# UNIT STORYLINE

## How and why does Earth's surface change?

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

## LESSON 1

3 days

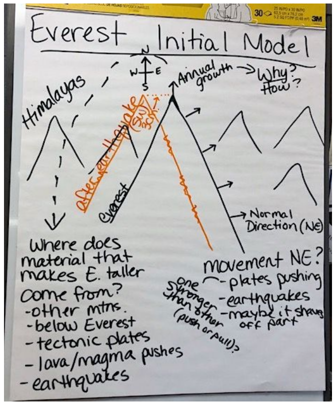
**What causes Mt. Everest to move in different ways?**

Anchoring Phenomenon

*During a recent earthquake, Mt. Everest suddenly reversed direction moving backwards 3 cm while maintaining a constant elevation.*

We observe two video clips and read about an earthquake on Everest describing how the regular movement of Mt. Everest was interrupted and temporarily reversed by the earthquake. We examine earthquake data and notice potential connections between the earthquakes and mountain ranges, and develop an initial model explaining how mountains grow, move, and change. We brainstorm related phenomena, ask questions, and generate a list of data and information we need to better understand Mt. Everest and how earthquakes may be related to mountains.

- Mountains can move in one direction normally, but can reverse direction during an earthquake.
- Mountains can get taller.
- There seems to be a pattern between earthquakes and mountain locations.



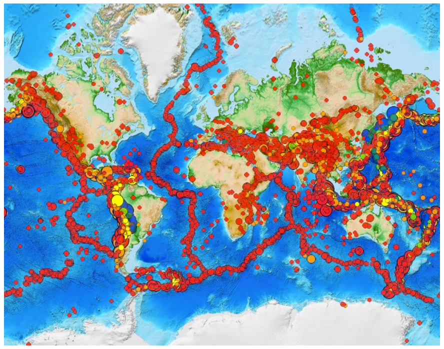

⇓ **Navigation to Next Lesson:** We figured out that the earthquake on Mt. Everest caused a change to the mountain's normal movement, and that this earthquake was part of a larger pattern in the area and around the world. We are curious about the patterns we saw with the earthquakes and how they could be related to mountains getting taller, shorter, and moving. We want to look at more data on earthquakes.

## LESSON 2

2 days

**How are patterns in earthquakes similar or different in locations around the world?**

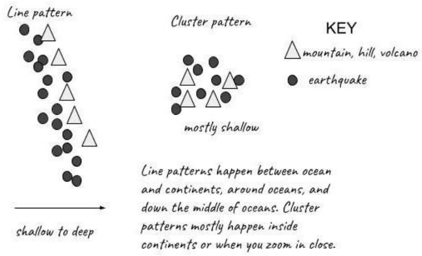
Investigation



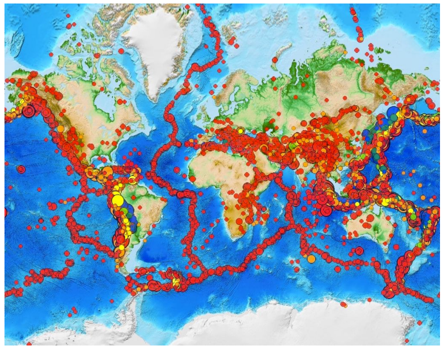
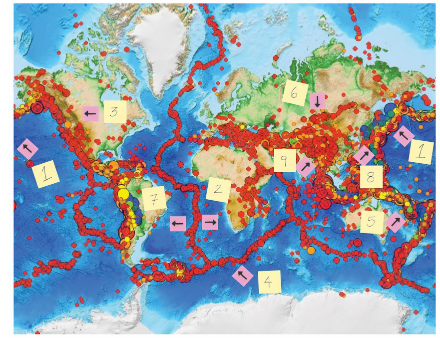
*Earthquakes appear in patterns of lines and clusters around the world.*

We gather more evidence of earthquake activity in different locations around the world using the Seismic Explorer tool. We look for patterns in earthquake activity in the Himalayas, the United States, and worldwide. We figure out:

- Earthquake patterns look like mostly lines or in large clusters of activity.
- In some locations, earthquakes get deeper as you move inland, but in other locations they are shallow.
- When you only look at a short time period, a pattern is not as clear as when you look at data across a longer time period.
- Locations with earthquakes appear "bumpy" on the relief map, which indicates higher elevations, even underwater.




⇓ **Navigation to Next Lesson:** We figured out that earthquakes appear in clusters and lines in specific locations around the world and these places have similarities and differences. We want to know more about what is causing these patterns and whether the patterns are related to the landforms.

<table>
<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>
<tr><td>LESSON 3<br>2 days<br>Why do earthquakes happen in specific patterns around the world?<br>Investigation</td><td><br>There are large pieces of Earth's surface that are moving. These seem to line up with where earthquakes occur.</td><td>We read two articles about earthquakes and how this data led scientists to figure out there are different pieces of Earth, called plates, that move.<br>We figure out:<ul><li>Earth's surface is not a solid continuous piece of crust; rather, there are pieces called plates and the edges can be observed using earthquake data.</li><li>A network of GPS sensors provide data on the speed and direction of plate movement.</li><li>The plates at Mt. Everest are moving toward one another at different speeds.</li><li>In other locations, the plates are either moving toward each other or away from each other, and at different speeds too.</li></ul></td><td></td></tr>
<tr><td colspan="4">⇓ Navigation to Next Lesson: We are wondering what the plates are made of and how these solid, large pieces of Earth can move.</td></tr>
<tr><td>LESSON 4<br>2 days<br>What are plates?<br>Investigation</td><td><br>Earth's plates are made of different kinds of material.</td><td>We use information from photographs, texts, and rock samples to develop representations of the plates. These representations describe plates as composed of thick layers of bedrock that vary in its composition of rock types, heaviness (density), and depth. We also gather information on bedrock, ultra-deep mines, and exploring data about earthquakes depth.<ul><li>Earth's plates are made of materials with different heaviness (density).</li><li>On the surface, what we see of plates is different, but below the surface they all are on bedrock that has different depths.</li><li>The deeper into the plates, the higher the temperatures become, indicating a heat source toward the interior of the Earth.</li><li>In some places, earthquakes can happen either very shallow or very deep.</li></ul></td><td><ul><li>All plates contain bedrock, which has different properties (like heaviness, density, and color) in different places.</li><li>Plates have different things on top of bedrock, including oceans and soil. Sometimes, bedrock is visible at the surface.</li><li>Every location on Earth is on a plate.</li><li>Bedrock goes deep (several kilometers down), but that is pretty shallow when compared to the size of Earth.</li></ul></td></tr>
<tr><td colspan="4">⇓ Navigation to Next Lesson: We figured out information about the depth, composition, and heaviness of plates, but now we are wondering what is below the plates.</td></tr>
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| Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it |
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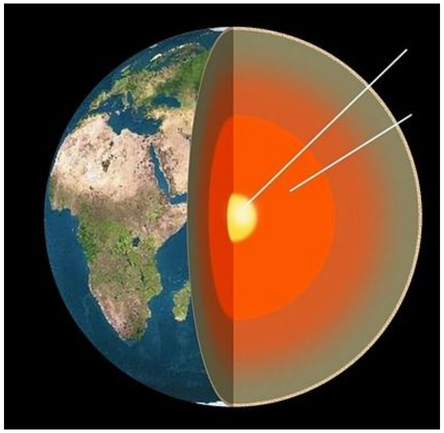
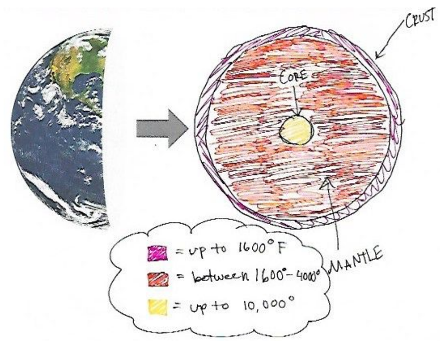
| **LESSON 5**<br>1 day<br>**What is below Earth's plates?**<br>Investigation | <br>*The plates are part of the Earth's crust, but there are other layers under the plates that are hotter than the surface.* | We read an article to obtain information about the different layers of the Earth and how the temperature increases up to over 10,000°F as you move from the surface towards the center, or core, of the Earth. This heat is transferred up through the layers of Earth. The diameter of the Earth is 7,926 miles and the thickness of the plates can be up to 44 miles, making the plates very thin in comparison. We use this information to revise the Earth model. We figure out:<br>• The crust of the Earth is the "skin" that covers the mantle and the core.<br>• Different layers of Earth have different temperatures and the core produces this energy.<br>• The mantle of the Earth is heated by the heat from the core. | <br> |

⇓ **Navigation to Next Lesson:** We know the Earth is made up of different layers with the plates being found on the outer layer. We wonder what might be happening below the crust that causes the plates to move.

| Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it |
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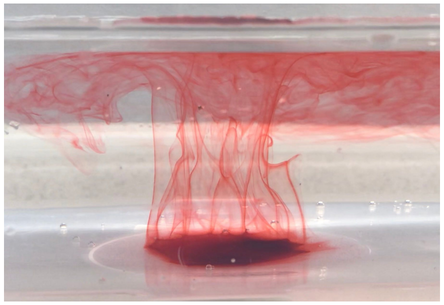
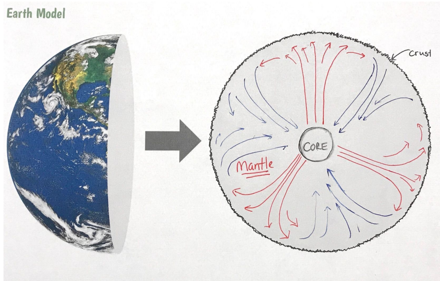
| **LESSON 6**<br>2 days<br>**How are the plates moving?**<br>Investigation | <br>*Convection within the Earth's mantle pushes and pulls plates at the surface in different directions.* | We consider the mechanisms within Earth's interior that cause the plates at the surface to move in different ways. Using a convection demonstration, we make observations before and after heat is added. We revise our the Earth Model to include how the flow of energy and the cycling of matter lead to movement within the mantle and at the surface. We figure out:<br>• Energy from the Earth's core heats up the mantle and causes molten rock to move around (hotter material rises to the surface and cooler material sinks).<br>• This circular movement, called convection, within the mantle causes plates to move at the surface.<br>• When the convection cell rises and pushes out and away, plates at the surface move away from one another. New crust forms when molten rock (magma) seeps through the crust and cools and hardens.<br>• When parts of the convection cell sink back down into the mantle, plates are pulled together and collide at the surface. | <br> |

⇓ **Navigation to Next Lesson:** We figure out generally how movement in the mantle maps to movement of the plates. We now want to apply our thinking to explain what is happening at Mt. Everest and in other cases.

| Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it |
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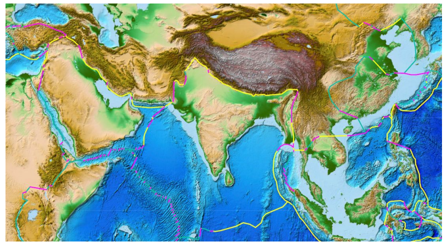
## LESSON 7

1 day

**How much have the plates moved near Mt. Everest?**

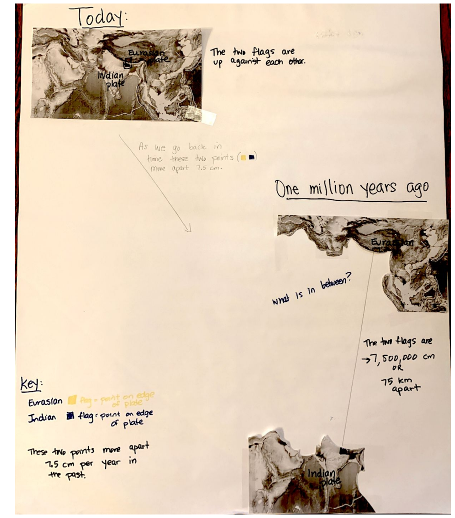
Investigation



*Plates move over long periods of time which affects what happens on the surface of the Earth.*

We use data and evidence from earlier lessons to figure out how far apart the two points on the plate boundaries of the Eurasian and Indian plates would have been at different points in time. We develop a time series model for these two points on the plate boundaries today, at 10 years, 100,000 years and 50 million years ago. We figure out:

- Using current movement data from the Eurasian and Indian plates, we can represent where these two plates would have been in the past.
- Two points on the plate boundary between the Eurasian plate and Indian plate move apart in a proportional manner over time.
- Plates on Earth have been moving for millions of years.



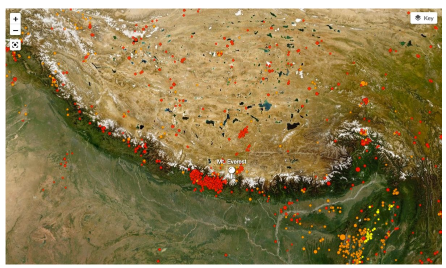

⇓ **Navigation to Next Lesson:** We figure out that the plates have been moving for millions of years and now we wonder how this can help us explain what happened at Mt. Everest.

## LESSON 8

2 days

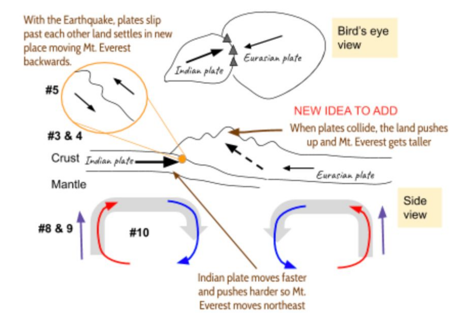
**How does plate movement explain movement at Mt. Everest and other places in the world?**

Putting Pieces Together, Problematizing

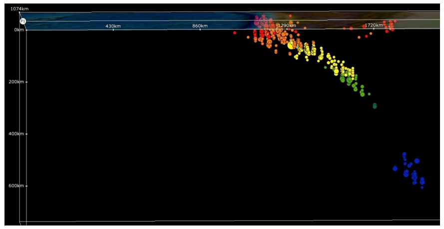
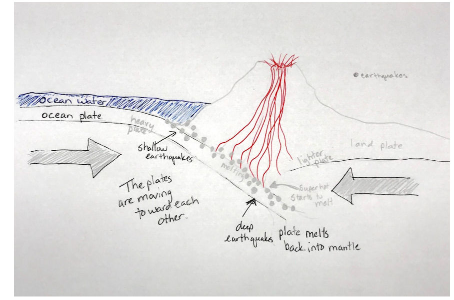


*The Himalayas region is created by the collision of the Eurasian and Indian plates over a long period of time, but this is also a region that experiences sudden changes during earthquake events.*

We develop a Gotta-Have-It Checklist and then a consensus model to explain the different kinds of movement at Mt. Everest. We evaluate other locations we previously investigated to determine if those locations can be explained by our Mt. Everest model. We realize we need a new model to explain what is happening where plates spread apart. We revise our Gotta-Have-It Checklist and develop a new consensus model for explaining locations where plates spread apart. We revisit locations where plates collide and recognize that we cannot explain the presence of volcanoes in some locations and the difference in earthquake patterns. We decide we still need additional information to complete our models.




⇓ **Navigation to Next Lesson:** We figured out that mountains are formed when two plates collide and land lifts up. We also figured out that two plates can spread apart and new crust forms between. We are curious about why there is a difference in the earthquake patterns at different locations and why some places near plate boundaries have volcanoes while other places do not.

| Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it |
|---|---|---|---|
| **LESSON 9**<br>2 days<br>**Why do volcanoes form in some places?**<br>Investigation<br> | <br>*A video simulation and reading add a missing idea for what happens as some plates collide.* | In this lesson, students obtain information and data from a variety of sources to find out why volcanoes form in some places. They watch a video, view animations, read text, and analyze data to determine the cause of volcano formation and consider if it matches what they have learned so far about Earth's plates and how they move. We figure out:<br>• When plates of different heaviness collide, volcanoes and trenches form because the heavier plate "sinks" into the mantle under the lighter plate.<br>• As the sinking crust recycles back into the mantle, it melts and some magma pushes to the surface to form volcanoes and new crust.<br>• Earthquakes occur at greater depths as one plate is sinking below another. |  |

⇓ **Navigation to Next Lesson:** We figured out why volcanoes form in some places and now we are ready to explain all our case sites.

| Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it |
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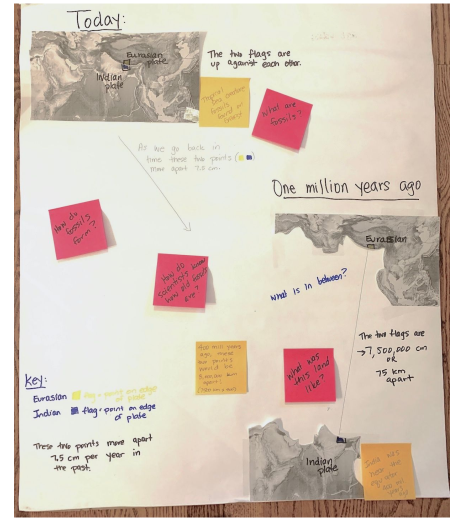
| **LESSON 10**<br>2 days<br>**How do the mantle and plates interact to explain earthquakes and landforms at locations on Earth's surface?**<br>Putting Pieces Together, Problematizing | <br>*Movements at Mt. Everest can explain movements at other locations on Earth.* | We update our Gotta-Have-It Checklist and review and track similarities and differences across three consensus models which explain the different types of plate movement. We construct explanations to account for the interaction between the mantle and the plates that explains earthquake patterns and landforms. We revisit our DQB to track our progress in the unit and to discuss possible next steps. We figure out:<br>• A combination of energy from the mantle transferred to the crust causes plates to move in different ways.<br>• The main movements are colliding or spreading away from one another.<br>• When plates of similar density collide, they can push up mountains; when plates of different densities collide, one will sink and melt into the mantle, causing volcanoes to form at the surface.<br>• It is this interaction of movement in the mantle and plates that shape different places on Earth's surface. | *We can use what we know about how movement in the mantle moves plates at the surface to explain where mountains might form, where volcanoes might form, and what kind of earthquake patterns we might see.* |

⇓ **Navigation to Next Lesson:** We've been looking at plate movement data and locations of mountains and volcanoes, but we are wondering what other kind of evidence scientists use to study Earth's past and what it is like today.

| Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it |
|---|---|---|---|
| **LESSON 11**<br>1 day<br>**How could a fossil get to the top of Mt. Everest?**<br>Anchoring Phenomenon, Investigation | <br>*Tropical sea creatures from 400 million years ago are found at the top of Mt. Everest.* | We read a transcript of an interview with a geologist about fossils found on Mt. Everest. From this interview, we find that these fossils are of tropical sea creatures that were alive 400 million years ago. We use this new information to revisit our consensus model to see if we can explain how and why fossils of sea creatures could be found at the top of Mt. Everest. This leads to new questions that we add to our DQB. We figure out:<br>• Fossils of tropical sea creatures have been found at the top of Mt. Everest<br>• The fossils that were found at the top of Mt. Everest are older than the Himalayas.<br>• The northern part of India used to be closer to the equator 400 million years ago. | <br> |

⇓ **Navigation to Next Lesson:** We read about 400 million year old fossils from tropical sea creatures found on the top of Everest. We are wondering how these fossils got to the top of the mountain.

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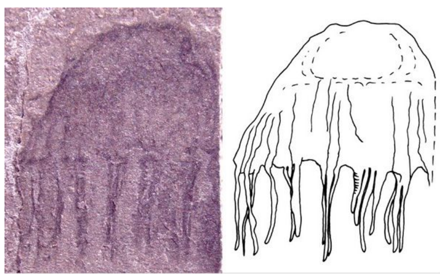
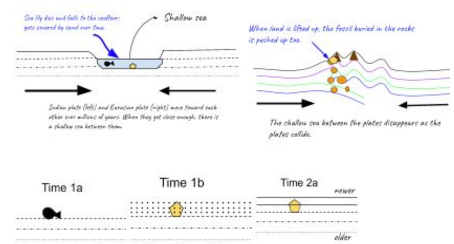
| **LESSON 12**<br>3 days<br>**How do fossils form?**<br>Investigation | <br>*Rock layer and fossil evidence from Utah indicate that the area may have been located near an ancient tropical ocean at some point in Earth's prehistoric past.* | We examine fossil evidence from around the world and study how fossils form through a video and reading. Then, using rock layer evidence, we examine the relative ages of fossils and we figure out how to predict whether specific locations may have once been covered by water. We review and use our knowledge of mountain uplift to explain how older rock layers, and buried fossils, can end up at higher elevations in Utah. We apply our new understandings to explain the presence of sea lily fossils on Mt. Everest. We figure out:<br>• There are layers of rock, and younger rock layers are mostly on top of old layers.<br>• The relative age of a fossil can be determined by examining the surrounding rock layers.<br>• Fossils arise from ancient plants and animals buried and preserved under many layers of rock. | <br> |

⇓ **Navigation to Next Lesson:** We figured out that the sea lily fossil on Mt. Everest can be explained by the presence of an ancient sea floor that is now one of the highest rock layers on Mt. Everest. We wonder why this area, which formed from a solid sea floor millions of years ago, is nearly gone and only exists at the very highest peaks in the Himalayas.

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

## LESSON 13

3 days

**Why is there so little ancient seafloor left on the top of Mt. Everest?**

Investigation


*Other places on Earth are experiencing a loss of sediment and rock layers, like Mt. Everest.*

We look at different locations where materials and layers seemed to be vanishing or breaking down. We conduct some investigations, read text, and watch time-lapse photos to determine what might have happened in those different landscapes and over what timescale. We think back to Mt. Everest to determine why so little of the ancient seafloor is left at the top of the mountain. We figure out:

- Wind and water (rain, ice) break down rock into smaller particles, which physically changes Earth's surface over a long period of time.
- Weathering and erosion happen in many different ways and are driven by atmospheric and biological forces.
- Over time, ice, glaciers, and wind have contributed to the breakdown of the ancient seafloor on the top of Mt. Everest.


⇓ **Navigation to Next Lesson:** We figure out that weathering and erosion take place on Everest, wearing away at the mountain. We also know that the mountain continues to grow. How can a mountain still grow if something is wearing away and breaking down the mountain?

## LESSON 14

3 days

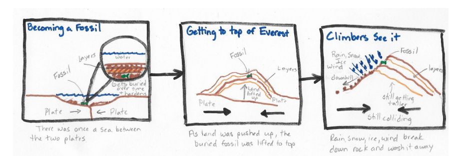
**How did a marine fossil get to the top of Mt. Everest?**

Putting Pieces Together

*Fossil records and rock strata provide evidence for the history of Mt. Everest.*

In this lesson, we put pieces together and use a time-series model to explain how a marine fossil formed, how the fossil ended up at the top of Mt. Everest, and was then exposed for climbers to find. First, we consider cycles of growth and decline in mountains. Then, we build a Gotta-Have-It Checklist to include items from previous lessons to build our time-series model. Finally, we use these ideas on an embedded assessment task and then revisit the DQB to celebrate our accomplishments. We figure out:

- Mountains grow and shrink at big scales over long periods of time. Sometimes they are actively getting bigger or uplifted, but at other times they are shrinking through weathering and erosion.
- Fossil records and rock layers help scientists know what places were like a long time ago (such as an ancient sea) and what they became today (such as the tallest mountain in the world).




## LESSONS 1-14

29 days total