Chapter 7
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7.1 Overall Structure of Planet Earth

- Mantle
- Two-part core
- Thin crust
- Hydrosphere (oceans)
- Atmosphere
- Magnetosphere
7.2 Earth’s Atmosphere

- The blue curve shows the temperature at each altitude
- Troposphere is where convection takes place—responsible for weather
Convection depends on warming of ground by the Sun.
7.2 Earth’s Atmosphere

Ionosphere is ionized by solar radiation and is good conductor

Reflects radio waves in the AM range, but transparent to FM and TV

Ozone layer is between ionosphere and mesosphere; absorbs ultraviolet radiation
Chlorofluorocarbons (CFCs) have been damaging the ozone layer, resulting in ozone hole.
Surface heating:

- Sunlight that is not reflected is absorbed by Earth’s surface, warming it.
- Surface re-radiates as infrared thermal radiation.
- Atmosphere absorbs some infrared, causing further heating.
This is known as the greenhouse effect.
Scattering of light by air depends on the wavelength of the light—the wavelength of blue light is closer to the size of air molecules, so it is scattered most strongly. The amount of molecular scattering is proportional to the inverse fourth power of the wavelength of the light.
When the Sun is close to the horizon, light is scattered by dust in the air. The more dust, the more scattering; if there is enough dust, the blue light is greatly diminished, leaving a red glow in the sky.
7.2 Earth’s Atmosphere

History of Earth’s atmosphere:

- **Primary atmosphere** was hydrogen, helium; this escaped Earth’s gravity
- **Secondary atmosphere**, from volcanic activity, mostly nitrogen
- **Life appeared**, creating atmospheric oxygen
One result of modern society has been to increase CO$_2$ levels in the atmosphere. A corresponding increase in global average temperature has been seen as well. Exactly how much the temperature will continue to increase is not known.
Discovery 7-1: The Greenhouse Effect and Global Warming

Some possible consequences of global warming:

• Rise in sea level
• More severe weather
• Crop failures (as climate zones change)
• Expansion of deserts
• Spread of tropical diseases away from the tropics
Seismic waves: Earthquakes produce both pressure and shear waves. Pressure waves are longitudinal and will travel through both liquids and solids. Shear waves are transverse and will not travel through liquid, as liquids do not resist shear forces. Wave speed depends on the density of the material.
7.3 Earth’s Interior

We can use the pattern of reflections during earthquakes to deduce the interior structure of Earth
7.3 Earth’s Interior

Currently accepted model

- Inner core
- Outer core
- Mantle
- Crust

Note the sharp density change between Earth’s core and mantle.

Density (Kg/m³)

Temperature (K)

Depth below surface (km)
Mantle is much less dense than core
Mantle is rocky; core is metallic—iron and nickel
Outer core is liquid; inner core is solid, due to pressure
Volcanic lava comes from mantle, allows analysis of composition
History: Earth was probably molten when formed and remelted due to bombardment by space debris. Heavier materials sank to the center. Radioactivity provides a continuing source of heat.
Radioactive Dating

The number of protons in an atom’s nucleus determines which element it is. However, there may be different isotopes of the same element, with the same number of protons but different numbers of neutrons. Many of these isotopes are unstable and undergo radioactive decay. This decay is characterized by a half-life $T$:

Fraction of material remaining $= \left(\frac{1}{2}\right)^{t/T}$
Radioactive Dating

This plot shows the fraction of the original sample remaining as a function of time.

- 100% at the start
- 50% after one half-life
- 25% after two half-lives
- 12.5% after three half-lives
- Remaining fraction decreases exponentially.
Half-lives have been measured in the laboratory for almost all known isotopes. Knowing these, we can use them for determining the age of samples by looking at isotope ratios.

The most useful isotope for dating rock samples is uranium-238, which has a half-life of 4.5 billion years, comparable to the age of the Earth.
The dating process involves measuring the ratio between the parent nucleus and the daughter nucleus (lead-206 in the case of uranium-238).
Continental drift: The entire Earth’s surface is covered with crustal plates, which can move independently.
At plate boundaries, earthquakes and volcanoes occur.
Earth’s upper mantle, near a plate boundary; this is a subduction zone, where one plate slides below another.
7.4 Surface Activity

A plate colliding with another can also raise it, resulting in very high mountains.
Plates can also slide along each other, creating faults where many earthquakes occur.
Finally, plates can move away from each other, creating rifts.
The new crust created at rift zones preserves the magnetic field present at the time it solidified. From this, we can tell that field reversals occur about every 500,000 years.
Plate motion is driven by convection.
7.4 Surface Activity

If we follow the continental drift backward, the continents merge into one, called Pangaea
7.5 Earth’s Magnetosphere

The magnetosphere is the region around the Earth where charged particles from the solar wind are trapped.
7.5 Earth’s Magnetosphere

These charged particles are trapped in areas called the Van Allen belts, where they spiral around the magnetic field lines.
Near the poles, the Van Allen belts intersect the atmosphere. The charged particles can escape; when they do, they create glowing light called *aurorae*.
Tides are due to the gravitational force on Earth from Moon—force on the near side of Earth is greater than force on the far side. Water can flow freely in response.
The Sun has less effect because it is farther away, but it does modify the lunar tides.
Tides tend to exert a “drag” force on the Earth, slowing its rotation.

This will continue until the Earth rotates synchronously with the Moon, so that the same side of the Earth always points toward the Moon.
Summary of Chapter 7

• Earth’s structure, from inside out: core, mantle, crust, hydrosphere, atmosphere, magnetosphere

• Atmosphere is mostly nitrogen and oxygen; thins rapidly with increasing altitude

• Greenhouse effect keeps Earth warmer than it would otherwise be

• Study interior by studying seismic waves

• Crust is made of plates that move independently
Summary of Chapter 7 (cont.)

• Movement at plate boundaries can cause earthquakes, volcanic activity, mountain ranges, and rifts

• New crust formed at rifts shows evidence of magnetic field reversals

• Earth’s magnetic field traps charged particles from solar wind

• Tides are caused by gravitational effects of Moon and Sun