Animal Origins—The Cambrian Explosion

The geological timescale is marked by significant geological and biological events, including the origin of the earth about 4.6 billion years ago, the origin of life about 3.5 billion years ago (*see the box* "The Origin of Life on Earth—Life from Nonlife"), the origin of eukaryotic life-forms about 1.5 billion years ago, and the origin of animals about 0.6 billion years ago. The latter event marks the beginning of the Cambrian period. Animals originated relatively late in the history of the earth—in only the last 10% of the earth's history. During a geologically brief 100-million-year period, all modern animal phyla (along with other animals that are now extinct) evolved. This rapid origin and diversification of animals is often referred to as "the Cambrian explosion."

Scientists have asked important questions about this explosion since Charles Darwin. Why did it occur so late in the history of the earth? The origin of multicellularity seems a relatively simple step compared to the origin of life itself. Why do no fossil records document the series of evolutionary changes during the evolution of the animal phyla? Why did animal life evolve so quickly? Paleontologists continue to search the fossil records for answers to these questions.

One interpretation regarding the absence of fossils during this important 100-million-year period is that early animals were soft-bodied and simply did not fossilize. Fossilization of soft-bodied animals is less likely than fossilization of hard-bodied animals, but it does occur. Conditions that promote fossilization of soft-bodied animals include very rapid covering by sediments that creates an anoxic environment that discourages decomposition. In fact, fossil beds containing soft-bodied animals have been known for many years.

The Ediacara fossil formation, which contains the oldest known animal fossils, consists exclusively of soft-bodied forms. Although named after a site in Australia, the Ediacara formation is worldwide in distribution and dates to Precambrian times. This 700-million-year-old formation gives few clues to the origin of modern animals, however, because paleontologists believe it represents an evolutionary experiment that failed. It contains no ancestors of modern animal phyla.

A slightly younger fossil formation containing animal remains is the Tommotian formation—named after a locale in Russia. It dates to the very early Cambrian period, and it also contains only soft-bodied forms. At one time, the animals present in these fossil beds were assigned to various modern phyla, including the Porifera and Cnidaria, but most paleontologists now agree that all Tommotian fossils represent unique body forms that arose early in the Cambrian period and disappeared before the end of the period, leaving no descendants in the modern animal phyla.

A third fossil formation containing soft-bodied animals provides evidence of the results of the Cambrian explosion. This fossil formation, called the Burgess Shale, is in Yoho National Park in the Canadian Rocky Mountains of British Columbia. Shortly after the Cambrian explosion, mud slides rapidly buried thousands of marine animals under conditions that favored fossilization. These fossil beds provide evidence of virtually all of the 32 phyla described in this text, plus about 20 other animal body forms that are so different from any modern animals that they cannot be assigned to any one of the modern phyla. These unassignable animals include a large swimming predator called *Anomalocaris* and a soft-bodied, detritus- or algae-eating animal called *Wiwaxia*. The Burgess Shale formation also has fossils of many extinct representatives of modern phyla. For example, a well-known Burgess Shale animal called *Sidneyia* is a representative of a previously unknown group of arthropods (insects, spiders, mites, crabs).

Fossil formations like the Burgess Shale show that evolution cannot always be thought of as a slow progression. The Cambrian explosion involved rapid evolutionary diversification, followed by the extinction of many unique animals. Why was this evolution so rapid? No one really knows. Many zoologists believe that it was because so many ecological niches were available with virtually no competition from existing species. Will zoologists ever know the evolutionary sequences in the Cambrian explosion? Perhaps another ancient fossil bed of soft-bodied animals from 600-million-year-old seas is awaiting discovery.