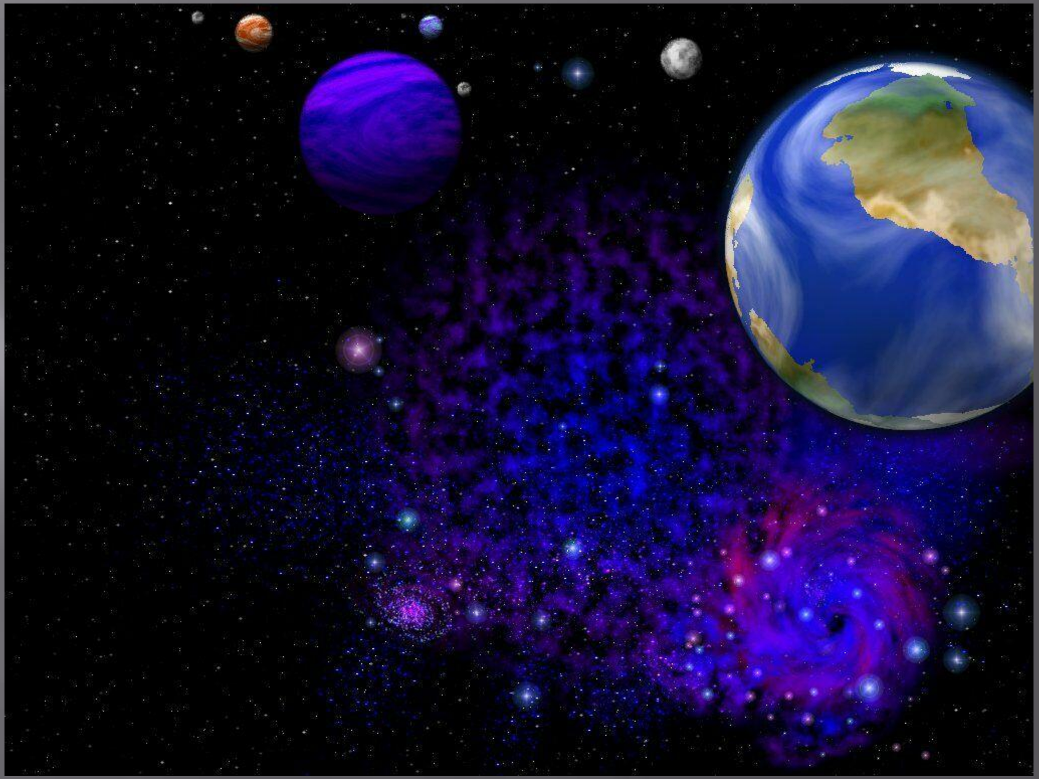
Topic 2: Origins Of Planet Earth



How Could This Be?

Earth In A Big Universe

Origin 1 - Universe

- **Creationism (Non-Scientific View):**

- Belief in the bible led to the idea that Earth has a recent origin or beginning. Based on the genealogical tables in the Old Testament, James Ussher (the Irish prelate - 1581 - 1656) concluded that Earth was created by God in the year 4004 B.C.

- 4004 B.C. + 2011 A. D.= 6, 015 Years Old

Origin 2 - Universe

- Big Bang Theory → Solar Nebula Hypothesis

- Big Bang Theory (Scientific View):
- All matter in the universe was once together as one large volume (i.e. a dense, hot, and massive ball of gases).
- Pressures and temperatures in relation to the gases were incredibly high.
- The large volume of matter (single source) exploded; flinging matter in all directions. This is believed to have occurred about 20 billion years ago.
- This event (i.e. the Big Bang) is believed to have marked the origin of all matter and space.
- The Big Bang Theory suggests that the universe, including the solar system that we know, is a part of an expanding system. As a result, all galaxies in the universe are moving farther away from each other with each passing day.

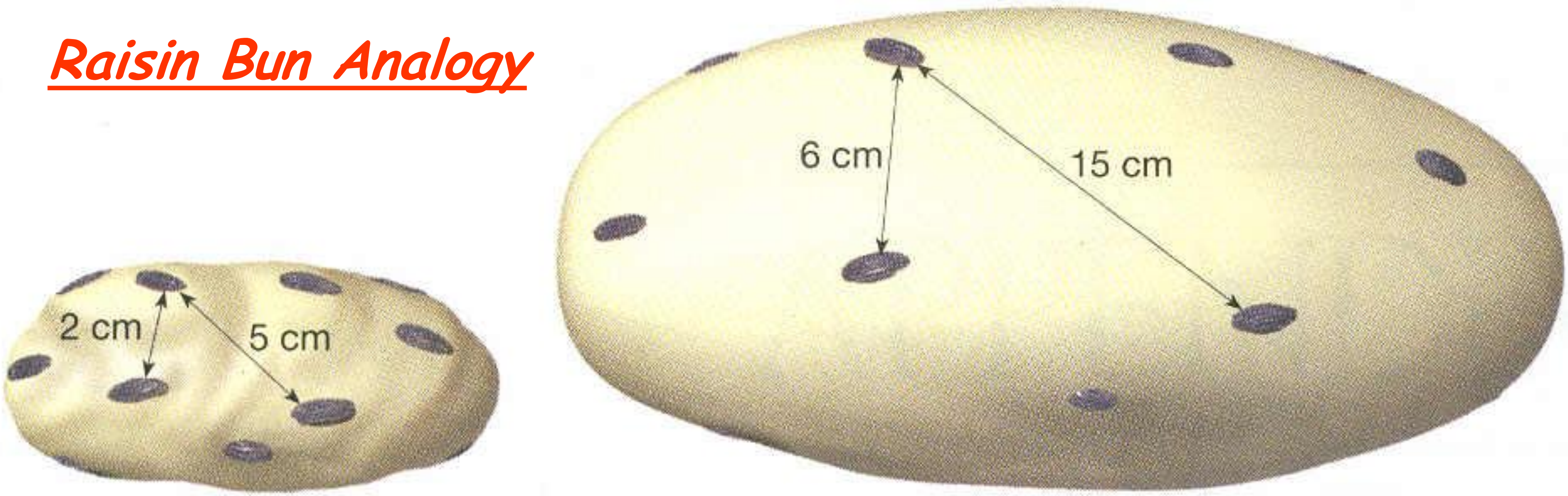
SONG

- **“The Big Bang Theory Theme Song” - YouTube**

- Listen to the song and reflect on how the first verse describes the things we discussed in this lesson.

Origin 2 - Universe

Raisin Bun Analogy

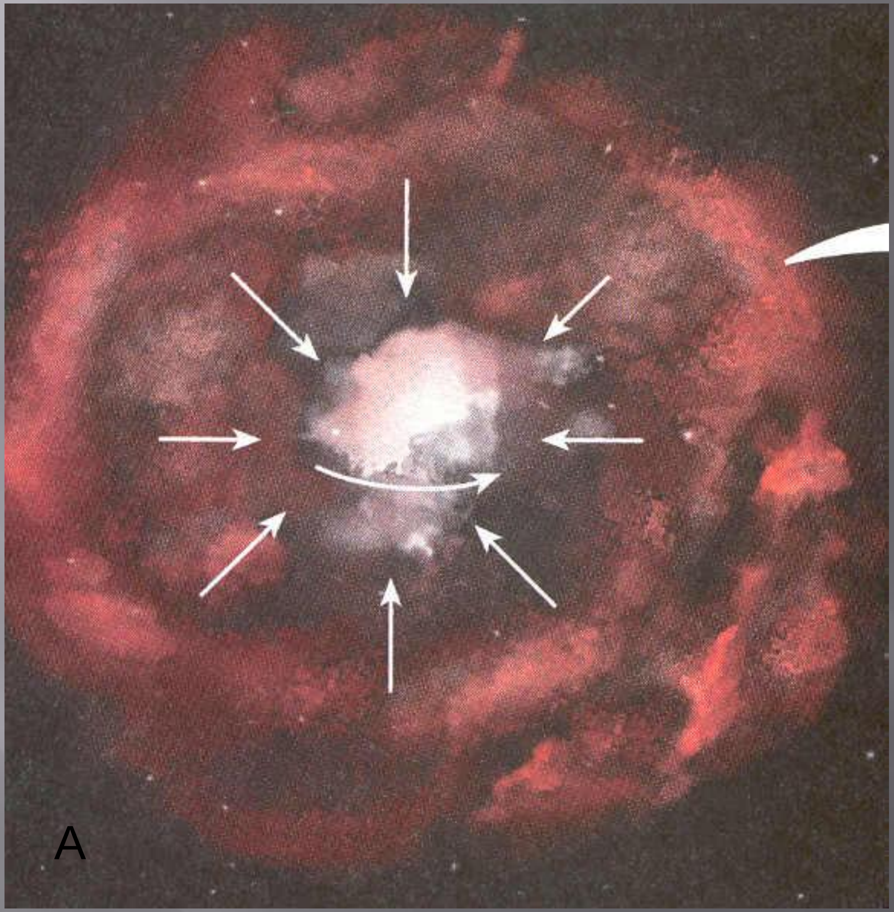


A. Raisin bread dough before it rises.

B. Raisin bread dough a few hours later.

Origin 2 - Universe

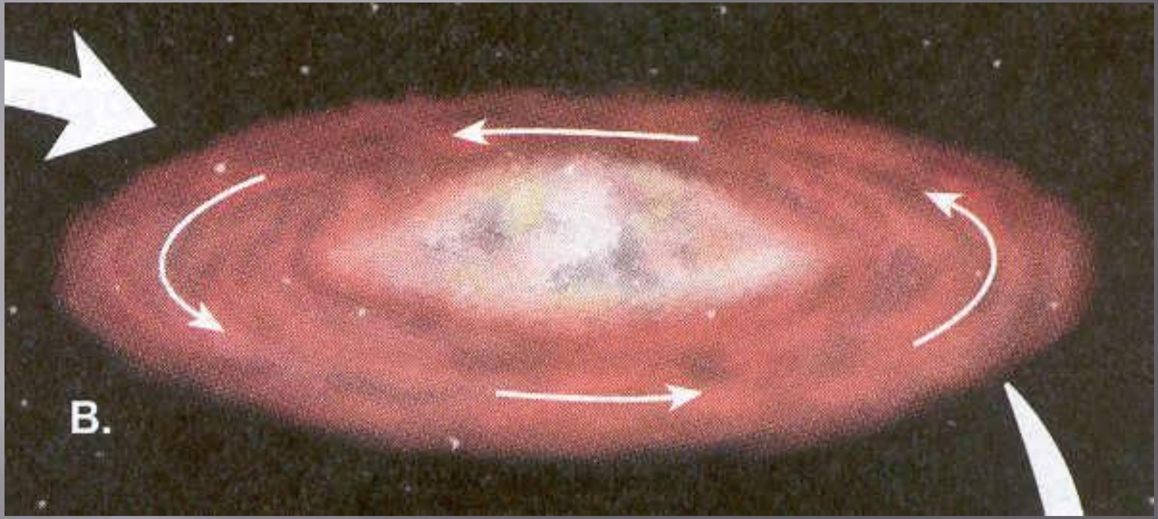
- <u>Solar Nebula Hypothesis (FOUR STAGES)</u>:
- Originally, hydrogen was the only element in the universe.
- Under gravity, the hydrogen atoms accumulated to form stars.
- Within these stars, fusion combines hydrogen atoms to form energy and heavier elements.
- Over time, stars use up their hydrogen fuel and explode (i.e. supernova); releasing clouds of hydrogen, helium, and heavier elements.
- This cloud of matter (mostly hydrogen and helium as well as small amounts of other heavy elements) began to contract under its own gravity.
- This material began to slowly rotate faster and faster.



Stage 1

Origin 2 - Universe

- The cloud of materials began to flatten under the rotational force.



Stage 2

Origin 2 - Universe

- Within the rotating disk, small nuclei formed from which the planets later formed.
- The majority of the matter within the disk was pulled towards the center where it was gravitationally heated forming the protosun.
- Temperatures out in the disk dropped significantly and small rock and mineral particles (e.g. iron and nickel) started to condense.
- Over tens of millions of years, these particles collided and accreted together to form the protoplanets (as well as moons and other small bodies).

Stage 3

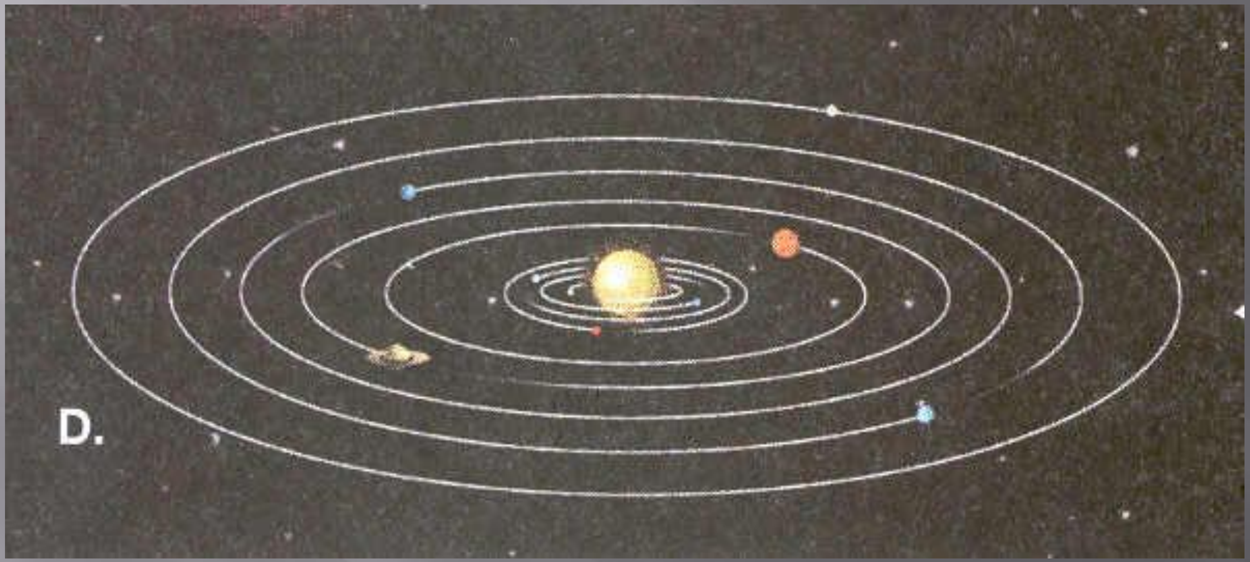
SMART – Earth Changes

PLANET FORMATION

Origin 2 - Universe

- As the planets (as well as moons and other small bodies) accumulated more particles, space in between the planets (as well as moons and other small bodies) started to clear.
- With time, most of the remaining particles (i.e. debris) were swept out into the universe by solar winds.

- IT IS STILL IN THE PROCESS OF CLEARING!



Stage 4

STSE – Core!

- “The Search For Other Solar Systems”
- (1) Read and (2) Think/Pair/Share

STSE 1

- <u>Remember</u>:

- Universe Versus Solar System
- *The Universe incorporates several solar systems.*
- *A solar system is represented by planets orbiting stars.*

- Habitable Zone
- *This zone in a solar system is all about the location of planets in areas (in relation to its where liquid water can exist on the surface. This is not too far from the star it is orbiting (too cold) or too close to the start it is orbiting (too hot).*

STSE 1

- If you can find planets orbiting stars (other than the sun), then you have found a solar system.
- There have been 1500 solar systems found to date.

- <u>Five Methods for Finding Solar Systems</u>

1. *Radial Velocity Method*
2. *Transit Photometry Method*
3. *Astrometry Method*
4. *Microlensing Method*
5. *Direct Imaging*

- <u>Activity</u>: In a group of seven, pick one method to read about and to discuss. Appoint one person in the group to report to the entire class on what the method involves. Each group must work on a different method.

STSE 1

- Transit = The passage of a planet between a star and the Earth.

- Extrasolar planets = Planets that exist in other solar systems (as opposed to the solar system where Earth exists). These are called exoplanets.

- Gemini North
- *The Gemini Observatory Program has been in operation by Canada and its purpose is to find extrasolar planets. The powerful telescopes remove the effect of twinkling stars, thereby allowing for clearer views out into space. They also minimize star light, thereby allowing for more focus on light being given off by the extrasolar planets.*

- Kepler Mission
- *Designed to survey a portion of our region of the Milky Way Galaxy to discover Earth-sized planets in or near the habitable zone and determine how many of the billions of stars in our galaxy have such planets. 1500 found to date!*

STSE 1

- Theory for Solar System Formation is "Solar Nebula Hypothesis". It infers that a solar system should have rocky inner planets and larger gaseous planets much further out.
- The solar systems found do not fit the pattern described above. Large gaseous planets have been found close to their parent stars. Maybe gravity and friction has caused the larger planets to move. Alone, the "Solar Nebula Hypothesis" seems too simplistic. Maybe it just represents the formation and configuration of early planets.
- When extrasolar planets are found, the light they emit is very significant. This is because the atmosphere surrounding each planet influences the light that gets emitted. Water, methane, and ozone are required in atmospheres in order for them to be able to support life. Detailed spectrometry could tell scientists if life (as we know it) exists on planets.

STSE 1

- This STSE proves the importance of advancements in scientific methods and technology. We can now observe other solar systems. Also, we humans are being forced to re-examine our theories of solar system formation (e.g. “Solar Nebula Hypothesis”).

Segregation/Formation Of Earth's Layers

- Thanks to nature (i.e. heat and gravity)

<u>**Sources**</u>**:**

1. Radioactive Decay

2. Particle Collisions

3. Residual Heat

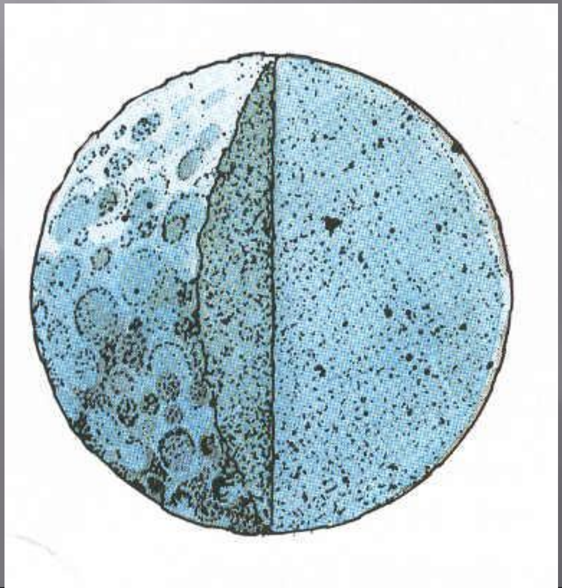
Related to density

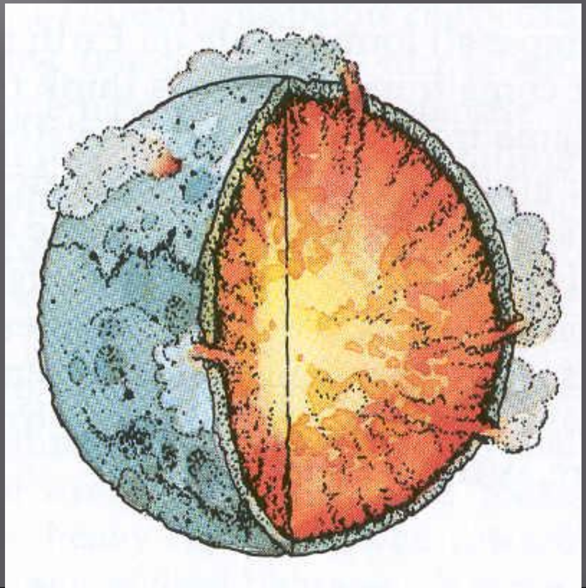
Segregation/Formation Of Earth's Layers

- On Earth, the heat from particle collisions and radioactive elements produced melting of the interior.
- Denser material sank to the Earth's center (due to gravitational forces) and the lighter materials floated upwards. This process is often referred to as <u>differentiation</u> or <u>segregation</u>.
- This sorting of material by density, early in Earth's history, is still occurring today; but on a smaller scale.
- Gases are released from Earth's interior through volcanoes.
- Because of the segregation/differentiation process, the geosphere (Solid Earth) developed various layers that have different properties. See figure 1.15 on page 22.

Segregation/Formation Of Earth's Layers

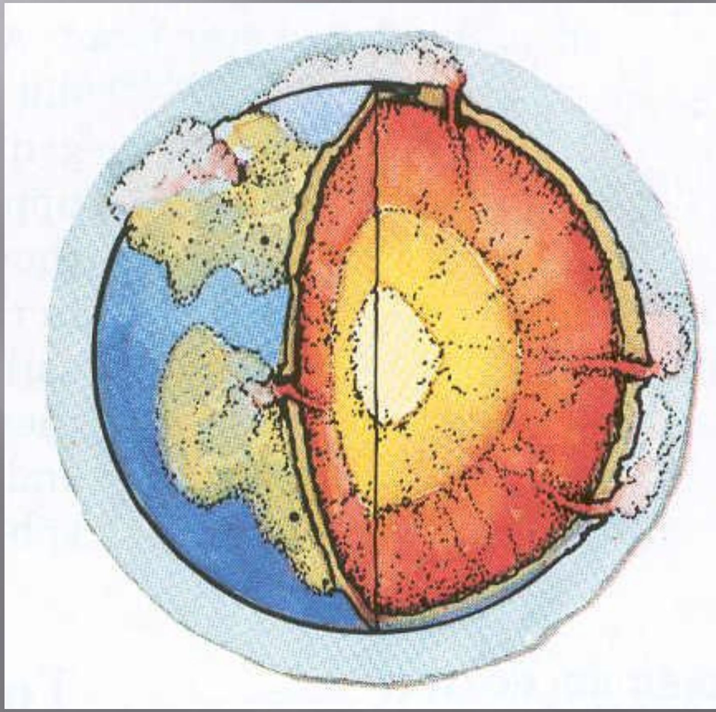
- It was thought that Earth was not always layered as it is today. Some scientists suggest that Earth was somewhat like the moon billions of years ago, particularly in terms of appearance.
- The composition of ancient Earth was thought to be the same throughout. It is believed to have separated (<u>segregated</u> or <u>differentiated</u>) later in Earth's history.

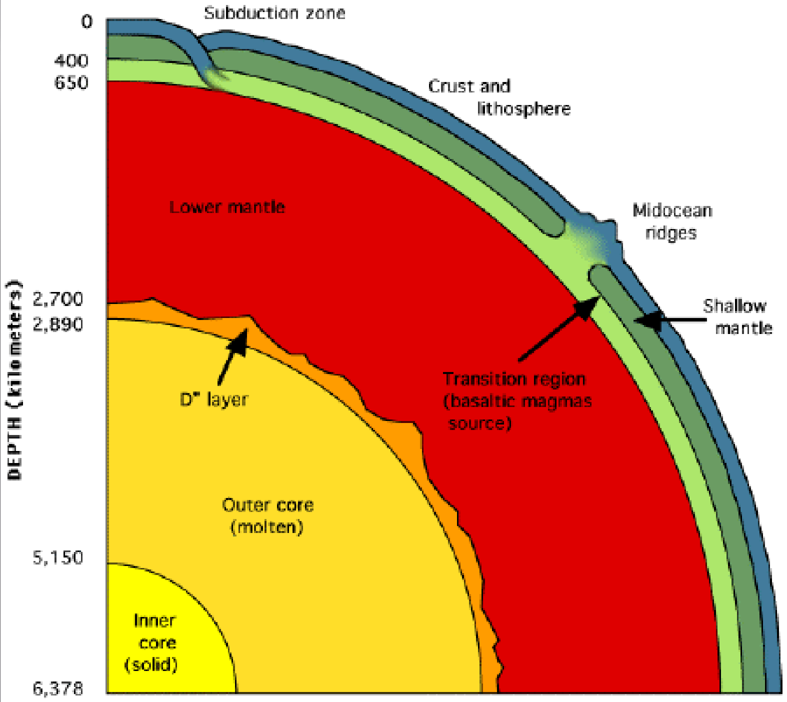




Segregation/Formation Of Earth's Layers

- It was the process of <u>segregation/differentiation</u> that led to the formation of Earth's layered structure.
- See diagram - Textbook – Page 20 - Discuss





Earth's Layers

- The heavier material (e.g., nickel, iron, magnesium) that concentrated close to Earth's center formed the inner core and outer core.
- The lighter and less dense material (e.g. silicon, aluminum, copper) that moved upwards closer to Earth's surface formed the lithosphere (crust).
- The material in between formed Earth's mantle. Note that the upper mantle is referred to as asthenosphere.

Going Deep Inside Earth

- Temperature inside Earth increases at a rate of approximately 35 degrees Celsius per 1 Kilometer. This is referred to as the geothermal gradient.

- Density and pressure inside Earth increases as depth inside Earth increases.

YouTube – "Layers of the Earth"

The Core

- There is an inner core and an inner core.

- Inner Core:

- Solid metallic sphere.
- 1216 kilometers thick.
- Mostly iron and nickel, and magnesium (high density due to segregation).

- Outer Core:

- Approximately 2270 kilometers thick.
- Molten liquid (high density due to segregation).
- Seismic waves (i.e. s-waves or secondary waves) do not pass through the outer core. (this is how we know).
- Iron, nickel, and rock.

The Mantle

- Mantle (i.e. Lower Mantle):
- The thickest layer within the Earth.
- Approximately 2885 kilometers thick.
- Molten magma ("liquid that acts like a solid").
- More iron minerals than above. There are also magnesium and silicon minerals. (i.e. low density and high density minerals due to segregation).
- Upper mantle density = 3.7 g/cm^3.

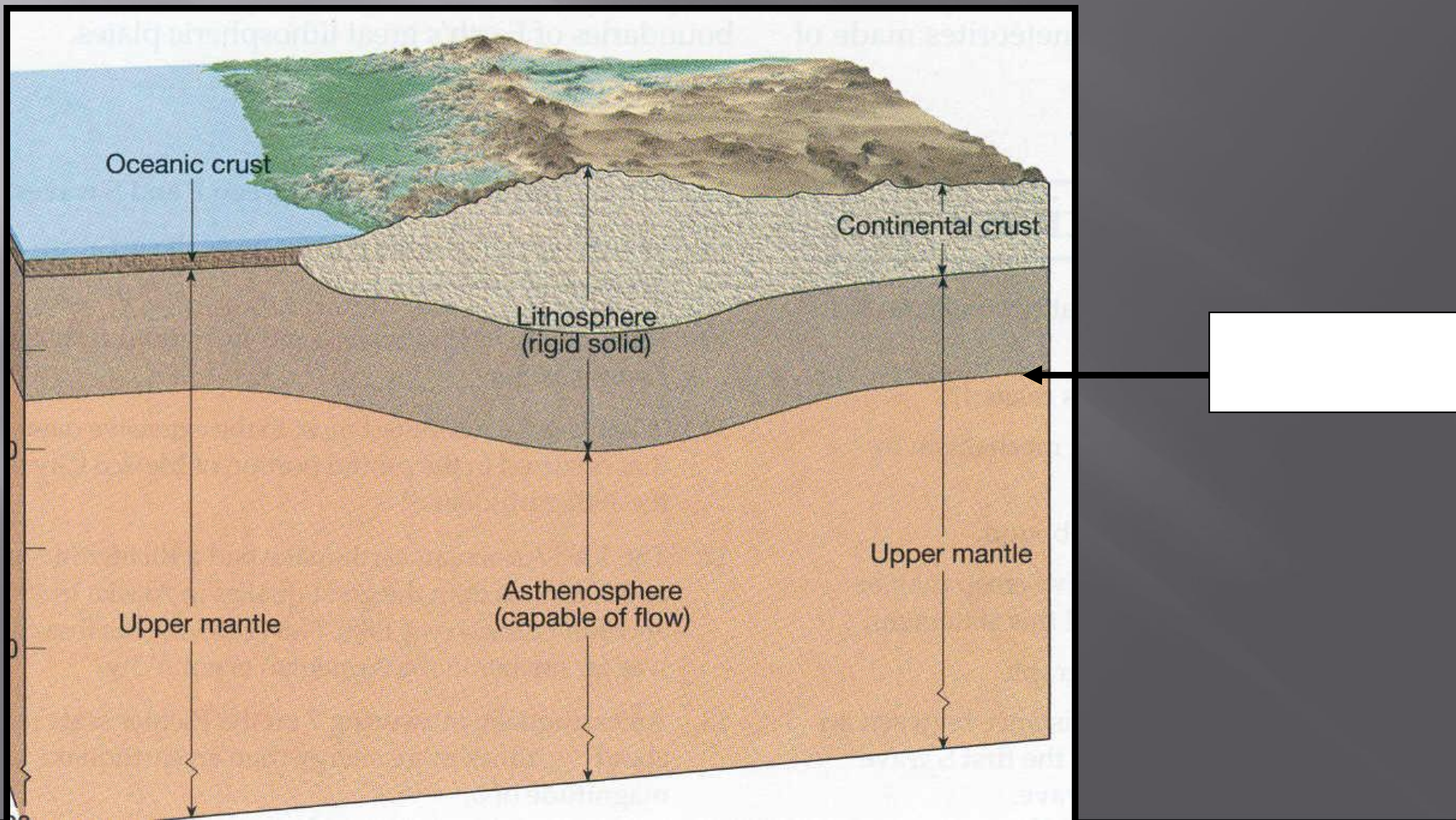
The Asthenosphere

- Asthenosphere (i.e. Upper Mantle):
- A subdivision of the mantle situated below the lithosphere and above the lower mantle.
- 100 - 700 kilometers down.
- Plastic layer, hot and weak rock, and 10 % molten. Think of it like an “Eatmore” bar.
- More dense than the crust.
- The asthenosphere is capable of gradual movement. This is the layer that the tectonic plates rest upon.

·Mohorovicic Discontinuity

The boundary that separates the lithosphere from the mantle.

The MOHO is identified by a change in rock density.



The Lithosphere

- <u>Lithosphere</u>:
- The thin outer layer of the Earth (i.e. shell).
- Located directly above the asthenosphere.
- Approximately 100 kilometers thick (i.e. includes the entire crust as well as a portion of the upper mantle (NOT THE ASTHENOSPHERE).
- Thickest beneath the continents.
- Thinnest beneath the oceans.
- Solid and rigid/brittle.
- Continents are made up of mostly granitic rock (sialic) (Low Density).
- Ocean crust is made up of mostly basaltic rock (simatic) (Relatively High Density).
- Average density = 2.3 g/cm^3.
- Comprises the tectonic plates.