Section C: The Origins of Animal Diversity

1. Most animal phyla originated in a relatively brief span of geological time
2. “Evo-devo” may clarify our understanding of the Cambrian diversification
1. Most animal phyla originated in a relatively brief span of geological time

- The fossil record and molecular studies concur that the diversification that produced most animal phyla occurred rapidly on the vast scale of geologic time.
- This lasted about 40 million years (about 565 to 525 million years ago) during the late Precambrian and early Cambrian (which began about 543 million years ago).
The strongest evidence for the initial appearance of multicellular animals is found in the last period of the Precambrian era, the Ediacaran period.

Fossils from the Ediacara Hills of Australia (565 to 543 million years ago) and other sites around the world consist primarily of cnidarians, but soft-bodied mollusks were also present, and numerous fossilized burrows and tracks indicate the presence of worms.

Recently, fossilized animal embryos in China from 570 million years ago and what could be fossilized burrows from rocks 1.1 billion years ago have been reported.

Data from molecular systematics suggest an animal origin about a billion years ago.
• Nearly all the major animal body plans appear in Cambrian rocks from 543 to 525 million years ago.

• During this relatively short time, a burst of animal origins, the **Cambrian explosion**, left a rich fossil assemblage.
  
  • It includes the first animals with hard, mineralized skeletons
• Some Cambrian fossils in the Burgess Shale in British Columbia and other sites in Greenland and China are rather bizarre-looking when compared to typical marine animals today.

• Some of these may represent extinct “experiments” in animal diversity.

• However, most of the Cambrian fossils are simply ancient variations of phyla that are still represented in the modern fauna.
• On the scale of geologic time, animals diversified so rapidly that it is difficult from the fossil record to sort out the sequence of branching in animal phylogeny.

• Because of this, systematists depend largely on clues from comparative anatomy, embryology, developmental genetics, and molecular systematists of extant species.
2. “Evo-devo” may clarify our understanding of the Cambrian diversification

- There are three main hypotheses for what caused the diversification of animals.

(1) **Ecological Causes**: The emergence of predator-prey relationships led to a diversity of evolutionary adaptations, such as various kinds of protective shells and diverse modes of locomotion.

(2) **Geological Causes**: Atmospheric oxygen may have finally reached high enough concentrations to support more active metabolism.
(3) Genetic causes: Much of the diversity in body form among animal phyla is associated with variations in the spatial and temporal expression of Hox genes within the embryo.

- A reasonable hypothesis is that the diversification of animals was associated with the evolution of the Hox regulatory genes, which led to variation in morphology during development.
  - Biologists investigating “evo-devo,” the new synthesis of evolutionary biology and developmental biology, may provide insights into the Cambrian explosion.
- These three hypotheses are not mutually exclusive.
Some systematists studying animal phylogeny interpret the molecular data as supporting three Cambrian explosions, not just one.
• For the three main branches of bilateral animals - Lophotrochozoa, Ecdysozoa, and Deuterostomia - the relationships among phyla within each are difficult to resolve, but the differences between these three clades are clear, based on their nucleic acid sequences.

• This suggests that these three clades branched apart very early, probably in the Precambrian, perhaps associated with the evolution of the Hox complex.

• Rapid diversification within each clade may have been driven by geological and/or ecological changes during the early Cambrian.
• By the end of the Cambrian radiation, the animal phyla were locked into developmental patterns that constrained evolution enough that no additional phyla evolved after that period.

• Variations in developmental patterns continued, allowing subtle changes in body structures and functions, leading to speciation and the origin of taxa below the phylum level.

• In the last half-billion years, animal evolution has mainly generated new variations on old “designs”.

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