Unit 1:

Introduction to Earth Science – The Evolution of Planet Earth

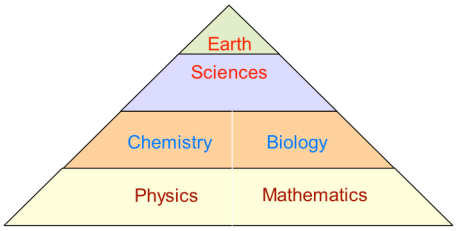
Earth Systems 3209 - Preface – Careers

Before we begin learning about The Earth and how it works, it is important to note the kinds of work associated with Geosciences. Below, there is a list of fields and careers that identify specific areas and "jobs" an Earth Science background can get you. Please take some time to identify each. Some terms may not be familiar to you, but as the year progresses will come to know them.

Field	Description
Minerology	
Crystallography	
Gemology	
Petrology	
Volcanology	
Geochemistry	
Sedimentologist	
Hydrology	
Structural geologist	
Volcanologist	
Seismologist	
Geomorphologist	
Geochemist	
Geophysicist	
Hydrologist	
Petrologist	

Earth Systems 3209 - Unit 1 Lesson 1 - Introduction

Earth Science (or Geoscience as it is sometimes referred) is the name for all the sciences that collectively seek to understand Earth and its neighbours in space. It is a relatively new science, based on the fact that a lot of the proof we use to understand how our Earth works has only come around in the last 100 years or so. Earth Science also incorporates areas from the "other" sciences like: Math, Biology, Chemistry and Physics. This means that it was "built" from the other sciences.



Different branches study the different parts of Earth;

1) Solid Earth 2) Liquid Earth 3) Gaseous Earth 4) Space

Textbook Reference:
Pages 5 – 7

1) Solid Earth

Geology – study of the solid Earth

Divided into two broad areas;

i) Physical ***Geology*** - examines the materials composing Earth and seeks to understand processes that operate beneath and upon its surface

ii) Historical ***Geology*** – seeks an understanding of the origin of Earth and the development of the planet through its 4.6 billion year history.

Branches related to Geology include:

Seismology – study of earthquakes and seismic waves

Paleontology – study of fossils and life on Earth

Geomorphology – study of landscape features on Earth

Mineralology – study of minerals

Volcanology – study of volcanic activity

2) Liquid Earth

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

3) Gaseous Earth

Meteorology – study of the atmosphere; weather and climate

4) Space

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.

Common Errors and Misconceptions

Meteorology is the study of the atmosphere which focuses on weather and climate, whereas, meteorites fall under the study of astronomy

The impact meteorites have on Earth's surface falls under the study of ***Geology***.

The Nature of Scientific Inquiry – a Review

In order to be truly introduced to any type of science, you must first remember the parts of scientific inquiry that are essential in learning and understanding.

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

Observation, Hypothesis, Fact, Theory, Law

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

Hypothesis - a preliminary, untested, educated guess that provides an explanation to some idea. A hypothesis must go through extensive testing to validate its accuracy. Often several hypotheses are formulated to try and explain the same facts and observations.

Fact - data collected from observation and measurement that 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. It explains observable facts that occur in nature. Example - Theory of Plate Tectonics

Law - Is a generalization about the behavior of nature from which there has been no known deviation after numerous observations or experiments. It describes observable facts that occur in nature.

Therefore the nature of scientific inquiry is also called the scientific method. It takes the following path: **Observation→Hypothesis→Fact→Theory→Law**. This isn't always reflective of how scientific knowledge progresses.

Sample Problems

1) Which of the following branches of Earth Science focus on the study of atmospheric conditions?

(A) astronomy (B) meteorology
(C) seismology (D) paleontology

2) Which branch of Earth Science focuses on the study of fossils?

(A) astronomy (B) meteorology
(C) palaeontology (D) seismology

3) Which branch of Earth Science focuses on the study of Earth's water systems?

(A) hydrology (B) palaeontology
(C) petrology (D) seismology

4) Which branch of earth science would most likely study the origin of meteorites?

(A) astronomy (B) geology
(C) meteorology (D) oceanography

5) Which scientific concept has the highest degree of certainty?

(A) hypothesis (B) law
(C) observation (D) theory

6) Which is a generalization about the behaviour of nature from which there has been no known deviation after numerous observations and experiments?

(A) a fact (B) a law
(C) an inquiry (D) a theory

Earth Systems 3209 - Unit 1 Lesson 2 – Origins of the Universe

Origin of the Universe

Throughout history many ideas about the origin of the universe was hypothesized.

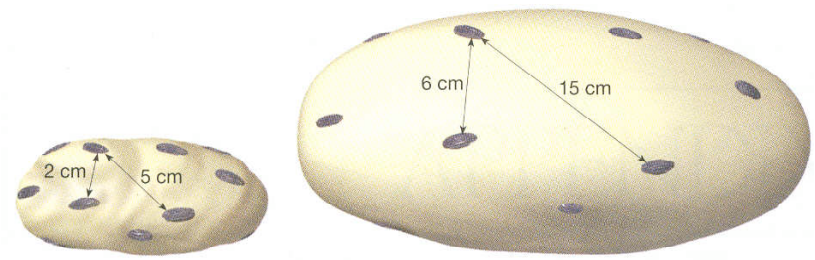
These ideas range from;
Creationism where some supreme being (God) created the universe, to more scientific views such as **The Big Bang.** Regardless, early ideas changed with time as new evidence was discovered to change initial models and theories of the universe.

Textbook Reference;
Pgs. 588 – 589

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. Think of it like baking a raisin bun. In your lump of dough, the raisins are close together. As you cook it, the dough rises, and they get farther apart.

Raisin Bun Analogy

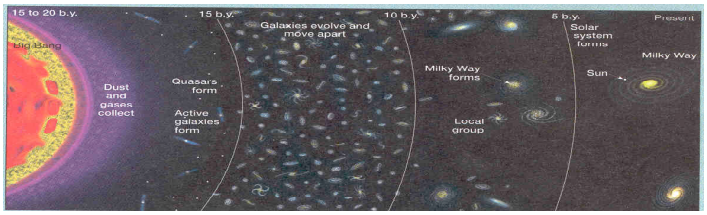


A. Raisin bread dough before it rises.

B. Raisin bread dough a few hours later.

During the Big Bang:

- The universe was confined to a dense, hot, super massive ball of gases
- 20 billion years ago, an explosion hurled this material in all directions
- This 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



Some links:
Song- http://youtu.be/uS3qDDzgPio
Video - http://youtu.be/RLMeA3M_PaU

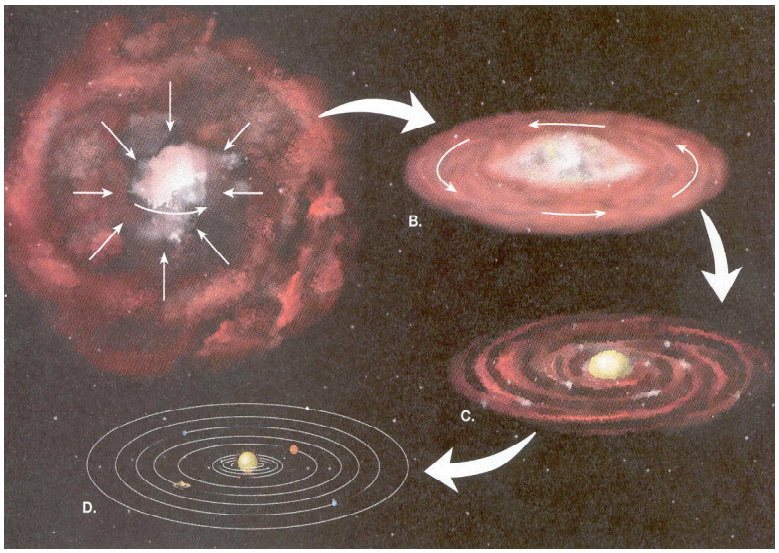
Our Solar System was formed by what Scientists have termed the ***Solar Nebular Hypothesis.*** This idea explained the formation of the solar system through **four stages.** Astronomers believe that all parts of our solar system formed at essentially the same time and from the same material.

Stage 1
- Approximately 5 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

Stage 2
- Rotation caused most material to concentrate in the center
- The central rotating mass of gases was packing tightly upon 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

Stage 3
- 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

Stage 4
- 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



Common Errors and Misconceptions

- Students would not include all stages of formation of the solar system.

- Students would confuse solar nebula with big bang.

Sample Problems

1. According to the Solar Nebular Hypothesis, what is the correct sequence of events leading to the formation of our solar system?

(A) collection of gas and dust → formation of flattened rotating disk → formation of the sun → formation of planets

(B) collection of gas and dust → formation of planets → formation of flattened rotating disk → formation of the sun

(C) formation of the sun → collection of gas and dust → formation of planets → formation of flattened rotating disk

(D) formation of the sun → formation of flattened rotating disk → collection of gas and dust → formation of planets

2. Explain the origin of the solar system according to the Solar Nebula hypothesis. (2%)

*Note: This is an actual public exam question. The mark breakdown is as follows: This question is worth **2 marks** and requires a **four part** answer. ½ **mark** for each part of the answer.*

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Do STSE #1

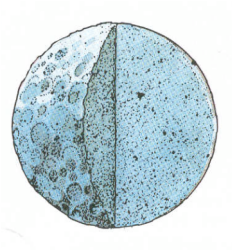
Earth Systems 3209 - Unit 1 Lesson 3 – Segregation of the Earth into Layers

In order to understand the **Origin of the Earth**, you must first recall the last lesson about the Origin of the Universe. As a quick reminder:

Earth formed billions of years ago. It 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.

The Early Earth

It is thought that Earth was not always layered as it is today. Some scientists suggest 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. It separated later in Earth's history.

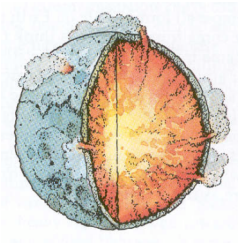


Segregation of Earth

This is a process that took place in four steps

Step 1:

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 the Earth.



Step 2:

Gravitation caused great streams of hot heavy liquids to move toward Earth's center, melting the lighter rock material and forcing 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.

Step 3:

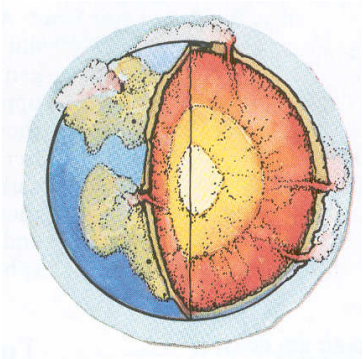
The **heavier material (nickel and iron)** that go to Earth's center formed **the inner and outer core**. The **lighter and less dense material** that moved upwards closer to the surface formed **Earth's crust**. The material in between formed earth's mantle.

Step 4:

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

Fully label this diagram using the following terms:

Crust	Inner Core
Outer Core	Mantle
Atmosphere	Geosphere
Hydrosphere	



Review

1. How does the solar nebular hypothesis explain the segregation of the geosphere into layers?

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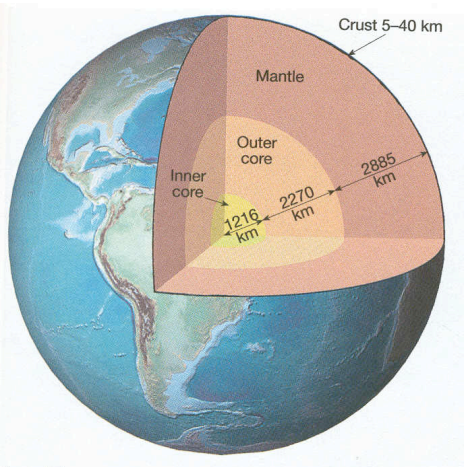
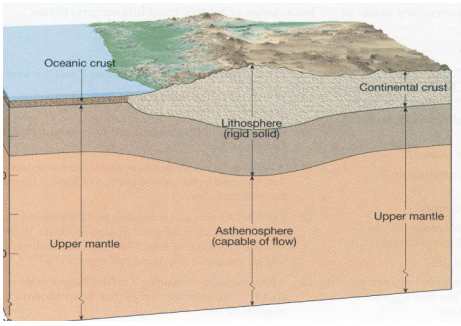
Earth Systems 3209 - Unit 1 Lesson 4 – The Earth's Interior

The model of the Earth that scientists put forth is based on indirect evidence which includes the study of seismic waves into Earth's interior. The diagram below outlines the four major layers inside of Earth and a cross section.





On the Diagrams above, label the following:

Lithosphere	Oceanic and Continental Crust
Asthenosphere	Moho
Lower Mantle	Outer Core
Inner Core	

Lithosphere:

This is a cool, rigid layer located directly above the asthenosphere. It is approximately 100 km thick, which includes the entire crust and a portion of the uppermost mantle. This makes up the tectonic plates (sometimes called lithospheric plates).

Crust (two types)

1. The Continental Crust which is roughly 30 to 40 km thick, is felsic in nature and has low density.
2. The Oceanic Crust which is approximately 5 km thick, is mafic in nature and has high density.

Notice the fact that each type of crust has different densities and different thicknesses. That is because a greater amount of Continental Crust will weigh the same as a smaller amount of Oceanic Crust. This is a concept we will go into more detail with later.

Mohorovicic Discontinuity (Moho)

This is the boundary separating the crust and the mantle. It is distinguished by a sudden increase in rock density due to a change in temperature and composition. Here, the velocity of seismic waves show a sudden increase as well.

Asthenosphere (Upper Mantle)

This is located approximately 100 km to 700 km in depth. It is a hot, weak zone of rock that is capable of gradual movement. This is the layer that the crustal plates rest upon.

Lower Mantle

This layer is approximately 2200 km thick and consists of high-density rocks rich in compounds of iron (Fe), magnesium (Mg), and silicon (Si).

Outer Core

This layer is approximately 2270 km thick and consists of liquid iron and nickel (Ni). Seismic waves (S-waves) do not pass through this layer.

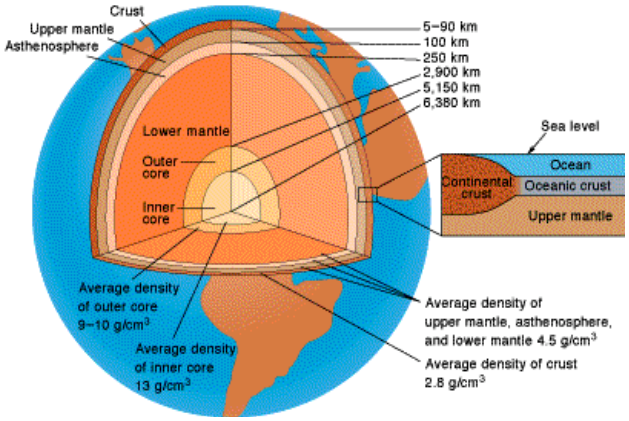
Inner Core

This layer is approximately 1216 km thick and consists of solid iron and nickel. It is said that the solid inner core of the Earth, followed by a free flowing liquid outer core, creates its magnetic field.

Temperature and Density Increases with Depth

The temperature inside Earth increases at a rate of approximately 35 degrees celcius per kilometer. This is referred to as the Geothermal Gradient.

The density inside the Earth also increases as depth inside Earth increases (Recall the Earth Segregating into layers)



Earth Systems 3209 - Unit 1 Lesson 5 – The Earth's Sphere's

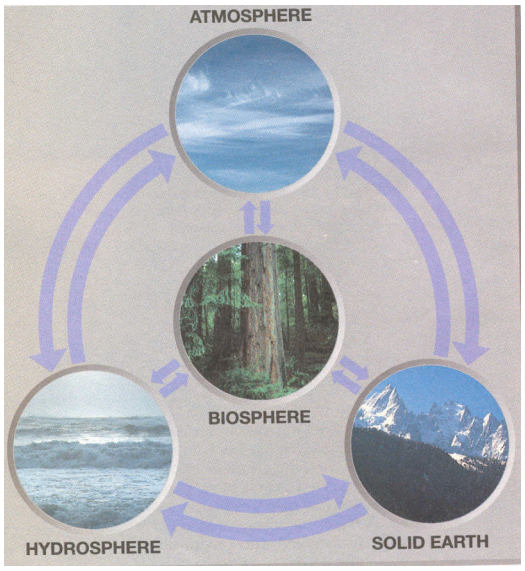
The Earth is a system of four interdependent reservoirs through which matter and energy flows.

These four reservoirs are:

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

These spheres are closely connected and function as one system.

Reference: Tarbuck Text p. 2-5



1) Geosphere

This is 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.

2) Hydrosphere

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

3) Atmosphere

The gaseous layer that surrounds Earth mainly comprised of nitrogen (78%), oxygen (21%) and carbon dioxide (<1%). Examples include the air we breathe.

4) Biosphere

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

Earth's Spheres

Earth System is powered by two sources:

1) Sun (solar energy) drives external processes of Earth. For example: weather and climate, ocean circulation, and erosional processes.
2) Residual heat and Radioactivity drives internal processes of Earth. For example: volcanoes, earthquakes and mountain building.

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.

Example:

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.

Can you think of some examples of interactions between two or more spheres? (Place the words in the correct boxes. You can use some more than once!)

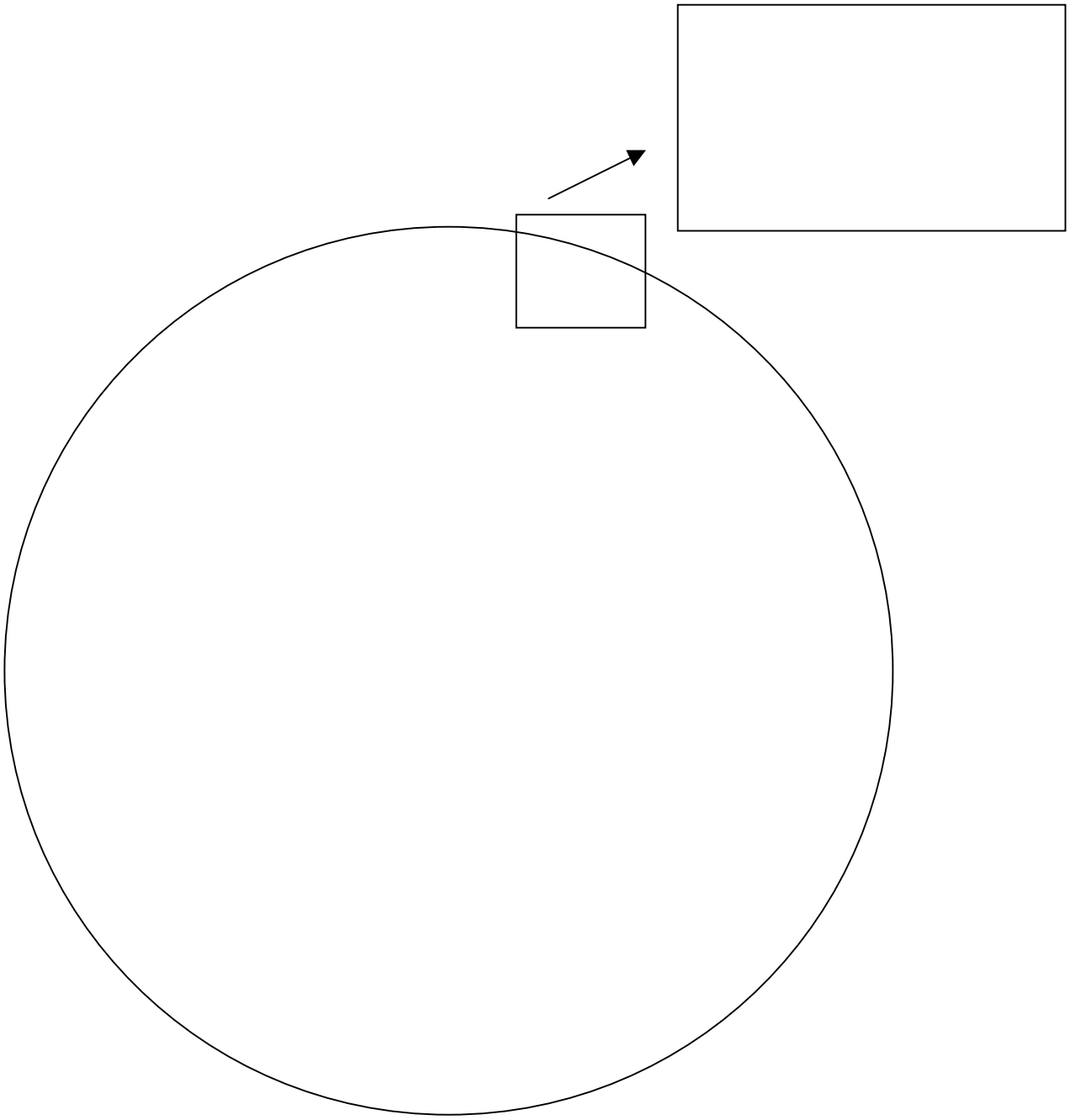
	Atmosphere	**Geosphere**	**Hydrosphere**	**Biosphere**
Atmosphere				
Geosphere				
Hydrosphere				
Biosphere				

Word List:

Ozone change	erosion	El Nino	coal
Photosynthesis	nutrient cycles;	Hurricanes;	tsunamis;
volcanoes;	wave action	Plate tectonics;	

Earth Systems 3209 **Name: _____**
Unit 1 Review Assignment (To be handed in): **Section ___**

1. **Construct a fully labeled diagram that shows the different layers of the earth, as well as the approximate thickness of each.**



2. **a) The Earth System consists of four spheres. Identify each of these spheres and indicate their main components in the space below.**

b) Using your own example, describe a situation that demonstrates how each of the spheres are interrelated.

a)

i)
ii)
iii)
iv)

b)

Earth Systems 3209 Unit 1 Test Review

Please answer the following completely and on your own paper. You may type them, or handwrite them legibly.

Definitions

Earth Science-Geoscience	Astronomy	Geology
Oceanography	Meteorology	Big Bang Theory
nebular hypothesis	inner core;	outer core;
mantle (asthenosphere);	lithosphere (continent)	hydrosphere
lithosphere (Oceanic)	atmosphere	

Review Questions

1. Explain how the Earth is differentiated into layers, and identify each layer.
2. Describe the formation of the universe using the Big Bang Theory
3. Describe the four stages of the nebular hypothesis that led to the formation our solar system
4. Describe the interaction among the hydrosphere, lithosphere, and atmosphere, using one major event.