1 ***Earth's Evolution Through Time***

Earth 9th edition – Chapter 22

2 **Earth's evolution: summary in haiku form**

Super-continents
have come and gone many times:
giant bumper cars.

3 ***Key Concepts***

- The origin of Earth and the evolution of its atmosphere.
- Precambrian time: Earth's first 4 billion years.
- The Paleozoic Era: life "explodes."
- The Mesozoic Era: age of the dinosaurs.
- The Cenozoic Era: age of mammals.

4 ***4 of Earth's spheres***

5 ***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 (~9 billion years later)
  - As material collected, high velocity impacts of matter, called planetesimals, caused Earth's temperature to increase

6 ***Big Bang to Planetesimals***

7 ***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

8 ***Proto-earth to Earth 1.0***

9 ***Origin of atmosphere & oceans***

- Earth's primitive atmosphere, which consisted mainly of H_2O vapor and CO_2, formed by a process called outgassing
  - Gases trapped in the planet's interior are released by volcanic eruptions
  - This process continues today

10 ***Earth: 4 Billion Years Ago?***

11 ***Outgassing led to Atmosphere***

12 ***Outgassing Continues:***

13 ***Origin of atmosphere & 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

14 ***Oxygen in the Atmosphere, 3.5 Ga***

O_2 + Fe-rich rocks → Fe_2O_3
(a.k.a. rust, hematite)

15 ***Origin of atmosphere & 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

16 ***White Cliffs of Dover – ocean floor chalk***

17 ***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

18 ***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

19 ***Rift Pattern on Lava Lake***

20 ***Old Rocks in Greenland – 3.8 Ga***

21 ***Formation of continental crust***

22 ***Crustal Ages***

23 ***Geologic Provinces of North America***

24 ***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

25 ***Possible configuration of Rodinia***

26 ***Phanerozoic history***

- Phanerozoic encompasses 542 million years
  - Divided into the Paleozoic, Mesozoic, and Cenozoic eras
- Paleozoic era
  - Dominated by continental collisions as Pangaea began to assembled
    - Formed the Caledonian, Appalachian, and Ural Mountains

27 ***Formation of Pangaea***

28 ***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 Farallon plate

29 ***Changing Ocean Circulation***

30 ***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

31 ***Late Mesozoic paleography***

32 ***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
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33 ***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
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34 ***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

35 ***Precambrian Stromatolites***

36 ***Modern Stromatolites***

37 ***Life through time***

38 ***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
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    -
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39 ***Trilobite – early ocean dweller***

40 ***Ammonites***

41 ***Paleozoic marine invertebrates***

42 ***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

43 ***Pennsylvanian-age coal swamp***

44 ***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
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    -

45 ***From fishes...***

46 ***The Great Dying: 250 Ma***
47 ***Figure 22.B (left)***
48 ***Figure 22.B (right)***
49 ***Mesozoic Era: Age of 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

50 ***Mesozoic Era: Age of 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

51 ***Triassic-age Petrified Log***
52 ***Ichthyosaur***
53 ***Mesozoic Crocodile***
54 ***Tyrannosaurus***
55 ***Pteranodon, a flying reptile***
56 ***Mesozoic Era: Age of 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

57 ***Night comes to the Cretaceous, 65 Ma***
58 ***Cenozoic Era: Age of mammals***
- In the Cenozoic, mammals replace 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

59 ***Extinct Cenozoic Animals***
60 ***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
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61 ***End of Chapter***