SPASH ASTRONOMY
CHAPTER 6: EARTH AS A PLANET
OVERHEAD LECTURE NOTES

1. When Renaissance astronomers realized that other planets were worlds it led to the idea of "the plurality of worlds". What did "the plurality of worlds" mean?

It was the assumption that other planets had climates and life forms like Earth's.

2. Why have a chapter in an astronomy book on [redacted] Earth?

By studying Earth as one of the planets, we are discovering how these processes work and learning how Earth displays similarities to, as well as differences from, other worlds.

3. How old is [redacted] Earth?

Take your choice, either less than 10,000 years ago if you believe in creation or 4,600,000,000 years ago if you agree with radioisotopic dating.

4. How can we learn what is at the interior of [redacted] Earth (the core)?

The world's deepest drill hole is in the Soviet Union, 250 km north of the Arctic Circle. It reached a depth of 12.5 km in 1989, on the way to a planned 15 km. The deepest known rocks, brought the surface by ancient volcanic processes are believed to have originated at depths of 300 to 400 km in the upper mantle - but even this is only 5-6% of the way to the Earth's center. Our best clues about the interior come, instead, from earthquake waves that pass through Earth's material. Waves traveling through the Earth are called seismic waves. Earth's core was discovered in 1906 when observers found that they received modified seismic waves from earthquakes on the far side of the Earth compared to waves of nearer earthquakes.

5. Name and describe the six interior regions of [redacted] Earth's structure. Note Figure page 133.

1. The Earth contains a central **inner core** of solid nickel-iron metal.
2. The outer core is liquid nickel-iron. The entire inner and **outer core's** radius is about 3500 km, just over half the Earth's radius.
3. The core is surrounded most of the way out to the surface by a layer of dense rock, called the **mantle**. Near the surface, the densities of the rocks are typically lower.
4. Just below the top layer described below is a partly melted layer that is much less rigid and less strong. The underlying partly melted layer is called the **asthenosphere** (about 100 to 350 km deep)(from Greek roots for "weak shell")
5. The **lithosphere** (about 100 km deep) is the solid layer at the surface of Earth or any other such planet.
6. The **crust** of the Earth is a thin outer layer of lower-density rock about 5 km thick under the oceans and about 30 km thick under the continents.

6. Name three ways heat can escape from the hot interior of [redacted] Earth:

Heat always flows from hot to cooler regions, and it can flow by three methods.
1). radiation; an example is the radiant heat that reaches us through space from the Sun.
2). conduction; an example is the flow of heat through a metal cooking pot, whose handle might grow too hot to touch.
3). convection; which is heat flow by movement of the heat-carrying medium, like, the buoyant ascent of warm air in a thundercloud or the rise of a hot air balloon.

7. How can radiation, conduction and convection affect a planet?

Once a planet heats up, its insides cool by all three processes. As the planet cools, the surface layers solidify, forming a relatively rigid surface layer of rock - the lithosphere. These currents bring up hot mantle material, creating "hot spots" in the Earth's crust where volcanoes are likely. Just like arctic explorers crossing ice floes that are floating on the ocean, we are living on a rigid layer that "floats" on a more fluid base. As the asthenosphere shifts, it can stretch the lithosphere only so far before the brittle lithosphere cracks. This is what we perceive as an earthquake.

8. What is the theory of plate tectonics?

As the asthenosphere drags on the more brittle lithosphere, it cracks the lithosphere into large, continent-scale pieces called plates. Cracks along the margins of plates are usually the sites of volcanoes and earthquakes, since molten magma from below can squeeze up to the surface through the cracks, and since plate collisions cause stresses as plates rub together, eventually leading to rock fracturing in the form of earthquakes. The string of shallow earthquakes down the mid-Atlantic marks a plate boundary where new lava is rising from below. On the ocean floor it erupts and piles into a feature mapped by oceanographers in the 1960s - the Mid-Atlantic Ridge.

Eruption of new lavas at these sites pushes apart the neighboring plates, causing the Americas to drift westward and Europe eastward relative to the plate boundary. On the west coast of the Americas, the American continental plate collides with the Pacific plates, crumpling and riding up over them as the margins of the Pacific plates slide under the American plates. This crumpling is the explanation of major western American mountain chains like the Sierra Nevada and the Andes.

Fractures caused by earthquakes are called faults. Colliding plate regions are laced with faults like the famous San Andreas fault (figure pg. 131). Much geological evidence supports the theory of plate tectonics. At one time all the continents were one large land mass called Pangaea.

The theory of plate tectonics also explains why rock units on Earth older than 1 or 2 billion years are so rare. Most older surfaces have been crumpled beyond recognition or driven downward under other plates, only to be remelted, mixed with mantle material, and perhaps reerupted as new lavas.

9. Why are the surfaces of Mars and the Moon more ancient than Earths?

Smaller worlds cool faster than big worlds, so their lithospheres get thicker in the small amount of time. Thus their surfaces are more stable and more protected against asthenosphere currents far below. Lava does not so frequently gain access to the surface. Convection can't so easily drive plates apart or cause them to drift into each other.

10. Name two other important processes in Earth's evolution:

1). Volcanism is the eruption of molten materials from a planet's interior onto its surface. This underground molten rock, called magma, is under pressure, often charged with gas such as steam, less dense than surrounding rock, and highly corrosive. Therefore it tends to work its way to the surface, especially in regions where fractures provide access. When it reaches the surface, it erupts and is then called lava. Space exploration has shown that volcanism is one of the most important processes forming landscapes on other planets.
2). Among all known planets, the Earth undergoes the most active processes of landform destruction. Largely, this activity is due to the Earth's thick atmosphere and flowing water, which other planets lack. On the Earth, **erosion** and deposition, especially by flowing water, are the most important landscape-forming processes, but this is not true on all other planets.

11. What causes Earth's magnetism?

Geophysicists believe that liquid iron in the outer core is slowly convecting and that these motions set up electric currents in the metal. A magnetic field will exist around any electric current, and Earth's field is thus attributed to currents in the liquid metal core. The presence or absence of a magnetic field thus becomes an important indicator of the presence of an iron core inside a planet.

12. Where did Earth's atmosphere come from and how did it evolve to become todays atmosphere?

The early dense atmosphere is believed to have come from volcanic outgassing of Earth's hot interior as the planet formed. Volcanoes emit primarily steam (H_2O, 58% by weight) and carbon dioxide (CO_2, 24%) As the earliest atmosphere cooled, water vapor condensed into liquid water and formed oceans, leaving a thick atmosphere of CO_2, much denser than today's atmosphere.
Today's atmosphere, however, is composed 76% nitrogen molecules (N_2) by weight and 23% oxygen molecules (O_2). How did it get that way? One important process was that the CO_2 of Earth's early atmosphere dissolved in Earth's unique ocean water. Plants explain the transition from a CO_2 dominated atmosphere to an atmosphere with 23% O_2 around 2 to 2.5 billion years ago.
If there were no plants to maintain the atmosphere's oxygen , it would disappear "quickly" in millions or hundreds of millions of years.

13. Why do winds blow?

Any turbulent motions require an energy source to keep them going. Heat is transferred through the atmosphere and sets up convective motions. In this case the energy source is sunlight. Even if we stopped all wind sunlight would beat down on the noontime side of the Earth, warming the ground and warming the air. The air near the ground would eventually become warm enough to expand and rise. New air would flow in laterally along the ground to take its place; thus winds would arise.

14. What causes Coriolis drift?

The air near the equator is warmed more than at the poles, so when the air near the equator rises the air from the poles move toward the equator to fill in the gap. Well the earth is rotating at 1,000 miles/hr. at the equator and none at all near the poles so as the air moves toward the equator it is dragged in a counterclockwise rotation in the Northern Hemisphere and a clockwise rotation in the Southern Hemisphere.

15. In what ways has space influenced [redacted] Earth, what is the astronomical connection? Are we ([redacted] Earth) isolated from astronomical influences?

No way. Impacts of interplanetary debris, called meteorites, have occurred throughout geologic history. Many brick size meteorites hit Earth every year and some have been up to tens of miles across (much less seldom) Meteorite impact craters have been created by the larger impacts. (Arizona figure 6-14 page 126) Note Geological Time Scale table on page 144. This time scale shows slow, long-term shifts in Earth's biology and environment, and also a few abrupt changes.

16. What two planetwide changes are of most concern to our planet now and why?

1). Changes to the ozone layer

Ultraviolet rays from the sun are being absorbed by the ozone layer of the high atmosphere, 20 to 50 km high. The fact that most of these rays don't reach the ground is good for us because they damage organic molecules. Suntans and skin cancers are two examples of their effects on organic molecules in our skin. However, as is now well known, certain chemicals called chlorofluorocarbons (or CFCs), widely used in air conditioners and other devices, enter the air and eventually break down the ozone molecules (O_3).

2). The carbon dioxide content of the atmosphere.

This problem is believed to be due to forest burning and industry. A CO2 increase by more than 10% has been clearly observed in data taken since 1860. The problem is that CO2, though a minor constituent of the atmosphere, is one of the most effective of the so-called greenhouse gases. The greenhouse effect is a warming of the air that comes about because the infrared radiation can't get back out of the system easily.