

Genetics and Evolution IB 201 06- Lecture 7

Cambrian Explosion & the Fossil Record

I History of Life

This is represented unevenly in the fossil record. Enormous gaps exist in the organisms that have been preserved over time, eons of time. The earth is 4,550 million years old (abbreviated Ma for *mega anna*), but only at about 550 Ma are there good records of the first appearance of hard-shelled animals, including trilobites (lobster-like marine organisms) and mollusks. Between 550 and the 40 Ma comprising the Cambrian period, most of the major phyla appear in the fossil record. This rapid burst of organic diversity of multicellular organisms, known as the **Cambrian explosion**, occurred within only 0.9% of the overall history of the planet. The remaining time since then represents only about 14% of the overall history of the earth. The eon that preceded the Cambrian boundary is known as the **Precambrian (= Archaean and Proterozoic eras)** and represents the other 85% of earth's history (approx. **4 billion years**).

II. Geological Time Scale

To appreciate this massive radiation and put it into perspective with the overall history of the earth, it is necessary to understand the geological history of the planet. The 4.5 billion years since the earth was formed has been divided into a hierarchical scale of time periods (see F&H, pp. 58-59). The scale was based originally on different distinctive rock strata found beneath the surface of the earth, each layer with a unique set of plant and animal fossils (**index fossils**), which represent different time intervals.

The earliest intervals are associated with the deeper layers of rock, the more recent time intervals correspond to the upper layers. This was known as the **Law of Superposition** (younger above, older below). The relative age of each interval, each with their unique fossils, have more recently been assigned absolute dates based on the technique of radiometric dating (see F&H, pp. 58-top 62).

Geological Time Intervals (eons, eras, periods, epochs, stages) [= e e p e s]

Eon 1: Precambrian—4,550 – 5,550 Ma (4.55 - 5.55 billion yrs) [Ma = *mega anna*, or mya = million years ago]

Eon 2: Phanerozoic—550 mya - Present

- **Era 1: Paleozoic** (lasted 292 million years)

Periods: Cambrian, Ordovician, Silurian, Devonian, Missippian, Pennsylvanian, and Permian [C O S D M P P E]

- **Era 2: Mesozoic** (186 million yrs)

Periods: Triassic, Jurassic, Cretaceous

- **Era 3: Cenozoic** (65 million yrs to present)

Period: Tertiary

Epochs: Paleocene, Eocene, Oligocene, Miocene, Pliocene [P E O M P]

Period: Quarternary

Epochs: Pleistocene, Holocene

**Familiarize yourselves with the time of first appearance of the most basic fossil plant forms (e.g., first appearance of flowering plants) and animal forms of the major geological Periods. In particular know when the first bacteria, eukaryotes, land plants, jawless fish, fish with jaws, insects, dinosaurs, mammals, placental mammals, first apes, earliest *Homo* came on the scene (Use, e.g., Figure 2.18, p. 59,

III. Darwin's Dilemma

The abrupt absence of apparent fossils in the strata below the Cambrian layer (the oldest rocks) looked like a void in the history of life, and in Darwin's view, posed a threat to his theory that all organisms, living and extinct, evolved from earlier common ancestors.

Where were the Precambrian ancestors?

Although recognized as a dilemma in the mid-1800's, it wasn't until the mid-1900's that significant Precambrian fossils were found. These were not large, multi-celled organisms, but rather minute **microfossils**, extremely difficult to find and study.

Where Have all the Fossils Gone?

The fossil record is largely due to chance contingencies:

Erosion—rocks weather away and are carried to oceans where they settle (70% of earth surface covered by oceans). Eroded rock formations leave *gaps*. Nowhere does a continental rock sequence cover all ages.

Plate tectonics—movement of continental masses over the globe destroys ocean sediments and contorts the land masses. Oldest ocean deposits are young—not more than 250 Ma.

Although the plates move only 3 cm/ yr, they move apart with sudden jerks, causing earthquakes. The collision of plates causes sediments to be pushed deep into the magma and melted; they bubble up to form mountains such as the Himalayas and Andes.

Recycling—99.9% of all organic matter is recycled (death, decay, reabsorption). The 0.01% not recycled is the pool that fossils come from. Fossils are unrecycled pieces of dead organisms, but only the hard parts that resist decay: shells, bones, teeth, chitin of insects.

Precambrian microfossils (e.g., cyanobacteria and single-celled algae) are even more vulnerable

Biology and Geology conspire to obscure

- Must be buried to escape recycling
- Escape being crushed and compacted
- Tiny and hard to detect
- When detected, require painstaking preparation to see microfossils

IV. Cambrian Explosion of Animals: Diversification of Body Plans

A. Development of the Embryo and Body Plan

Diploblast : [Ctenophora (comb jellies) and Cnidaria (jelly fish)]

2 embryonic tissues (ectoderm, endoderm)

— usually with radial symmetry, or asymmetric

Triploblast [All other animals]

3 embryonic tissues (ectoderm, endoderm and mesoderm)

usually with bilateral symmetry (left/right)

B. Major Phylogenetic Splits in the Animal Tree

Phylogeny divides the Animals into two big groups, based on the basic body plan

Radially symmetric groups

Ctenophora

Cnidaria

Bilaterally symmetric groups

Bilateria = the rest of the animals

Protostomes: during gastrulation of embryo mouth area forms first

Deuterostomes: gastrulation forms mouth secondarily, after anal region

C. Important Fossil Discoveries:

Ediacaran Fauna (South Australia)—565 Ma: (Martin Glaessner in 1950)
oldest known fossils of multicelled animals; all soft-bodied— sponges, jellyfish, etc

Burgess Shale (Canadian Rockies)— 520-515 Ma: (C. D. Walcott in 1909)
trilobites (arthropods), molluscs, chordates, jawless lampreys

Questions to consider:

1. What are some of the morphological innovations in organisms that occurred during or just before the Cambrian explosion?
2. What ecological interactions may have influenced the evolution of the Cambrian forms?

References

- Freeman, S. and Herron, J. C. *Evolutionary Analysis*, 3rd Ed. Prentice Hall, New Jersey. (pp. 663-677).
- Schopf, J. W. 1999. *Cradle of Life: The Discovery of Earth's Earliest Fossils*. Princeton Univ. Press, Princeton.
- Winchester, S. 2002. *The Map that Changed the World: William Smith and the Birth of Modern Geology*. HarperCollins, New York.