 'science' in early cultures had to be one that was quickly applicable to survival of humankind. Thus, interest in a science such as paleontology was not important until modern times. However, some people did notice, question and wonder. The Egyptians, with all the mining, building and interest in the natural world that they displayed, must certainly have had some basic knowledge of rock formations and mineralogy, and an idea of natural processes of the earth. However, written references to this knowledge are unknown. The same is true for the Babylonians, though it is known that they considered the stars the force behind catastrophic natural phenomena.

The only ancient written records related to geosciences come from the Greeks. Living in the Mediterranean Sea where earthquakes are a common occurrence and the volcanos are occasionally active, the Greeks were always interested in natural processes, and often wrote down their observations. As long ago as 540 B. C., Xenophanes of Colophon attempted to explain geological phenomena. He wrote that in certain places where earth is mingled with the water of the sea, the former is dissolved by the latter, proof of this being seen in the fact that on land, sea shells are found. Xanthos of Sardis, living around 500 B.C. noticed the shells in the rocks, and concluded that the sea must have covered the places they occurred.

At about the same time, Herodotus described similar fossils in Egypt, and gave his opinion that the shells were probably the indurated remains of food stores of the pyramid builders.

Aristotle (384-322 B.C.), an extremely keen observer, simply stated, "A great many fishes live in the earth motionless and are found when excavations are made" (Adams, 1938). He understood fundamental earth processes, stating:

> The Sea now covers tracts that were formerly dry land, and will one day reappear where we now find land. We must look on these mutations as following each other in a certain order, and with a certain periodicity ... These phenomena escape our notice because they take place successively during periods of time, which in comparison of our brief existence, are immensely protracted (Geikie, 1962).

The Pythagoreans believed in a 'central fire' in the earth — quite a modern view. But, on the other hand, earthquakes were thought to be due to the wind, or as the result of air being forced out of the ground. The Greeks in general had also acquired considerable practical knowledge of stones and their uses. As the Roman culture became dominant on the continent, citizens of the empire used and expanded the practical knowledge of their predecessors, but seemed little concerned with developing explanations of the origin of the materials with which they worked.

The Middle Ages

After the fall of the Western Empire, the learning that survived in Europe was generally restricted to religious establishments, such as the monasteries, which were generally little concerned with natural knowledge; but at least they preserved the works of the older cultures. The Arabs too, treasured the older works and translated and kept alive interest in the sciences in general.

During the Middle Ages and the following Renaissance, ideas that arose to explain the presence of fossils were many and varied, lacking a common base of knowledge of normal earth processes. Many of the old Greek ideas were revised and elaborated. One of the more persistant theories was that "lapidus Figuati," or 'figured stones' were simply mineral concretions with a chance resemblance to live organisms such as the plant-like forms made by frost on a window. Sometimes, this resemblance was assumed to be due to a 'plastic force' in nature, which caused many unrelated forms to have similar appearances, such as the root of a plant resembling the shape of a man or animal. Some observers believed the formative agency to be outside the earth, and due to the occult influence of the stars. A religious fanatic or two postulated the theory that they were due to the forces of evil, intending to mislead or terrify mankind (Geikie, 1962).

Belief that any well-preserved fossil could be due simply to chance or to a purely physical force in nature, and not be organic in origin, may seem far fetched to us. However, knowledge of life processes was very limited until the twentieth century. Pasteur's work to prove that life itself didn't spontaneously originate out of inorganic constituents on a continuing basis was done as recently as the 1860's.

The Renaissance Period

By the time of the Renaissance, organized religion had gained a firm hold on the minds of Europeans. Science was looked upon to support the writings of the Bible, and publishing a work that in any way disagreed with the Holy Book was a punishable crime. At any rate, the view that shells in the rocks were evidence that the land had been a sea floor, now raised above the water, became unpopular. An argument against continental upheavals was that the Bible stated that land and sea were separated on the third day of creation, while animal life did not begin until the fifth day.

An acceptable escape from this dilemma was to use major flooding as a explanatory force to cause mass mortality of animals and quickly bury them in an earthen matrix. Though the original proponent of this view is unknown, the idea of a wide-spread or universal deluge caught on quickly and was very popular for a long time. The Church was very supportive of this view, since it nicely supported Noah's great flood. However, this theory failed to explain neighboring rock units of totally different fossil fauna, and it assumed fossil-bearing rock formations were very young.

Alternative explanations were not totally eliminated. In 1508 Leonardo da Vinci explained the organic nature of seashells dug from a canal near his home, and he especially ridiculed the notion that they could have been formed by the influence of the stars. He gained little attention, however.

In 1564, Falloppipo of Padua put forth his view that these "figured stones" were due to a process of fermentation set up in the rocks where fossils are found. He even went so far as to say that the circular movement of these vapors formed the buried urns and pots that occasionally were also found buried, never recognizing their human workmanship (Adams, 1938).

Another original idea was presented by Majali, who suggested that fossil shells were ejected by the force of submarine volcanic explosion. By the middle of the 1600's, however, a few scientists began to realize the true nature of fossils and the processes involved in their formation. In 1669, Nicolas Steno published his findings on studies of rocks and the fossils they contained. A summary of his views from Geikie (1962) will show why his work is referred to even today:

> The strata of the earth are such as would be laid down in the form of sediment from turbid water. The objects enclosed in them, which in every respect resemble plants and animals, were produced exactly in the same way as living plants and animals are produced now. Where any bed encloses either fragments of another, and therefore older, bed, or the remains of plants or animals, it cannot be as old as the time of the Creation. If any marine production is found in any of these strata, it proves that at one time the sea has been present there; while, if the enclosed remains are those terrestrial plants or animals, we may suspect the sediment to have been laid down on land by some river or torrent.

He goes on to state rules for determining relative ages of the rock units, and was one of the first to stress the idea that the earth's crust contains a record of a chronological sequence of events, and that the history of the earth can be deciphered from it.

Despite work like this, based on awareness that remains of past life are indicators of conditions at that time, other theories were still common.

In 1678, Athanasius Kircher, Jesuit monk and author of several volumes, expressed belief in a 'Spiritus Plasticus' being responsible for the shapes of 'fossils' that included letters of the Greek and Latin alphabet, geometrical figures, and representations of heavenly bodies. In 1705, Robert Plot put forth his opinion on the question of the day:

> This brings me to consider the great question, whether the stones we find in the forms of shell-fish be lapides sui generis (formed of the earth) naturally produced by some extraordinary plastic virtue, latent in the earth? Or whether they rather owe their form to the shells of the fishes they represent, brought to the places where they are now found by a Deluge, earthquake, or some other means, and being turned into stones as we find them now? I must confess I am inclined to the opinion that they are lapides sui generis, than that they are formed in an animal Mould. The latter opinion appearing at present to be pressed with far more insuperable difficulties than the former (Adams, 1983).

He then asks why fossils could not be 'ornaments' for the inner parts of the earth, since flowers have been created to adorn the surface of the earth, although like fossils, they are of no use.

To confuse the issue further, Johann Beringer (1667-1738), a professor of medicine at the University of Wurzburg, became the victim of an unusual joke. A keen fossil hunter, he often went searching along neighboring hillsides for figured stones. These he found in good quantity, containing all kinds of interesting shapes, pictures, and alphabet letters. It seems that some students had been having a good time making these clay figurines and placing them in areas where he often went searching. When the prank was revealed, Beringer attempted to buy back his own publication in order to save his reputation (Scott, 1973). Hoaxes such as this tended to discredit even the best of work in fossil studies.

Later Developments

The debate continued and basically was not settled until the end of the 18th century, when the evidence increasingly favored those who believed in the organic origin of fossils.

Carl Linnaeus (1707-1778) included a number of fossil forms in his great attempt to classify all animals and plants, *Systema Naturae.*

On the practical side, by 1791 an English drainage engineer named William Smith realized that the fossil content of the rocks was the clue to unraveling the succession of strata. In developing his interest in finding an easy way to identify rock units for specific uses, he published the first geologic map of England and a scheme for correlation of different rock units based on his recognition that fossils and formations occur in an orderly sequence (Gillispie, 1951).

The individual that probably had the greatest influence on ending debate on the origin of fossils was Georges Cuvier (1769-1832). Being an expert comparative anatomist and a well-known scientist, he prepared excellent reconstruction of fossil forms and began to understand the relative ages of many fossils. He recognized the progression of vertebrate forms, from fish to mammals, but did not believe in any transmutation theory (Bowler, 1976).

The study of fossils came to be identified in the nineteenth century as a legitimate branch of scientific research bridging both geology and biology. It was christened "paleontology" by Ducrotay de Blainville and Fischer von Waldheim in 1834 and gained a sort of notoriety after Darwin's *Origin of the Species* (1859) helped put the new science in a cross-fire between evolutionists and creationists.

In the United States of the 1870's, paleontologists were known as "bone-hunters" or "bone-pickers" by western settlers. Native Americans had even less flattering labels for them. On record is the verdict of the Sioux that F.V. Hayden was a lunatic and therefore under the protection of Wakan Tanka (Russell, 1976). That was the level of tolerance for a new science one hundred years ago, when humankind was just beginning to read life history written in the rocks.

Some Reflections

Why did it take so long to 'prove' that fossils were once living, and they died where rock now lies? The biggest problem was a simple lack of understanding of geologic processes. Until there was some idea of how rock itself was formed, and the differences in rock types were recognized, it was impossible for even a knowledgeable person to sort improbabilities from possibilities. Over-generalizations also got in the way. A fossil was termed a 'figured stone' and any unusually shaped stone was included into this group. Only when awareness grew that these didn't all have the same origin did men generate theories that better fit their observations.

Religion, of course, was a problem for a while. No one was going to risk a heresy trial over the origin of a fossil shell or fish. Also, the idea of individual, discrete acts of divine creation of recent origin had widespread appeal. It kept cosmology on a human scale that was more readily grasped and appreciated than is the idea of a cosmic continuum and humbling awareness of geologic history billions of years longer than man's existence.

Summary

Fossils have been known to man since pre-historic times. Some early philosophers arrived at a conception of the organic nature of fossils and imagined movements of the sea which allowed marine creatures to get isolated on land.

During the Middle Ages, fossils were generally considered freaks of nature, inorganic products of physical forces. Later, after the Renaissance brought fresh interest in the sciences, fossils were shown to be the remains of once living animals and plants. Eventually, in the nineteenth century, study of these remains became a recognized speciality known as the science of paleontology.

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