Chapter 17 Study Guide and Case Studies: Life and Mass Extinctions

Key Concepts

- Earth is uniquely positioned in the Solar System and has favorable orbital parameters that climate is moderate.
- Together with organic compounds, H₂O in liquid form is considered a key chemical to allow the development of life as we know it.
- The origin of water in the Solar System is debated. Two proposed sources are primordial water within the solar System, and comets.
- A somewhat dated scheme to classify life has 5 (or 6) kingdoms (e.g., plants, fungi, animals) that branch out into subcategories. In that tree of life, homo sapiens shares a common ancestor with apes and birds evolved from dinosaurs.
- Earth was lifeless for the first billion years. For the following 2 billion years, only prokaryotes existed, first archaeobacteria, shortly after eubacteria including cyanobacteria that are capable of photosynthesis. Eukaryotes (lifeforms with cells containing a nucleus) as single-celled organisms followed 1.1 billion years ago.
- Life as we know it (incl. lifeforms with hard parts) developed only about 550 million years ago at the beginning of the Cambrian period. This is the time when life forms with easy-to-fossilize hard parts developed.
- Fossils are hard remnants of ancient life forms. Fossils are either hard parts that turned into rocks, or structures that reacted with chemicals to harden, or casts in rock left behind when soft parts occupied that space. That space may have been filled by other chemicals later.
- Cambrian explosion of life: During a 40-million-timespan, life 'exploded' into many different species along the tree of life. All lineages on the tree of life developed during that time.
- With the arrival of cyanobacteria, photosynthesis profoundly changed the composition of Earth's atmosphere, adding oxygen, and removing some carbon dioxide. Most carbon dioxide was probably removed by geological processes (weathering of rock).
- Photosynthesis is the number 1 oxygen producer on Earth. It uses sunlight, water and carbon dioxide to produce cellulose (or sugars) and oxygen.
- On other planets and satellites, other life forms may exist whose metabolism is based sulfur (chemisynthesis) instead of on oxygen, though this process is slower.
- Earth's history is categorized in eons, era, and periods. Earth's history of the last 550 million years is divided into 11 major periods, starting with the Cambrian. The beginning and end of a period is largely dictated by the geological fossil record. A new period typically begins at a time of a mass extinction or other major change in the environment.

- The current period is the Quaternary. The Quaternary is subdivided into epochs. The most recent one is the Holocene that started at the end of the last ice age.
- In an extinction of a species, so many individuals die that reproduction fails. In a mass extinction, many species are affected.
- A mass extinction can be triggered by the removal of just one species in the food chain
- While Earth has witnessed extinctions of species throughout its history, there were 5 major natural mass extinctions at the end of the following periods: Ordovician, Devonian, Permian, Triassic, Cretaceous
- The mass extinction at the end of the Permian area affected 90% of all species, and 60% of marine life. Possible causes include a massive release of Methane and related global warming, an asteroid impact, or massive flood basalt eruptions in Siberia.
- The mass extinction at the end of the Cretaceous caused the demise of the dinosaurs. It was most likely triggered by an asteroid impact that created the Chixhulub crater. A second possibility is massive flood basalt eruptions in India (Deccan Traps).
- The current mass extinction is mainly due to human activity, incl. deliberate and accidental extinctions.
- Natural causes of mass extinctions include, impact of large space objects, climate change, plate tectonics, massive (flood basalt) volcanism, sea level change, changes in ocean processes and chemistry, release of greenhouse gases (particularly methane, gas hydrates). Also: interruption of the food chain, new predators or competitors, new diseases, habitat loss.
- Anthropogenic causes of mass extinction include the last 4 factors, but also release of greenhouse gases, use of herbicides, pesticides and toxins, overhunting and overharvesting.
- Species extinction at the end of the last ice age may have been caused by climate change but also by humans and they increased needs for food and building materials. Some species include the woolly mammoth, mastodon, giant sloth, saber-toothed tigers but also the steppe bison and wild horses.
- More recent extinctions include many flight-less birds that went extinct shortly after their discovery by humans, mainly as a consequence of overhunting but also as a consequence of introducing cats and other predators.

Key Terms

- Solar System
- Primordial water
- Archaeobacteria
- eubacteria
- cyanobacteria
- eukaryotes
- photosynthesis

- chemisynthesis
- eons, eras and periods
- Life as we know it
- Cambrian explosion of life
- Extinctions and mass extinctions
- Fossils
- Quaternary

- Holocene
- Ice age
- Earth's five major mass extinctions
- Earth's sixth mass extinction
- Causes of mass extinctions
- Impacts
- Climate change

- Release of greenhouse gases
- Habitat loss
- Interruption of food chain
- Introduction of predators, competitors, diseases, toxins
- Sea level change
- Flood basalts

Questions for Review

- 1. What are astronomical factors that allowed life on Earth to develop?
- 2. What are chemical factors that allowed life on Earth to develop?
- 3. Where did water on Earth come from?
- 4. What kind of life did Earth have during its first billion years?
- 5. Describe the emergence of life forms on Earth throughout its history?
- 6. Why would the fossil records be 'more complete' since about 550 Mio years ago?
- 7. How did photosynthesis get started on Earth?
- 8. Which process is the most important process on Earth to produce atmospheric oxygen?
- 9. How is Earth's history divided?
- 10. What is an extinction of a species? How does it differ from a mass extinction?
- 11. When were Earth's major mass extinctions?
- 12. What are natural causes of mass extinctions?
- 13. What are possible causes for the mass extinction near the end of the Permian period?
- 14. What are possible causes for the mass extinction near the end of the Cretaceous period?
- 15. What are possible causes for the mass extinction at the end of the last ice age?

Case Studies

Case Study 1: DDT and Bird Eggs – A nearextinction



Figure 17.C1 Brown Pelicans roosting at La Jolla Cove. The birds exhibit their mating plumage (black neck). The bird was listed under the U.S. Endangered Species Act from 1970 to 2009. Since 1988, the IUCN lists the bird 'a species of least concern' after it rebound following the ban of DDT.

An example of an unintended near catastrophe for birds was the introduction of dichlorodiphenyltrichloroethanol (DDT). First synthesized in 1874, it was discovered in 1939 as a very effective insecticide, and was used in the 1940s against disease vectors such as mosquitoes that transmit malaria and typhus. DDT was advertises as harmless to humans and its Swiss discoverer Paul Hermann Müller received the Nobel Prize in Medicine. But DDT had catastrophic environmental effects. The 1962 book 'Silent Spring' cataloged the decimation of birds in areas where DDT was used. DDT builds up in fat tissue and reduces calcium in egg shells. The egg shells were too thin for successful breed and hatch. Among many songbirds affected, larger birds such as the Brown Pelican, the Bald Eagle (the national bird of the U.S.), the Osprey (fish hawk) and the Peregrine Falcon also were driven to near-extinction. While the carcinogenic role of DDT in human is still an area of research, DDT also decimated 'useful' insects such as pollinators. The book and the public outcry it caused led to the ban of DDT in the U.S. in 1972. A worldwide ban on agricultural use was formalized under the Stockholm

Convention on Persistent Organic Pollutants though its limited use continues. Since the ban, many birds have made a comeback, including the Brown Pelican, the Bald Eagle and the Peregrine falcon.