7-4.2 Week 2

Geoscience Processes

Reflect

Look at the two images of the Grand Canyon and a landslide. What geoscience processes do they have in common? What is different about how these two structures formed? Understanding the processes that form and change our Earth requires an analysis of two scales. One scale measures the time it took for the process to take place, and a second scale measures the size of the area involved.

The Grand Canyon with the Colorado River at the bottom

For example, the immense size of the Grand Canyon marks it as one of the biggest canyons in the world: it is 277 miles (446 km) long, 18 miles (29 km) wide, and over a mile (1,800 meters) deep. The landslide covers only 50 feet. The Grand Canyon was carved out through the very slow process of weathering and erosion by the Colorado River. It cut through the surrounding plateau for over billions of years, but the landslide happened very quickly. Both the Grand Canyon and the landslide reflect the ability of geoscience processes to change the surface of Earth. These changes can affect big or small areas over a long or short period of time.

Landslide over a highway in Southern California

What Do You Think?

Slow Changes to Earth

What do you think causes slow changes to Earth? Wind, water, and ice can cause changes to Earth's surface slowly over time. Nature's change agents have scoured Earth's surface for billions of years, creating slow changes to landforms. This has resulted in a diversity of landscapes. Water from the Colorado River gouged out the majestic mile-deep Grand Canyon. Water deposited the silt from ancient seas on the broad Texas plains. Glacial ice scraped away sides of mountains in the north, leaving behind long lakes, which became the Great Lakes. They deposited the rubble hundreds of miles downslope, creating the rocky northeastern states. For millennia, relentless winds have chipped away at sandstone formations, leaving behind unusual rock formations typical of the Southwest. All regions on Earth have been slowly altered, each with their own unique story of change.

Water carved the Grand Canyon.

Water deposited silt on the Texas plains.

Glacial ice left flat rocks the N.E. states

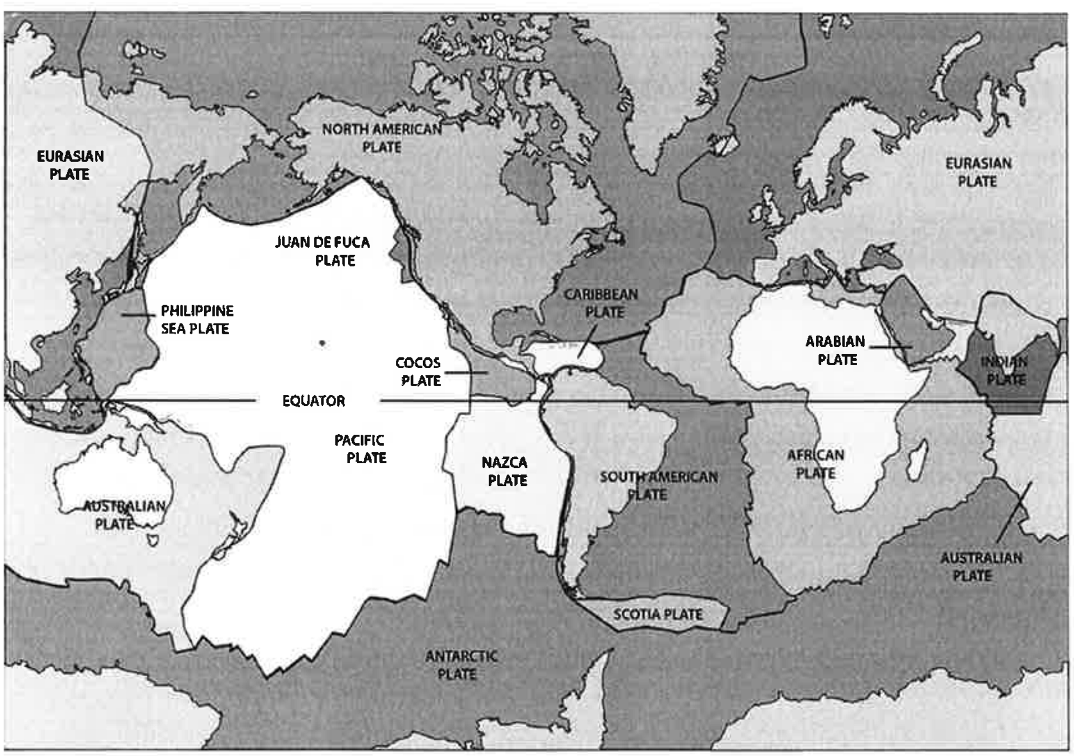
Wind sculpted sandstone.

Look Out!

You have learned that different rock types form from layers of sediment compacting and cementing (*sedimentary rocks*); from the melting, cooling, and crystallization of magma (*igneous rocks*); and from heat and pressure that change rocks (*metamorphic rocks*). All rocks, as well as the surface of which they are a part, change over time. Rock can transform into another type of rock through crystallization, metamorphism, or erosion and sedimentation. Rock layers can be moved, eroded, lifted up, tilted, or broken. If rock layers look different than when they formed, it is because these layers have been changed by geoscience processes.

Consider the tilted rocks in the picture on the right. These rocks are located in Zion National Park in Utah. Geologists know these rock layers were deposited horizontally during the Jurassic period, about 200 million years ago, when the area was covered by a shallow tropical sea. The area was tropical at that time. A geologic process caused the tilt in the rock layers. What caused these rock layers to tilt? The answer is **plate tectonics**. Scientists use knowledge of geologic processes as well as observations of the rock layers and fossils to determine how an area's plate tectonic movement, environment, climate, and plant and animal life have changed over time.

> **plate tectonics** – the idea that the outer layer of Earth, the lithosphere, is divided into plates that move around on the layer below, the asthenosphere



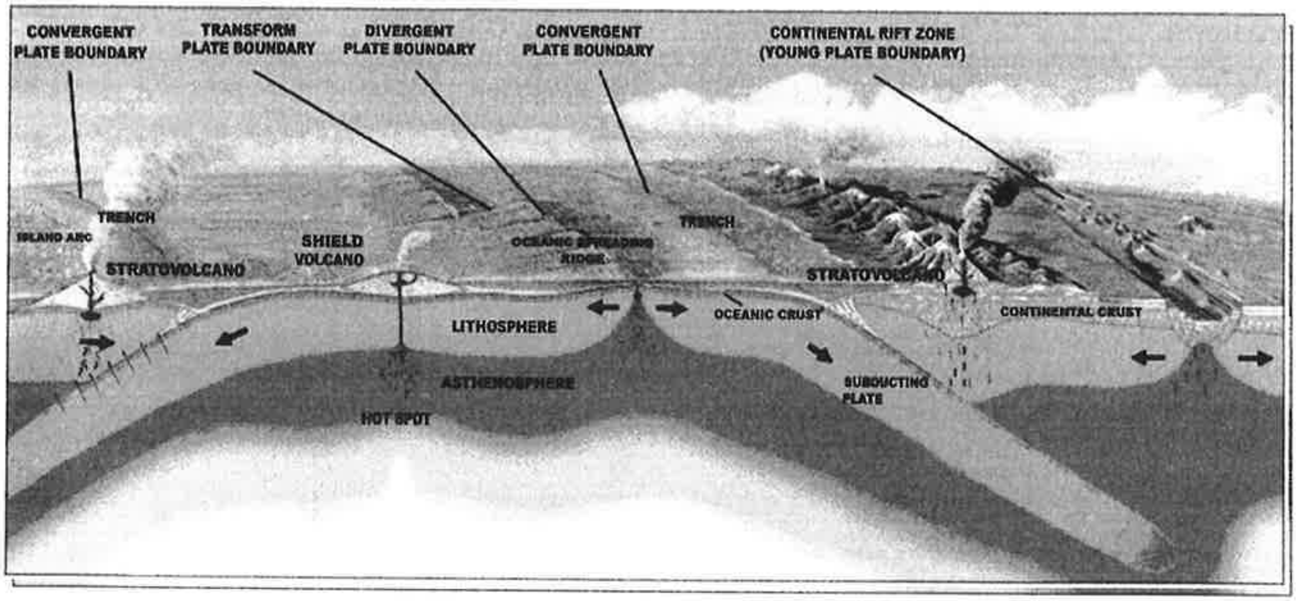
TECTONIC PLATES

The movement of these plates causes continental shift, mountain formation, earthquakes, volcanoes, ocean trenches, mid-ocean ridges, and rift valleys. The major plates on Earth are the African Plate, Antarctic Plate, Eurasian Plate, Indian Plate, Australian Plate, North American Plate, South American Plate, and Pacific Plate.

Reflect

Tectonic plate movement is a slow, large-scale geoscience process. Can you find different Earth features associated with different types of plate boundaries below?

Plate Tectonics

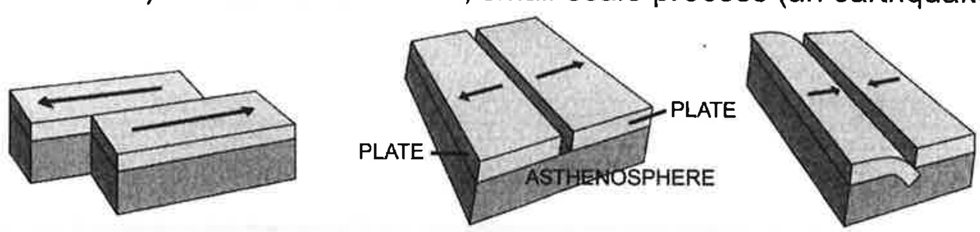


Convection currents in the asthenosphere cause three types of slow movement (over hundreds of millions of years) where plates meet.

Divergent boundaries are where plates move apart at mid-ocean ridges and magma rises, forming new ocean floor. This pushes oceanic plates east and west toward continental plates.

Convergent boundaries are where oceanic and continental crust collide, causing the oceanic crust to slide under (subduct). This forms volcanoes, mountain ranges, earthquake zones, and deep ocean trenches. Where two continental crusts collide, the plates can fold into mountains.

Transform boundaries are where plates slide past each other horizontally. Tension can build up as they slide and then suddenly release in an earthquake. This is an example of a slow, large-scale process (plate movement) combined with a fast, small-scale process (an earthquake).



Transform boundary   Divergent boundary   Convergent boundary

What Do You Think?

Paleontology, or the study of fossils and how they were formed, helps determine how Earth has changed over time. The oldest fossils date back to the Archaean eon (3.5 billion years ago). Fossils can range in size from just micrometers in diameter to gigantic ones the size of dinosaurs. Observations made from fossils can be used to describe the climate, environmental conditions, and plant and animal life at any given time in Earth's history, as far back as the first life on Earth.

Supereon	Eon	Era	Period	Epoch	Million years ago
	Phanerozoic	Cenozoic	Quaternary	Holocene	0 to 0.01
				Pleistocene	0.01 to 2.6
			Tertiary – Neogene	Pliocene	2.6 to 5.3
				Miocene	5.3 to 23.0
			Tertiary – Paleogene	Oligocene	23.0 to 33.9
				Eocene	33.9 to 56.0
				[illegible]	[illegible]
		Mesozoic	Cretaceous		66 to 145
			Jurassic		145 to 201
			Triassic		201 to [illegible]
		Paleozoic	Permian		252 to 299
			Pennsylvanian		299 to 323
			Mississippian		323 to 359
			Devonian		359 to 419
			Silurian		419 to 444
			Ordovician		444 to [illegible]
			Cambrian		[illegible]
Precambrian	[illegible]	Neo (Late)			541 to 1,000
		Meso (Middle)			1,000 to 1,600
		Paleo (Early)			1,600 to 2,500
	Archean	Neo (Late)			2,500 to 2,800
		Meso (Middle)			2,800 to 3,200
		Paleo (Early)			3,200 to 3,600
		Eo			[illegible]
	Hadean				4,000 to 4,600

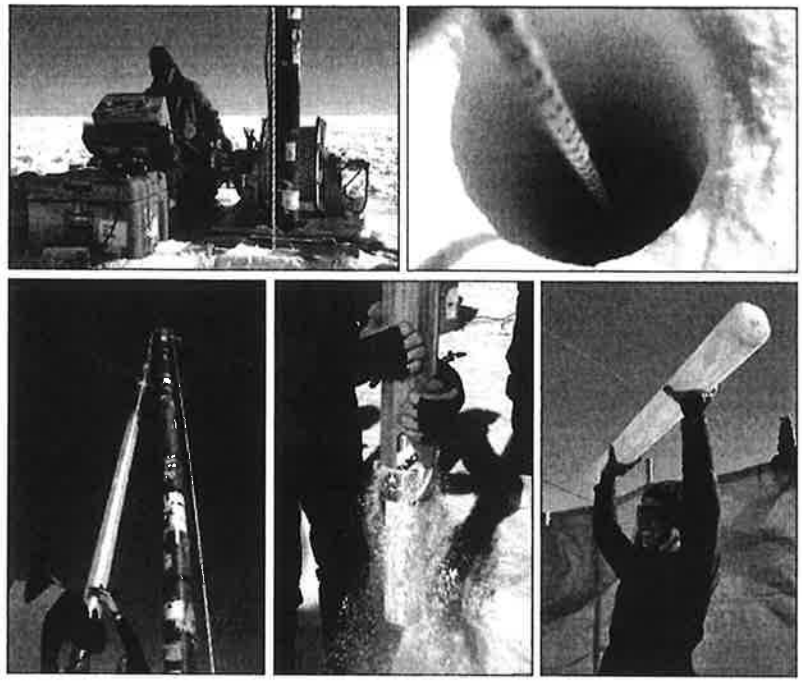
What Do You Think?

What kinds of fossils have been found in the region where you live? How have these fossils contributed to the history of Earth?

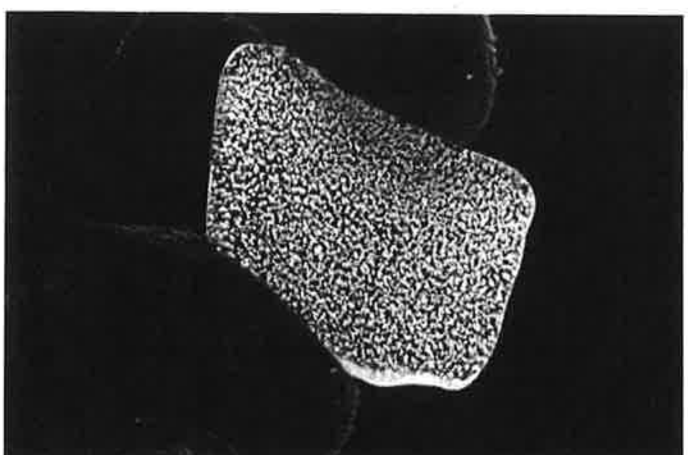
Look Out!

When you think of fossils, you might think of dinosaurs, mastodons, or large ferns that lived long ago. However, fossils from microscopic organisms tell us more about the climate of Earth's past than larger specimens.

Ice cores are another piece of evidence used to describe Earth's history. Ice cores are typically removed from an ice sheet. These are most commonly from the polar ice caps of Antarctica, Greenland, or high mountain glaciers. The ice forms from the buildup of annual snowfall. The lower layers of the core are older than the upper layers, much like rock layers. Ice cores contain ice formed over hundreds of thousands of years. These core samples help reconstruct the climate record over the age range of the core. Each core contains an abundance of information in its **inclusions**.



inclusions – imperfections in the ice, such as bubbles, pollen, dust, ash, and microscopic organisms



This sample taken from an ice core shows tiny gas inclusions.

For example, air bubbles get trapped in the ice as it forms. These air bubbles are a part of the atmosphere from that time. The gas in these air bubbles can tell us what the atmosphere was like hundreds of thousands of years ago (e.g., carbon dioxide levels).

Scientists use microscopic organisms and other types of matter (pollen, dust, or ash) in the layers of ice to determine what organic matter was present or if forest fires or volcanic eruptions were occurring. They use the thickness of each ice layer to predict the temperatures on Earth through a given year, decade, or century.

What Do You Think?

Have you ever seen a sculpture that has been outside for many years? If the sculpture is of a person, the nose and mouth might be worn down. The face might have cracks in some places. The way the sculpture looks now is probably not how it looked when the artist made it. Think of the famous Sphinx in Egypt. This sculpture was made more than 4,000 years ago. Over thousands of years, some parts of the Sphinx have worn away.

Just like structures that humans build, Earth's *landforms* change over time. Take mountains, for example. Some mountains are tall with steep slopes. They have sharp, jagged peaks. Over time, though, their slopes will become gentler. Their peaks will become more rounded and smooth, like the face of the Sphinx. These changes happen when rocks break down and move to new places. The forces that changed the Sphinx are the same forces that have changed Earth's surface for billions of years: weathering, erosion, and deposition.

Reflect

Weathering from ice helped create these natural arches in Utah.
Over many years, parts of the rocks were worn away, leaving empty spaces.

What causes weathering?

One way that landforms change over time is called *weathering*. Weathering happens when forces in nature break down rocks into smaller pieces. There are two types of weathering: mechanical and chemical. Mechanical weathering occurs when rock is physically broken. One example of mechanical weathering is when ocean waves crash against sea cliffs and create sea arches. Chemical weathering occurs when slightly acidic groundwater reacts chemically to dissolve rock. Chemical weathering can dissolve bedrock and cause sinkholes to form.

Different things cause weathering. Wind carries tiny particles of soil and rock called sediment. As wind blows against a mountain, the sediment grinds against it. This grinding action breaks off pieces of the mountain. Liquid water can also cause weathering. Rivers carry sediment that grinds against rocks in the riverbed. Over time, large formations such as canyons can form. Ice can also cause weathering.

Water expands when it freezes. If water seeps into cracks in rocks and then freezes, the ice pushes the cracks a little wider. After melting and refreezing many times, the ice will split the rock into pieces. This split rock at a state park in Connecticut resulted from repeated freezing and thawing. This type of mechanical weathering is called frost wedging.

What Do You Think?

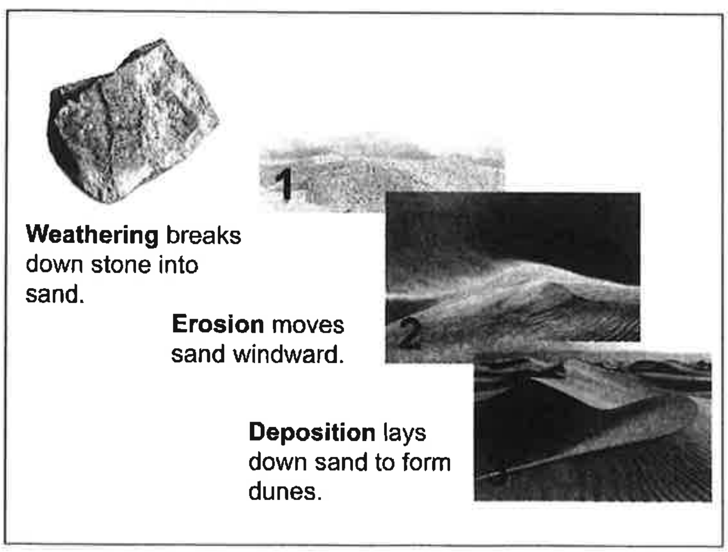
The rocks at the edge of a waterfall tend to be round and smooth. Why do you think the rocks are this way? What caused the weathering? Where else might you see how weathering changes land?

Look Out!

These towering rock formations are called *hoodoos.* Short, intense rainfalls are one agent of erosion that forms these structures.

Changes can be slow or fast. Changes to land happen at different speeds. A volcano or an earthquake can change landforms in minutes! Wind, water, and ice are just as powerful, even though they cause changes more slowly. For example, earthquakes can cause very large and powerful waves called *tsunamis*. Tsunamis can have speeds of 20–30 miles per hour and can be 10–100 feet tall. They can cause devastating damage to land, buildings, and human life. In some cases, wind, water, and ice take much longer to change Earth's surface. They may even take millions of years. Look at the tall, skinny towers of rock in the picture to the right. They formed from an area of rock that is 30–40 million years old. The rock is still changing today. Scientists predict that in another few million years, the rock towers will appear very different.

Fast geoscience processes are often catastrophic events such as tsunamis, earthquakes, volcanic eruptions, landslides, windstorms, floods, and meteorite impacts. In contrast, slow geoscience processes are often so slow that they go undetected. Examples of these are plate tectonic movement and erosion of mountains, river valleys, and beaches.



Weathering, Erosion, and Deposition

Weathering is not the only way in which landforms change. When rocks break down into smaller pieces, those pieces often get moved. This movement of rock particles to a new place is called *erosion.* When those pieces are finally laid down, that deposition builds up the surface. Weathering, erosion, and deposition work together to change Earth's surface.

Try Now

Consider the following landforms and the geoscience processes that formed them. Classify each process as short- or long-term and small- or large-scale.

Landform	Process	Time Frame (long or short)	Scale of Area (large or small)
Sea cliff or sea cave	Weathering and erosion		
Mid-ocean ridge	A divergent plate boundary creating new ocean floor		
Fault-block mountains	A divergent plate boundary causing rock to fracture and tilt		
Transform fault	A transform boundary creating a fault line		
Sand-covered beach	Deposition		
Volcanic mountain chain	A convergent plate boundary causing volcanic activity		
River delta	Deposition		
U-shaped valley	Glacial erosion		

Reading Science

Name: ______________________ Date: __________

Mount Everest and the Gobi Desert

1 Mount Everest is part of the mountain chain known as the Himalaya. Adventurers from all over the world come to try to climb it. Mount Everest is the highest mountain in the world. Could it have a connection to the Gobi Desert, over 1,000 miles away? The regions of Earth are linked in surprising ways through four interrelated systems. These systems are the lithosphere, atmosphere, hydrosphere, and biosphere.

2 The four Earth systems are always interacting. A change in one system will often cause a change in the others. These changes can be small or far-reaching. But what exactly are these systems? The lithosphere is all of the rocks that make up the planet. The atmosphere is the blanket of gases that surround Earth. The hydrosphere is all of the planet's water—liquid, solid, or gas. Living organisms make up the biosphere.

3 A very slow example of interactions among Earth's systems is the process of building mountains. The surface of the lithosphere is rigid. It is broken into seven huge pieces and several smaller ones. These pieces are the tectonic plates. These plates move very slowly across the surface of the planet. They move between 1 and 10 cm per year. This causes the landmasses to change their position.

4 The Eurasian tectonic plate is one of Earth's largest plates. It is made of most of Europe and Asia. On the map, India is a part of Asia. It is, however, on a different tectonic plate. Dinosaurs roamed the planet 100 million years ago. At that time, India was an island in the southern hemisphere. India was closer to Australia than it was to Asia. Then the Indian plate separated from Madagascar. It began to slowly move north. India finally began to collide with Asia 50 million years ago. This slow collision formed Mount Everest and the Himalayan mountain range.

Reading Science

5 Two huge plates rammed into one another. The rigid rock crumpled and bent. Finally, it was pushed upward to form the Himalayan mountain range. The Himalayan range is now the highest mountain range in the world. Peaks grew to an average height around 6,000 m (20,000 ft). Mount Everest towers 8,848 m (29,029 ft) into the sky. The Himalaya are still rising up to 1 cm each year. Eventually, the Indian plate began to slide under the Eurasian plate. Over the last 10 million years, this has lifted the area known as Tibet. A very high, flat plateau formed. The Tibetan plateau is about the same size as the eastern United States. It is also the highest land area in the world. Elevations there average over 5,000 m (16,400 ft) above sea level. It may be the highest plateau in Earth's history. This is 2,000 m higher than before the collision with India. The plateau is still being lifted up.

6 So far, only changes to the lithosphere have been described. The land and the rocks have been moved, bent, and lifted. What does this have to do with the other Earth systems? First, a very tall mountain range blocks normal atmospheric wind flows. In fact, northern India has much warmer winters than other places that are the same distance from the equator. The Himalaya act as a barrier. The mountain range blocks the cold air masses that come from the north pole during winter. This keeps India warm.

7 India and the surrounding portions of southern Asia have a seasonal weather pattern called monsoon. During the summer, air flows off the Indian Ocean toward central Asia. The wind is reversed during the winter. Air from central Asia flows outward. This is different than the usual pattern of wind flow in the tropics. Normally in the tropics, the trade winds blow from the northeast all year long. Scientists found that the south Asian monsoon started with the rise of the Tibetan Plateau. Due to its great height, the plateau gets very hot in the summer Sun. This causes the air over Tibet to rise higher into the atmosphere. A large, seasonal area of low pressure forms. Air from southern Asia and the Indian Ocean flows toward Tibet. The opposite happens in the winter months. The high elevation chills the air over Tibet more than the surrounding land. An area of dense, cold, high pressure forms. Winds start in areas of high pressure and flow away from them.

8 The hydrosphere is also affected. In summer, the warm, moist air from the Indian Ocean flows toward Tibet. It must rise over the Himalayan mountain range. Air cools as it rises. It cannot hold as much water vapor. This water falls as rain over northern India or snow in the Himalaya. The air loses most of its water before it reaches Tibet and central Asia. The air gets very dry. It can bring little rain to the land it now blows over. This "rain shadow" cast by the Himalayan Mountains is the cause of the Gobi Desert. The Gobi Desert is the largest desert in Asia. It covers parts of China and Mongolia. It is about the same size as the country of Peru.

Reading Science

9 All of these interactions have had a big effect on the biosphere. Before the tectonic collision, most of Asia had the same habitats and wildlife. Now there are many different ecosystems in the mountains and valleys of the Himalaya. New ecosystems have also developed due to the differences in rainfall. Each area has its own unique wildlife. Bactrian camels roam the Gobi. Snow leopards stalk the Himalayan cliffs.

10 The lithosphere's tectonic plates have moved over many millions of years. This has formed the Himalayan Mountains and the Tibetan Plateau. This has also changed the movement of air in the atmosphere, which changed the climate across large parts of Asia. Interactions with the hydrosphere have changed where rain falls. The biosphere has changed with the other three systems. Different creatures live in the new ecosystems. What a large shadow this is, even for a mountain as large as Everest.

Reading Science

1. Which word in paragraph 1 helps you determine the meaning of **interrelated**?

   A. Regions

   B. Linked

   C. Surprising

   D. Systems

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2. Put these Earth system processes in order from slowest to fastest.

   A. Collision of Indian tectonic plate with Eurasian plate; uplift of the Tibetan Plateau; formation of the Gobi Desert; yearly monsoon wind cycle

   B. Collision of Indian tectonic plate with Eurasian plate; uplift of the Tibetan Plateau; yearly monsoon wind cycle; formation of the Gobi Desert

   C. Uplift of the Tibetan Plateau; collision of Indian tectonic plate with Eurasian plate; yearly monsoon wind cycle; formation of the Gobi Desert

   D. Yearly monsoon wind cycle; formation of the Gobi Desert; uplift of the Tibetan Plateau; collision of Indian tectonic plate with Eurasian plate

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3. What is a **monsoon**?

   A. Very hot summer weather

   B. A large rain storm with fast circulating winds

   C. A type of climate often found in mountains and high-altitude regions

   D. A regional weather pattern characterized by a seasonal change in wind direction

Reading Science

4. How does a mountain range cause a rain shadow?

A. The slow movement of tectonic plates squeezes the water away from the region behind the mountain range.

B. A continual interaction between the lithosphere and the hydrosphere changes where the rivers flow.

C. A continual interaction between the lithosphere and the atmosphere changes where the rain falls.

D. The extreme height of the mountains blocks the Sun during certain times of the year.

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5. Which of the following is a valid conclusion you can make about Earth systems after reading this passage?

A. Changes to patterns in the atmosphere do not affect the biosphere.

B. Tectonic plates move too slowly to affect the other Earth systems.

C. The atmosphere and the hydrosphere work independently of each other.

D. Millions of years of gradual change can produce interactions that have a big effect.

Concept Attainment Quiz

Name: ______________________ Date: __________

I. Vocabulary Matching

Match each term on the right to the correct definition.

1. ______ Natural processes that happen on Earth
2. ______ An extremely small scale
3. ______ The continuation theory of continents drifting and plates moving
4. ______ Relating to the whole world
5. ______ Movement of Earth's crust, resulting in a violent shaking of the ground

A. Plate tectonics

B. Microscopic

C. Global

D. Earthquake

E. Geoscience processes

II. Identification

Use the clues provided to fill in the blanks.

Word Bank

volcanoes	geothermal	continental	microscopic	landslides
earthquakes	plate tectonics	geoscience		

1. ____________________ processes can result in events that occur relatively quickly or gradually over time.
2. Some events such as __________________________ and __________________________ build up gradually over time but have a sudden impact.
3. Other events such as ______________________ happen quickly and affect a relatively small area of Earth.
4. _____________________________ drifts take a very long time to occur, yet they affect Earth on a very large scale.

Concept Attainment Quiz

III. Open-Ended Response

Answer the questions below. Use additional paper if needed.

1. How long do geoscience processes take to occur?

2. Describe the difference between a small-scale and a large-scale geoscience process.