

## Plate Tectonics, Fossils, & Extinction

In 1915 German geologist Alfred Wegener proposed the **theory of continental drift** by arguing that the earth's continents move over time on earth's surface.

Today **plate tectonic theory** based on Wegener's work is accepted as the unifying theory of geology, the study of earth's physical structures.

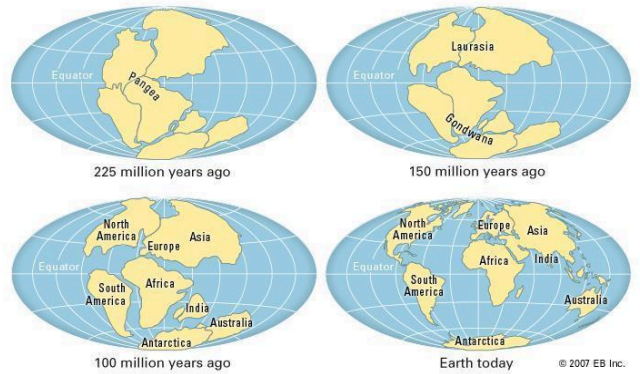
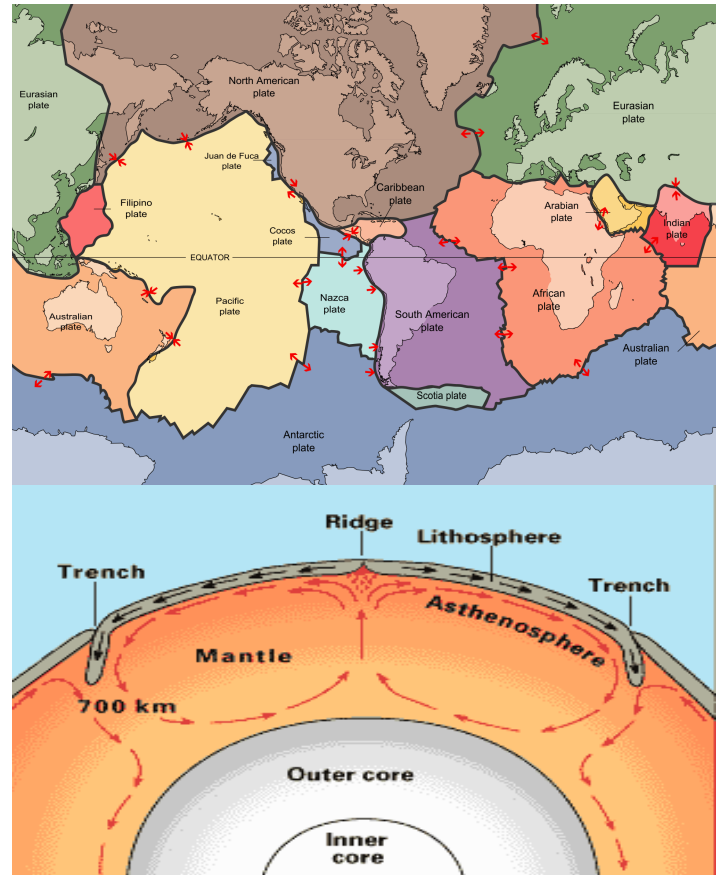


Plate tectonics is the theory that the outer rigid layer of the earth (the ***lithosphere***) is divided into a couple of dozen "plates" that move around across the earth's surface relative to each other, like slabs of ice on a lake. Plates are made of lithosphere topped with oceanic and/or continental crust.

The plates are moved around on Earth's surface by seafloor spreading. Convection in the mantle drives seafloor spreading. Oceanic crust is created at mid-ocean ridges. The crust moves outward from the ridge over time. The crust may eventually sink into the mantle and be destroyed. If a continent sits on a plate with a mid-ocean ridge, the continent will be pushed along.



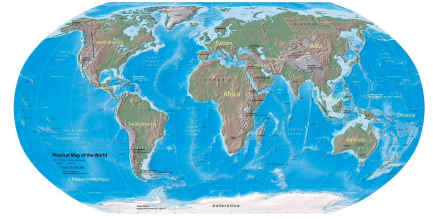
## What evidence supports the theory of plate tectonics?

*In this lab you will gather evidence to support a justification for plate tectonic theory*

## Part 1: Continental shapes, radioactive dating, and fossils

### Activity 1: Continental shapes

Have you ever looked at a map of the world and noticed how the continents appear to fit together? Does South America appear to fit within Africa? Why would this be?



[A. Make a copy of this file](#) Each group member should copy their own file

B. Try and fit the continents together like pieces in a puzzle.

C. Take a screenshot of your model, paste it below, and use it to answer the following questions

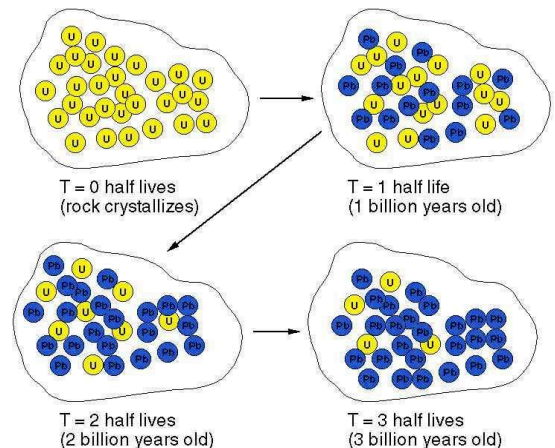
1. Describe any patterns you noticed between continents and how they fit together

2. Earth is estimated to be 4.5 billion years old. If the continents as they appear today are able to fit together into one landmass what does this suggest about the past locations and appearance of earth's continents?

3. Is the ability of earth's continents to fit together as they are shaped today sufficient evidence to support plate tectonic theory? Why or why not?

### Activity 2: Radioactive dating and fossils

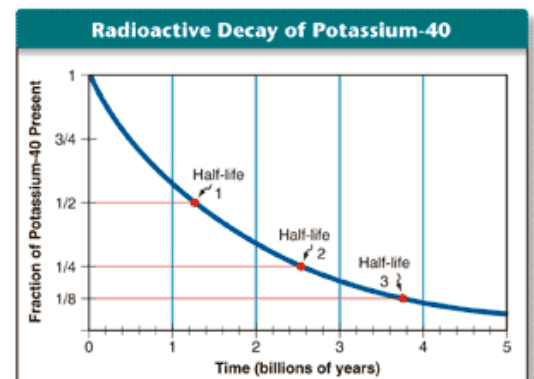
**Radioactive dating** is a method used by scientists to determine the age of fossils and rocks. Radioactive isotopes decay into smaller atoms at a fixed rate. For example, a rock made of uranium (U) will decay half of its atoms into lead (Pb) over exactly 1 billion years. After 2 billion years half of the remaining uranium atoms will decay into lead. The decay of half of a radioactive sample is referred to as **half life**.



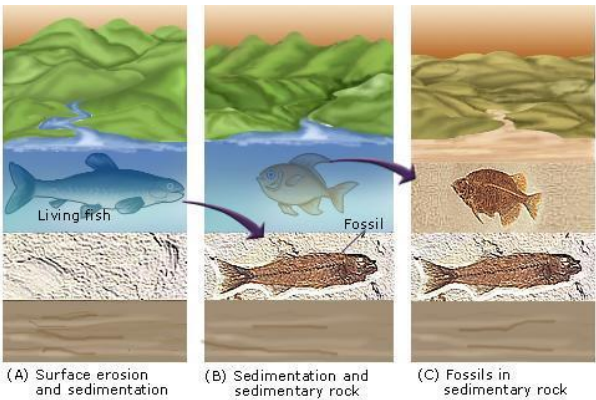
Let's do a few practice problems to understand how half life is used to date fossils and rocks.

1. How old is a fossil containing 50% of its original potassium-40?

2. If 100 grams of potassium-40 containing sedimentary rock disintegrate over 3.8 billion years, how many grams remain?

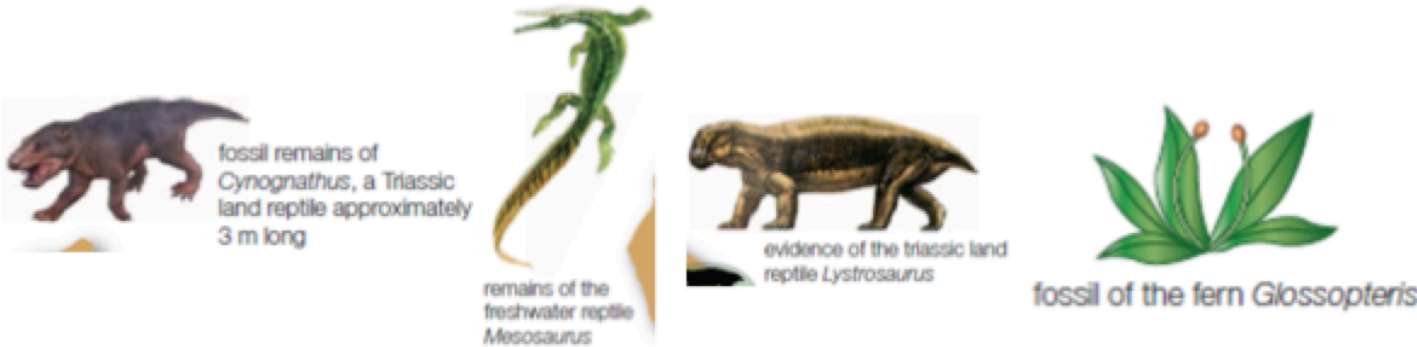


**Paleontologists** are scientists who study fossils. Fossils form when organisms die near the formation of sedimentary rock. Over time the bones of organisms are replaced with minerals or the pressure of forming rock creates an impression in the shape of an organism.



When a fossil is discovered its location, relative age, and radioactive dating age are documented and recorded into databases such as the [paleobiology database](#) . The location and ages of fossils provides profound insights into how the continents may have been formed in the past. Let’s examine fossils dated between 335 - 175 million years ago.

- A. Make a copy of the fossil data for each of the species below. **Recommendation. Have each person in your group download and complete 1 spreadsheet.**
- a. [Cynognathus](#)      b. [Mesosaurus](#)      c. [Lystrosaurus](#)      d. [Glossopteris](#)

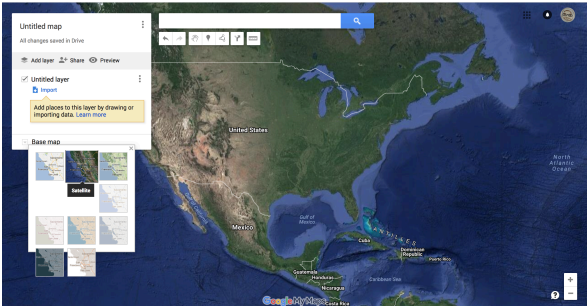


B. Complete the first cell in columns D, E, and F by doing online research and using google images. Copy and paste your response for columns D and E for every row. For column F, paste an image link (right click the picture and select image address link) and copy and paste into every row.

A	B	C	D	E	F	G	H	I
Name	longitude	Latitude	Description Of Skeletal Features	Climate Prediction	Picture of Fossil			
cynognathus	26.111111	-30.906944	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	-68.639999	-34.880001	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	16.466667	-21.1	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	16.42639	-21.0875	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	16.480556	-21.1	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	27.233334	-31.700001	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	27.233334	-31.700001	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	26.375557	-31.59639	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	27.233334	-31.700001	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	164.050003	-84.349998	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	26.320278	-30.993889	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			
cynognathus	26.700001	-30.683332	epic bones!	Cold as ice!	<a href="https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326">https://thumb9.shutterstock.com/display_pic_with_logo/764968/764968.1326</a>			

C. Open [google my maps](#) and create a map. **SHARE YOUR MAP WITH YOUR GROUPMATES.**

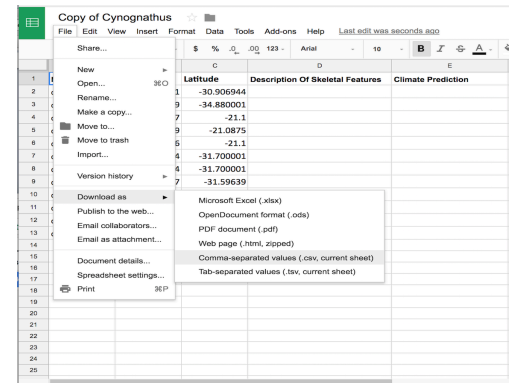
D. Click ‘base map’ and select ‘satellite’





**Each person in your group should do steps E - J with their respective spreadsheet**

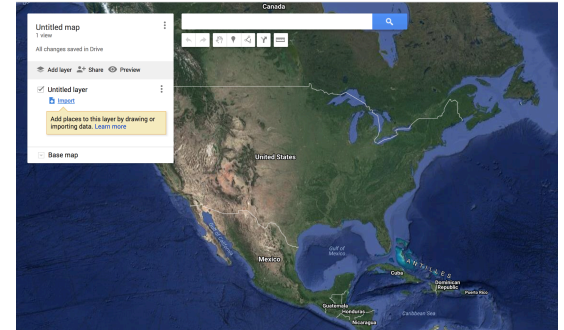
E. Download each of your spreadsheets as .csv files. In google sheets select 'file', 'download as', '.csv - comma separated values'



F. In my maps, select 'import' under 'untitled layer'

G. Select one of your .csv files

H. Google my maps will automatically select longitude and latitude. Select continue.



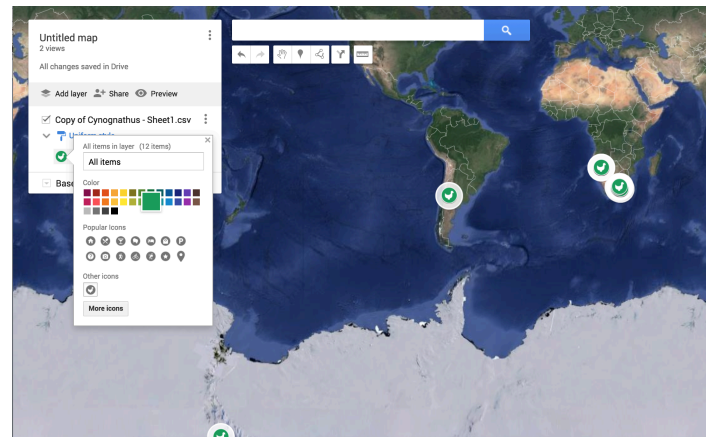
I. Select 'name' as the column to title your markers

J. Your map will now show the location for every fossil. Select the paint can icon next to 'all items'.

K. Select a unique color and image for your data points

L. Repeat this for each spreadsheet until your map shows all four fossils.

**1. Paste a link or a screenshot of your map below**



[Make a copy of this file](#). Use your fossil google my map to determine the position of the continents 335 - 175 million years ago based on fossil evidence on these google slides.

**2. Paste a screenshot of your arranged continents below**



3. Describe how you used fossil evidence to determine what the location of the continents must have been 335 - 175 million years ago.

4. Compare your map to [a map of the continents as they are formed today](#). What does this suggest about the stability and change of earth's surface over the past 335 million years?

5. Scientists currently believe that 335 million years ago the continents formed together into one supercontinent called **pangea**. [View this map of pangea and compare it to the google slide formation you made](#). What effects do you think the drifting apart of continents from Pangea to today could have had on species over time? For example, imagine a species that lived on Pangea but was separated by ocean as south america drifted from Africa over millions of years.

6. Predict **THREE** ways how the movement of plates can influence the evolution of species.

## Part 2: Convection currents and plate boundaries

### Activity 3: Convection Currents

What causes earth's plates to move?

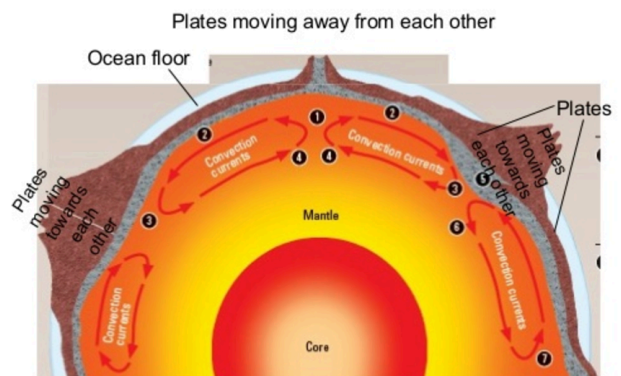
Tectonic plates are made of a relatively cold layer of rock called **the lithosphere** that rest on top of hot liquid rock known as the **mantle**.

### Hot things rise. Cold things fall.

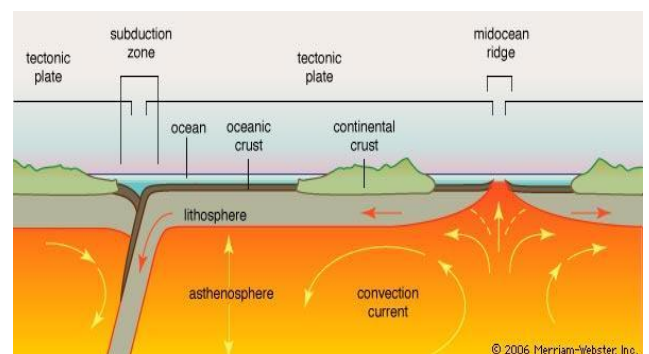
When hot mantle close to the earth's core rises towards the surface it cools causing the mantle to fall back down towards the core. This creates a cycle of rising and falling mantle known as a convection current.

Tectonic plates resting on top of the mantle are moved by convection currents. When plates collide they can move into the mantle and be melted. Rising mantle can then reach the surface and cool to form new plate boundaries.

### d. Why do tectonic plates move?



Tectonic plates float on molten mantle, driven by heat energy/convection currents



## Procedure:

1. Let's see what effect uneven temperatures can have on liquids and gases. Obtain a split tank from your teacher. Make sure the tank divider is secure. Note: [This video can be used if split tanks are not available](#)

2. Pour **cold blue water** into one side of the split tank.

3. Pour **red hot water** into the other side of the split tank.

4. Write your prediction on what will happen when you remove the divider below

5. Pull the divider and carefully observe what occurs.

6. Dispose of the liquids in the sink. Rinse and clean your split tank



1. Draw a model of what you observed in the video

2. Explain your observations using your model or film as evidence

3. Describe how this activity supports the movement of tectonic plates by convection currents in the earth's mantle

4. How does the scale and proportion of this water model compare to convection currents in the earth's mantle? What effect would a planetary scale have that a small plastic model wouldn't?

## Activity 4: Plate boundaries

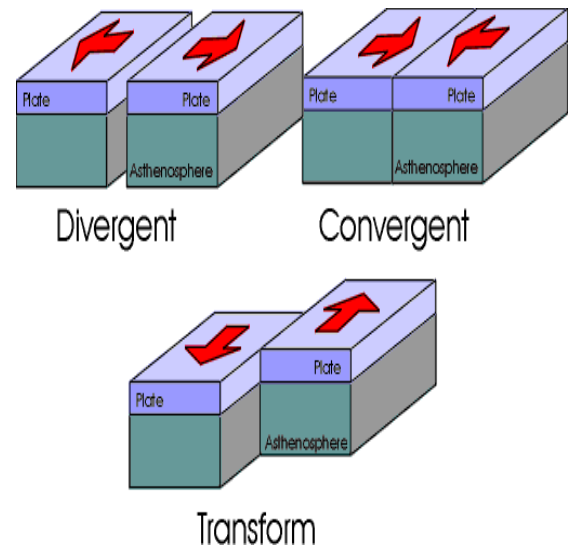
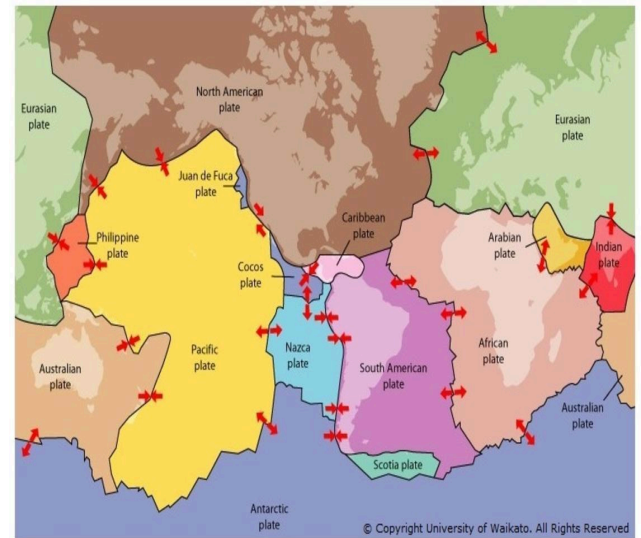
The movement of tectonic plates by convection currents causes the earth's plates to move away or towards each other and to move side-by-side. Where tectonic plates meet are known as **plate boundaries**. [Please watch this video for more information](#)

The three primary types of plate boundaries are:

**Divergent boundary:** two tectonic plates move away from each other. Not unlike how same magnetic poles repel each other. As the plates move, deep fissures are created in the earth's crust. Magma oozes up from the mantle into the gap and hardens, forming a new crust.

**Convergent boundary:** two tectonic plates collide head on. Imagine two quarterbacks who tackle each other head on. As they make contact, the force of the impact ripples through both of their bodies. This force also ripples through the plates, causing earthquakes when they collide. These boundaries can buckle up to form mountain ranges or one plate can be subducted into the mantle.

**Transform boundary:** two plates slide against each other. It's like grinding two bricks together; both get damaged and there is a lot of friction. Rocks along the boundary are pulverized and a brand new linear fault valley or undersea canyon appears. Not to mention the severe earthquakes that happen as a result.



1. Examine [this plate boundary](#) of San Andreas fault located [between these plates](#) . What type of plate boundary do you think is occurring here? Explain your answer
2. Examine [this plate boundary](#) of the African Rift valley located [between these plates](#). What type of plate boundary do you think is occurring here? Explain your answer.
3. Examine this [plate boundary](#) within India located [between these plates](#) . What type of boundary do you think is occurring here? Explain your answer.



#### 4. Describe how plate boundary movement can form mountain ranges and new ocean floor

### Part 3: Extinction

#### Activity 5: [Earth's major extinction events](#)

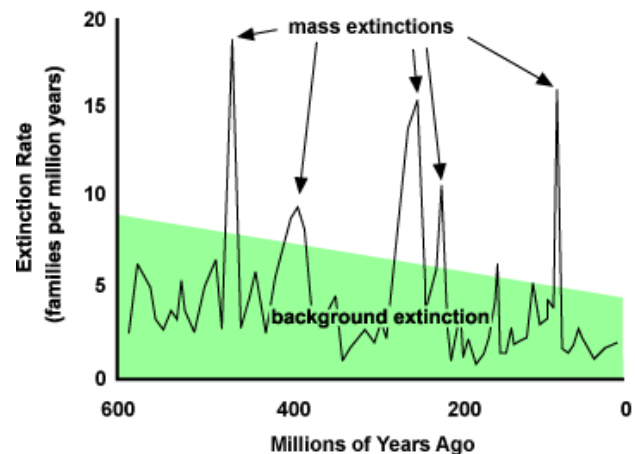
##### What is extinction?

Extinction is the end of an organism or group of organisms by the death of every member of a species. Species that still exist are referred to as being extant.

##### How normal is extinction?

Extinction is a natural process of evolution by natural selection. Selective pressures such as changes in the environment cause extinctions to occur every year at a rate of 1 to 5 species a year. This 'normal' rate of extinction is referred to as the **background extinction rate**.

The extinction of a large number of species at a rate greater than the background extinction rate is known as a **mass extinction event**. These events are typically caused by catastrophic events on earth. Thus far there have been 6 mass extinction events. [Today you are currently living through the sixth great extinction event, the holocene or Anthropocene extinction.](#)



1. [Examine each of the 6 major extinction events using this link to complete the table below.](#) Click the hand with the white finger to access the information.

Extinction Event	Time Period	Environmental Factors	Affect Species & Total Species Lost
End Ordovician			
Late Devonian			
End Permian			
Triassic			
Cretaceous			

Anthropocene			
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1. Describe the causes of mass extinction events
  
2. Did you notice in patterns between each extinction event? Explain your answer
  
3. With each extinction event many species remained extant (did not go extinct). What could explain, in evolutionary terms, why life has persisted through mass extinction events?
  
4. [Examine the anthropocene by exploring this interactive](#). Describe THREE ways human activity is contributing to the current anthropocene extinction event.
  
5. The previous five mass extinction events occurred over 25+ million years of environmental change. Our current extinction event has occurred over only 100+ years! Will species be able to adapt to such rapid environmental changes? Explain your answer