Creating the Nation's first BioPark

National Zoological Park · Smithsonian Institution · Washington, D.C. 20008-2598

1846–1996 Smithsonian

Letter From the Desk Of David Challinor
June 1997

In last month's letter, I discussed the possible role of humans in species extinction. This letter will consider how some animals became extinct independently of human action and how other animals successfully survived for extraordinarily long periods of time.

Other than some archeobacteria that may still survive from life's origin on earth, most (99+%) organisms that evolved on this planet have become extinct. Extinction is the rule rather than the exception. Massive species extinction is best attributed to the dynamic condition of the earth. Continents continually move in all directions (up, down and sideways), global polarity reverses at roughly 100,000-year intervals,[1] and our planet is constantly (in geological time) bombarded with projectiles from space. Earth's rotation is gradually slowing (1 second every 50,000 years) and the moon is spiraling away from us at about 1-1/2" a year. Subject to such unexpected and irregular assaults and changes, it is no wonder that so many of earth's organisms do not adapt quickly enough to new conditions to survive.

Organisms that apparently survived for millions of years are those that could tolerate a range of temperatures and changing physical conditions. Thus when extreme climate change occurred after a long, enduring, stable environment, some species survived by moving to habitats that were protected from these extreme changes. For example, the deep-dwelling coelacanth, a fish living around the Cormoro Islands in the Madagascar Channel, is the sole surviving species of at least 60 species of coelacanth that thrived during the Devonian period (350 to 400 million years ago). Today's coelacanth has hardly changed from its closest ancestor of 60 million years ago, as observed in fossils. Evidently the original coelacanths were shallow water dwellers, so their remains were quickly covered with silt and bottom sediments, thereby ensuring good fossil remains. At the end of the Cretaceous period (65 million years ago), some coelacanths moved to deeper water where conditions for fossil formation do not exist, and hence no coelacanth fossils from that period on have been found. Living conditions at a depth of 300 m evidently stayed uniform enough for the present coelacanth to survive for 60 million years.

---

[1]The earth's current polarity is north, i.e. a compass points to the north magnetic pole. When polarity reverses, a compass would point to a south magnetic pole.

If a species cannot find a uniform safe habitat as did the coelacanth, another extinction avoidance strategy is to be flexible in habitat requirements. Fossil records show that during the Pleistocene era in North America (the last 1 million years), there existed about 15 species of carnivores, coyote-sized or larger; today there are only seven. Gone are the sabertooths, dire wolves, short-faced bears, huge American lions and bear-dogs. Coyotes, however, are still expanding across North America in a variety of habitats from California suburbs to New England forests by exploiting a varied diet of plants and animals. Some animal species, particularly insects that are short-lived but prolific breeders, can adapt to change by exploiting those characteristics of its morphology through breeding that allows them to survive long enough to develop into a new species. Natural extinction of those members of the species that had disadvantageous characteristics can occur rapidly, in a few centuries or even decades, in sharp contrast to the successful endurance of the coelacanth and the coyote.

Extinctions thus occur when habitat conditions change too rapidly for the occupants to adapt. Species disappear for reasons as varied as the loss of their regular food source and an inability to switch to other diets, or by being unable to adapt to variations in sunlight, temperature, nutrient regimes, parasites, predators, diseases, salinity and a host of other critical factors. The scale of such extermination ranges from declining single species units succumbing to a species-specific disease or parasite, to whole orders of fauna such as the dinosaurs. Although humans watched the death of the last known passenger pigeon, human-observed extinctions are relatively rare events. For evidence of prehuman extinctions, scientists must depend on fossil dating to record when a species died out.

Fossils are the critical evidence of prehistoric life. The conditions necessary to create and preserve fossils, however, are limited. Plant and animal remains are preserved in ancient tar pits, at the bottom of sink holes, and in the compacted sediment of sea and lake beds. For the latter only tectonic upheaval can bring the buried fossilized remains to the terrestrial surface for paleontologists to find. Only the hard parts of animals (bones, teeth, shells, etc.) are preserved; soft parts, except for the occasional outlines of soft tissue, almost always disappear. However, despite this limitation, paleontologists can reconstruct the general appearance of long extinct animals and plants from their scattered remains.

The more fossils scientists collect and identify, the clearer becomes the image of past life on our planet. The greatest extinction of animals, determined to date through fossil records, occurred at the end of the Permian era (240 million years ago).

More than 90% of species in the oceans and about 70% of terrestrial vertebrate families disappeared. Insects were also reduced; 8 of 27 known orders of Permian insects disappeared. Plant fossils, however, showed relatively little evidence of mass extinctions. At the time of these mass extinctions Pangea, the super continent, still existed and scientists can only speculate as to what caused such a catastrophic event and how long it went on: two million years? one million years? or less?

The Permian-Triassic boundary calamity was probably the result of a combination of factors, all with complex interactions. One hypothesis proposes a three-phase sequence: Climate changes caused marine basins to dry out, thereby reducing the habitat area of shallow water invertebrates; concurrently, massive volcanic eruptions may have darkened the daylight; and global warming from a build-up of CO_2 in the atmosphere may have depleted O_2 in the ocean depth causing anoxia and further disruption of life.

Fossil records show the next great extinction occurred at the boundary of the Jurassic and Cretaceous eras (roughly 145 million years ago). Recent evidence indicates that this extinction event could have been partially caused by a meteorite impact near the border of Botswana and South Africa, which produced a crater about 75 km wide. Although extinctions were not as great as those of the Permian/Triassic boundary, nevertheless about 20% of all groups of species were wiped out. A meteorite, when approaching the earth at a steep angle, compresses the air before it so densely that at contact the energy release is so great that the meteorite evaporates instantaneously, resulting in a huge explosion that carries the resulting debris high into the stratosphere. There the dust soon circles the earth, blocking a portion of normal sunlight. This reduction in solar radiation evidently had such a direct effect on photosynthesis and other solar-controlled processes that global climate was severely altered until the atmospheric debris settled.

A third massive global extinction re-occurred almost a million years later at the boundary of the Cretaceous and Tertiary eras (65 million years ago). Strong geological evidence indicates that this event also coincided with a meteorite striking the earth near Mexico's Yucatan Peninsula. The resulting crater is about 300 km wide. Other geological evidence indicates increased volcanic activity during this period, as well as falling sea levels. This extinction event is perhaps the best known because it marked the demise of the dinosaurs, which had successfully dominated life on earth for about 70 million years. These beasts died out because, we surmise, they could not adapt to the changed global climate.

More abrupt extinctions occurred among single-celled marine organisms. Charles Marshall of UCLA believes that fossil evidence shows that 50 to 75% of ammonite species, which resembled the spiral-shelled Chambered nautilus on exhibit at the Zoo, disappeared along the west coast of Europe about the time of the Yucatan meteorite impact. Until then they were one of the dominant invertebrate species in the shallow waters of the world's oceans and their fossils are relatively common in many parts of the world.

The climate changes that most likely ended the dinosaurs' reign in the Tertiary era (65 million years ago) left a wide new habitat for endothermic mammals to exploit. Although some scientists think that there may have been warm-blooded dinosaurs, others believe that had there been, they probably were not as tolerant of temperature extremes as mammals. In any case, mammal species soon evolved elaborate strategies for cold weather survival, including hibernation, caching mast (acorns, beech nuts, etc.) for winter food, and changing diet to eat the foliage of evergreens and the shoots of hardwoods. Many developed thick coats for insulation against low temperatures. Their rapid evolution was perhaps most remarkable in North and South America where, until the end of the Pleistocene era (about 12,000 years ago), an impressive assemblage of mammals occupied both continents, free from human competition. This is an example of the global replacement of a large and complex population (dinosaurs) by its contemporaries (birds and mammals).

There are myriad organisms sharing the earth with humans today and understandably we interact principally with those we can easily see, use and enjoy. However, we should realize that the first kingdom of life[2] -- the monera or one-celled organisms without a cell nucleus -- have been on earth since life began; they seem to be the most adaptable of all life forms. They can live inside us, in boiling hot springs, and even in deep sea volcanic vents where they convert the hydrogen sulfide gas spewing into the water into proteins. Considering their ubiquitousness and success at exploiting our planet, we should all be humbled because our presence here on earth is but a fleeting moment compared to the duration of their presence.

David Challinor
202/673-4705
202/673-4607 FAX

---

[2]The five kingdoms of life are: Monera; Protists (one-celled organisms with a nucleus); Fungi, Plants, Animals.