Common Student Ideas about Earth's Changing Surface

	Common Student Idea(s)	Scientific Explanation
Changes in Earth's Surface	The world has always looked the way it does now. OR Any changes to Earth's surface have happened quickly and all at once.	Earth's surface is continually changing. The speed at which it changes varies depending on the processes and forces involved. The speed can range from abrupt to very slow, and combinations of both types of actions shape Earth's surface.
	Except for a few volcanoes erupting and a few big earthquakes happening, Earth's surface won't change that much in the future. *[Students have a difficult time imagining that Earth's surface undergoes radical changes.]*	Whereas students grasp the immediate impacts of observable events like volcanic eruptions and earthquakes, scientists pay attention to events and processes acting on Earth's surface that aren't observable over short time periods, such as the effects of erosion and weathering over thousands of years or the results of tectonic-plate movement over millions of years. These unobservable mechanisms explain most of the landforms that exist on Earth today, and scientists use them to predict future changes to Earth's surface.
	Rocks don't change.	Rocks, a component of Earth's landscape, also change with varying speed. Through the process of weathering, large blocks of rock material are broken apart into smaller pieces that become pebbles, sand, and silt. When wind, water, or glaciers move these rock bits and they're deposited and buried, compacted, and cemented together, they can become *sedimentary rock*. When rocks are buried deep under layers of other rock material, if there's enough heat and pressure to cause a change in their chemical makeup, they can become *metamorphic rock*. Through tectonic movement, some rock material is driven into lower levels of the lithosphere (Earth's surface layer) and melts into magma, which can eventually cool and harden to form *igneous rock*.
Earth's Interior	Earth's surface (crust) is thick because it's made up of continents and mountains and valleys. Continents are huge, and mountains can be very tall.	Although continents seem huge to us, and mountains can be very tall, Earth's crust is thin compared to the thickness of Earth's interior (the core and mantle).
	The inside of Earth is full of dirt and rocks, just like the ground we dig into. You can dig a tunnel all the way to China.	No scientist has ever journeyed to the center of Earth or dug a tunnel all the way to China. But by studying the movement of seismic waves (generated by earthquakes on Earth's surface), scientists have learned quite a bit about Earth's interior, which consists of several layers. The surface layer, made up of dirt and rocks, is called the *crust*. The portions of crust that carry continents are thicker—and less dense—than the portions of crust under the oceans. Below the crust is a layer of slow-moving, mostly solid but viscous rock known as the *mantle*. The composition of Earth's core is very different from the mantle and crust. It's believed to consist primarily of very hot metal—iron and nickel—rather than a mixture of chemicals that make up the rock material of the mantle and crust.

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Earth's Interior	The inside of Earth simply holds up the crust.	Earth's interior (especially convection currents in the hot, slowly moving mantle) causes the movement of the crust. This movement plays a huge role in determining the shape of the crust.
Earth Is Built Up: Mountain Building	Mountains are made of molten rock. OR All mountains are volcanoes.	Mountains formed through volcanic activity are made of molten rock that has cooled and hardened. However, not all mountains are volcanic. Tectonic-plate activity causes the formation of mountains from either volcanic eruptions or uplift.
	Continents sit "on" tectonic plates.	Earth's crust is divided into interlocking sections called *tectonic plates* that make up the entire surface and aren't defined by Earth's continents. There are 12 major plates and many smaller plates. Some plates consist entirely of oceanic crust; for example, the Pacific Plate carries no continent at all. However, other plates consist of both oceanic and continental material. An example is the North American Plate, which is much larger than the continent of North America, consisting of a portion of the crust under the Atlantic Ocean from North America to the midocean ridge (the line down the center of the Atlantic that marks the place where plates are spreading apart). Similarly, the African Plate is much larger than the African continent itself.
	Tectonic plates don't cover the whole surface of Earth. For example, continents are plates, but oceans aren't.	The entire surface of Earth—all of the crust—consists of tightly fitting, interlocking plates of differing sizes. Continents sit on top of these plates.
	Tectonic plates are located far beneath Earth's surface.	Tectonic plates make up Earth's crust, which is the outer layer of Earth, including its surface.
	Tall mountains are older.	Shape and height alone can't be used to determine the age of a mountain. The movement of tectonic plates builds mountains, and the processes of weathering and erosion tear them down. The rate of erosion and weathering depends on such factors as the amount of rainfall an area gets, cycles of freezing and thawing, rock makeup, vegetation, and slope.

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Earth Is Built Up: Mountain Building	In billions of years, some mountains on Earth will grow so tall, they'll almost reach outer space.	Forces of mountain building—driven by the collision and spreading of tectonic plates—are continually building up volcanic and nonvolcanic mountains. Many active mountain ranges, such as the Himalayas, the Rockies, and the Andes, continue to grow taller through these forces. However, at the same time, other forces on Earth's surface are wearing down the mountains. The processes of weathering and erosion break apart rock surfaces on mountains and everywhere else on the planet, and this weathered material is carried from areas of higher elevation to areas of lower elevation. Eventually this material (called *sediment*), carried by wind and water, ends up in the lowest places on the surface—the ocean floor. This continual cycling of Earth's materials explains both the limits of mountain building and why weathering and erosion haven't caused the planet to become entirely flat.
	Volcanoes and earthquakes build mountains rapidly.	Volcanic eruptions can occur rapidly, but tall volcanic mountains like Mount Rainier in Washington State and Mount Fuji in Japan are usually the result of many volcanic events that span long periods of time. Nonvolcanic mountain ranges are created when the pressure of colliding plates causes uplift. These collisions aren't sudden but occur over millions of years.
	Volcanic eruptions happen when a mountain "opens," and they stop when it "closes."	Volcanic eruptions are the result of pressure building in a magma chamber under Earth's surface. When enough pressure builds, eruptions break through layers of rock above the magma chamber. These eruptions cease when the pressure in the chamber has been released. Usually the rock above the chamber hardens as erupted magma cools.
	Volcanoes are located randomly across Earth's surface.	Volcanoes occur in specific patterns around the globe. Most volcanoes occur where plates collide and are the result of subduction, during which a more-dense plate sinks under a less-dense plate and melts as it descends into Earth's mantle. Another pattern of volcanoes occurs where plates diverge or pull away from each other. Most of this volcanism occurs under the oceans, creating long, continuous mountain ranges we can't see. Volcanoes can also form where plates pull apart under a continent; the volcanic activity under the African Rift Valley is an example. The Hawaiian Islands and the geysers of Yellowstone National Park are examples of volcanic activity far from plate boundaries. These volcanoes are caused by hotspots in the mantle that burn through the crust.

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Earth Is Built Up: Mountain Building	Volcanoes are found only on land.	Volcanoes on land, such as Mount St. Helens in Washington State and Mauna Loa in Hawaii, are most familiar to students. Volcanoes occur even more frequently under oceans, such as those encircling the Pacific Ocean—the Ring of Fire—where plate collisions along with subduction are occurring at or near the midocean ridges where plates pull apart, and thus, magma emerges to form long volcanic ridges.
	Volcanoes always erupt violently.	The different types of volcanic eruptions, from nonviolent lava flows to violent explosions, depend on the composition of the magma: its silica content, its temperature, and the presence of gases and water in the magma chamber. When magma is low in silica, it tends to be more fluid and create nonviolent eruptions like those of Mauna Loa in Hawaii. Magma high in silica tends to build up greater pressure in magma chambers, resulting in more-violent eruptions consisting of large plumes of volcanic ash. The eruptions of Mount St. Helens in 1980 and Mount Pinatubo in the Philippines in 1991, and the 2010 eruption of volcanoes in Iceland that disrupted air traffic due to the quantity of ash strewn throughout the atmosphere are examples of violent eruptions with little or no lava flow.
	Volcanoes sit on top of islands like Hawaii.	The Hawaiian Islands aren't land masses through which volcanoes have erupted. Each island is the visible tip of a volcano that originally formed from the ocean floor as the Pacific Plate moved over a stationary hotspot, a plume of magma that rises from the mantle. Only the island of Hawaii still has active volcanoes. Other islands have moved past the hotspot, and the volcanoes that formed these islands have become dormant. The beginnings of a new island are evident even now under the ocean surface as the island of Hawaii moves off the hotspot.
	Volcanoes located far from a plate boundary are formed because a hotspot is moving underneath them.	Volcanoes not associated with plate boundaries are formed when plates move over *stationary* hotspots in the mantle. The hotspots themselves don't move.
	Earthquakes shaking in a region around a volcano cause volcanic eruptions. OR Volcanoes erupt because heat builds up and has to get out.	Several factors trigger volcanic eruptions, but three predominate: (1) the buoyancy of the magma (related to its chemical makeup compared to the rock around it), (2) the pressure created from gases in the magma, and (3) additional magma entering an already-filled magma chamber.

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Earth Is Worn Down: Weathering and Erosion	Weathering and erosion are basically the same process, so either word can be used.	When rocks are exposed to Sun, water, wind, the cycles of freezing and thawing, and the action of biological agents like plant roots, they break down. This process of breaking down rock material is called *weathering*. *Erosion* refers to processes by which wind, water, or glaciers carry the weathered particles from one location to another. Weathering and erosion are two *distinct* processes that together are responsible for wearing down Earth's surface.
	Weather and weathering are the same thing.	Weather plays a significant role in the process of weathering, but weather and weathering are not the same thing. *Weathering* describes any process by which rock material is broken down. *Physical weathering*—breaking apart rock from bigger pieces to smaller pieces without any change in the chemical composition of the rock—can be caused by cycles of freezing and thawing, by the expansion of water that freezes in cracks in rock surfaces, or by non-weather-related forces, such as plant roots that grow in cracks in rock surfaces and cleave the rocks apart. *Chemical weathering* means breaking rock apart by changing it chemically, such as when groundwater dissolves the minerals in bedrock, creating intricate cave systems. Both physical and chemical weathering are closely related to weather—rainwater, humidity, temperature changes—but these factors are just part of a much larger process of weathering that results in wearing down Earth's surface.
	Rocks break, or shrink, because they get old.	Rocks don't break or shrink because of age. They break apart into smaller rocks over time and eventually break down further into sand or silt through the processes of physical and chemical weathering.
	Water shrinks when it freezes. *[The idea that water expands when it freezes is difficult for students to accept.]*	The concept of water expanding when it freezes is important when thinking about how it breaks apart rock. When water in existing rock cracks freezes, it expands and exerts pressure on the rock, causing the crack to expand or the rock at the site of the crack to break apart.
	Rocks explode when frozen water is in them.	Rocks don't explode suddenly like soda bottles left in the freezer for too long. Over time, as water freezes in cracks, rocks may break into many pieces.
	Erosion happens quickly. For example, tsunamis may be the most important factor in wearing down Earth's surface (including mountains).	Erosion happens at differing rates depending on the material being moved and the force moving the material. Landslides and tsunamis may result in fast changes in Earth's surface, while other examples of erosion, such as the forces carving the Grand Canyon, take place over much longer time periods.

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Earth Is Worn Down: Weathering and Erosion	Erosion is a bad thing that people cause (e.g., bad farming techniques, strip mining).	Although human activity can increase the rate of erosion, this phenomenon occurs all the time in nature, regardless of human activity. Erosion itself is neither good nor bad; it's simply a natural Earth process.
	Rivers flow through valleys; they don't make the valleys.	Rivers change the land they flow through. When elevation varies significantly from one point in a river to another and the slope is steep, swift-flowing water cuts a deep channel into the land. When a river passes through a landscape that has less of a slope, the water flows more slowly, and the cutting action of the river is reduced or stops altogether. In this case, the water erodes the banks, widening the river and smoothing over the waterfalls.
	Most rivers flow from north to south.	Rivers flow from higher elevations to lower elevations without regard to compass direction (north, south, east, or west).
	Mountains get smaller when the plates that collided to form them move apart again.	Mountains get smaller as a result of erosion and weathering. Plates also don't move toward each other and then apart (i.e., back and forth). They move side by side, sliding past each other.