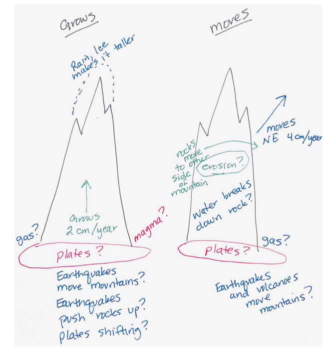
UNIT STORYLINE

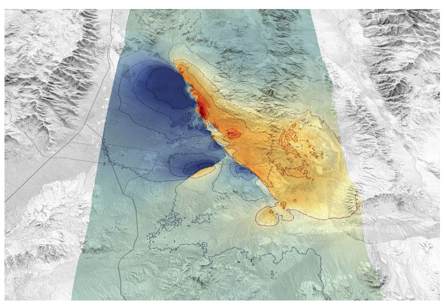
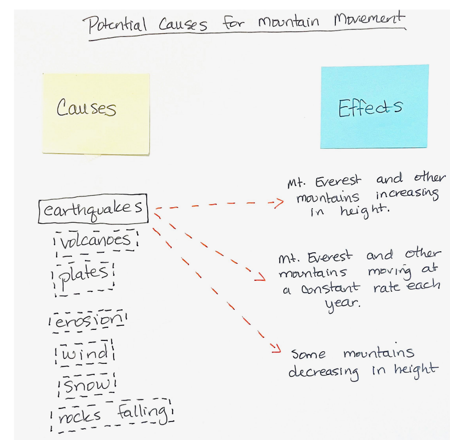
What causes Earth's surface to change?

How students will engage with each of the phenomena

HANDS-ON/ LAB ACTIVITIES | VIDEOS OR IMAGES | DATA SETS | READINGS | COMPUTER INTERACTIVES

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 1 4 days **What is causing Mt. Everest and other mountains to move, grow, or shrink?** Anchoring Phenomenon	 *Mount Everest and other mountains change in height and location.*	We read about how Mt. Everest is getting taller and moving yearly to the northeast. We analyze other mountain peaks around the world and find that other mountains are also getting taller, but others are shrinking. We develop an initial model explaining how mountains grow, move, and shrink. We brainstorm related phenomena, ask questions, and generate a list of data and information we need to better understand how mountain peaks can grow, shrink, and move. We figure out: • Some mountains move. • Mountains can get taller. • Mt. Everest is growing over time - new data shows. • Mountains can also shrink.	

⇓ **Navigation to Next Lesson:** We identified a variety of possible causes for growth and movement of mountains, one of the main ones were earthquakes .... So are there patterns between where earthquakes are found and where mountains are located?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 2 2 days **How are earthquakes related to where mountains are located?** Investigation	 *After an earthquake occurred in Ridgecrest, California, a shift in the location and the elevation of the surface was observed.*	We look at data sources from Ridgecrest, CA before and after an earthquake. We use Seismic Explorer to determine that there seems to be a pattern with greater earthquake activity at mountains that are increasing in elevation. We figure out: • The ground moves back and forth in an earthquake. • Some parts of the surface crack open with a noticeable difference in between the ground on either side of the crack after an earthquake. • Earthquakes exist on or near almost all mountain ranges. • There seems to be a correlation between when mountains were highest or growing and where the eqs are the largest or most frequent. • While earthquakes seem to be correlated to changes in elevation, we are uncertain what is occurring under the surface, and what the land is like under the surface.	

⇓ **Navigation to Next Lesson:** We think that earthquakes are correlated to mountain changes in location and elevation, but want to know what is underground where earthquakes occur.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

LESSON 3

2 days

How does what we find on and below Earth's surface compare in different places?

Investigation

The properties of solid rock, bedrock, change as we move deeper underground due to increasing pressure and heat.

After we figure out that earthquakes are correlated to mountain changes, we wonder what is happening underground where earthquakes occur and what we will find at and below the surface in different places around Earth. We develop models and gather data from various media and investigations about the structure and composition of materials at and below the surface. We share observations and data and update our Progress Trackers. We figure out:

- Sediment and solid rock make up Earth's surface.
- Solid rock, known as bedrock, is found on, near, or below the surface of Earth.
- As we move deeper underground, rocks become increasingly hotter and compressed.
- This can cause rocks to change state, and tend to more readily move and shift.
- The rock deep below the ocean bottom is denser than the rock deep below the continents.

Site	Data Source(s)	Materials at the Surface	Materials Below the Surface
Resolution Mine in Arizona			
Mt. Everest and the Himalayan Mountains			
Mt. Aconcagua and the Andes Mountains			
Mt. Mitchell and the Appalachian Mountains			
Mt. Hotaka and the Hilda Mountains			
Mt. Narodnaya and the Ural Mountains			

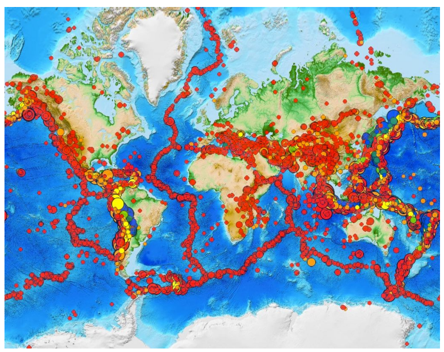
⇓ **Navigation to Next Lesson:** We have considered how bedrock compares at different places on Earth, and now we are wondering what happens to that bedrock when an earthquake occurs.

LESSON 4

2 days

What is happening to Earths' surface and the material below it during an earthquake?

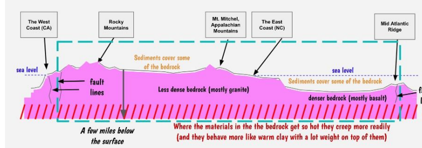
Investigation



Plates on Earth's surface are surrounded by long lines of fault lines. There are many plates that make up the surface of Earth.

We develop a profile view model of Ridgecrest. We use a foam board to model the bedrock and determine the break in the land must go all the way through the bedrock. We analyze the area of the earthquake by making a cross section in Seismic Explorer. We develop a profile model of North America. We determine that the big sections of Earth between long fault lines are plates. We look at a world map for where there could be other plates on the map. We figure out:

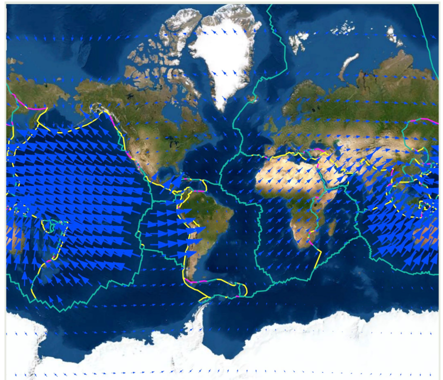
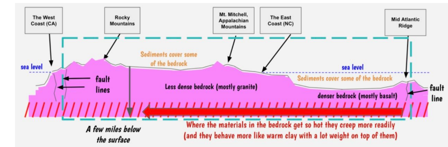
- Sections of bedrock in between the fault lines of cracks from earthquakes are called plates.
- These cracks go down through the bedrock to where the rock begins to creep and move.
- There are other plates in the world that can be found in between the lines of other long sections of fault lines.
- Models of the crust and mantle have scale limitations due to the size of the Earth and its layers.



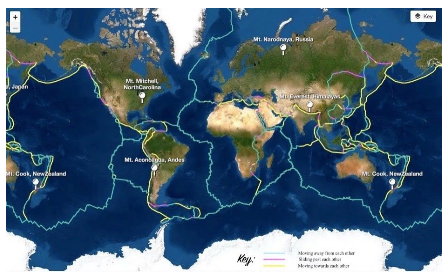
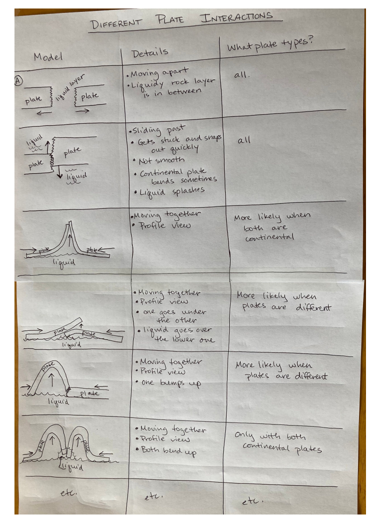
*The system boundary around this entire piece of solid rock between a longer fault line and another longer fault line edge is something that scientists refer to as **a plate.***

This plate includes all the different materials found in the bedrock and all the sediments on the surface.

⇓ **Navigation to Next Lesson:** If the North American plate is one solid plate and Mt. Mitchell is moving to the west 2 cm per year, then what is causing the mountains to move? If when a plate moves and everything above it moves too, then can plates move a whole mountain?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 5 1 day **How does plate movement affect the land around mountains such as Mt. Everest?** Investigation, Putting Pieces Together	 *Plates on Earth move at constant speeds and in specific directions.*	We look for patterns in GPS data to examine land movement around Mt. Mitchell, and use a physical model to demonstrate that the entire North American plate moves at a constant speed and in a specific direction. We further revise a cross section model of the North American plate from the previous lesson to connect its movement to the behavior of the deeper, hotter bedrock. We use Seismic Explorer to investigate the movement of all plates on Earth's surface. We figure out: • All plates are constantly moving in different directions and at different speeds. • Plates move because they sit on top of deeper, warmer rock layers which move, or creep. • When creep occurs, mountains and all other features on the plate above also move.	

⇓ **Navigation to Next Lesson:** All these plates are moving which helps us explain how mountains move, so how does this help us explain what happened at Mt. Everest and other mountains that are seeming to grow? Or about mountains that are shrinking?

LESSON 6 3 days **How could plate movement help us explain how Mt. Everest and other locations are changing in elevation?** Investigation, Putting Pieces Together	 *When plates on Earth move, they can move together, move apart or slide past each other. Sometimes one plate goes under another and/or pushes another plate up.*	We use models of plates and plate movement to identify and describe in detail the results of plate interactions between plates of similar or differing densities, and develop drawn models to communicate our findings. We use the models we develop to help explain what might cause the elevation changes and other changes we know about at Mt. Everest. We consider how earthquakes could be a result of uneven plate movement. We celebrate how many questions we can now answer from the DQB. We figure out: • When plates move towards each other, they collide and mountains can get taller. • Plates can move next to each other in opposite directions. • Plate boundaries or edges are rough and so when they interact they can get stuck against each other or slip against each other which we can feel as earthquakes. • Plate movements cause earthquakes. • Plate movements can cause mountains to get taller.	

⇓ **Navigation to Next Lesson:** We see that earthquakes and plates have an impact on mountain size and movement, but we also saw evidence of some other potential causes that seemed to be occurring at places where these mountains were forming. We decide to revisit the cause board and see what other potential causes might be impacting mountains related to plate movement.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

LESSON 7

1 day

What happens at mountains where we see volcanic activity?

Investigation

Volcanoes occur where oceanic plates collide with continental plates. Volcanoes can either build up or destroy landforms when they erupt.

In this lesson, we use map images to determine that most volcanoes occur along the boundary between oceanic and continental plates. We observe and describe what happens when a denser oceanic plate collides with a less dense continental plate. We revisit our mountain cards from Lesson 1, and read to figure out that volcanic eruptions can either add new earth material to existing landforms or destroy them. We update our Potential Causes for Mountain Movement Chart. We figure out:

- Volcanoes occur in lines where an oceanic plate collides with a continental plate.
- When an oceanic plate collides with a continental plate, the oceanic plate moves under the continental plate.
- The oceanic plate heats up, causing the bedrock and sediments to melt and the water in the sediments to boil.
- The melted earth materials and steam move upward through openings called volcanoes in the continental plate.
- Volcanic eruptions can cause mountains to grow or shrink in height.

Site	Types of Changes (yearly)		Event (yes or no)		Are the changes to the mountain caused by volcanoes?
	Location	Elevation	Volcanoes	Earthquakes	
Mt. Everest	4cm NE	6-7cm increase	no	yes	No, there are no volcanoes nearby
Mt. Mitchell	3cm W	decreasing	no	very few	No, there are no volcanoes nearby
Mt. Aoraki	7cm N	1-2cm increase	yes	yes	No
Mt. Aconcagua	3cm N	10cm/10yrs avg. increase	yes	yes	No
Mt. Hotaka	1cm SE	4mm increase	yes	yes	The change in location is not, but the increase in elevation might be, since Mt. Hotaka is an active

⇓ **Navigation to Next Lesson:** We now know that volcanoes can occur where plates are colliding and as one goes under the other some of the magma comes to the surface. What is happening where plates are moving apart?

LESSON 8

2 days

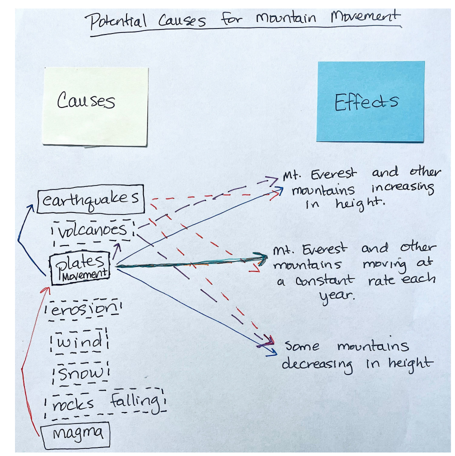
What is occurring at locations where two plates are moving away from each other?

Investigation

Steaming cracks in the ground can be found along the Mid-Atlantic Ridge in Iceland.

We make claims about what could be occurring at the Mid-Atlantic Ridge. We collect evidence to determine if the claims are supported or refuted by evidence. We use our knowledge of the ridge, volcanoes, and the presence of magma to update our Potential Causes for Mountain Movement chart. We figure out:

- Plates are moving apart along the Mid-Atlantic Ridge.
- Scientists call the place where two plates are moving apart a ridge.
- Magma from the mantle is pushing up from under the plate, which can be seen in places like volcanoes and fissures in Iceland and along ridges.
- New oceanic plate material is being formed at ridges.
- The pushing of magma on the plates causes the plates to move, which causes changes to mountain elevation and location over time.



⇓ **Navigation to Next Lesson:** We have updated our Potential Causes for Mountain Movement chart to reflect magma from the mantle as a mechanism for plate movement, and think we can now explain the causal chain of events that can lead to a change to mountain elevation and a change in location over time.

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<tr><th>Lesson Question</th><th>Phenomena or Design Problem</th><th>What we do and figure out</th><th>How we represent it</th></tr>
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LESSON 9

1 day

What causes mountains to change?

Putting Pieces Together

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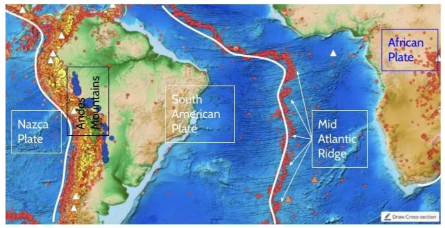

Mountains change due to plates moving caused by magma moving.

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We revisit our Potential Causes for Mountain Movement chart to take stock of what we have figured out. We revise this chart to capture the causal chain of events that need to occur for a mountain to move or grow. We revisit the DQB to see what questions we can answer and we make predictions about what we think the Andes mountains and the Mid-Atlantic Ridge will look like in the future and what it looked like in the past. We figure out:

- Plates move because the magma underneath them is moving.
- Plate movement causes changes to mountains.

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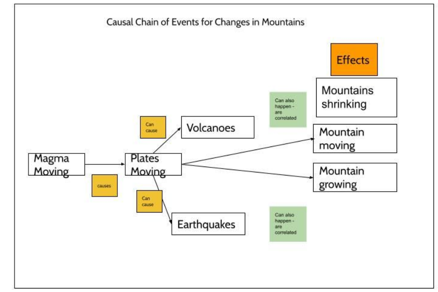

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⇓ **Navigation to Next Lesson:** Now that we know what causes mountains to grow and form, we wonder if the mountains we have been investigating (and the plates they are connected to)have always been where they are today, or were they in very different places and at very different heights in the very distant past.

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LESSON 10

2 days

Where were Africa and South America in the past?

Investigation

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The distance between continents has been increasing over time.

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We use math to determine that Africa and South America could have been together 146 million years ago and reason out data from this time period will be found underground. We look for patterns in mapped data across the continents from this period. We then complete an exit ticket to make a claim about the two plates touching. We figure out:

- Oceanic plates that were created over time were not always in existence.
- Average rates of plate movement and plate direction can be used to determine where plates were once located.
- Small changes to the distance between continents can add up to larger visible changes seen from a larger scale.
- Older rock and associated fossils can be found under younger rock and fossils.
- To support that two land masses were once together, patterns in data across the two land masses need to be similar or the same.
- Data from rock strata, fossils, and other changes in land supports that the African and South American continents were once together at the Mid-Atlantic Ridge.

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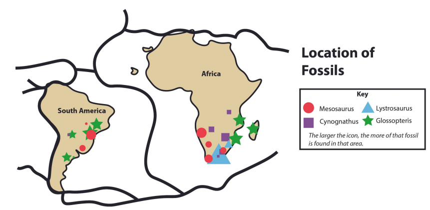

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⇓ **Navigation to Next Lesson:** Though we determined that Africa and South America were once together in the distant past (millions of years ago), we are now wondering if other continents (and the plates they are connected to) used to be located in different places on Earth as well in the distant past.

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<tr><th>Lesson Question</th><th>Phenomena or Design Problem</th><th>What we do and figure out</th><th>How we represent it</th></tr>
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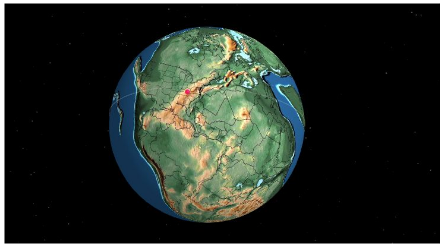
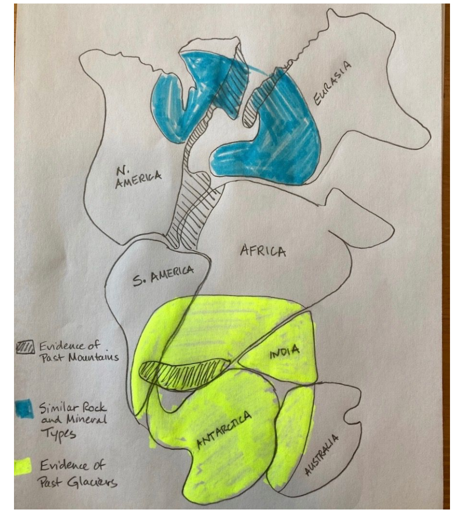
<td>LESSON 11
2 days
Where were the other plates located in the distant past?
Investigation, Putting Pieces Together</td>
<td>
Continental plates have moved over the surface of the spherical Earth over many millions of years, resulting in their current locations on the globe.</td>
<td>We use multiple types of data from models of all the land masses as evidence to develop a flat map model that predicts where the land masses used to be located relative to each other millions of years ago. We identify and discuss the strengths and weaknesses of the evidence supporting our model. We diagram our model and the data that supports it, and articulate our reasoning to explain the positions of the land masses millions of years ago that are predicted by the model. We figure out:
All major land masses were once touching, forming a part of a large single landmass that existed hundreds of millions of years ago.
Multiple sources of data are necessary to determine where plates were located in the past.</td>
<td>
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<tr><td colspan="4">⇓ Navigation to Next Lesson: We are wondering where mountains that aren't at plate boundaries today, like the Applachians and Urals, come from?</td></tr>
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<td>LESSON 12
1 day
Where did mountains that aren't at plate boundaries today, like the Appalachians and Urals, come from?
Putting Pieces Together, Problematizing</td>
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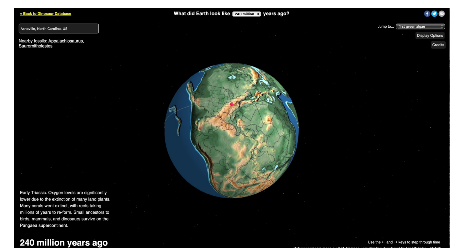
The Appalachian Mountains are decreasing in elevation, and the Ural Mountains are neither increasing nor decreasing in elevation.</td>
<td>We use map images and data to compare the mountain sites we are studying. We remember that the Appalachians are decreasing in elevation, while the Urals are neither increasing nor decreasing. We know that colliding plates cause mountains to form and increase in elevation, but the Appalachians and the Urals are not located near plate boundaries. We use evidence from an online simulation to construct an explanation for how and when the Applachians and the Urals were formed. We figure out:
The Appalachian Mountains, first formed 470 million years ago, and the Ural Mountains, formed more than 300 million years ago, were both created in the same way that other mountains were formed--through plate collisions.
Plate interactions cannot explain why the Appalachians are decreasing in elevation or why the Ural Mountains are neither increasing or decreasing in elevation.</td>
<td>

Ian Webster/DinosaurPictures.org.</td>
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<tr><td colspan="4">⇓ Navigation to Next Lesson: Though we figure out when the Applachians and the Urals were formed, this still doesn't explain why there would be decreases in height occurring at Mr. Mitchell (in the Appalachians) if there is no plate boundary there now, and why we don't see similar decreases in height in a different mountain range where there is no current plate boundary now (the Urals).</td></tr>
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LESSON 13

1 day

What causes mountains to shrink in elevation?

Problematizing

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Scientists can measure both the rate of uplift and the rate of erosion at different mountain sites.

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After recalling what we already know about erosion and weathering, we read about erosion rates and how scientists use these rates to determine how erosion is changing the surface. Then, using both the erosion rates and uplift rates for Mt. Everest and Mt. Mitchell, we develop a representation of each model and how these two processes are affecting them. We determine that when erosion rates are higher than uplift rates, like at Mt. Mitchell, a mountain will shrink in elevation. We figure out:

- The relationship between the erosion rates above the surface and the uplift rates below the surface determine the elevation above sea level.
- Erosion rates greater than uplift rates result in decreases in elevation, erosion rates less than uplift rates result in increases in elevation, and erosion rates equal to uplift rates results in no elevation change.

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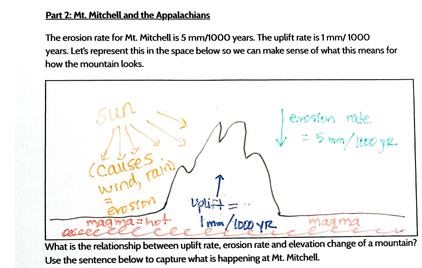

Part 2: Mt. Mitchell and the Appalachians

The erosion rate for Mt. Mitchell is 5 mm/1000 years. The uplift rate is 1 mm/ 1000 years. Let's represent this in the space below so we can make sense of what this means for how the mountain looks.

What is the relationship between uplift rate, erosion rate and elevation change of a mountain? Use the sentence below to capture what is happening at Mt. Mitchell.

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⇓ **Navigation to Next Lesson:** Now that we know that there are processes above Earth's surface, as well as processes below the surface that affect how Earth's surface changes, we want to see if we can use both of these sets of processes to explain one of the lingering questions from Lesson 1 (a marine fossil on the top of Mt. Everest), as well as any lingering questions on our Driving Question Board.

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LESSON 14

2 days

How is there an exposed marine fossil on Mt. Everest? And, what other remaining questions from our Driving Question Board can we now answer?

Putting Pieces Together

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Ancient marine fossils can be found at the top of many mountains.

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We revisit our Driving Question Board and determine what questions we have made progress on. We explain our related phenomena. We revisit our mountain cards to determine that we still need to explain the presence of marine fossils on mountains. We gather evidence to help support what is occuring for marine fossils to end up on mountains and take an assessment. We then revisit our Driving Question Board and answer our unit question. We figure out that:

- Plate movement has caused uplift to occur at mountains, pushing up rocks that used to exist on ancient seafloors.
- Over time, marine fossils from the ancient seafloor are exposed due to erosional processes.
- Erosional processes will always be occurring and will continue into the distant future.

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⇓ **Navigation to Next Lesson:** There is no next lesson.

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LESSONS 1-14

26 days total