Earth Science, 12e
Earth’s Evolution through Geologic Time
Chapter 12
Birth of a planet

• The history of Earth began about 13.7 billion years ago with the Big Bang.
• This provided the elements, along with material from former stars, to form the solar system.
  • As material collected, high-velocity impacts of matter, called planetesimals, caused Earth’s temperature to increase.
Birth of a planet

• Formation of Earth
  • Iron and nickel melted and sank to form the metallic core while rocky material rose to form the mantle and Earth’s crust
Formation of the early Earth

Figure 12.5
Origin of the atmosphere and oceans

- Earth’s primitive atmosphere, which consisted mainly of $\text{H}_2\text{O}$ vapor and $\text{CO}_2$, formed by a process called **outgassing**
  - Gases trapped in the planet’s interior are released by volcanic eruptions
  - This process continues today
Origin of the atmosphere and oceans

- Water vapor condensed to form clouds and rainwater that formed the oceans.
- About 3.5 billion years ago, photosynthesizing bacteria began to release oxygen.
  - Oxygen levels steadily increased over time.
  - Eventually, oxygen levels were sufficient for ozone to develop in the atmosphere.
Origin of the atmosphere and oceans

- Outgassing produced acidic conditions that caused an accelerated rate of weathering of Earth’s rocky surface
  - Products of this weathering were carried to the oceans, thus increasing the salinity of the oceans
  - Oceans also served as a depository for carbon dioxide
Precambrian history

- The Precambrian, which is divided into the Archean and the Proterozoic eons, spans almost 90% of Earth’s history.
  - Much of Earth’s stable continental crust was created during this time.
    - Partial melting of the mantle formed volcanic island arcs and ocean plateaus.
    - These crustal fragments collided and accreted to form larger crustal provinces.
Precambrian history

• The Precambrian, which is divided into the Archean and the Proterozoic eons, spans almost 90% of Earth’s history
  • Much of Earth’s stable continental crust was created during this time
    – Larger crustal areas were assembled into larger blocks called cratons
    – Cratons form the core of modern continents
Formation of continental crust

Figure 12.12

Collison of volcanic arcs and oceanic plateau to form larger crustal fragment.

Melting in lower crust to form granitic magmas.
Precambrian history

• **Supercontinents**
  - Large landmasses that consist of all, or nearly all, existing continents
  - *Pangaea* was the most recent, but perhaps an even larger one, *Rodinia*, preceded it
  - Splitting and reassembling of supercontinents have generated most of Earth’s major mountain belts
  - Supercontinents have also profoundly affected Earth’s climate over time
Possible configuration of Rodinia

Figure 12.15
**Phanerozoic history**

- Phanerozoic eon encompasses 542 million years
  - Divided into the *Paleozoic, Mesozoic,* and *Cenozoic* eras

- **Paleozoic era**
  - Dominated by continental collisions as Pangaea began to assemble
    - Formed the Caledonian, Appalachian, and Ural Mountains
Formation of Pangaea
Phanerozoic history

- Mesozoic era
  - Early in the Mesozoic, much of the land was above sea level
  - By the middle Mesozoic, seas invaded western North America
  - Pangaea began to break apart and the westward-moving North American plate began to override the Pacific plate
Phanerozoic history

• Mesozoic era
  • Pangaea began to break apart and the westward-moving North American plate began to override the Pacific plate
    – Resulted in crustal deformation along the entire western margin of North America
    – Formed the Sierra Nevada and Rocky Mountains
Phanerozoic history

• Cenozoic era
  • Much of North America was above sea level throughout the Cenozoic
    – Eastern and western margins of the continent experienced markedly contrasting events
    – Atlantic and Gulf coastal regions, removed from active plate boundaries, were tectonically stable
**Phanerozoic history**

- **Cenozoic era**
  - Much of North America was above sea level throughout the Cenozoic
    - In the West, the Laramide orogeny (Rocky Mountains) was ending, the Basin and Range Province was forming, and volcanic activity was extensive
Earth’s first life

- First known organisms were single-celled bacteria, prokaryotes, which lacked a nucleus
  - One group of prokaryotes, called cyanobacteria, used solar energy to synthesize organic compounds, thus producing their own food
    - Fossil evidence of these bacteria include layered mounds called stromatolites
Paleozoic era: Life explodes

- Paleozoic marks the first appearance of life-forms with hard parts such as shells
  - Resulted in abundant Paleozoic fossils
  - Life in the early Paleozoic was restricted to the seas and consisted of several invertebrate groups including
    - Trilobites
    - Cephalopods
    - Sponges
    - Corals
Paleozoic marine invertebrates

Figure 12.26
Paleozoic era: Life explodes

• During the Paleozoic, organisms diversified dramatically
  • Insects and plants moved onto land
  • Lobe-finned fishes adapted to land and became the first amphibians
  • Large tropical swamps in the Pennsylvanian period became the major coal deposits of today
Pennsylvanian-age coal swamp

Figure 12.29
Paleozoic era: Life explodes

- During the Paleozoic, organisms diversified dramatically
  - A mass extinction at the close of the Paleozoic destroyed 70% of all vertebrate species on land and 90% of all marine organisms
Mesozoic Era: Age of the dinosaurs

- Mesozoic, literally the era of middle life, is often called the “Age of Reptiles”
  - Organisms that survived the extinction at the end of the Paleozoic began to diversify
    - **Gymnosperms** (cycads, conifers, and ginkgoes) became the dominant trees of the Mesozoic
    - Reptiles became the dominant land animals
    - First reptiles were small, but evolved rapidly, particularly the dinosaurs
Mesozoic Era: Age of the dinosaurs

- Mesozoic, literally the era of middle life, is often called the “Age of Reptiles”
  - Organisms that survived the extinction at the end of the Paleozoic began to diversify
    - Diversity of reptiles included large carnivorous dinosaurs, even larger herbivorous dinosaurs such as Apatosaurus, pterosaurs or flying reptiles, and Archaeopteryx, the predecessor of modern birds
Archaeopteryx fossil

Figure 12.32
Mesozoic Era: Age of the dinosaurs

- Mesozoic, literally the era of middle life, is often called the “Age of Reptiles”
  - At the close of the Mesozoic, many reptile groups became extinct
  - A few types survived, including the turtles, snakes, and lizards
Cenozoic Era: Age of mammals

- In the Cenozoic, mammals replaced the reptiles as the dominant vertebrate life-forms on land
  - Two groups evolved, the marsupials and the placentals
  - One tendency was for some mammal groups to become very large
  - Late Pleistocene extinctions eliminated these larger animals
Cenozoic Era: Age of mammals

• The Cenozoic could also be called the “Age of Flowering Plants”
  • Flowering plants (angiosperms) strongly influenced the evolution of both birds and herbivorous mammals throughout the Cenozoic
End of Chapter 12