

# Chapter 1: Earth as a System / Chapter 2: The Nature of Science

## I. *Branches of Earth Sciences*

- A. **Geology**- the study of the Earth- the study of the origin, history, processes (in and on the surface) and structure of the solid Earth.
- B. **Oceanography**- the study of the Earth's oceans and the life and processes that affect it. Earth is cover by about 71% water, most of which is found in Earth's oceans (salty).
- C. **Meteorology**- the study of Earth's atmosphere. This involves day to day weather and more long term processes such as climate and climate change.
- D. **Astronomy**- the study of Earth's place in space; the Universe beyond Earth. This branches involves all things that outside of the Earth system. Stars, planets, the solar system are several of examples.

## II. *Environmental Science and the Earth Sciences:*

Earth provides the resources that make life as well know it possible. Earth also provides the materials to enrich the quality of a person's life. Natural resources are things such as fresh water, clean air, rock and mineral resources and fossil fuels.

## III. **How Is Science Different from Other Fields of Study?**

A. As they study the natural world, scientists assume two things:

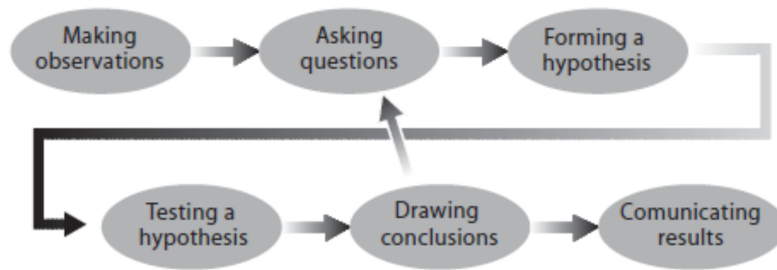
1. It is possible to understand nature.

*a. Scientists assume that with the right tools and correct methods, they can find the answers they are looking for.*

2. Nature is predictable.

*b. In general, scientists observe patterns in nature. From the way a pattern repeats, scientists can predict that an event will happen in a similar way in the future*

#### IV. What Are Scientific Methods?



#### V. OBSERVING AND ASKING QUESTIONS

A. Scientific methods generally begin with observation.

**Observation** is the process of using the five senses to collect information about the world. Observations that scientists make often lead them to ask questions.

#### VI. FORMING A HYPOTHESIS

A. Once scientists have asked a question and made a few observations, they might then form a hypothesis. A **hypothesis** is a possible way to explain or solve a problem. Scientists base their hypotheses on observations or on known facts about similar events.

#### VII. TESTING THE HYPOTHESIS

A. After scientists form a hypothesis, they look for ways to test it in an investigation. In some investigations, the scientist will make more observations and see if they fit the hypothesis.

B. In other investigations, a scientist will do an experiment to test a hypothesis.

1. An *experiment* is a set of procedures that a scientist carries out. Every experiment has conditions or factors that can change. These factors are called *variables*.

a. There are two types of variables.

i. **Independent variables** are factors that the scientist changes. (amount of water a plant receives)

ii. **Dependent variables** are factors that change as a result of the independent variables. (amount the plant grows in response to it being watered)

## VIII. DRAWING CONCLUSIONS

- A. Scientists must decide if their observations support the hypothesis, or show that the hypothesis was correct. In many cases, the results of an experiment are unexpected.
- B. If the results do not support the hypothesis, the scientists must throw out the hypothesis or change it.

## IX. How Do Scientists Use Models?

A. In Earth science, it is often impossible to use an experiment to test a hypothesis. Instead, scientists make additional observations to gather evidence.

- B. Scientists also may use models to test hypotheses they cannot test using an experiment. A *model* is a description or a representation of an object, an idea, a system, or an event. Some models describe objects, such as atoms. Others describe processes, such as the water cycle. Scientists often use models to study things that are too big, too small, too fast, too slow, or too dangerous to study directly.

1. Examples of models include:

Type of Model	Definition	Examples
Physical	three-dimensional models	globe
Graphical	two-dimensional models (pictures)	map, chart
Conceptual	description of an idea	flowchart
Mathematical	mathematical equation that describes the way a system or process works	$2 + 2 = 4$ (used to represent two items joined to two other items)
Computer	a type of mathematical model that uses a computer to do calculations and display results	computer model of Mount Everest

## X. How Do Scientists Make Accurate Measurements?

A. Scientists gather information during investigations. Measurement is a very important method for gathering information in most scientific investigations.

## XI. SI UNITS

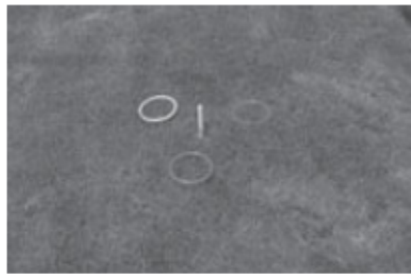
- A. Scientists need to be able to compare and analyze each other's results. Therefore, scientists around the world use a common system of measurement. The system is called the International System of Units, or SI. Meters and kilograms are examples of SI units.

Kilo	Hecto	Deka	Meter	Deci	Centi	Milli
			Liter			
			Gram			
			Newton			

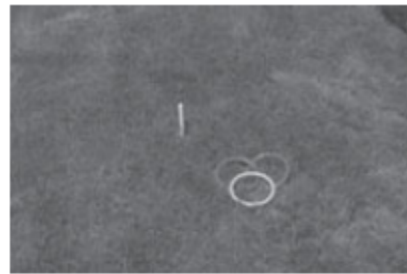
## XII. ACCURACY AND PRECISION

- A. Accuracy and precision are two ways to describe measurements.

1. **Accuracy** describes how close a measurement is to the true value (target).
2. **Precision** describes how exact a measurement is (close to other measures).



Good overall accuracy but poor precision



Poor accuracy but good precision



Good accuracy and good precision

## XIII. How Does Scientific Knowledge Grow?

- A. When scientists discover something new, they share their ideas with other scientists. The other scientists review and test the ideas before accepting the new ideas.

## XIV. SHARING RESULTS

- A. Scientists typically share their results as papers in scientific journals. They also share ideas at meetings with other scientists. Many journals are now published online so that scientists can share their ideas more quickly and easily.

## XV. PEER REVIEW

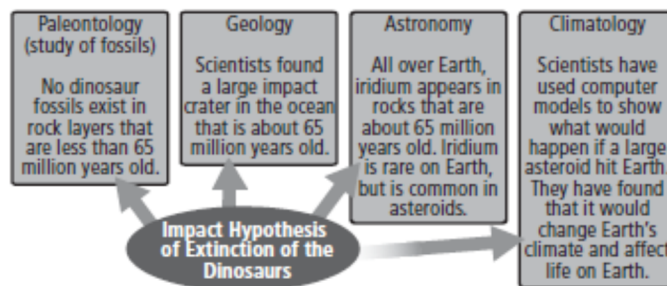
- A. Before scientists publish their work, they show it to other scientists who are experts on the topic. Those experts review the work. The reviewers may suggest changes to the investigation. They may also point out errors in thinking that scientists did not see. This process is called **peer review**.

## XVI. DEVELOPING A THEORY

- A. After a scientist publishes his ideas and results, other scientists typically test the hypothesis and build on the results. The process of repeated testing may continue for years. In time, the hypothesis may be proved incorrect, be changed, or be accepted by most scientists. When a hypothesis has been tested many times and becomes accepted, the hypothesis may help form a theory. A **theory** is an explanation that is supported by all existing observations and study results. However, if repeated results from later tests do not support the theory, scientists may need to change it.

## XVII. THE IMPORTANCE OF INTERDISCIPLINARY SCIENCE

- A. Scientists from many different fields of science share their ideas. Sharing ideas between fields is important because discoveries in different fields may add support to one idea. When an idea is supported by evidence from more than one field, the idea is more likely to be accurate. The figure below shows one hypothesis that is based on evidence from several fields of science.



Discoveries and ideas from different fields of science have helped scientists develop a hypothesis about how dinosaurs became extinct.

B. Scientific knowledge helps people understand the natural world. It also helps people develop new technologies, such as tools, materials, and processes. Many technologies are helpful, but some new technologies can cause problems. For example, plastic is a technology that is useful in many products. However, plastics can cause pollution and harm wildlife. An understanding of science is important for all citizens. Thinking scientifically can help people make wise decisions about products they buy, where they live, and even how they vote.

How did our Moon form?

## Chapter 2 Section 2: Energy in the Earth System

### I. What Is a System?

A. Earth scientists often say that Earth is a system. A system is a group of related objects or processes that work together to form a whole. Systems can be as small as an atom or as large as the whole universe.

B. The parts of a system interact, or affect one another. Systems can also interact with other systems. Systems can interact by exchanging matter or energy. *Matter* is anything that has mass and takes up space. *Energy* is the ability to do work. Heat, light, and vibrations are examples of energy.

#### C. Two kinds of systems

1. Open System - a system that exchanges both matter and energy with the surroundings. The jar shown to the right is an open system.



2. Closed System- system that exchanges energy but not matter with the surroundings. The sealed jar in the right hand picture is a closed system. Energy can move into and out of the jar. Because the jar is sealed, no matter can enter or leave the system.



C. Earth is almost a closed system. Energy enters the Earth system in the form of sunlight. Energy leaves the system in the form of heat. Only tiny amounts of matter enter and leave the system. Therefore, scientists often model Earth as a closed system.

### II. What Are Earth's Four Spheres?

A. The Earth system is made up of four "spheres." These spheres are not large round objects. They are the different areas where all of Earth's matter is found. The four spheres are the atmosphere, the hydrosphere, the geosphere, and the biosphere.

## 1. THE ATMOSPHERE (AIR)

- a. The **atmosphere** is the layer of gases that surrounds Earth. The air we breathe is part of the atmosphere.
- b. The atmosphere also protects Earth from much of the sun's harmful radiation.
- c. About 78% of Earth's atmosphere is nitrogen gas. About 21% is oxygen gas. The rest is made up of other gases, such as argon and carbon dioxide.

## 2. THE HYDROSPHERE (WATER)

- a. All the water on Earth makes up the **hydrosphere**.
- b. Almost all the water in the hydrosphere is salty. (97%)
- c. Only 3% is fresh water. Fresh water is found in streams, lakes, and rivers. It is also frozen in glaciers and the polar ice sheets and is found underground in soil and bedrock.

## 3. THE GEOSPHERE (EARTH)

- a. The **geosphere** is all the rock and soil on the continents and on the ocean floor.
- b. The geosphere also includes the solid and liquid rock and metal inside Earth.
- c. Some natural processes, such as volcanic eruptions, bring matter from Earth's interior to its surface. Other natural processes move surface matter into Earth's interior.

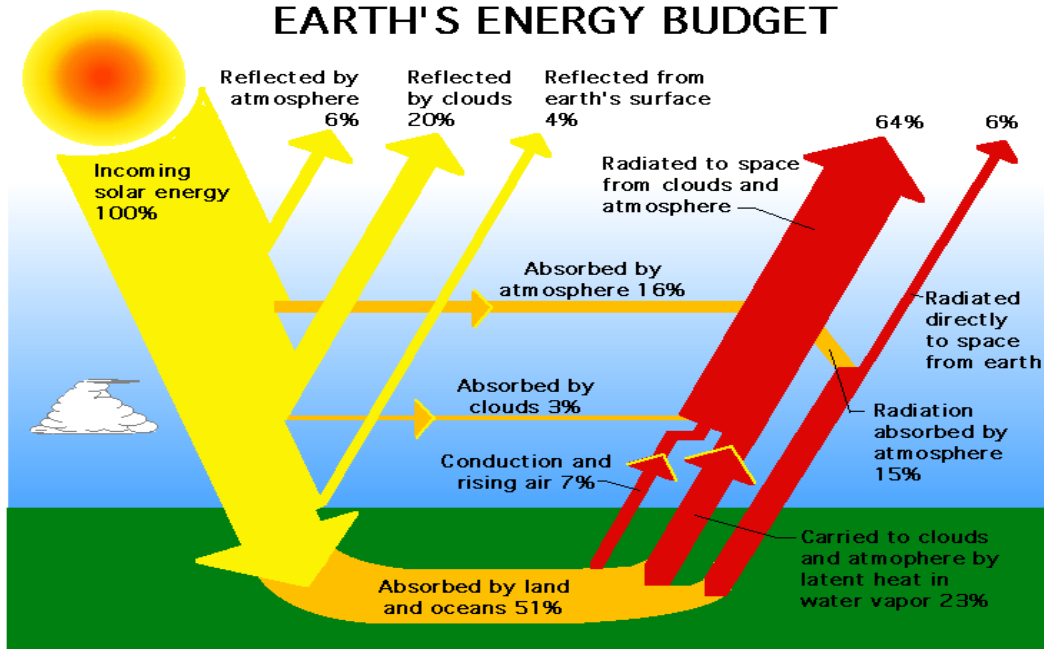
## 4. THE BIOSPHERE (LIFE)

- a. The **biosphere** is made up of all Earth's living things.
- b. Organic matter from dead organisms is also part of the biosphere.
- c. Once this organic matter has decomposed, it becomes part of the other three spheres.
- d. The biosphere extends from within Earth's crust to a few kilometers above Earth's surface.



### III. What Are the Sources of Energy in the Earth System?

A. Energy enters the Earth system in the form of sunlight. Energy also leaves the Earth system as heat. The amount of energy that enters the Earth system is the same as the amount of energy that leaves it. In other words, the energy that enters and leaves the system is balanced.



B. Solar Energy - 99.985% of the energy in the Earth System comes from sunlight. This energy represents about 1/20000000000% (2 Billionth of a percent of the total energy output of the Sun).

C. Geothermal Energy -.013% of the energy in the Earth System comes from Earth's interior. This energy drives the motion of Earth's plates, powers volcanoes, causes earthquakes, and is an important part of the rock cycle.

D. Tidal Energy – 002% of the energy in the Earth System is tidal energy. This energy is driven by the gravity of the Moon pulling on the liquid outer layer of Earth.

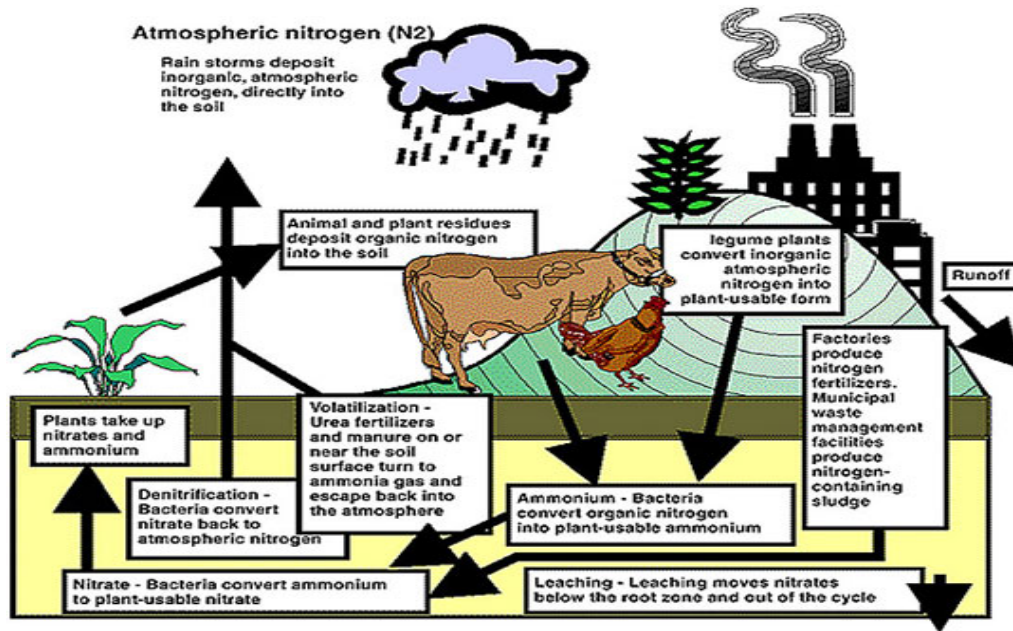
### IV. How Does Matter Move on Earth?

A. Like energy, matter moves between the parts of the Earth system. A place where matter or energy is stored is called a *reservoir*.

1. For example, the oceans, atmosphere, and living things are some of the reservoirs for water.
2. The group of processes that move matter between reservoirs is called a *cycle*.
3. Four important matter cycles on Earth are the nitrogen cycle, the carbon cycle, the phosphorus cycle, and the water cycle.

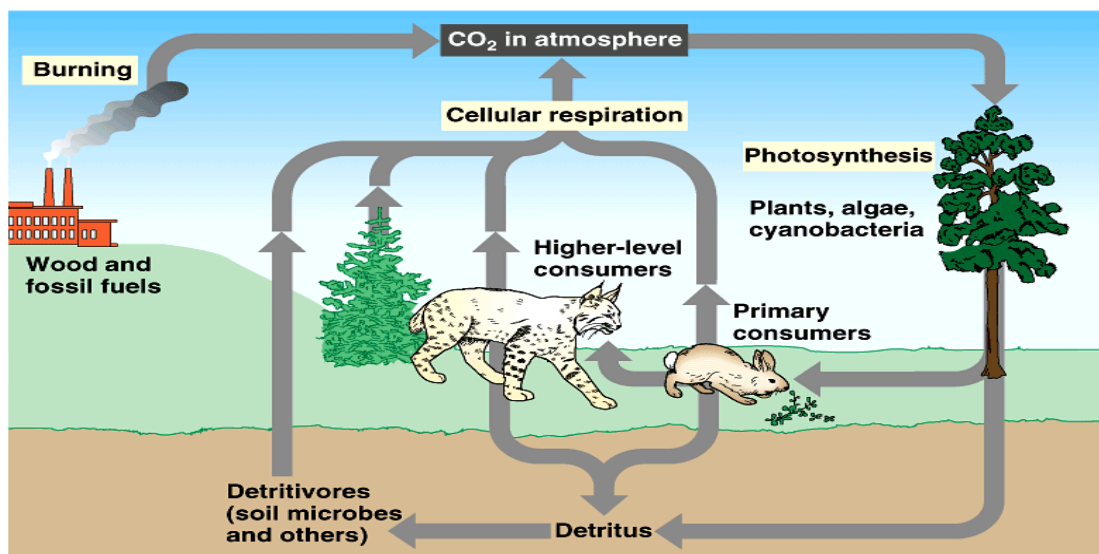
## V. THE NITROGEN CYCLE

A. Living things use nitrogen to build proteins and other important chemicals. The diagram below shows the processes that are part of the nitrogen cycle.



## VI. THE CARBON CYCLE

A. Almost all the chemicals that make up living things are based on carbon. Like nitrogen, carbon cycles through the Earth system. The diagram below shows the parts of the carbon cycle.



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B. Scientists often break the carbon cycle into two parts: the short-term carbon cycle and the long-term carbon cycle.

C. In one part of the short-term carbon cycle, plants take carbon dioxide from the atmosphere. They change the carbon dioxide into sugars and other chemicals in the process of *photosynthesis*. The plants use these chemicals to build and repair their cells.

D. Animals that eat the plants break down the chemicals in the plants. They use some of the chemicals for energy. In the process of *respiration*, they break the chemicals down to release the energy stored in them. Respiration produces carbon dioxide gas, which moves back into the atmosphere. Plants also carry out respiration, in addition to photosynthesis.

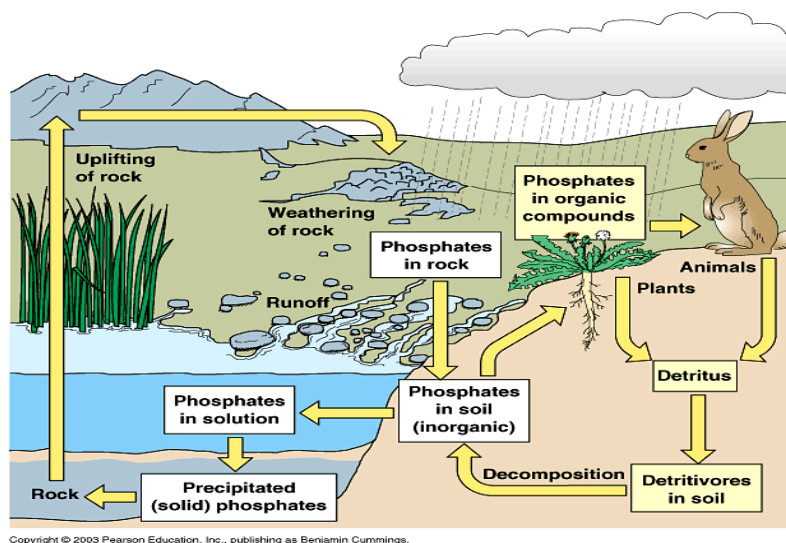
E. When living things die, bacteria break down their bodies. This process is called *decomposition*. Most of the carbon in their bodies changes back into carbon dioxide gas. Respiration, photosynthesis, and decomposition make up the short-term carbon cycle.

F. In the long-term carbon cycle, carbon moves through all four of Earth's spheres. The remains of some living things are buried underground. Heat and pressure change them into *fossil fuels*, such as coal, oil, and natural gas. This process takes millions of years. People burn fossil fuels for energy in a process called *combustion*. Combustion produces carbon dioxide.

## VI. The Phosphorus Cycle

A. Phosphorus is another element that living things use to build important chemicals. Unlike carbon and nitrogen, phosphorus generally does not exist as a gas. Therefore, it is not found in the atmosphere.

B. Most of the phosphorus on Earth is stored in rocks. Water and wind can break down the rocks and release the phosphorus. It can then flow into water and soil.

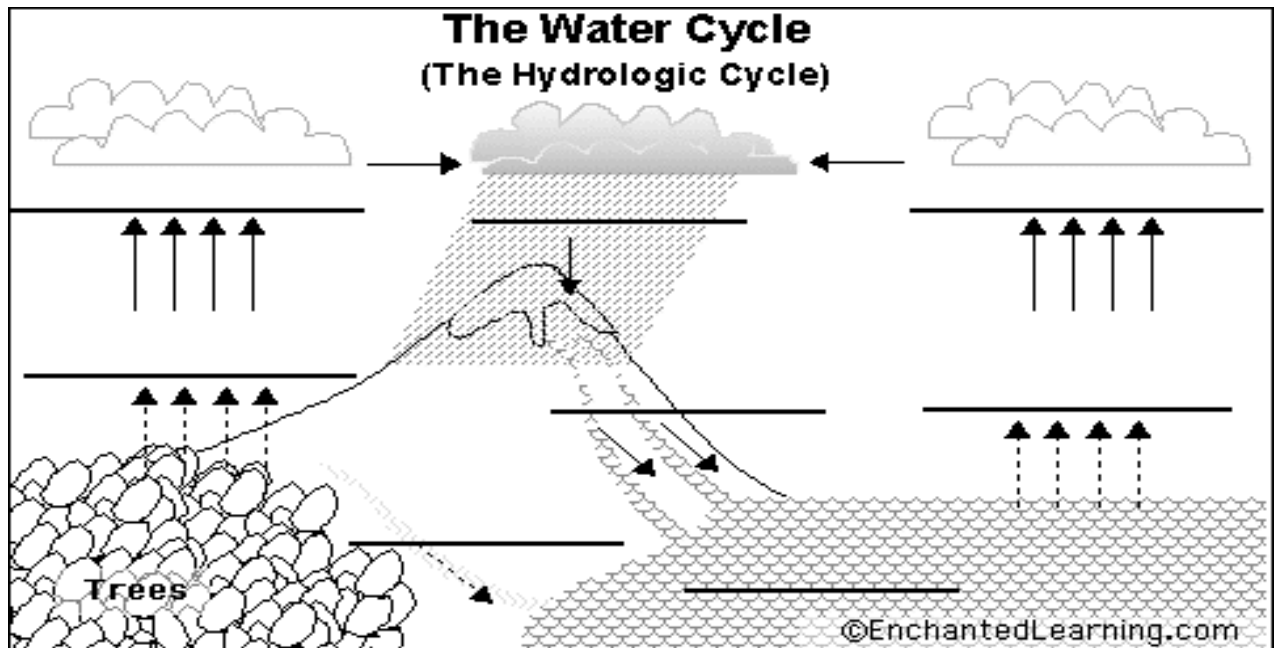


C. Plants get phosphorus from the soil. Animals get phosphorus by eating plants or other animals. The phosphorus in living things returns to the soil when the living things die and decompose.

## VII. The Water (Hydrologic) Cycle

A. Water is always moving between the atmosphere, land, oceans, and living things. This movement of water is called the water cycle.

B. In the water cycle, water changes state, from solid to liquid to gas and back again. The graphic below describes some of the processes in the water cycle.



Condensation  
Infiltration  
Accumulation

Run Off  
Condensation  
Evaporation

Transpiration  
Precipitation

Condensation = water vapor (gas) converting into liquid water

Evaporation = liquid water converting into water vapor (gas)

Precipitation = some form of water falling from the sky (Snow, rain, sleet)

Infiltration = liquid water soaking into the ground

Transpiration = water vapor being returned to the atmosphere by plants.