Earth systems 3209

Unit 1 (approx. 11 classes)

Earth Science is the name for all the sciences that collectively seek to understand Earth and its neighbours in space. Earth Science is no different from other sciences in that it depends to a large extent on large-scale cooperative efforts.

The following aspects make Earth science different from other sciences:

1. it draws from all other sciences (physics, chemistry, meteorology, astronomy, biology, etc.) to help us understand the Earth's environment;
2. it requires consideration of vast amounts of time with sequencing of events (chronology) and ages

Different branches study the different parts of Earth:

The Solid earth—The geosphere
The Gaseous earth-- the atmosphere.
The liquid earth-- the hydrosphere
The biosphere, -- the totality of life on Earth

Although each of Earth's four spheres can be studied separately, they are all related in a complex and continuously interacting whole that we call the **Earth system**.

The Earth is a system of four interdependent reservoirs through which matter and energy flows. These four reservoirs are the spheres and formed in the following order:

1) **Geosphere**
2) **Hydrosphere**
3) **Atmosphere**
4) **Biosphere**

These spheres are closely connected and function as one system.

Geosphere

- The entire solid Earth from the core to the surface. Basically, anything that is not hydrosphere, atmosphere, or biosphere.
- Examples that we see include the continental and oceanic crust

Hydrosphere

- All of the waters of the earth, including both surface and subsurface waters including ice.
- Examples include oceans, glaciers, lakes, rivers, and ground water.

Atmosphere

- The gaseous layer which surrounds Earth mainly comprised of nitrogen, oxygen and carbon dioxide.
- Examples include the air we breathe.

Biosphere

- The layer of life existing throughout the three preceding spheres.
- Examples include plants, animals, birds and fish.

The parts of the Earth System are closely linked so that a change in one part can produce changes in any or all of the other parts.

For Discussion:

1. ***Describe how a rainstorm might impact each of the 4 spheres.***
2. ***Describe the impact a forest fire might have on each of the 4 spheres.***
3. ***How would development of a hydroelectric dam impact Earth's 4 spheres?***
4. ***How might a volcanic eruption impact the other spheres?***

Volcanic eruptions

- *can interfere with surface drainage.*
- *can interfere with incoming solar radiation. Thus, change weather and climate (short term and long term).*
- *can interfere with the biosphere. Sensitive life-forms may be eliminated.*

Geology – study of the **solid** Earth

Can be further subdivided into the following branches:

Seismology – study of earthquakes and seismic waves

Paleontology – study of fossils and life on Earth

Geomorphology – study of landscape features on Earth

Mineralogy – study of minerals

Volcanology – study of volcanic activity

Also includes lesser known areas of study such as: crystallography, geochemistry, geomorphology, petrology & stratigraphy.

The Atmosphere- Gaseous Earth;

Includes:

- **Meteorology** – study of the atmosphere; weather and climate
- **Astronomy** – the scientific study of the universe and the relationship between Earth and the universe. It focuses on the observation and interpretation of celestial bodies in space
  - Note: The impact meteorites have on Earth's surface falls under the study of Geology

The Hydrosphere-Liquid Earth Includes:

- **Oceanography**
  - study of the oceans and oceanic phenomena
  - study of the composition and movements of sea water, as well as coastal processes, seafloor topography, and marine life
- **Hydrology**
  - study of Earth's fresh water systems including, rivers, streams, and groundwater

The following terms are important when referring to the development of scientific knowledge

Observation
Hypothesis
Fact
Theory L
Law

Observation: method using the five senses by which facts are collected to help support scientific hypothesis.

Hypothesis: a preliminary, untested, educated guess which provides an explanation to some idea.

- A hypothesis must go through extensive testing to validate its accuracy.
- often several hypothesis are formulated to try and explain the same facts and observations

Fact: data collected from observation and measurement which form the basis which scientific theories and scientific laws are formulated.

Theory: is a hypothesis that has undergone extensive scrutiny and all competing hypothesis have been eliminated can then be referred to as a scientific theory.

-A theory is not a guess.
-explains observable facts which occur in nature
-Example - Theory of Plate Tectonics

Note: No theory, including Plate Tectonics, is perfect. Anomalies exist and the theory does not explain everything.

Law: Is a generalization about the behaviour of nature from which there has been no known deviation after numerous observations or experiments.

- Describes observable facts which occur in nature
- Laws are not "mature theories."
- To be considered Law, no known contradictions should exist

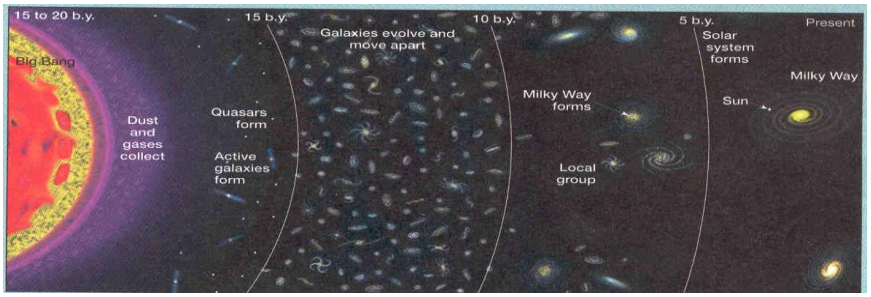
Note: The ***scientific method***, as outlined above, is rarely reflective of the way scientific knowledge really progresses

Origin of the Universe

Throughout history many ideas about the origin of the universe was hypothesized. These ideas range from; **Creationism** - where a supreme being (God) created the universe, to more scientific views such as: **The Big Bang.** Regardless, early ideas changed with time as new evidence was discovered to change initial models and theories of the universe.

Remember: The simple point here is that there are different views of the origin of the solar system.

The Big Bang: This theory explains the origin of the universe and suggests that the universe, our solar system included, is part of an expanding system where all galaxies are moving farther away with each passing day.



Big Bang Theory:

- Universe was confined to a dense, hot, super massive ball of gases .
- 14 Billion years ago, an explosion hurled this material in all directions
- marked the origin of all matter and space
- gases cooled and condensed forming stellar systems that we call galaxies
- 20 billion years in the future, the expansion will stop and gravitational attraction would follow where stellar material will collide to form a new hot, dense fire ball and the process starts again

"The Search for Other Solar Systems", Core STSE-Appendix A

Origin of Solar System

Solar Nebular Hypothesis: This idea explained the formation of the solar system through **four stages.** Astronomers believe that all parts of our solar system formed at essentially the same time and from the same material

- Approximately 4.6 billion years ago
- Huge mass of dust and gases began to contract under its own gravity
- Gas cloud began to rotate faster and faster as it contracted
- Rotation caused most material to concentrate in the center
- The central rotating mass of gases was packed tightly on itself and this caused it to heat up and burst into a newborn sun.
- Remaining dust and gases orbited around the central body as a flattened disk
- Temperatures within the rotating disk dropped and small particles such as iron and nickel started to form
- These particles collided for millions of years and accreted to form the planets, moons, and other small bodies
- As planets accumulated more particles, space in between the planets started to clear
- With time, most of the remaining debris was swept into space by solar winds

Remember: limitations exist in the application of science and technology to problems. *At some point there is some element of faith in the acceptance of such explanations*

Throughout all scientific Discoveries and Investigation there is:

(1) The need for revision of current theory in light of new evidence,

(2) The need to challenge evidence and

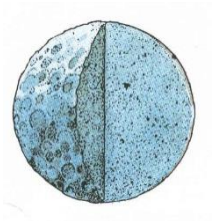
(3) The need for persistence if you expect to convince others that a change in thinking may be required from time to time.

Origin of Earth

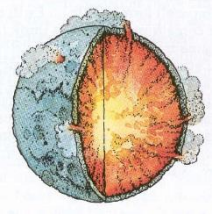
To understand the **origin of Earth**, we must focus on how earth formed billions of years ago. Earth formed as a direct result of the **"**Solar Nebula Hypothesis", which states, that a great cloud of gas and dust shrank under its own gravitation and transformed into the planets and natural satellites that make up the present solar system.

Early Earth

- It is thought that earth was not always layered as it is today. Some scientist suggests that Earth was a lot like the moon in appearance billions of years ago.

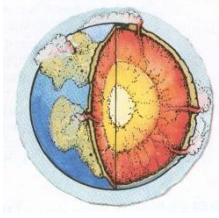


- The composition of the ancient Earth was thought to be the same throughout. Is separated later in Earth's history.
- Shortly after Earth formed, the interior of Earth **segregated** and took on a layered structure. Heat generated from the ***collision of particles*** and the decay of ***radioactive isotopes*** produced heat in earth's interior which was responsible for melting the heavier elements (Ni and Fe) within earth



- Gravitation caused streams of hot heavy liquids that moved Toward earth's center and melted the lighter rock material and forced it to the surface.

- 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.
- Atmosphere and oceans formed as a result of the gases given off by volcanic out gassing throughout Earth's history.

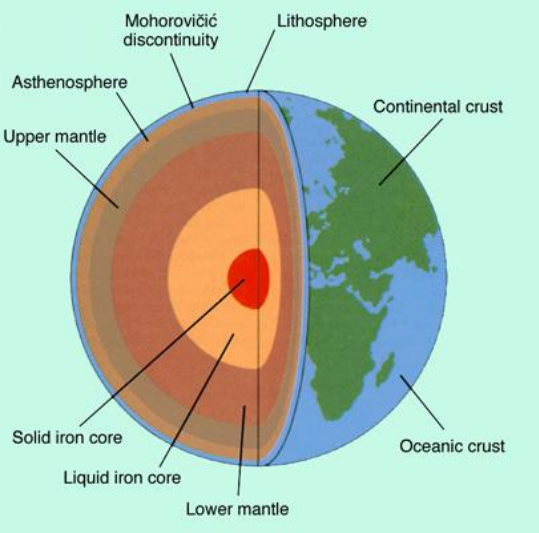


As a result of these processes:

- The inner core is solid and the outer core is liquid, and both layers are comprised of nickel and iron due to the process of segregation.
- Segregation caused high density elements to sink towards the middle of Earth.
- The mantle is the thickest Earth layer. It is a solid but has fluid-like qualities, and is comprised of both low density and high density elements due to segregation.
- The asthenosphere, the uppermost part of the mantle, besides having fluid-like qualities, is the weakest part of the mantle.
- The lithosphere (crust) is the top approximately 100 km of the Earth's interior and is comprised mostly of low density elements. The thickness of the crust varies depending on whether it is continental or oceanic.

Earth's Interior

The model scientist put forth is based on indirect evidence which includes the study of **seismic waves** into earth's interior. The Earth is separated into layers based on mechanical properties in addition to composition.



1. **Lithosphere (Crust)** The topmost layer is the **lithosphere**, which is comprised of the **crust** and solid portion of the **upper mantle**. The lithosphere is divided into many plates that move in relation to each other due to tectonic forces. The lithosphere essentially floats atop **a semi-liquid layer known as the asthenosphere**. This is a hot, weak zone of rock that is capable of gradual movement. This is the layer that the crustal plates rest upon.
   This layer allows the solid lithosphere to move around since the asthenosphere is much weaker than the lithosphere. The Crust is made up of silicate rock materials and makes up only about one percent of the Earth and is the thinnest layer in comparison to the other three layers. Most earthquakes occur in the Earth's crust. The thickness and the composition of the Earth's crust vary in the land and the ocean.

Main Characteristics:

- Cool, rigid layer located directly above the asthenosphere.
- Approximately 100 km thick, which includes the entire crust and a portion of the uppermost mantle.
    - **Continental Crust**: is about 32 kilometer thick and composed of lighter materials like granite, quartz and feldspar. Low Density
    - **Oceanic Crust**: measures about 10 kilometers and is mostly made up of basalt. High density.

2. **Mohorovicic Discontinuity (Moho)**
    - Boundary separating the crust and the mantle.
    - Distinguished by an increase in rock density. The pressure and temperature increases tremendously from the outer layers to the inner layers. .
    - Velocity of seismic waves show an increase.

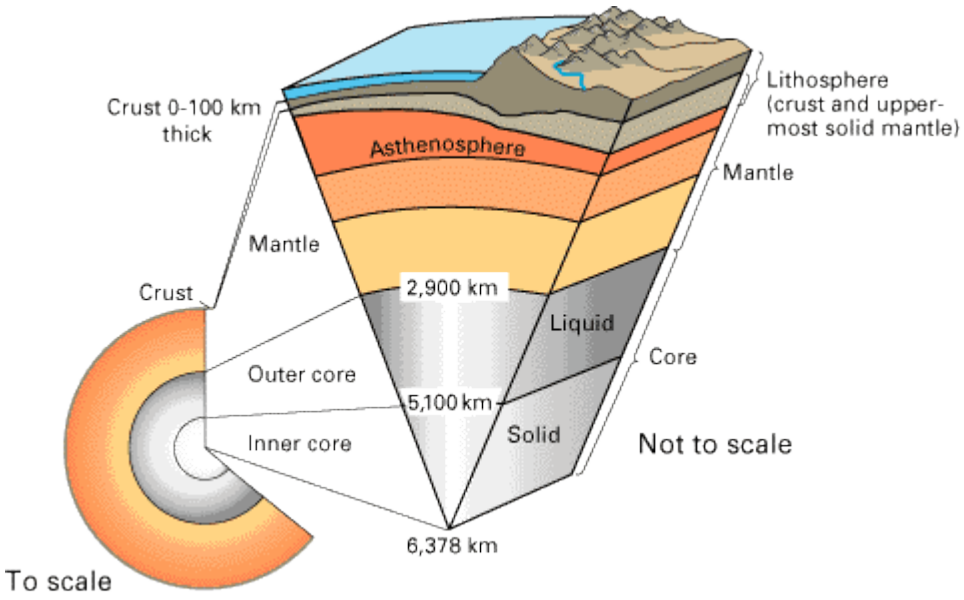
3. **Mantle:** The mantle, the largest layer of the Earth, is made up of iron, aluminum, calcium, magnesium, silicone and oxygen. In fact, most of the Earth's mass (about 80 percent) lies in the mantle. The temperature in this layer is estimated to be about 1000 degrees Celsius. It is in this layer that volcano magma is present. For better understanding, we can say that the mantle layer is divided into the upper and lower sections**. The upper mantle is much cooler** than the lower (deeper) section. The overall thickness of the mantle layer is 2900 kilometers. Consist of high density rocks rich in compounds of iron, magnesium, and silicon.

4. **Outer Core:** The outer core can be regarded as a ball of very hot metals. The outer core is **liquid and made up of iron and nickel.** The density is very high, but less than pure molten iron. Hence, scientists are of the opinion that sulfur and oxygen may be present in the outer core. (This is due to the fact that they dissolve easily in liquid iron.) The outer core measures 2200 kilometers in thickness. As the Earth rotates, the outer core (consisting of iron) spins over the inner core and generates the Earth's magnetic field, which is the factor responsible for functioning of the magnetic compass. Seismic waves (S-waves) do not pass through this layer. (liquid)

5. **Inner Core:** The inner core, as the name suggests, is the innermost layer of the Earth, and is characterized by extremely high temperature and pressure conditions. The temperature of the inner core layer is more than the sun's surface. The intense heat reflected from the inner core mobilizes the materials of the outer core and the mantle. **It is due to the high pressure that the inner core materials are unable to move, and hence remain solid nickel and iron**. The thickness of the inner core is believed to be about 1250 kilometers.

Recap! These layers came about as a result of:

1. heat (from radioactive decay,
2. residual heat
3. particle collisions
4. gravity
5. density



Earth is an evolving planet. Many processes are at work in its evolution. As a result, Earth is ever changing; at times a slow pace over millions of years, while other times a rapid pace through earthquakes, volcanoes, and landslides.

These features help define the dynamic nature of Earth.