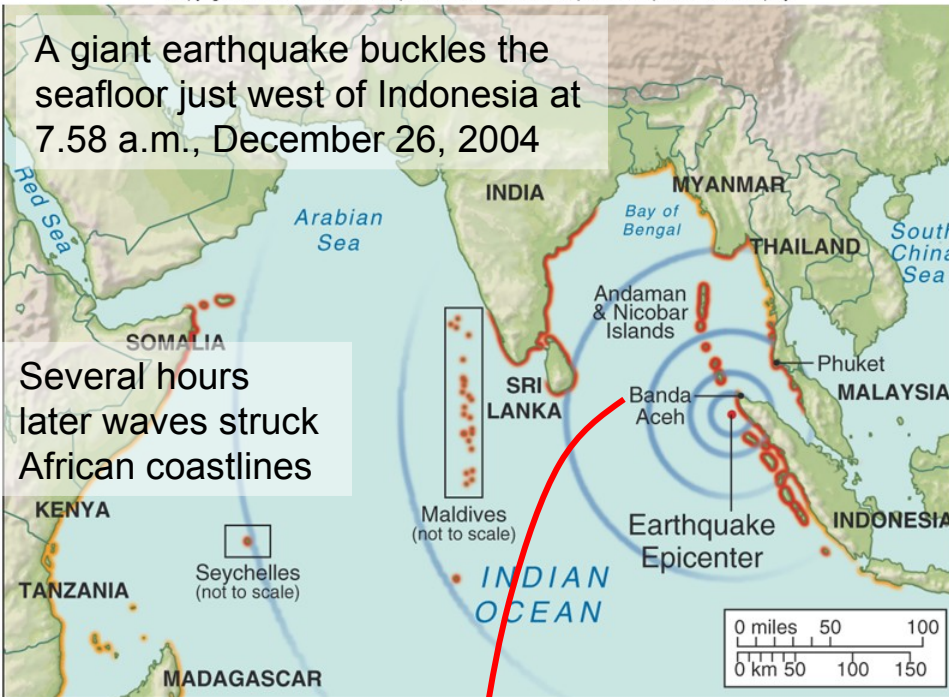


Chapter 1: Introduction to Earth Science

1. Earth Science and the Earth System
2. What is Science?
3. Doing Science
4. Science and Society
(subjective)

Are you ready for a natural disaster?

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Earth's crust is made of tectonic plates that move very slowly.

They move when enough stress builds at their interface. Can hold off a maximum stress. More stress results in sudden motion and a large release of energy – earthquakes and volcanoes

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Banda Aceh, Sumatra, Indonesia, was quickly devastated by waves up to 30 meters high

More than 230,000 people are estimated to have died following the earthquake and tsunami

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Earth Science and the Earth System

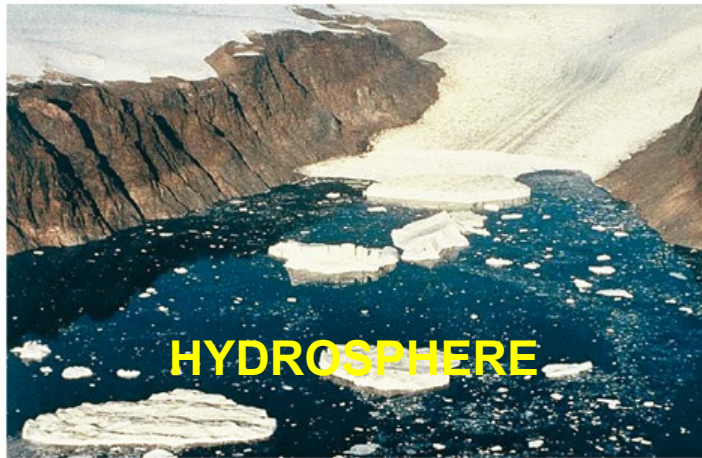
Earth Science

- The investigation of interactions among the four components of the Earth system . . .
 - atmosphere (air, weather)
 - hydrosphere (water, ice)
 - biosphere (plants, animals)
 - geosphere (land, rocks)
- . . . and their interaction with the exosphere (sun, space).

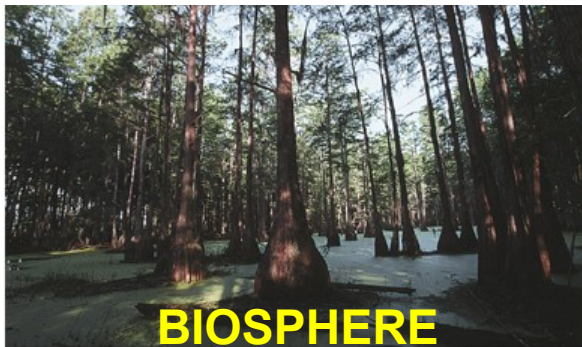
Earth Science and the Earth System

How do you interact with the components of the earth system?

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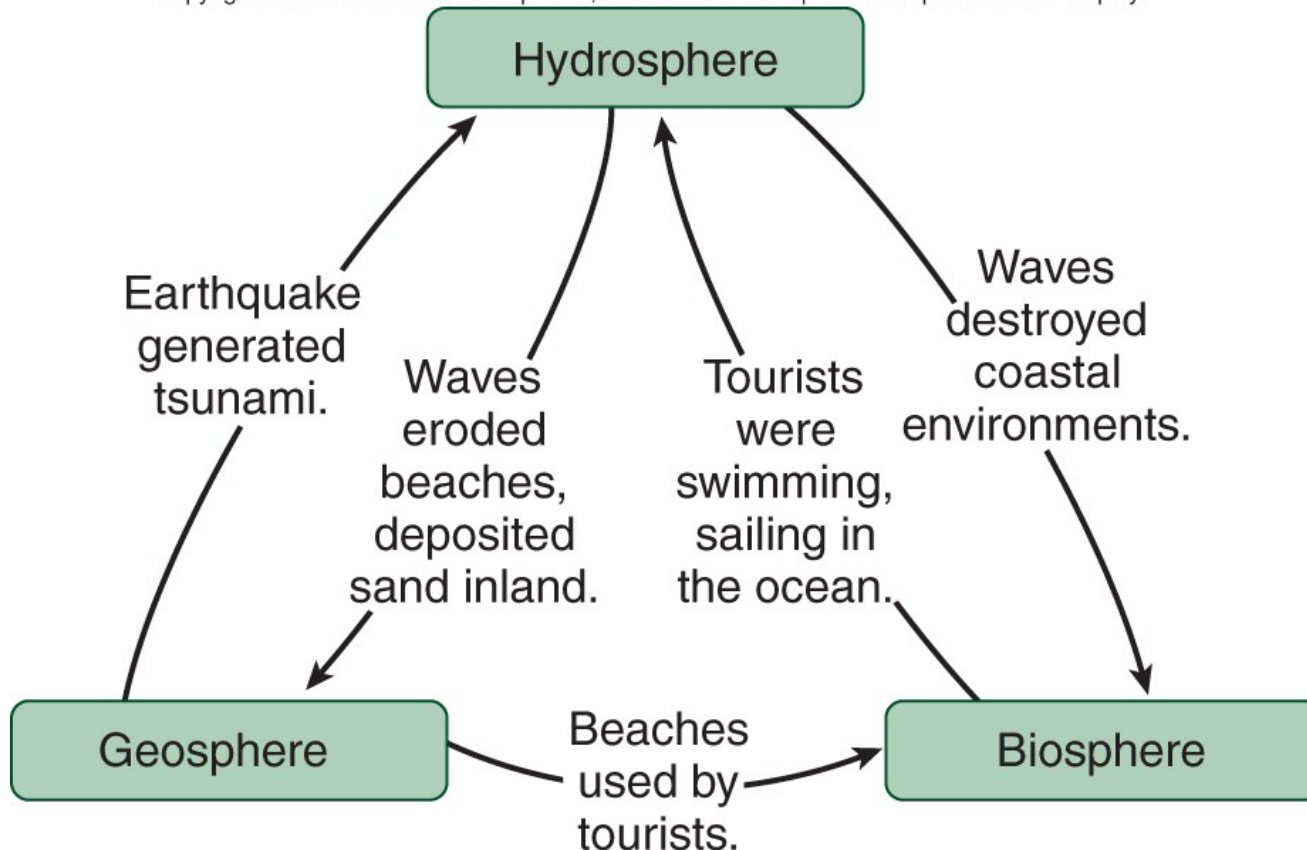


© USDA, John Wang/ Getty Images

Earth Science and the Earth System

How did the components of the earth system interact with each other in the tsunami example?

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What is Science?

Science is . . .

- . . . a process of discovery that increases our body of knowledge.
- . . . information that can be learned; much of it is waiting to be discovered.
- . . . the curiosity and creativity of scientists in the search for answers to critical questions.

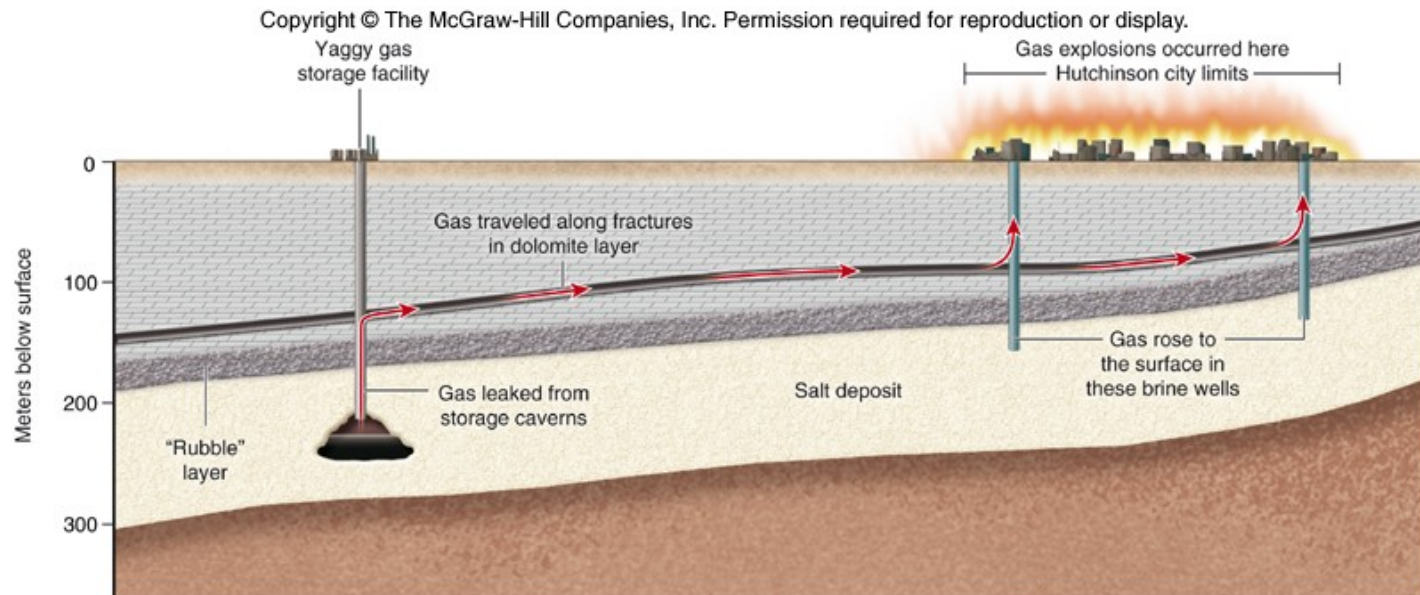
Science is not . . .

- . . . a list of facts to be memorized.

What is Science?

Hutchinson Gas Explosions (2001)

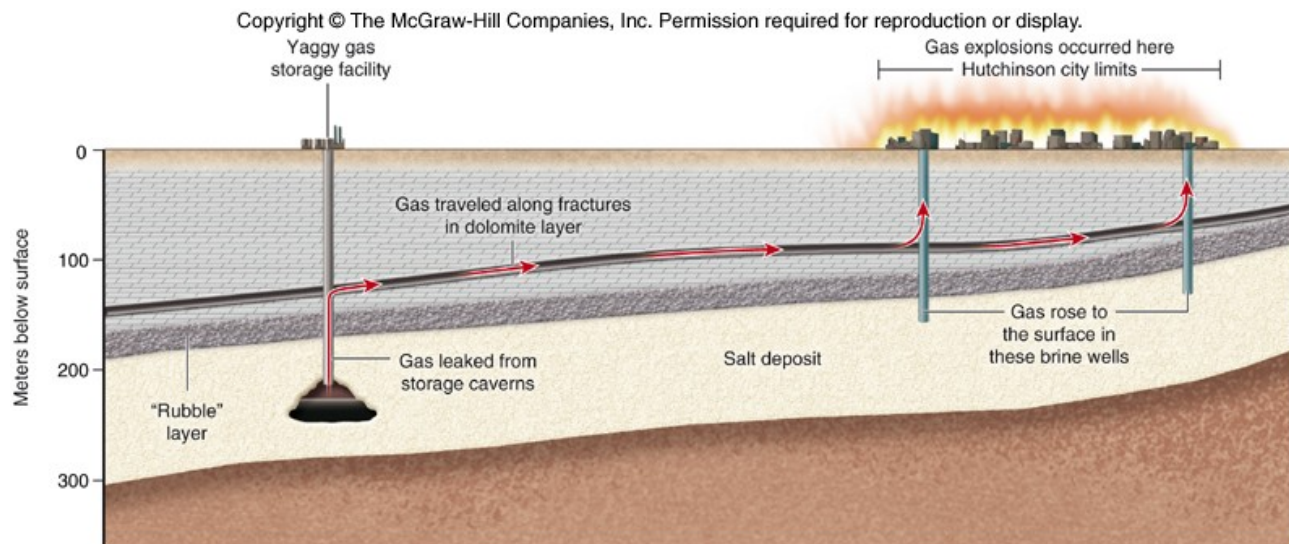
- Gas explosions in Hutchinson, Kansas, linked to gas storage facility
- Scientists hypothesized gas traveled to Hutchinson in fractures in underground rock layer



What is Science?

Hutchinson Gas Explosions

- A practical example of the use of science to resolve a dangerous situation
 - Scientific discovery → scientists found additional hazardous gas concentrations
 - Use of information → geologists used existing knowledge of rocks in region to predict the potential route of gas



Doing Science

To “do science” we need **observations**, a testable **hypothesis**, and one or more **predictions** based on the hypothesis.

- **Hypothesis** – a testable explanation that can be verified or falsified
- **Observations** – facts, measurements, information, data collected using the senses
- **Prediction** – a statement of what will happen in a given situation or set of circumstances

Science Concepttest

Which of the following statements is more accurate?

- A.** Observations are only as good as the hypotheses on which they are based.
- B.** Hypotheses are only as good as the observations on which they are based.

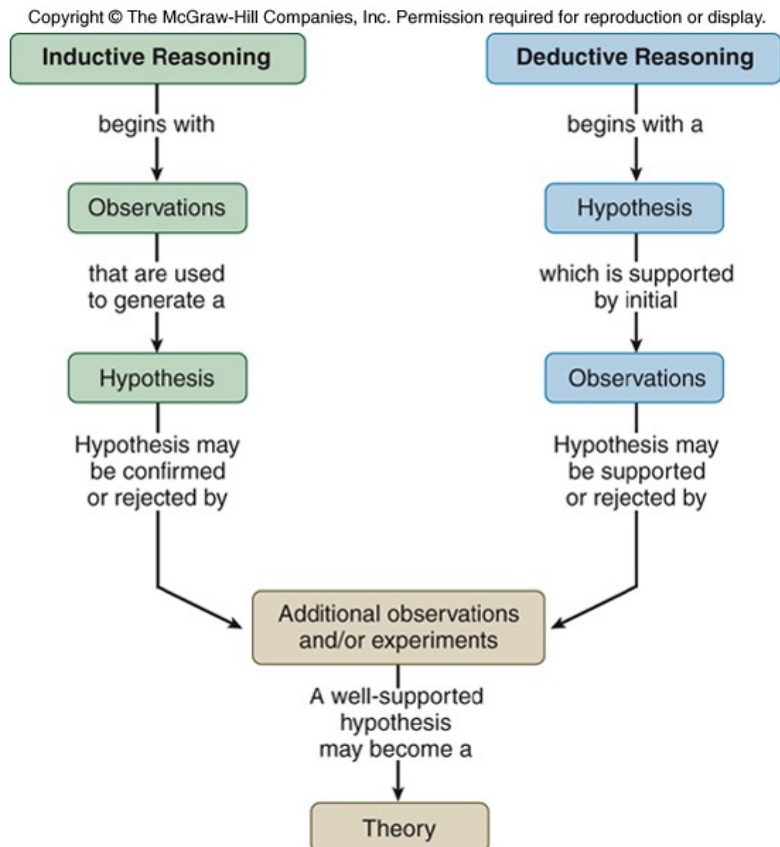
Doing Science

Hypotheses can be tested using either inductive or deductive reasoning.

1. Inductive reasoning

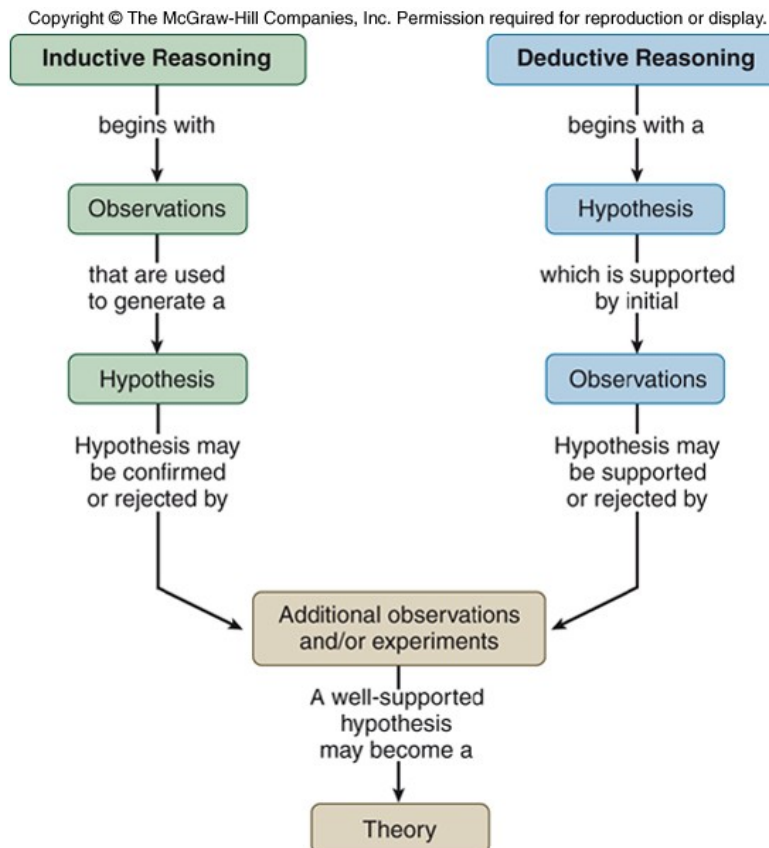
- drawing general conclusions from specific observations.

- Involves recognizing patterns in data



Doing Science

Hypotheses can be tested using either inductive or deductive reasoning.



2. Deductive reasoning - drawing specific conclusions based upon general principles.

- Involves applying laws, principles

Doing Science

Inductive Reasoning Example

1. Three massive hurricanes caused significant damage to the United States during 2005.
2. Hurricane Katrina had a pressure of 902 mbar; Hurricane Rita, 898 mbar and Hurricane Wilma, 882 mbar.
3. Therefore, massive hurricanes with low air pressures of around 900 mbar or less will cause large amounts of damage if they make landfall.

A general conclusion based on specific observations

Doing Science

Deductive Reasoning Example

1. All hurricanes form as low pressure systems over oceans.
2. Hurricane Harry is forming in the Atlantic.
3. Hurricane Harry must be a low pressure system.

A specific conclusion based on a general principle

Science Conceptest

Kathie studied the geology of several Hawaiian volcanoes and used her data to predict the potential dangers from the eruption of similar volcanoes on the Galapagos Islands.

What type of reasoning did she apply?

- A. Inductive reasoning**
- B. Deductive reasoning**

Science Concepttest

During orientation Amy learned that all classrooms on campus were air conditioned. She decided to bring a sweatshirt to class even on the hottest days.

What type of reasoning did Amy use?

A. Inductive reasoning

B. Deductive reasoning

Inductive / Deductive reasoning applied to Hutchinson pipeline

Initial fire caused by a local gas leak – Deductive
(expect gas leaks to cause fires)

Gas was migrating to Hutchinson along rock layers – Deductive
(expect gas moves easily between rock layers)

The subsurface had locations where gas could build – Inductive
(observe that subsurface has different rock layers, some of which have more crevices to store gas.)

The city was deemed safe – Deductive
(If wait long enough, gas will dilute to a safe level)

INDUCTIVE	– Draw conclusions from observations
DEDUCTIVE	-- Draw conclusions from expectation

Doing Science

Science follows some basic rules – that loosely define the **scientific method**

1. A scientific hypothesis is **tentative** and can change
2. A scientific hypothesis should be predictable and testable – test results should either support or falsify the hypothesis
3. A scientific hypothesis is based on data from empirical (based on experience) observations or experiments
4. A scientific hypothesis offers a well-defined **natural cause** to explain a natural event

Doing Science

Example of an emerging hypothesis

Global warming: Average temperature of Earth is increasing due to build up of greenhouse gases in atmosphere

Tentative – estimates of how much temperature is increasing will change

Empirical – measurements of increasing global temperatures

Predictable – if carbon dioxide increases by X, temperature will increase by Y

Natural cause – climate records of last 500,000 years show parallel changes in temperature and greenhouse gases

Doing Good Science

Not all science is “good” science: This can be of particular concern when reading about science reported in the popular media.

Common pitfalls:

- 1) Attacking scientists rather than the science
- 2) Misuse of authority

Can happen when politics conflicts science

- 3) Confusing cause and effect

If *this* happened, then *that* must have been the reason

- 4) Poor statistics

Using empirical data incorrectly

Science Conceptest

Luis and Walter Alvarez suggested the dinosaurs became extinct when an asteroid collided with the earth. They noted that *the rare element iridium was present in 66 million year old rock layers.*

The text in italics is an example of:

A. A hypothesis prediction

C. A

B. An observation **D.** A theory

Science and Society

Earth Scientist's role in Society:

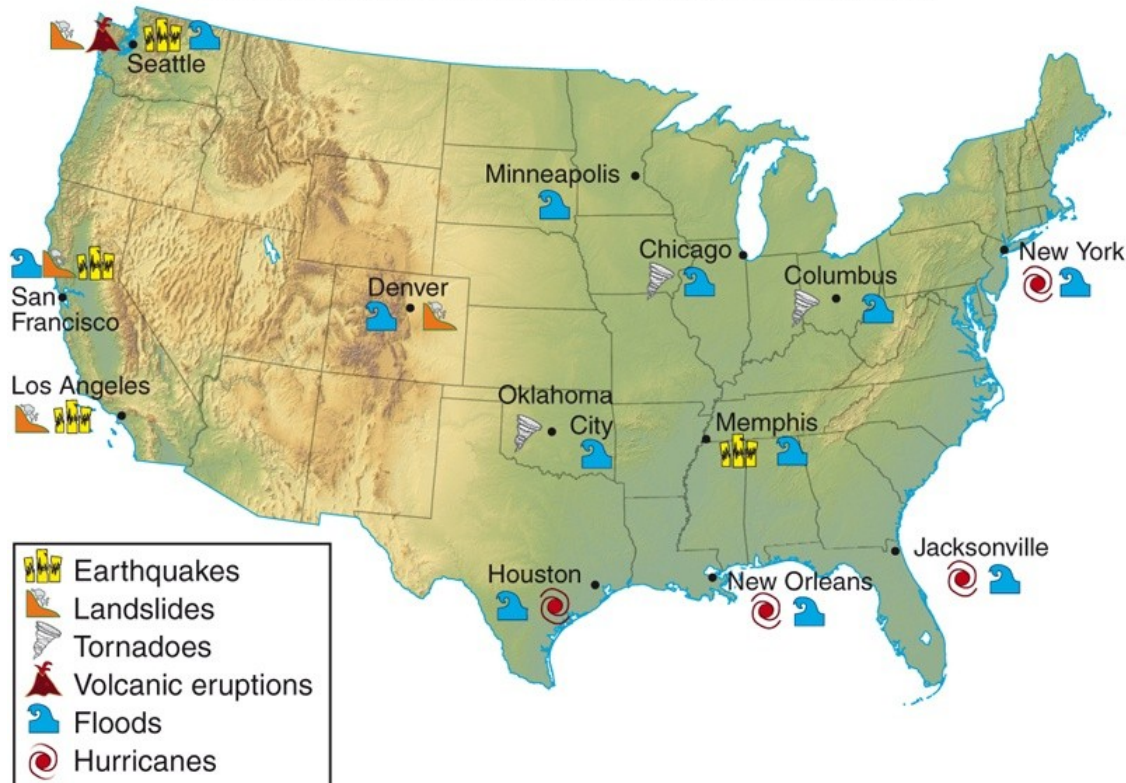
- Alert people to earth processes (hazards) that may cause damage or loss of life
- Provide for material needs of society by managing natural resources
- Protect us from activities that may endanger the natural environment
- Warn humanity of global threats such as climate change or an asteroid impact

Science and Society

Earth Scientist's role in Society:

- Alert people to earth processes (hazards) that may cause damage or loss of life

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Science and Society

Earth Scientist's role in Society:

- Alert people to earth processes (hazards) that may cause damage or loss of life
 - **Prevention** – Which hazards are we most likely (or least likely) to be able to prevent?
 - Example: Prevention of flooding as a result of construction of floodwalls and levees
 - **Adjustment** – strategies for minimizing the impact of hazards
 - Example: Building code regulations in areas of frequent earthquakes

Science Concepttest

Is evacuation of a city in advance of a hurricane an example of prevention or adjustment?

A. Prevention

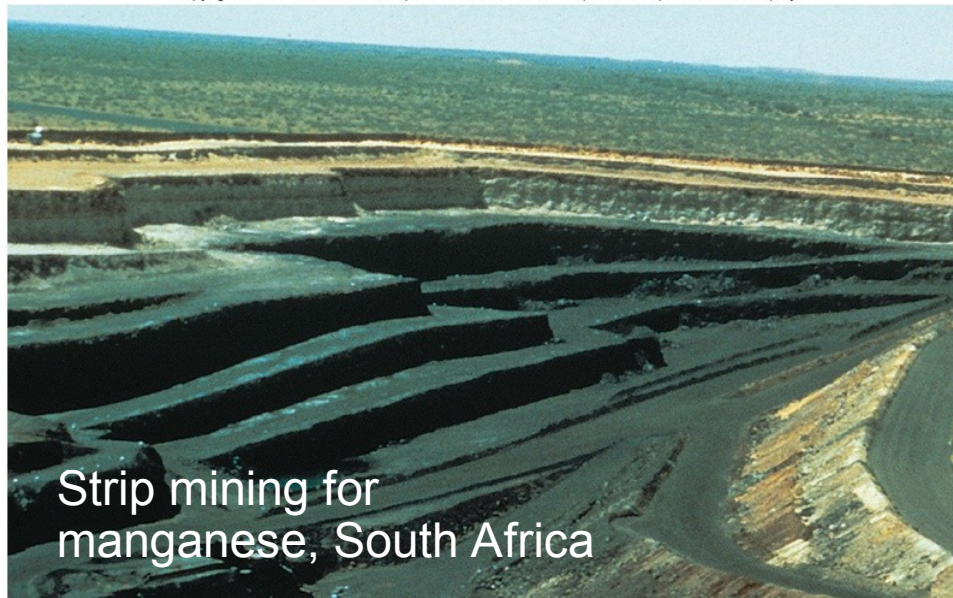
B. Adjustment

Science and Society

Earth Scientist's role in Society:

- Provide for material needs of society by managing natural resources
 - Renewable resources – water, soil, wind / solar / hydroelectric energy
 - Non-renewable resources – oil, coal, metals

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- **Sustainable society** – a society that satisfies its need for resources without jeopardizing the needs of future generations

Science and Society

Earth Scientist's role in Society:

- Provide for material needs of society by managing natural resources

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Science and Society

Earth Scientist's role in Society:

- Protect (Warn) us from activities that may endanger natural environments
- Human-induced air and water pollution can cause long-term harm to ecosystems

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*Exxon Valdez
oil spill and
clean up, Prince
William Sound,
Alaska*

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Science and Society

Earth Scientist's role in Society:

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- Educate humanity about global threats such as climate change or asteroid impact.



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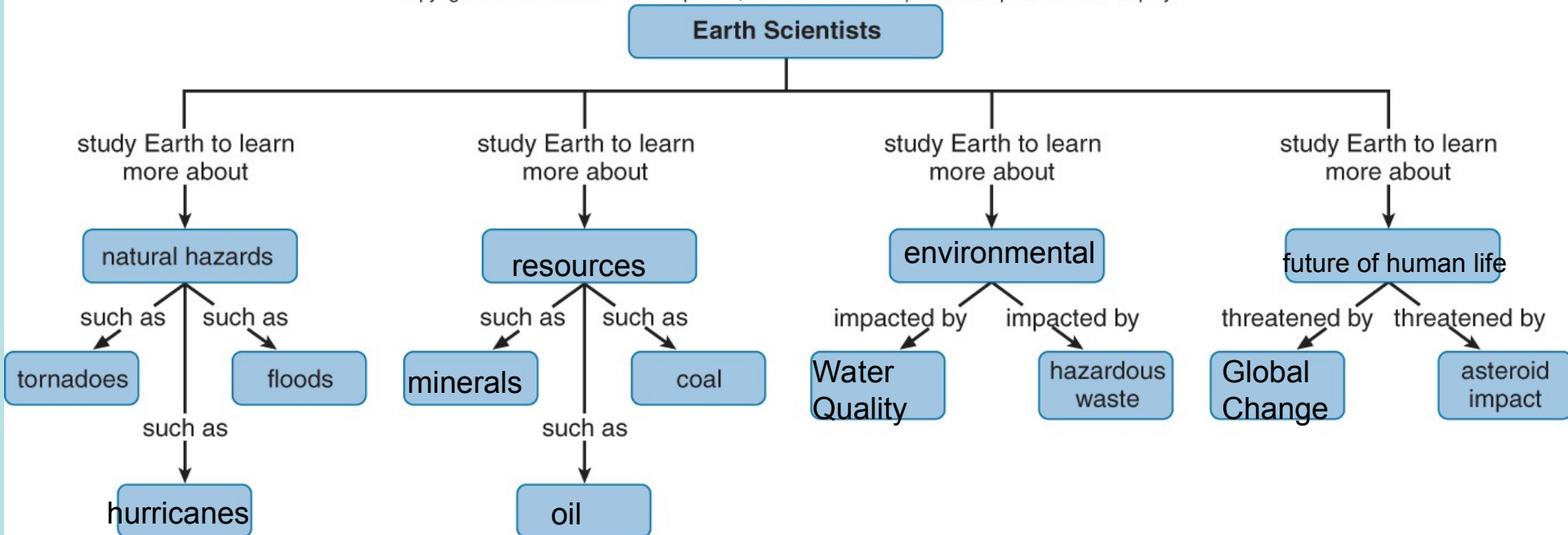
Science Conceptest

Why is Earth a “system?”

- A. The earth has several separate components like any system.
- B. The earth has multiple interactions like any system.
- C. The earth has interacting components like any system.**

Complete the following concept map by entering the most appropriate term in the box provided.

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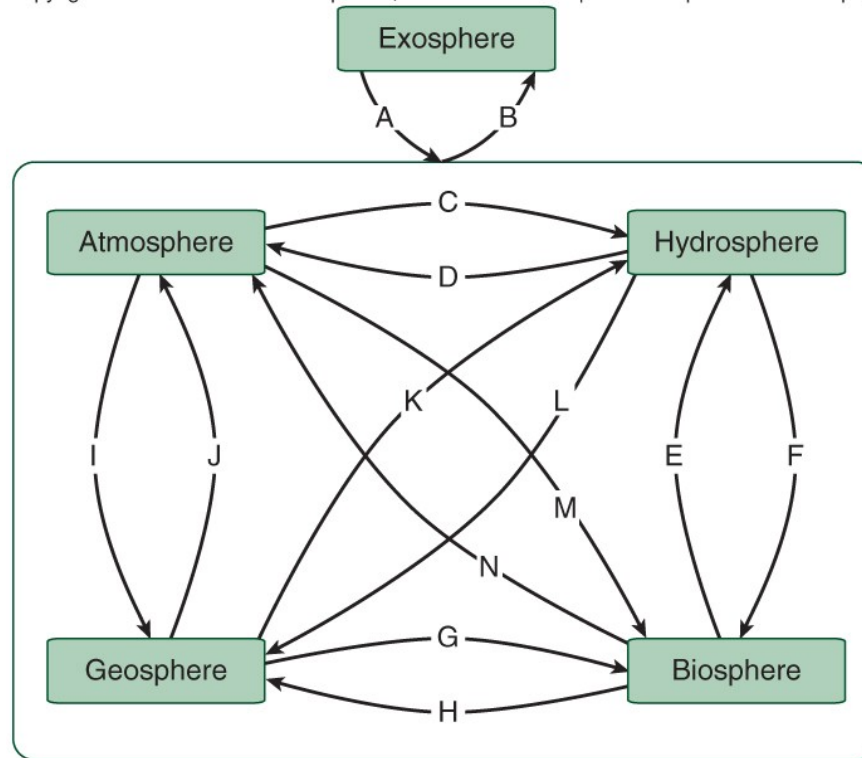


minerals	oil	future of human life	Environmental Health
resources	hurricanes	Global Change	Water Quality

Earth Science and the Earth System

How do the components of the earth system interact with each other?

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Some possible choices:

Plants absorb carbon dioxide gases.	M
Earthquake destruction causes deaths.	G
Wind blows sand.	I
Spacecraft explore deep space, Earth heats during day and cools by radiating energy at night	B
Continents deflect ocean currents.	K
Plants release oxygen.	N
Fish live in oceans.	E
Asteroid impacts Earth. Solar radiation heats Earth during day.	A
Volcano emits toxic gases.	J
Animals drink water.	F
Water evaporates from the oceans.	D
Humans mine coal.	H
Winds generate waves.	C

Intro. END