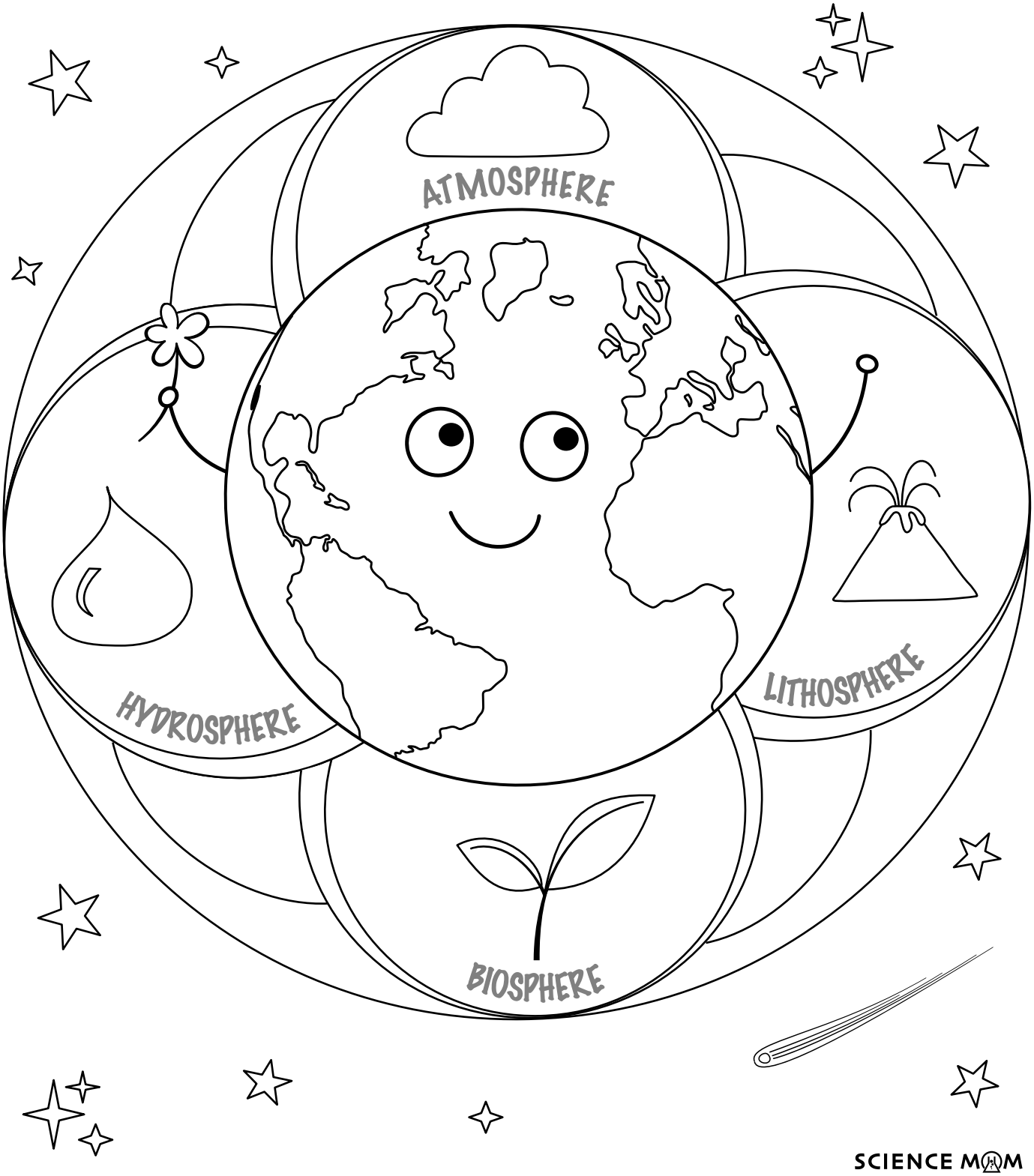
Earth Science



EARTH SCIENCE

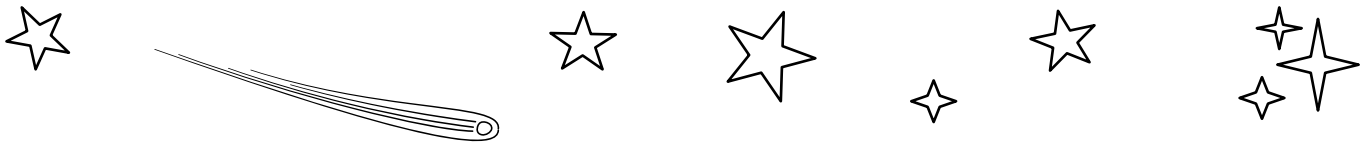
A SELF-PACED COURSE ON ATMOSPHERIC SCIENCE, GEOLOGY, AND HYDROLOGY

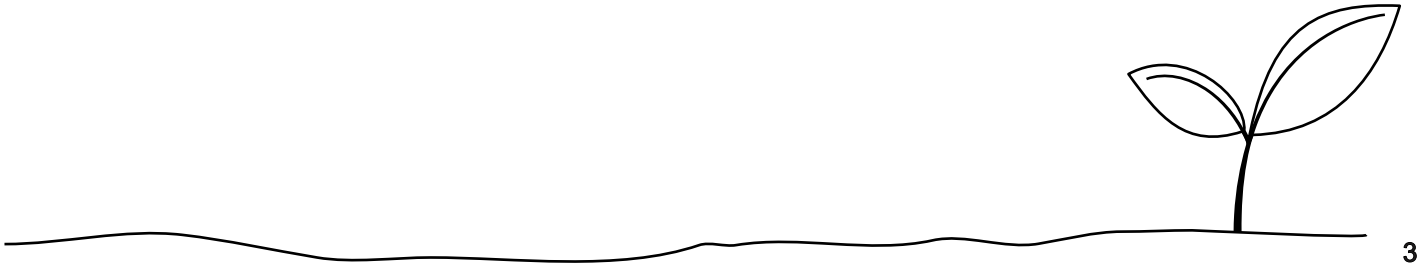
Video lessons with interative poll questions can be viewed for each lesson at: https://science.mom/earthscience or on the Science Mom YouTube channel under the "Earth Science" playlist.

There are 5 art projects and 5 science activities that can be completed throughout this course. Templates for the art projects are available in the appendix (pages 113-137 of this document) and a complete supply list is available on the following page. This class was designed to satisfy half of the 4th and 5th grade U.S. science standards, which are commonly referred to as NGSS or Next Generation Science Standards, which are listed in the table of contents.

Lessons were recorded live during January-May of 2021. The recordings and notes have been made freely available thanks to the support of our patrons on https://patreon.com/sciencemom

Have questions or suggestions? Contact jenny@science.mom or serge@science.mom





Supply List for Art & Science Projects:

Lesson 5 - Atmosphere Model

- Paper, Scissors
- Art supplies for coloring (any type)
- Printed templates (optional) found on pages 116-121

Lesson 8 - How do Planes Fly?

- Roll of toilet paper or a tissue
- 3 ping pong balls
- 2 pencils OR a ruler OR another long straight object
- 4 Balloons
- String or yarn
- Paper “helicopter” toy (instructions and templates on pages 114-115)
- A paper airplane (instructions on page 113)
- Hair dryer
- Tape

Lesson 14 - Climate Zone Quadramas

- Cardstock
- Crayons or markers for coloring
- Scissors
- Gluestick or tape
- Printed templates (optional) found on pages 125-137

Lesson 19 - Mason Jar Biomes

- 2 mason jars and lids
- 4 small disks of compressed coconut fiber OR 2 cups of potting soil
- ½ cup gravel, pebbles, or marbles for a drainage layer
- Food scraps from the kitchen
- 1 bright light that can be placed over one of the jars
- Small seeds such as clover, alfalfa, or creeping thyme

Lesson 22 - Spaghetti Bridge

- A box of spaghetti noodles (can substitute angel hair or other variety of long noodles)
- Tape OR Marshmallows
- A cup
- String or yarn
- A unit of weight such as coins, beans, or marbles

Lesson 25 - Layers of Earth

- Paper
- Art supplies for coloring (any type)
- Printed template (optional) found on page 122-125

Lesson 31 - Candy Rock Cycle

- Skittles or other round candy with a marking on one side (m&ms are a good substitute)
- Starbursts or other chewy candy that has different colors and will soften when warm
- Paper towel or plate
- Sidewalk chalk

Lesson 34 - Moons and Shadows

- Cardstock
- A white crayon
- Watercolors or markers
- Printed template (optional) found on pages 127 and129
- Sidewalk chalk

Lesson 37 - Waves

- 1 lightweight blanket or sheet
- 3 ping pong balls
- 1 slinky

Lesson 43 - Build-A-Map

- Modeling clay or play dough
- A marker
- Paper
- Art supplies for coloring (any type)

Author's note:

Although my target audience for this course is 4th and 5th graders, I've never been able to hold back from sharing big words and cool ideas. You'll find that some of the material is above grade level. I hope that's one of the things you enjoy about this curriculum, rather than a source of frustration.

These notes and their accompanying video lessons are posted online as a free and public resource.

You are welcome to download and print as many copies as you would like. You are encouraged to share these notes with your friends or students.

You are NOT allowed to sell these notes or to share images from them without attribution.

Far too often, quality education is unavailable to people experiencing financial scarcity. These notes are free because I believe in the power of education and want science to be accessible to *every* student.

If you enjoy this Earth Science class, please support our efforts by sharing the course (positive reviews and personal testimonials makes a huge difference!) or by joining us at: www.patreon.com/ScienceMom. The larger our network of students and supporters, the more courses like this we'll be able to create!

Thank you for being here. Let's work hard and grow smarter together.

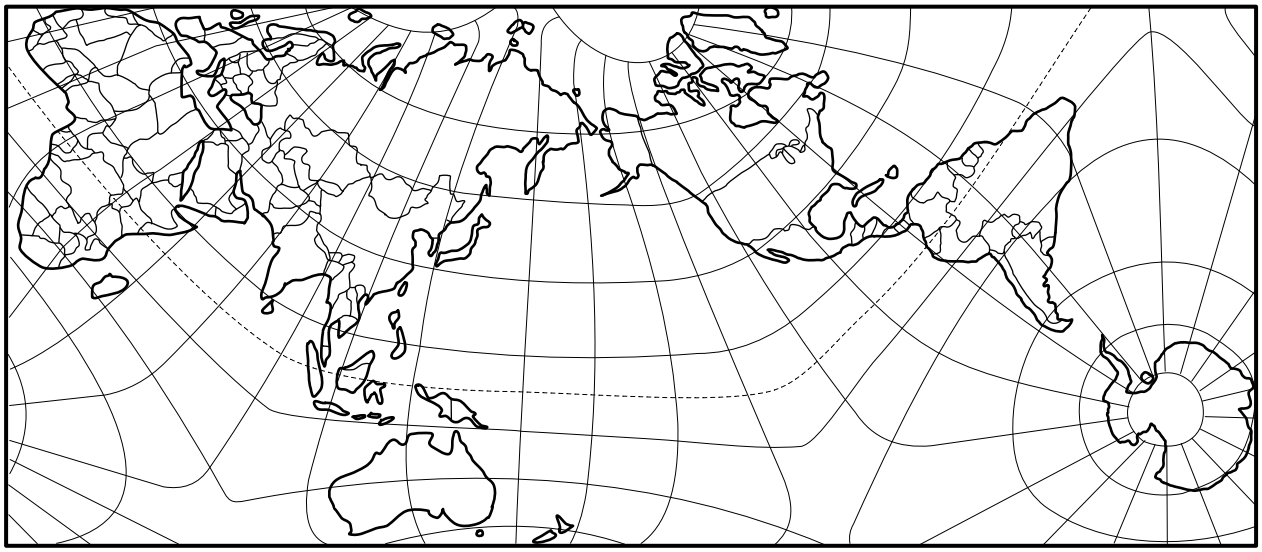
– Science MOM

How to get the most from this course:

This course can be used in a variety of ways! You can participate passively (just watch the videos), or actively by filling out the notes and completing the projects. You can do the entire course in sequence or participate in one lesson or section at a time.

For BEST learning, we recommend the following:

- ☑ Read the pages that go with each lesson before watching the video. Take 10-15 minutes to see if you can fill in the blanks.
- ☑ On "Quiz show" days, use the itempool link to take advantage of the interactive questions and test your knowledge. Prepare by taking the practice quiz before you watch the quiz show video!
- ☑ In each of the science activities, make predictions before you conduct the experiments.
- ☑ Download the answer key for the notes, but don't look at the answers until after you give things a try yourself!



The AuthaGraph map was invented by Hajime Narukawa and works by equally dividing the spherical surface of Earth into 96 triangles, then mapping these on to a tetrahedron before unfolding them to a rectangle.

Why Earth Science?

Why study Earth Science? Well, Earth is the only place in our solar system where we find **living things**. The animals, plants, fungi, and single-celled organisms that call Earth home have one important thing in common. They each live in and depend on these four spheres:

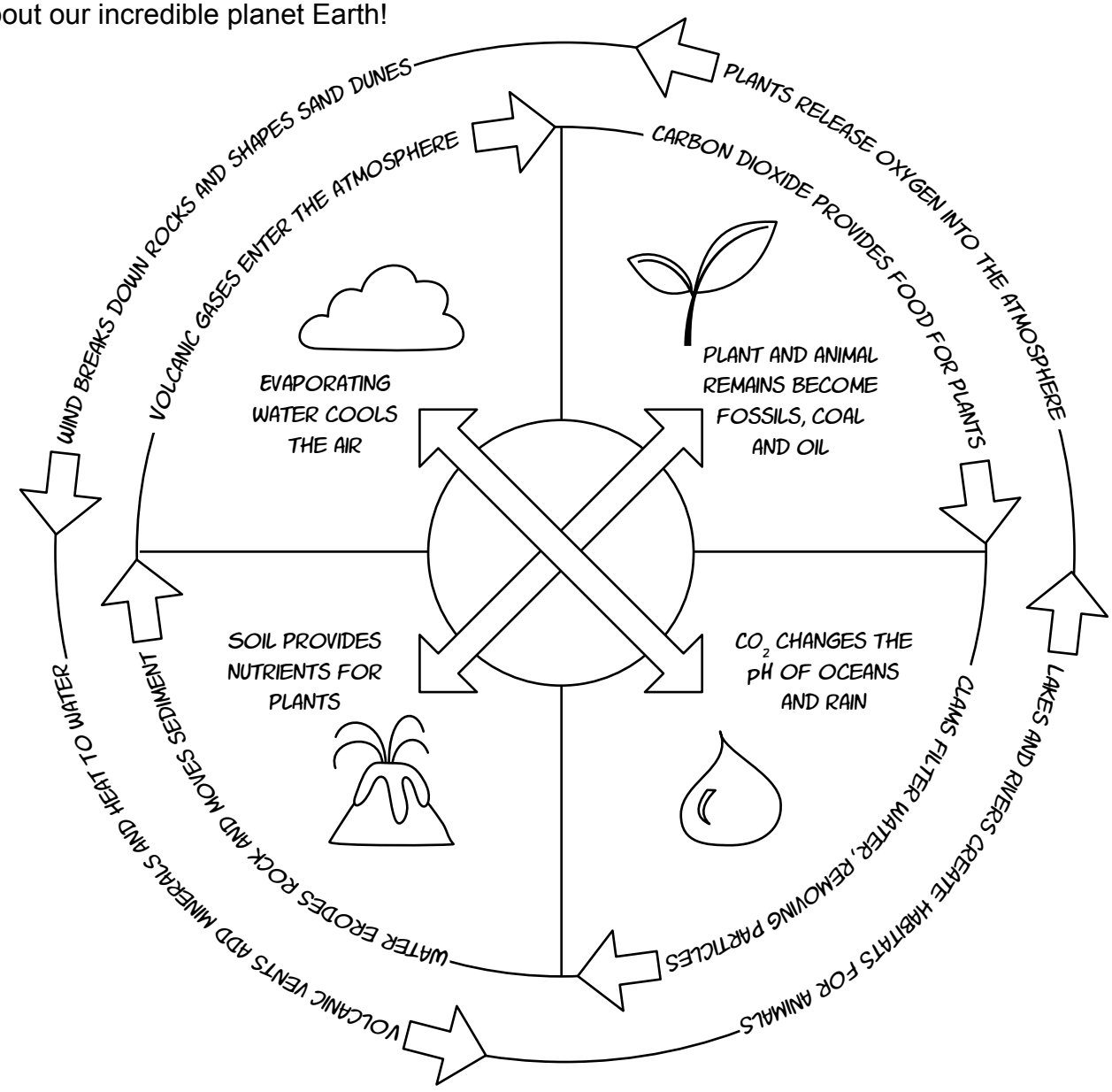

Atmosphere: all the air surrounding our planet


Lithosphere: all the rocks! The crust of our planet


Biosphere: all the living things on planet Earth


Hydrosphere: The water on, under, and above the surface of our planet

Each of these spheres interacts with the others in fascinating ways, and the study of these spheres and their interactions is called *Earth Science*. In this course, we're going to focus our attention on the atmosphere, lithosphere, and hydrosphere. We can't wait to show you more about our incredible planet Earth!



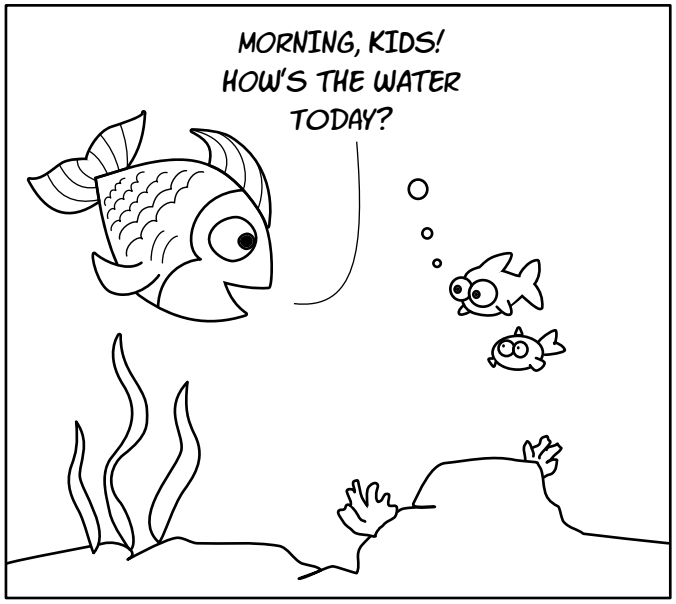
Part One:

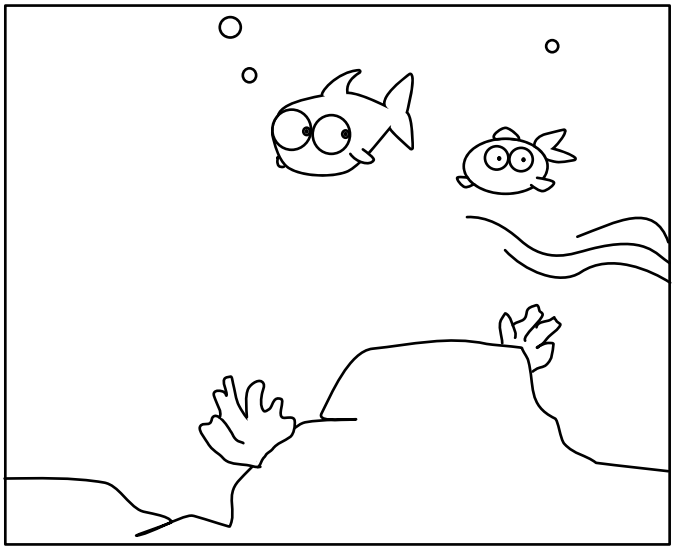
The ATMOSPHERE

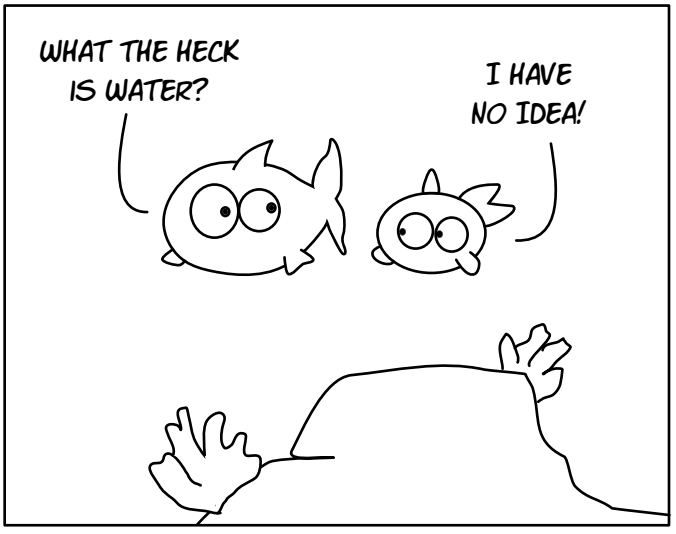
Have you ever felt sorry for a fish because it's trapped in a pond and can't walk around on land? Well, we live in air just like fish live in water, only we're too heavy to swim!

Just like a fish can't live without water, we can't live without air, which is a mixture of gases. The layer of gases surrounding a planet is called its atmosphere. Our atmosphere is important for more than breathing. It protects us from radiation, cycles nutrients and heat, and is the source of all our food.

Over the next several weeks, we'll learn exactly what it is that we're breathing and why it's so important for food, climate, weather, and life!







QUICK FACTS:

THE ATMOSPHERE IS MADE OF:

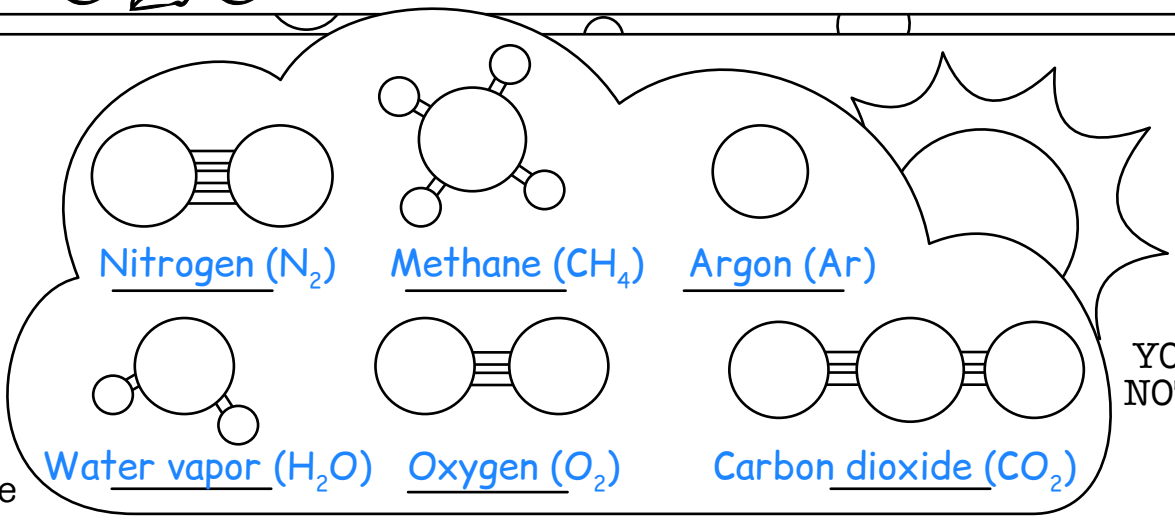
Nitrogen: 78%
Oxygen: 20.9%
Argon: 0.9%
Carbon Dioxide: 0.04%
Helium: 0.0005%
Methane: 0.0001%
Ozone: 0.00006%

At any given time, there is also a significant amount of ***water vapor*** in the air. But since the amount of water is constantly changing, it isn't included in percentages of atmospheric gases.

THE LAYERS ARE:

Troposphere: 1-12 km (1-7 miles)
Stratosphere: 12-50 km (7-31 miles)
Mesosphere: 50-80 km (31-50 miles)
Thermosphere: 80-700 km (50-440 miles)
Exosphere: 700-1,000 km (440-6,200 miles)

GASES of the ATMOSPHERE



Chemical Formula

Name

YOUR NOTES

Ar Argon

A noble gas. Argon is not reactive. It makes up about 1% of the atmosphere.

CH_4 Methane

A greenhouse gas. Methane is produced from living things (bacteria, cows, etc) and can be burned to produce carbon dioxide.

O_2 Oxygen

Animals and plants need oxygen to stay alive. Almost 21% of the atmosphere is oxygen.

CO_2 Carbon Dioxide

The most abundant greenhouse gas. Carbon dioxide is made by animals and combustion (burning fuels like wood, oil, or coal).

N_2 Nitrogen

The most common gas in the atmosphere (78% of the air is N_2 gas). Nitrogen is not reactive and not a greenhouse gas.

H_2O Water Vapor

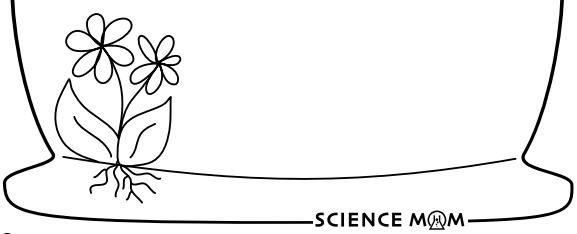
The amount of water vapor in the air is called humidity and it changes depending on the weather. Water vapor is also a greenhouse gas.

THE MOST IMPORTANT GREENHOUSE GASES:

Methane (CH_4)

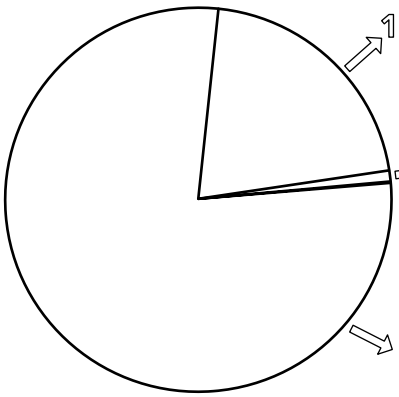
Water vapor (H_2O)

Carbon dioxide (CO_2)



SCIENCE MOM

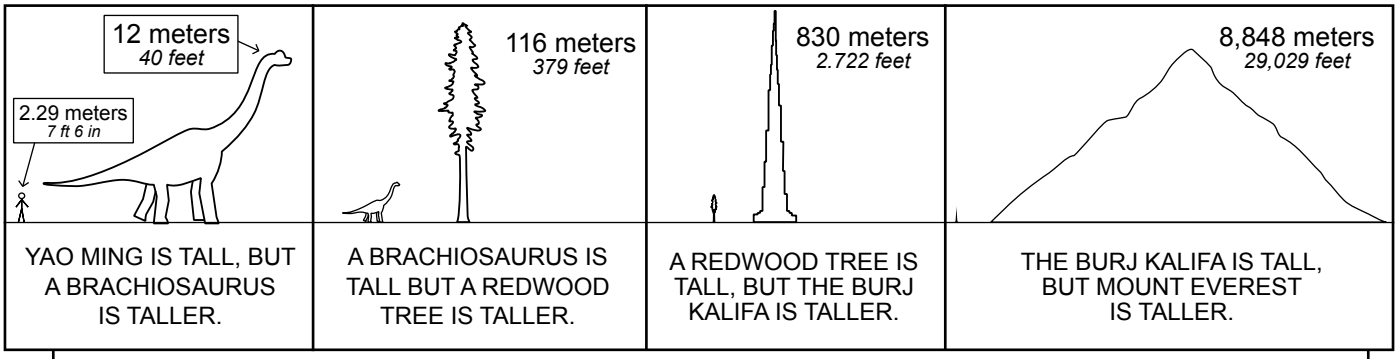
The 3 most abundant gases in the atmosphere:

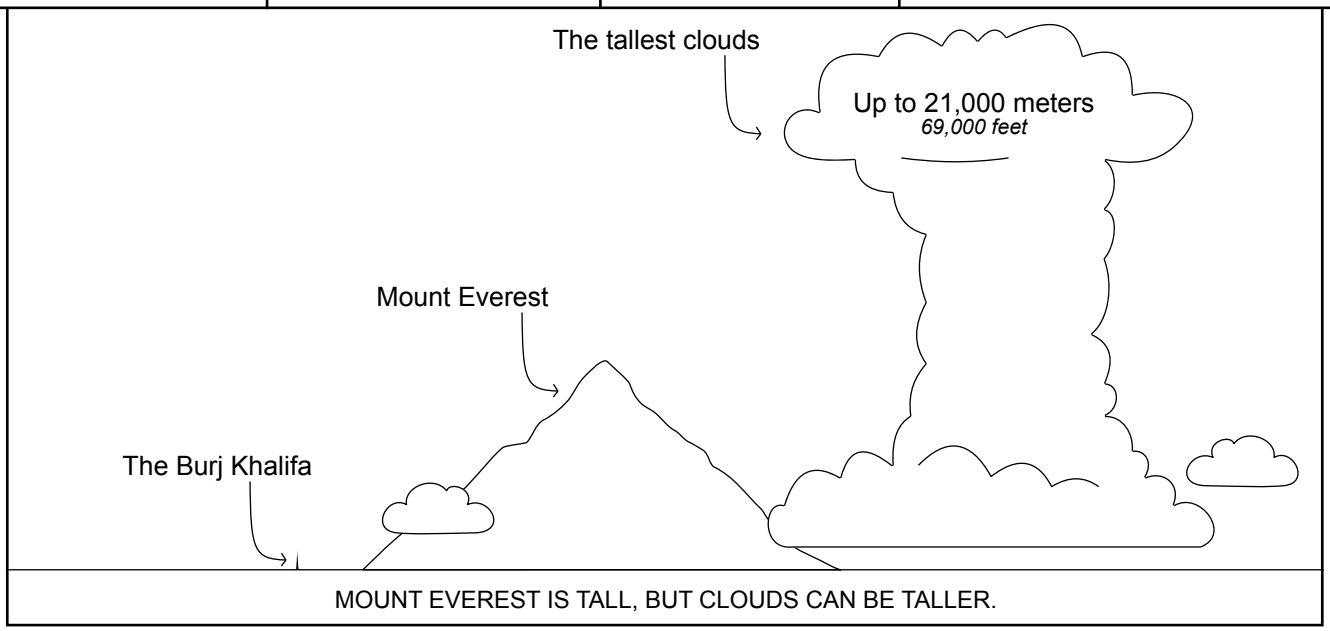


1. Oxygen (O_2)
2. Argon (Ar)
3. Nitrogen (N_2)

How TALL is the atmosphere?

Compared to how tall we are, the atmosphere is incredibly tall!
Compared to how thick the Earth is, it's rather small.





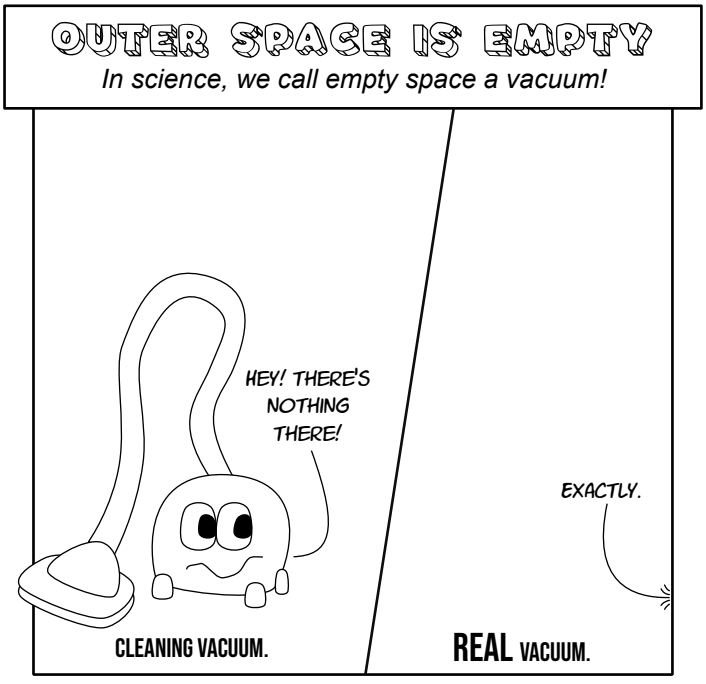
It's difficult to measure *exactly* where the atmosphere ends and outer space begins because the atmosphere doesn't have a "lid" or cap on top. The air just keeps getting thinner and thinner, until it's so thin that it acts and looks like the emptiness of outer space.

The lowest layer of the atmosphere (0-10 km) is called the *troposphere*. It's the warmest part of our atmosphere and where all our weather occurs.

The next layer is defined by the ozone layer, which protects our planet from harmful radiation. We call it the *stratosphere* (10-50 km).

The third layer is the *mesosphere* (50-85 km). When meteors enter our atmosphere and burn up, creating shooting stars, they are doing it in this layer.

The *thermosphere* (90-500 km) and *exosphere* (500-1000 km) are the next two layers. The air molecules are so far apart in these layers, they look and feel like the vacuum of outer space!



LAYERS of the ATMOSPHERE

Exosphere

500 km

Thermosphere

90 km

Mesosphere

In the troposphere and mesosphere, the air temperature gets cooler with higher altitude. In the stratosphere, the trend is the opposite. In this layer the air temperature gets warmer with higher elevation.

50 km

Stratosphere

40 km

30 km

OZONE LAYER

WOW!

20 km

10 km

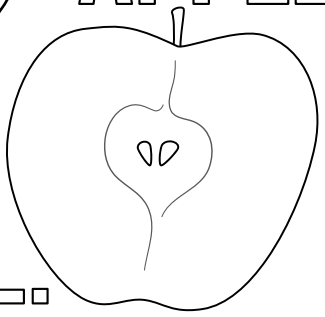
Troposphere

8 km

5 km

If our EARTH were the size of an APPLE

The ATMOSPHERE would only be as thick as THE PEEL.



COLOR ME RED WHERE THE AIR GETS WARMER AND BLUE WHERE THE AIR IS GETTING COLDER!

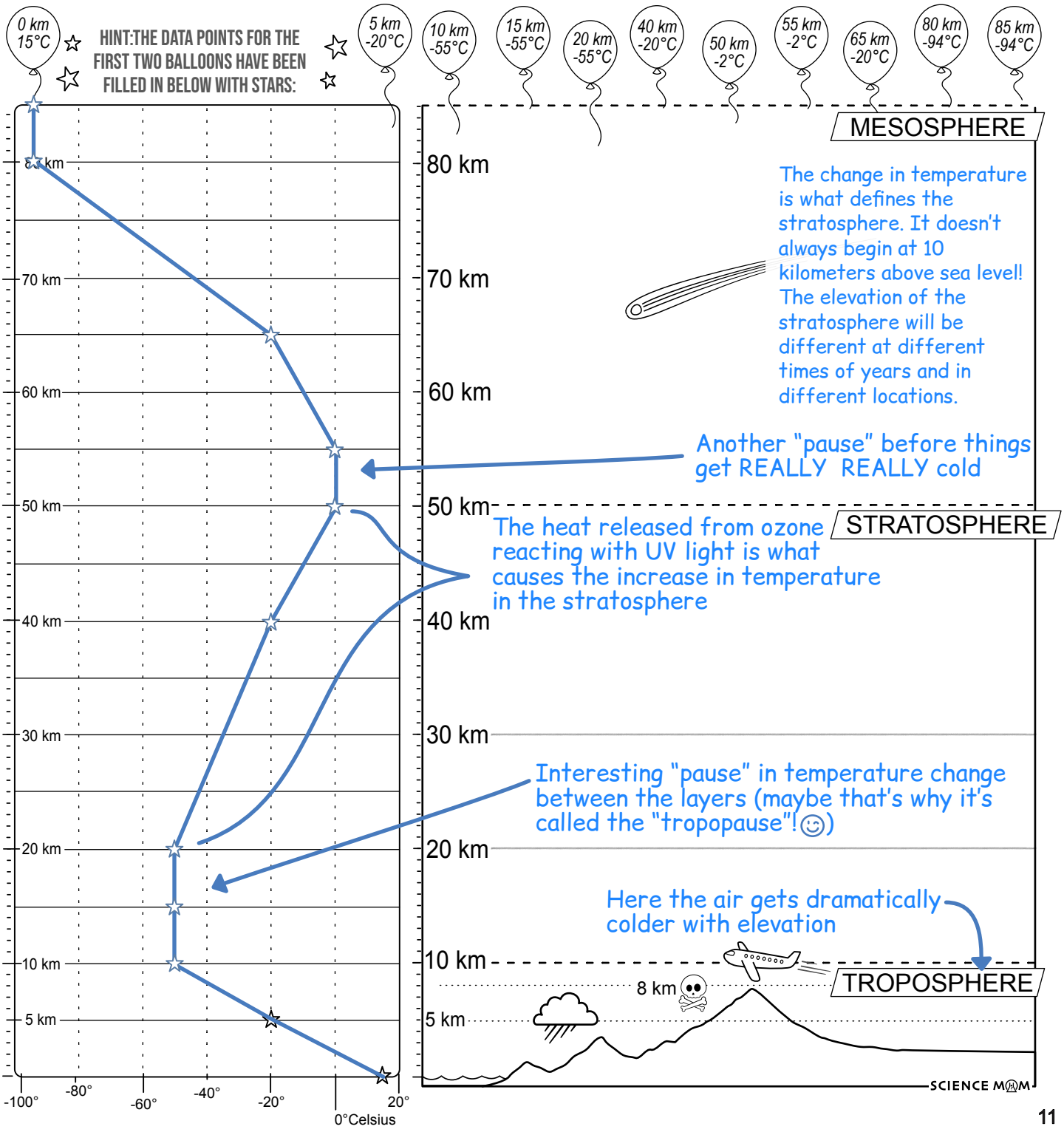
When meteors enter the atmosphere they burn up, creating shooting stars. This happens in the mesosphere.

Ozone is O_3 a molecule that absorbs harmful UV light. The ozone layer is in the stratosphere.

All of our breathable air is in the troposphere. People can adapt to live anywhere from sea level to 8 km above sea level.

Graph the temperature of the atmosphere

Hot air rises, so you might think that the air would keep getting warmer and warmer the higher you go. But don't forget that outer space is really cold! Each of the balloons below has a measurement. Put these data points on the graph and draw a line between them to discover how temperature changes with elevation. If you get a line like this: ⟍ that means the air is getting colder the higher you go. If the line looks like this: ⟋ then the air is getting warmer with higher elevation.



Layers of the ATMOSPHERE ART PROJECT

BUILD THE LAYERS, COLOR THEM WITH LETTER ART, OR BOTH. YOU CHOOSE WHICH PROJECT YOU WANT TO DO!

1 *Build the Layers*

Choose something for your "unit" and make sure you have at least 9 of them. It could be anything! Beans, pencils, pieces of licorice, Lego blocks, books, or pieces of paper that are cut to be the same size.

Place 1 unit down for the troposphere.

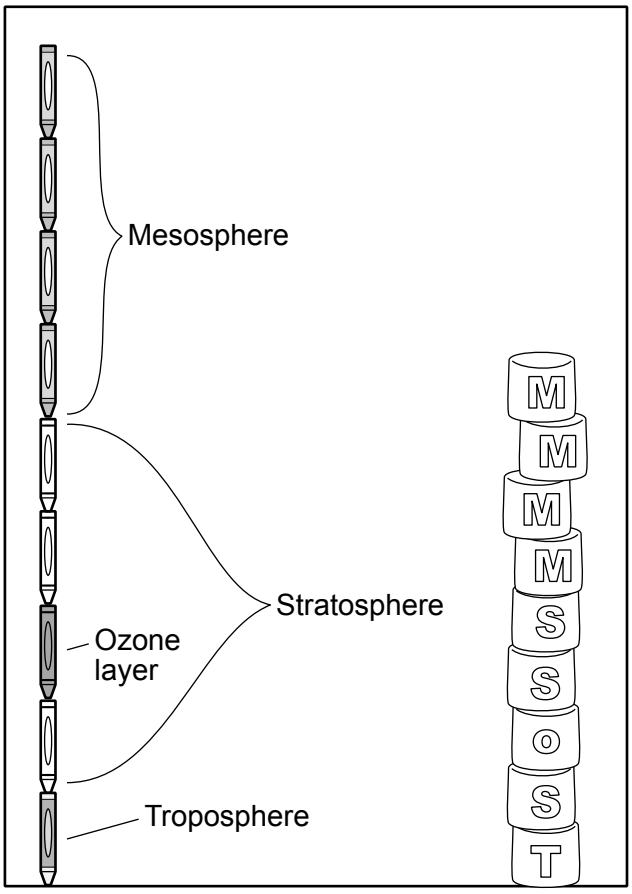
Place 4 units down for the stratosphere. The second of these units represents the ozone layer!

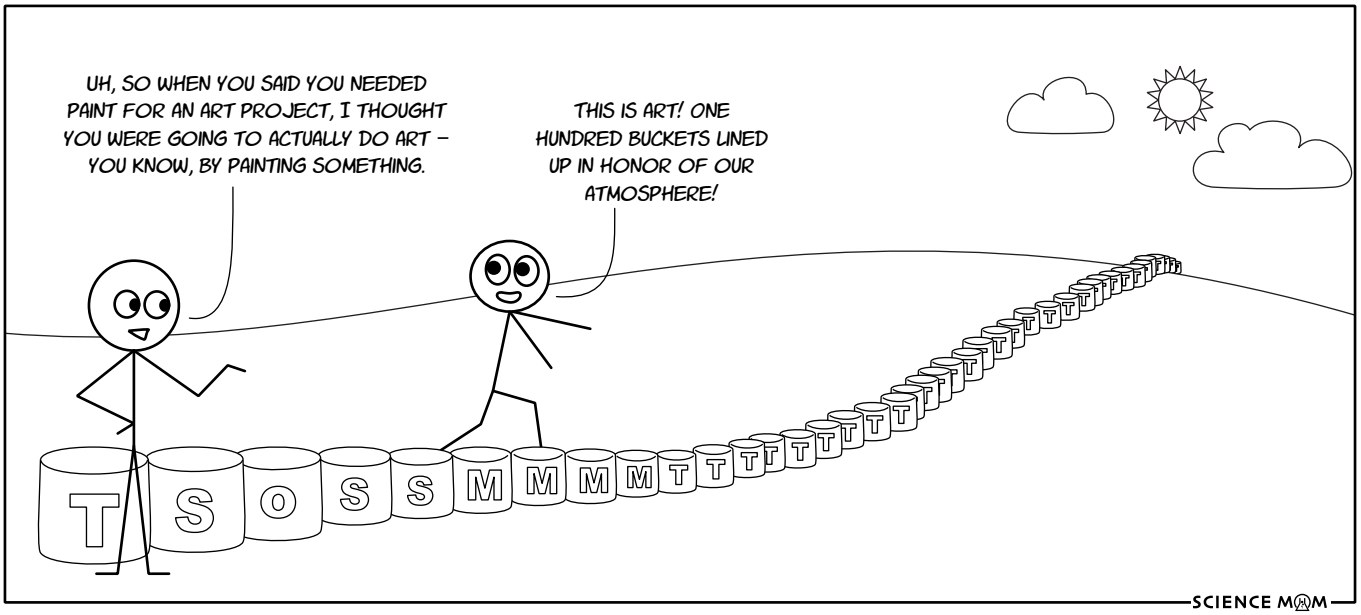
Place 4 more units down for the mesosphere. (*Three and a half units would be most accurate, but each of these layers can vary by location and season. Four units is a fair representation.*)

Your atmosphere model is complete! Or is it? Figuring out where the atmosphere ends and outer space begins can be tricky, because the air just keeps getting thinner, and thinner, and thinner.

In the thermosphere and exosphere, there's more than a *kilometer* of space between air molecules. Since these layers act and feel a lot like the emptiness of outer space, sometimes they aren't included when we talk about the layers of the atmosphere.

If you'd like to include them in your model, you'll need FORTY ONE additional units for the thermosphere and FIFTY more for the exosphere!





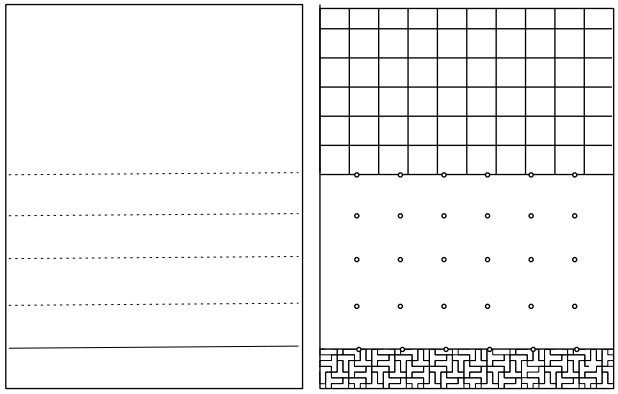
Layers of the ATMOSPHERE ART PROJECT

2 ***Art with Letters***

Print the Layers of Atmosphere template (page 117) OR create your own using a ruler by starting at the bottom and marking straight lines across the paper at approximately the following heights:

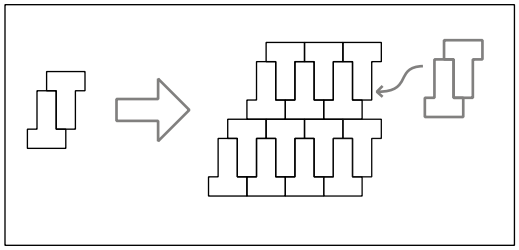
Draw 4 more lines (lightly) every 3.3 cm or 1¼ inches above the first line (these are the stratosphere. The ozone layer will be between the 1st and 2nd of these lines)

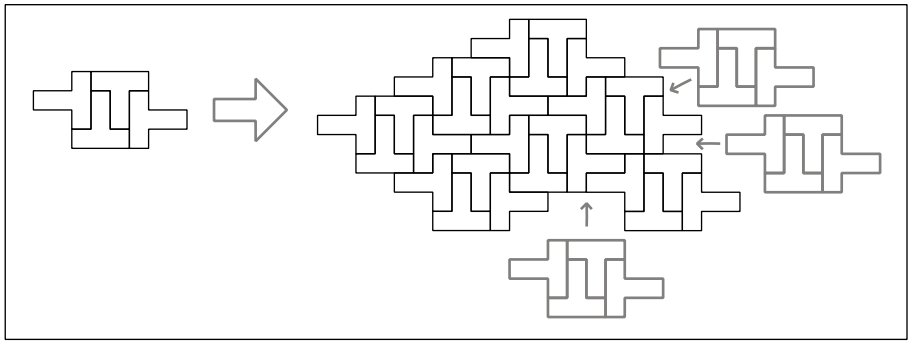
3.3 cm/1¼ in from bottom (represents top boundary of troposphere)



TROPOSPHERE LAYER

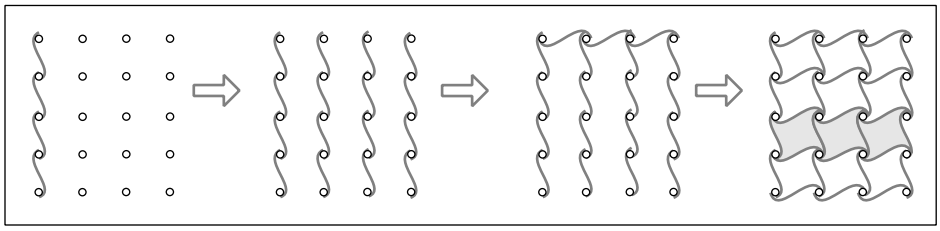
The troposphere layer in the template is decorated with a *tessellation* of the letter T. A tessellation is a repeating pattern with no overlaps and no gaps. You can make your own by repeating this basic shape of 2 letters, or 4 letters:

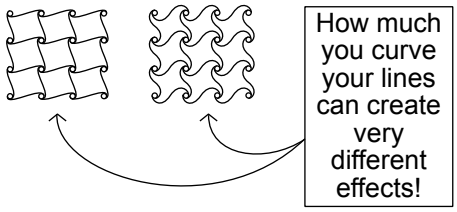




STRATOSPHERE LAYER

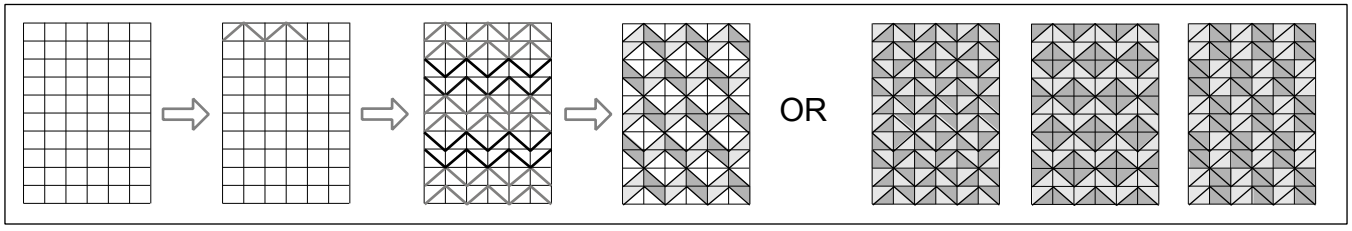
Make a grid of dots or circles on the 4 parallel lines and then connect the dots with the letter s. Then color the second row a different color for the ozone layer!





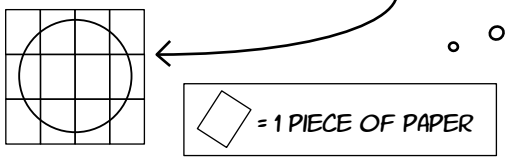
MESOSPHERE LAYER

Make a grid of parallel lines and then draw the letter M in between them, connecting the corners. If you shift every two lines over, then you'll end up with a pattern that can be shaded to look three dimensional! This is rather appropriate, since the air molecules in the mesosphere are spread VERY far apart. Of course, you can color yours any way you'd like!



How clouds are made

Most clouds are made of incredibly small droplets of water. These droplets are between 0.001 mm and 0.05 mm in size. Raindrops are 0.05 mm and larger, which is MUCH bigger than a water droplet. If the circles you see all around these words were water droplets, then THIS would be the size of a raindrop. To draw a raindrop at this scale, you'd need 12 pieces of paper!



WATER DROPLETS

RAINDROP

FILL IN THE BLANKS USING THESE WORDS:

gas	water	humidity	precipitation
float	condenses	merge	vapor

When water evaporates it turns into a **gas** called **water vapor**. The amount of water vapor in the air is called **humidity**. When water **condenses** it changes from a gas into a liquid. Clouds are made from water droplets so small that they can **float** in air. If enough water droplets collide with each other, they can **merge** to form a raindrop. Raindrops are too heavy to float, so they fall from the sky. This is called **precipitation**.

THE WATER CYCLE SONG

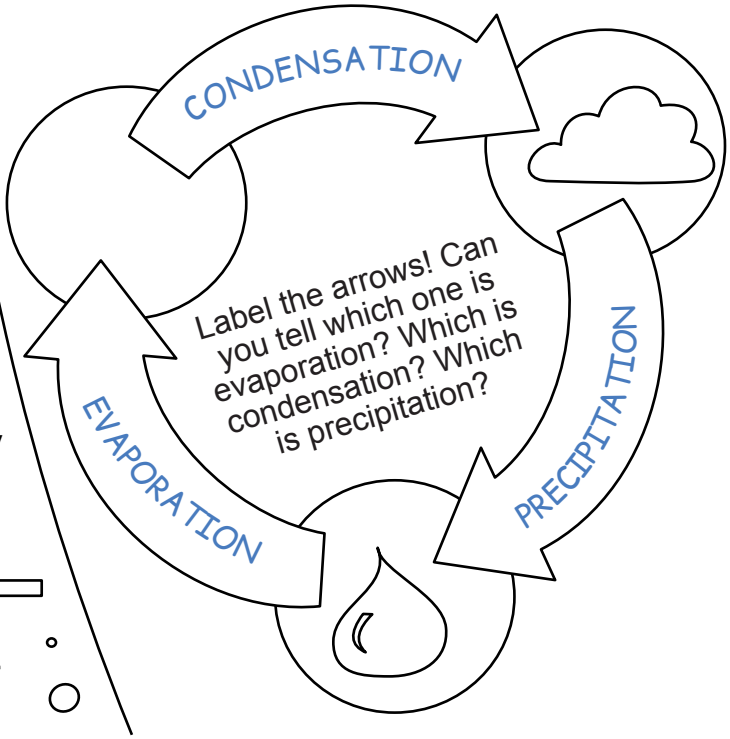
Sung to the tune of La Cucaracha. Best when performed with hand actions!

Evaporation,
Raise hands in a wavy motion
Condensation,
Clap hands together up high
Precipitation's when it rains,
Bring hands down low
The water goes round
Move hands in a circle
From cloud to wet ground
Move hands from high to low
That's the water cycle song!
Clap three times when done!

CLOUD IN A BOTTLE DEMONSTRATION

Will the cloud appear or disappear?

Increasing the pressure makes the cloud **disappear**.
Decreasing the pressure makes the cloud **appear**.

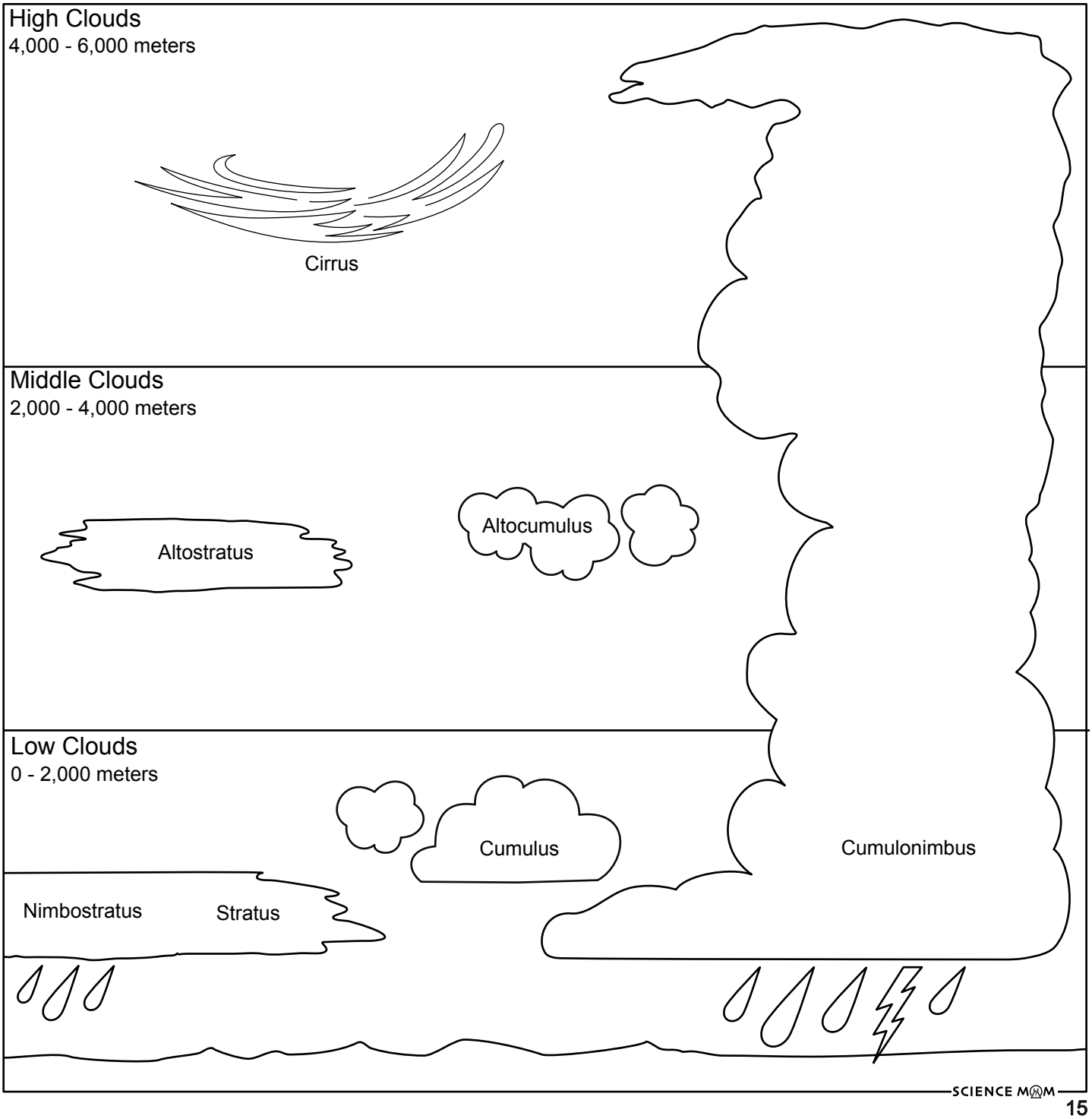


Types of clouds

CAN YOU USE THE CLUES FROM THE PICTURE BELOW TO FILL IN THE BLANKS USING THESE WORDS?

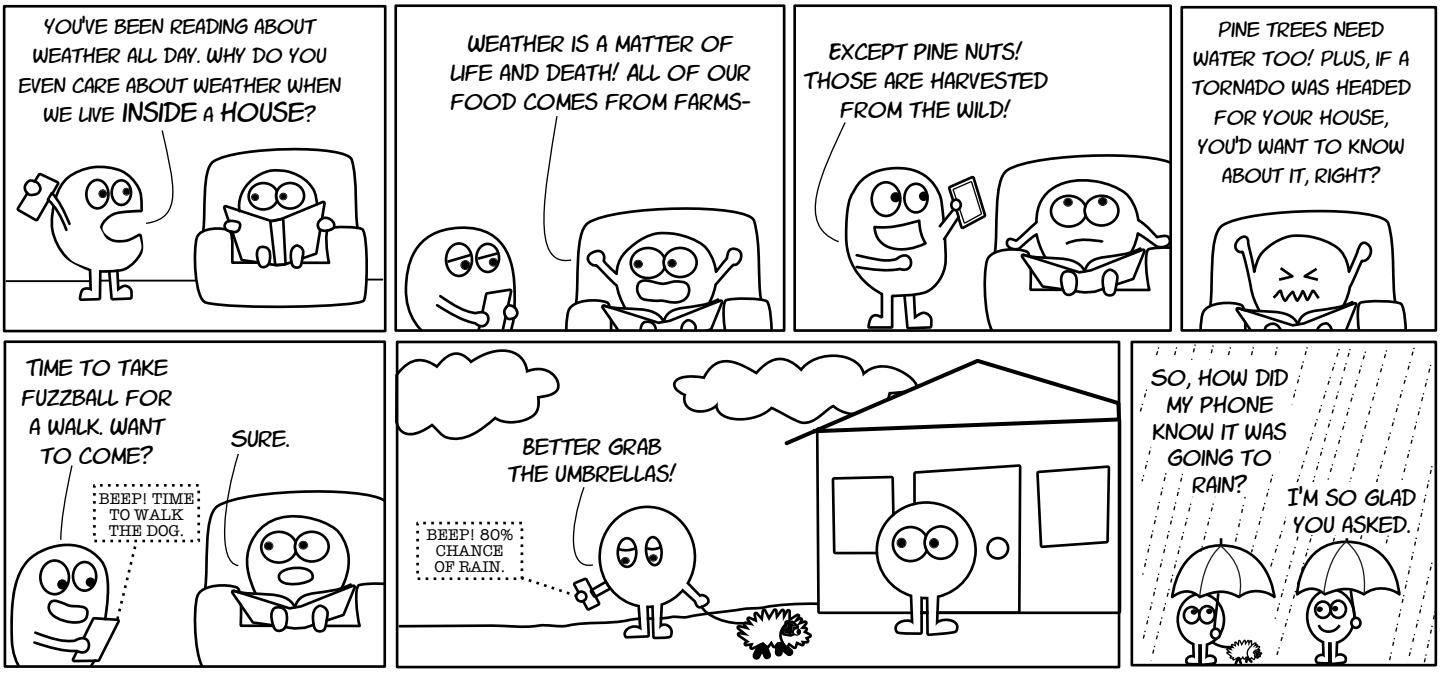
stratus	cumulus	
nimbo	alto	cirrus

The names of clouds come from Latin root words. In Latin, the word __nimbo__ means rain. __Cumulus__ means a heap or pile. __Stratus__ means to extend, spread out, or cover with a layer. __Alto__ means high or tall, and the word __cirrus__ means a lock of hair or a tuft of horsehair.



Why Weather?

Two Globs and a Dog - *by Science Mom*



YOUR DOODLE SPACE

Draw your favorite type of weather and describe it! Why is it your favorite?

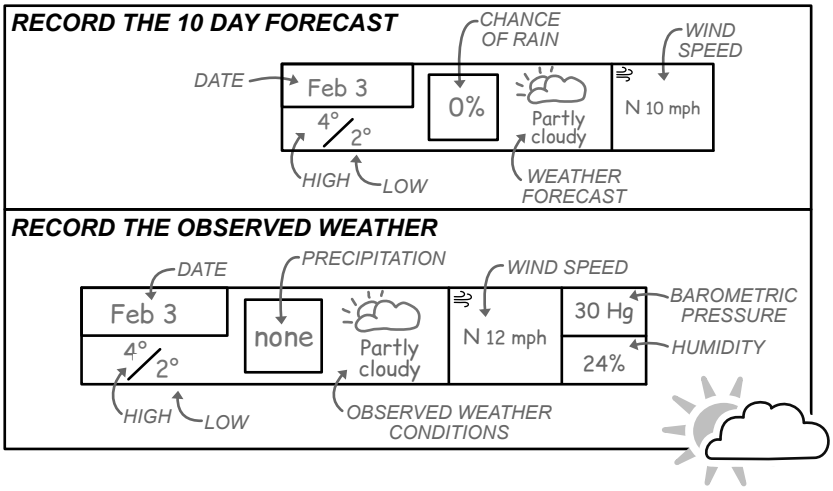
Your favorite weather: There is no right or wrong answer here! Different people will prefer different types of weather. Science Mom loves the rain and thunderstorms. Math Dad prefers sunny or partly cloudy weather that isn't too hot or cold.

Test the Forecast

Look up the 10 day weather forecast for where you live. Write down the expected high and low temperatures, the chance of precipitation, weather forecast, and the expected wind speed.

Then, over the next ten days, record the observed results! Record the barometric pressure and humidity for each day as well.

How closely did the forecast match your observations? What patterns or trends did you notice?



The 10 day forecast

The observed weather

Answers here will vary dramatically depending on location and time of year! But hopefully you'll see that the first 5 days of the forecast are predicted with more accuracy than the last 5.

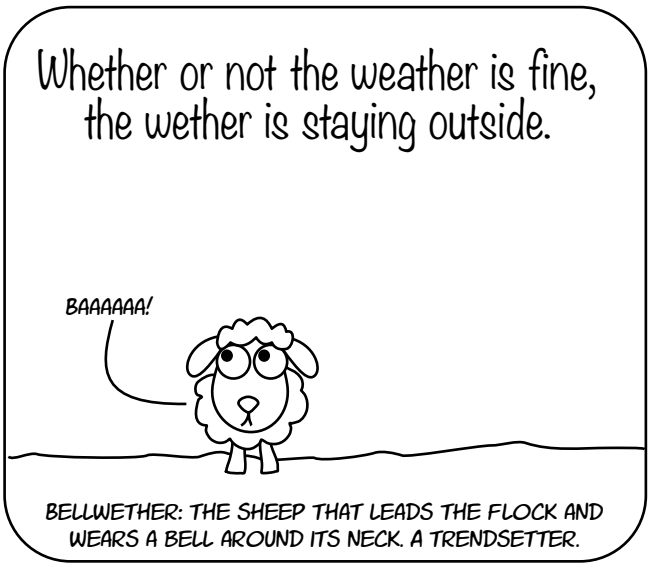
Making the Forecast

To predict the weather, you need to know where the wind is blowing from and what it's bringing with it. Scientists who study weather (meteorologists) make their predictions by measuring the cloud cover, temperature, humidity, barometric pressure, and wind.

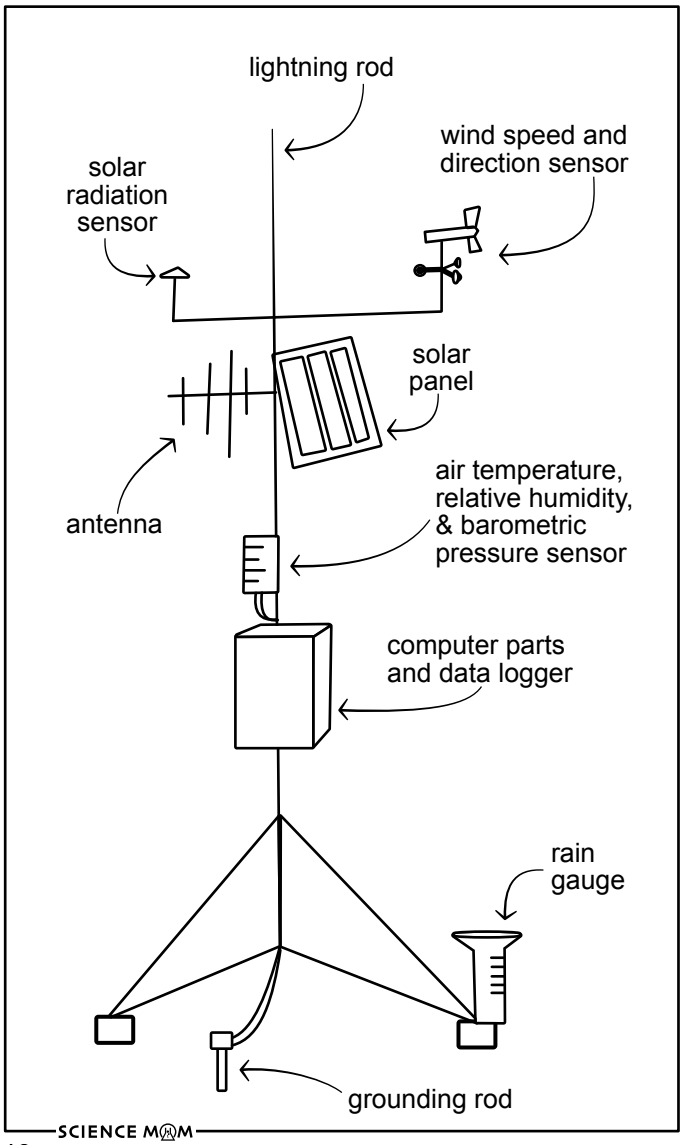
If they gather this information for a large enough area, then they can use models to predict the weather for the next 10 days. But how do you measure the temperature over five hundred miles of desert, or the wind that's blowing over an entire prairie?

There are two important ways scientists gather the information they need to predict the weather: from weather stations and satellites.

Then, once they have all of their data, they use computer models to predict what weather will happen next.



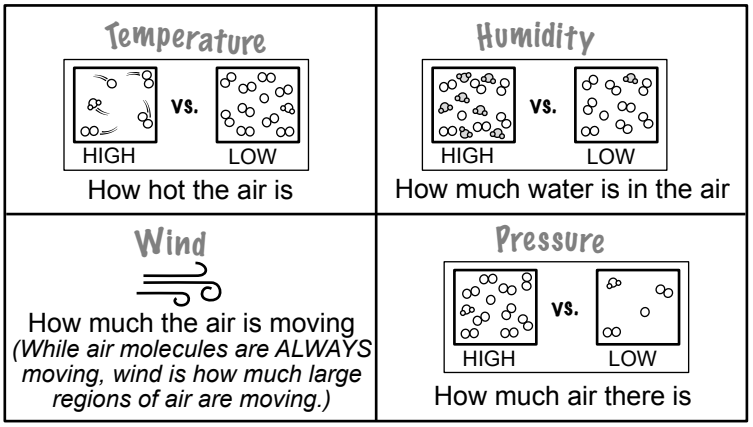
A MODERN WEATHER STATION



FILL IN THE BLANKS USING THESE WORDS:

thermometer	anemometer	meter
barometer	hygrometer	

An **anemometer** measures wind speed and direction. Air pressure is measured using a **barometer**. To measure the temperature, use a **thermometer**. To measure humidity, a **hygrometer** is the tool you'll need. You might have noticed that each of these tools contain the word **meter** which means "to measure." A good weather station will have all of these instruments, plus measure cloud cover and rainfall!

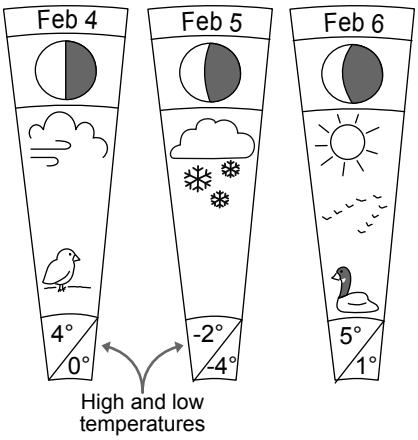


Make a Phenology Wheel

Phenology (“fen-ALL-oh-gee”) is the study of how variations in climate affect regular events in biology. By tracking the weather and then observing the living things around us, people can better understand how animals and plants are influenced by climate.

Have you ever wondered why the first migratory birds are seen on a slightly different day each year? Or how the leaves know to start turning colors in the fall? Creating phenology wheels can help point you to some of the answers.

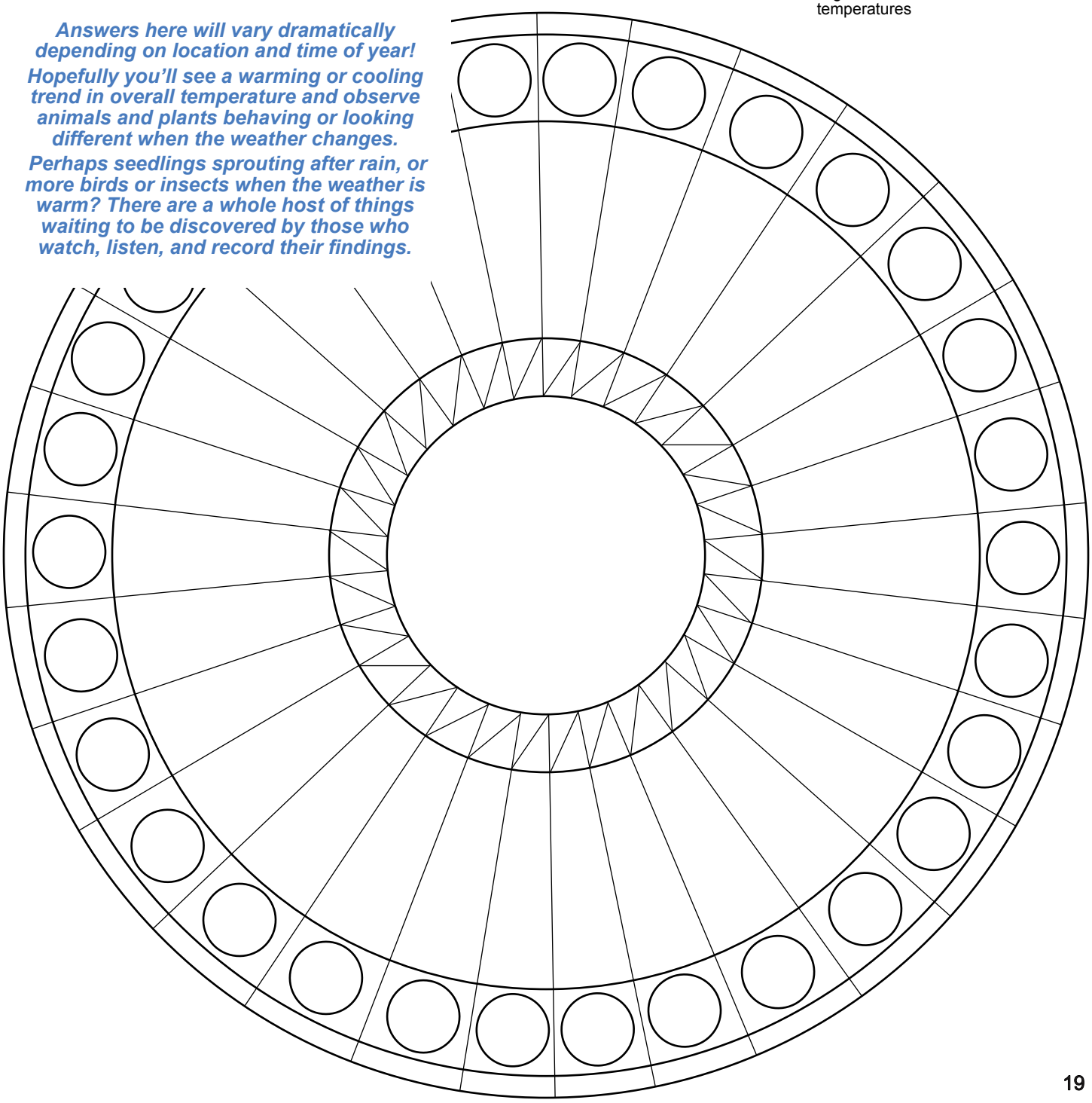
Create your own wheel by tracking the weather and moon phases for 30 days. In the space below each circle, draw a small picture to represent the weather, along with one observation relating to a living thing you observe outside. If you don’t observe any animals and the plants are dormant, color the view of the sky.



Answers here will vary dramatically depending on location and time of year!

Hopefully you’ll see a warming or cooling trend in overall temperature and observe animals and plants behaving or looking different when the weather changes.

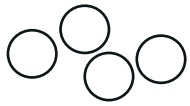
Perhaps seedlings sprouting after rain, or more birds or insects when the weather is warm? There are a whole host of things waiting to be discovered by those who watch, listen, and record their findings.



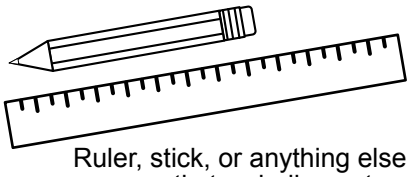
Hands-on Activity

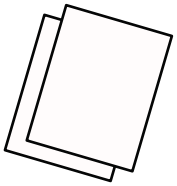
HOW DO AIRPLANES FLY?

MATERIALS:

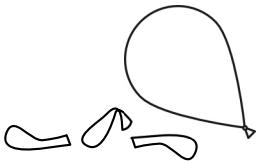

3 or 4 Ping Pong balls


Hair dryer


Ruler, stick, or anything else you can tie two balloons to.

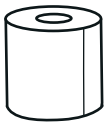

2 sheets of paper


Paper clip


3 to 4 balloons


String


Small object such as a peanut, penny, or raisin


Roll of toilet paper


Tape (optional)

Does air have weight?

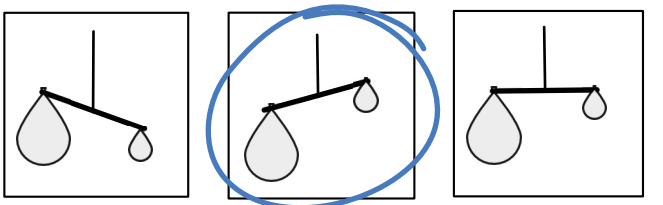
1. Attach 2 empty balloons to the pencil with tape.
2. Suspend the pencil from string so that it is balanced.
3. Carefully remove one balloon, blow it up and reattach it in the same place.
4. Circle your prediction.
5. Draw what happened.

How did your predictions differ from your results?

Answers will vary, but yours might look something like this:

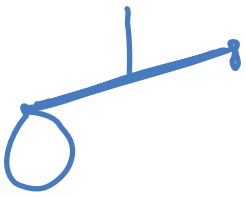
My prediction matched the results.

Will the inflated balloon be...



Draw what you see!

The balloon filled with air was heavier!



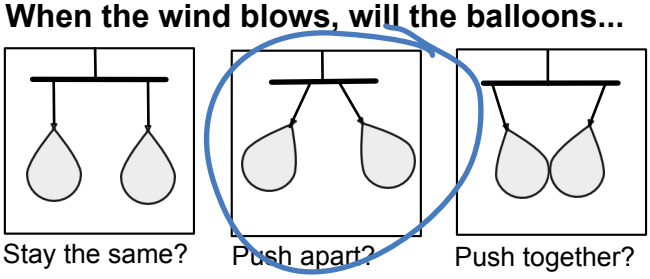
What does wind do?

1. Use the balloons from your previous experiment again, but blow up both of them.
2. Attach string to each.
3. Suspend the balloons so they are about ten cm (4 inches) apart.
4. Circle your prediction.
5. Blow air between the balloons and observe how they move!
6. Draw your results.

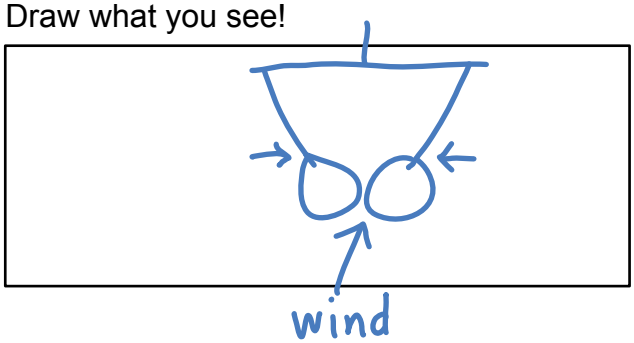
How did your predictions differ from your results?

I thought the balloons would push apart, but they came together!

When the wind blows, will the balloons...

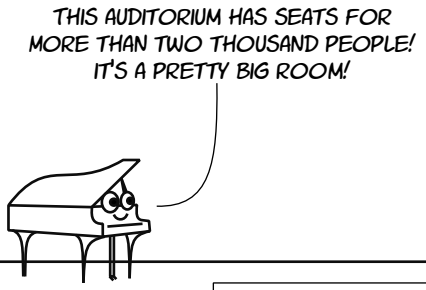


Draw what you see!



YOUR DOODLE SPACE

*If there is only a piano in Carnegie Hall, is the room empty? Nope. The room is full of air! But **how much does the air weigh?** Write down a guess below. Then draw the kind of music you'd play if you got to perform!*



HOW MUCH DOES THE AIR WEIGH? YOUR GUESS: 50 pounds?

THE ACTUAL AMOUNT: **31,750 kilograms (70,000 pounds!)**

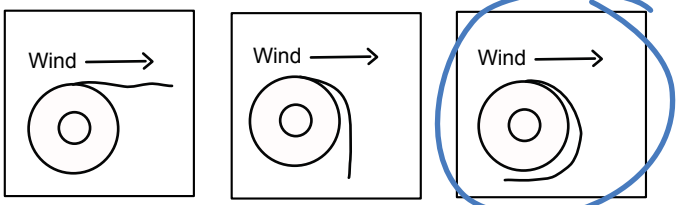
Tissue Trouble

1. Circle your prediction.
2. Hold a tissue roll so that it will unravel away from you.
3. Use your breath to blow over the top of the roll.
4. Draw your results.
5. (Optional) Try it with the hair dryer!

How did your predictions differ from your results?

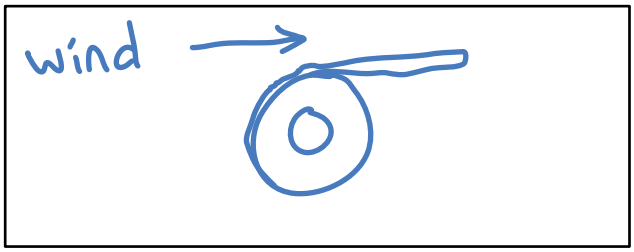
I thought the paper would curl under more but it lifted up!

When you blow over the top of a tissue roll, will it...



Lift up? Stay the same? Curve around?

Draw what you see!



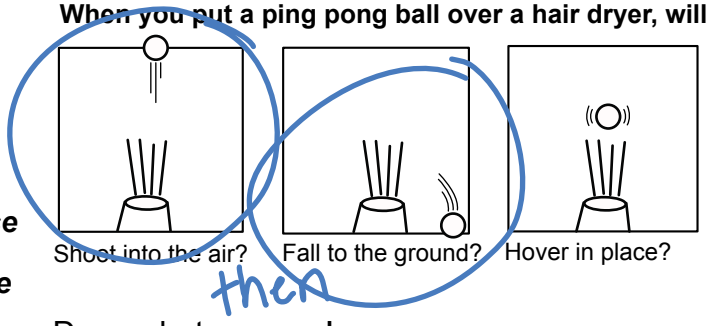
Ping Pong Ball + Hair Dryer

1. Circle your prediction.
2. Plug in your hair dryer and turn it on
3. Carefully place your ball a few inches above the air stream and let go.
   WARNING: Air from a hair dryer can get very hot! If your hair dryer has a "cool" button, use it! If it does not have a cool button, be sure not to leave it on too long and don't touch the top of the dryer because it will get hot!
4. Observe how the ball behaves.
5. Draw what happened.

How did your predictions differ from your results?

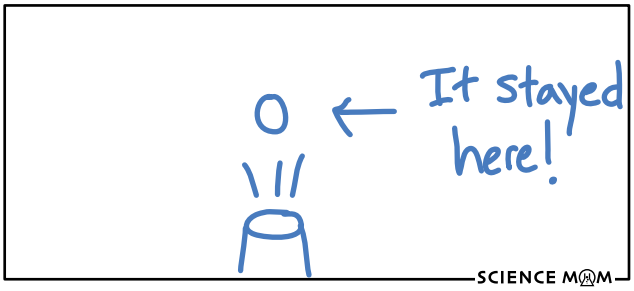
I thought the ball would shoot up and then fall down, but it stayed in one place!

When you put a ping pong ball over a hair dryer, will it...



Shoot into the air? Fall to the ground? Hover in place?

Draw what you see!

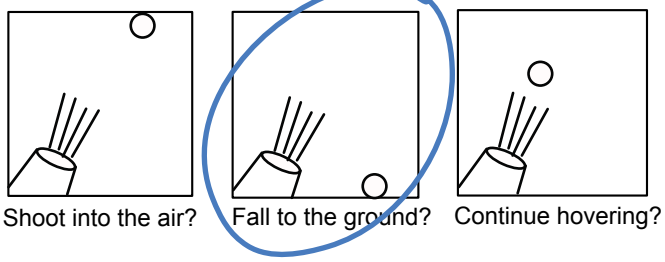


Air at an angle

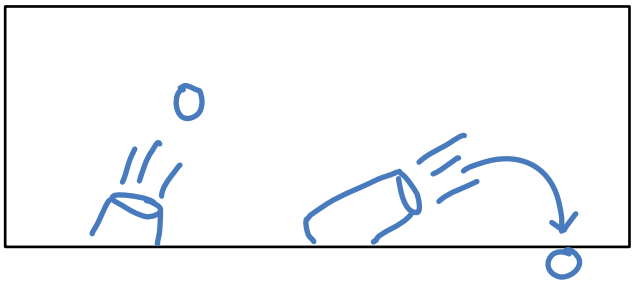
1. Circle your prediction.
2. Plug in your hair dryer and turn it on.
3. Carefully place your ball over the air stream. ***WARNING: Air from a hair dryer can get very hot! If your hair dryer has a "cool" button, use it! If it does not have a "cool air" button, be sure not to leave it on too long and don't touch the top of the dryer.***
4. What happens when you gently tip the dryer to the side?
5. Draw what happened

Did your predictions differ from your results?
I thought the ball would drop. If it was only tipped a little, the ball stayed floating. If it was tipped a lot, then the ball dropped.

If the hair dryer is tipped, will the ball...



Draw what you see!

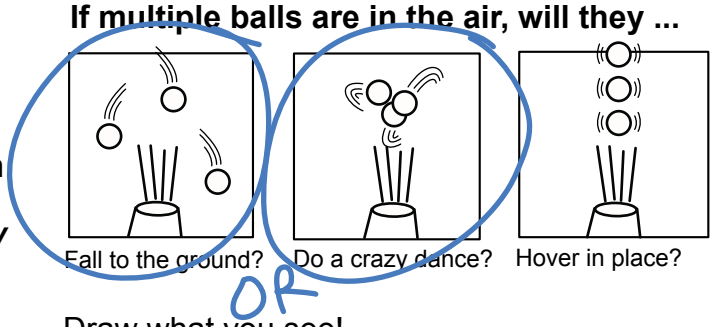


Two or three at once!

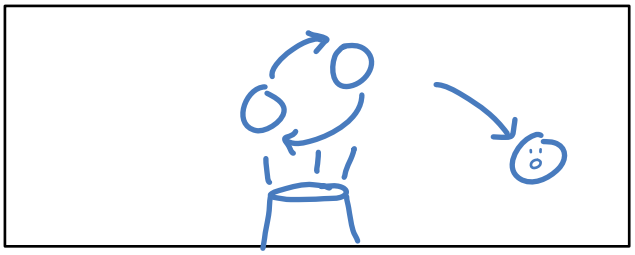
1. Circle your prediction.
2. Gather three ping pong balls.
3. Plug in your hair dryer and turn it on.
4. Carefully place your ball over the air stream and then add another ball and another. ***WARNING: Air from a hair dryer can get very hot! If your hair dryer has a "cool" button, use it! If it does not have a "cool air" button, be sure not to leave it on too long and don't touch the top of the dryer, it will be hot!***
5: Draw what happened.

Did your predictions differ from your results?
My prediction matched the results. The ping pong balls would dance around like crazy and then fall to the ground.

If multiple balls are in the air, will they ...



Draw what you see!

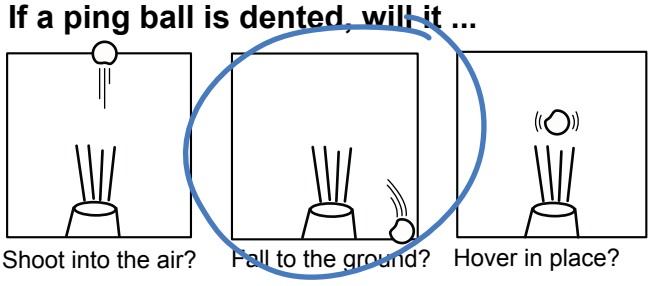


A Dented Ping Pong Ball

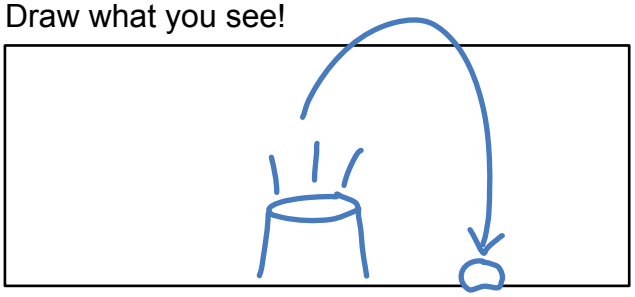
1: Circle your prediction.
2: Dent one of the ping pong balls by gently stepping or pushing on it.
3: Plug in your hair dryer and turn it on.
4: Carefully place your ball over the air stream. ***WARNING: Air can get very hot! If your hair dryer has a "cool" button, use it! If it does not have a "cool air" button, be sure not to leave it on too long and don't touch the top of the dryer because it will be hot!***
5: Draw what happened.

Did your predictions differ from your results?
My prediction matched the results.

If a ping ball is dented, will it ...



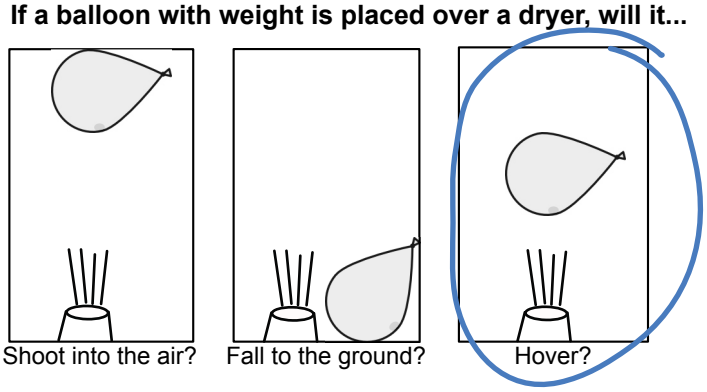
Draw what you see!



Flying Balloons?

1. Circle your prediction.
2. Place a penny, raisin, or peanut in a balloon and then inflate the balloon and tie it off.
3. Carefully turn on the hair dryer and place the balloon over the air stream. ***WARNING: Air from a hair dryer can get very hot and hot air will pop the balloon! If your hair dryer has a "cool shot" button, use it! If it does not have a "cool air" button, be sure not to leave it on too long and don't touch the top of the dryer.***
4. Draw what happened.

If a balloon with weight is placed over a dryer, will it...



Draw what you see!

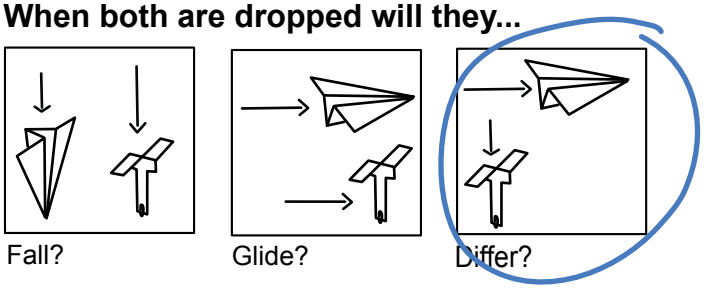
Did your predictions differ from your results?

My prediction matched the results.

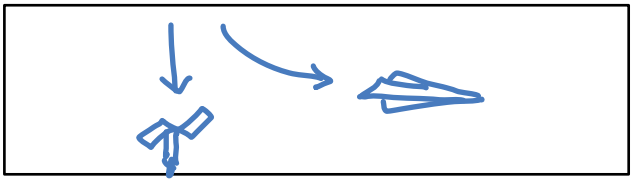
Helicopter vs Plane

1. Build your helicopter and plane. See pages 113-114 if you would like directions.
2. Circle your prediction.
3. Toss your helicopter and plane from the same height.
4. How do their flight patterns differ?
5. Draw your results

When both are dropped will they...



Draw what you see!

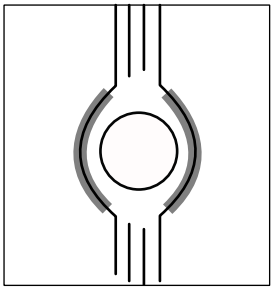


Did your predictions differ from your results?

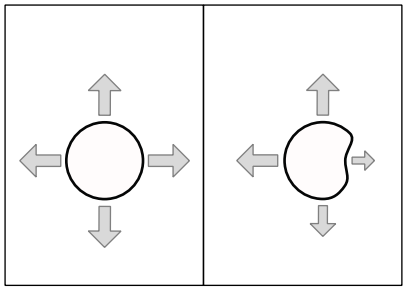
My prediction matched the results.

NOTES ABOUT LIFT AND PRESSURE

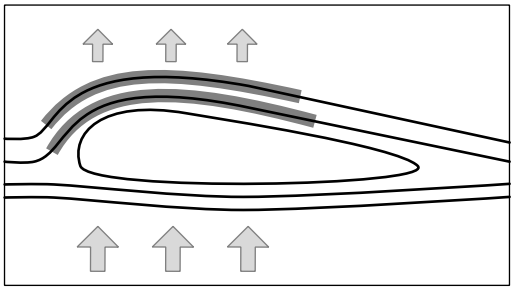
Another fun variation I tried was placing my hand over the top of a floating ping pong ball. If I slowly lowered by hand, the ball dropped. If I put a toilet paper roll over the top of the ping pong ball, the ball shot through the tube and flew into the air!



When fast moving air meets the ping pong ball, it **speeds up** to go around the ball.



Faster air = lower pressure. The lower pressure pulls evenly in all directions on a round ball, but unevenly on a dented ball.

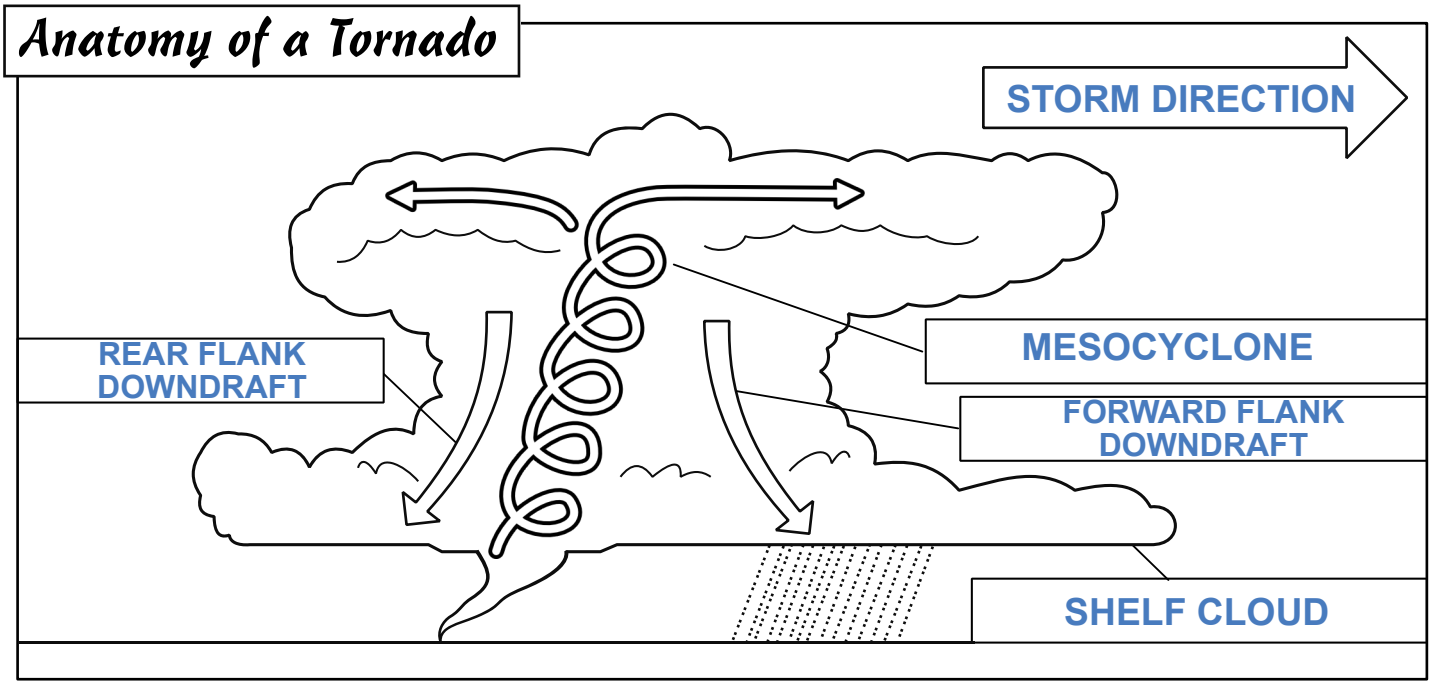


Air moves faster over the curved surface of a wing, and the change in pressure provides lift.

SEVERE STORMS

ALL ABOUT TORNADOES + HURRICANES / TYPHOONS

Anatomy of a Tornado



FILL IN THE LABELS ABOVE USING THESE WORDS:

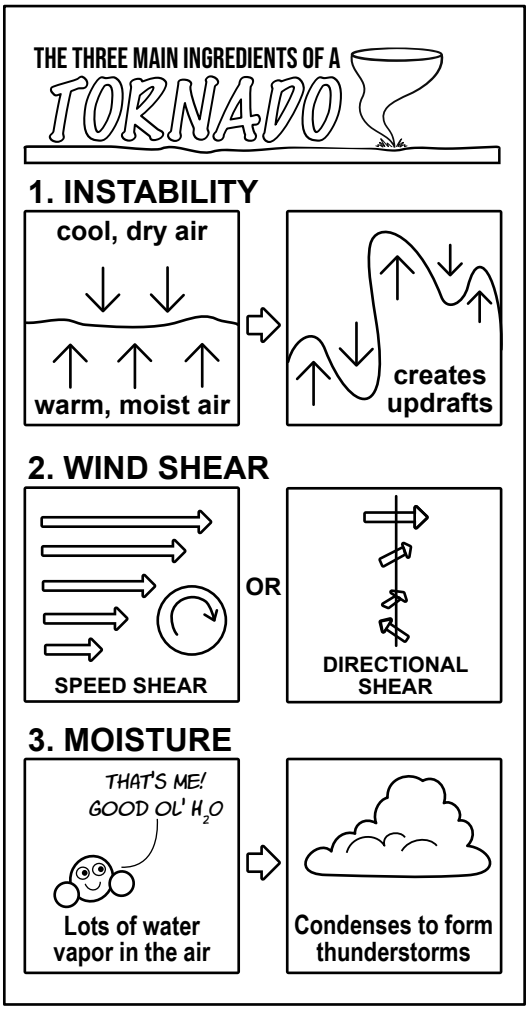
STORM DIRECTION | MESOCYCLONE | FORWARD FLANK DOWNDRAFT | SHELF CLOUD | REAR FLANK DOWNDRAFT

Your notes:

Everyone's notes will be different. Include details from class that stand out to you! They might be things like:

More tornadoes form in the plains of the United States than anywhere else in the world because "tornado alley" is where cold dry air from Canada meets warm moist air from the Gulf of Mexico: perfect for large thunderstorms.

The U.S. has more than 1,200 tornadoes each year.

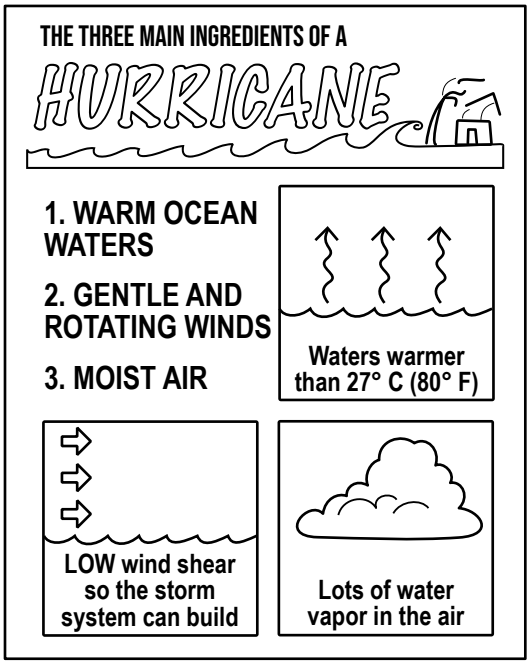


Your notes:

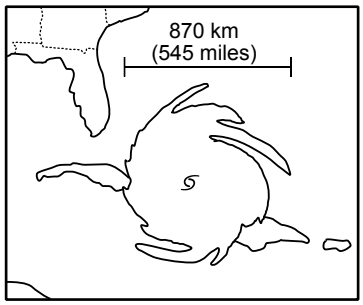
Because of the curved shape of our world, different parts of Earth move at different speeds and this produces the Coriolis effect.

Because of the Coriolis effect, tropical cyclones north of the equator rotate counter-clockwise (when viewed from above) but cyclones south of the equator rotate clockwise.

Hurricanes form over warm water and transfer large amounts of heat from the water's surface to the upper atmosphere.



Tropical Cyclones are usually called HURRICANES if they form in the Atlantic or Northeastern Pacific, and TYPHOONS if they occur in the Northwest/ South Pacific. They are huge storm systems, ranging from 100 to 2,000 kilometers across!

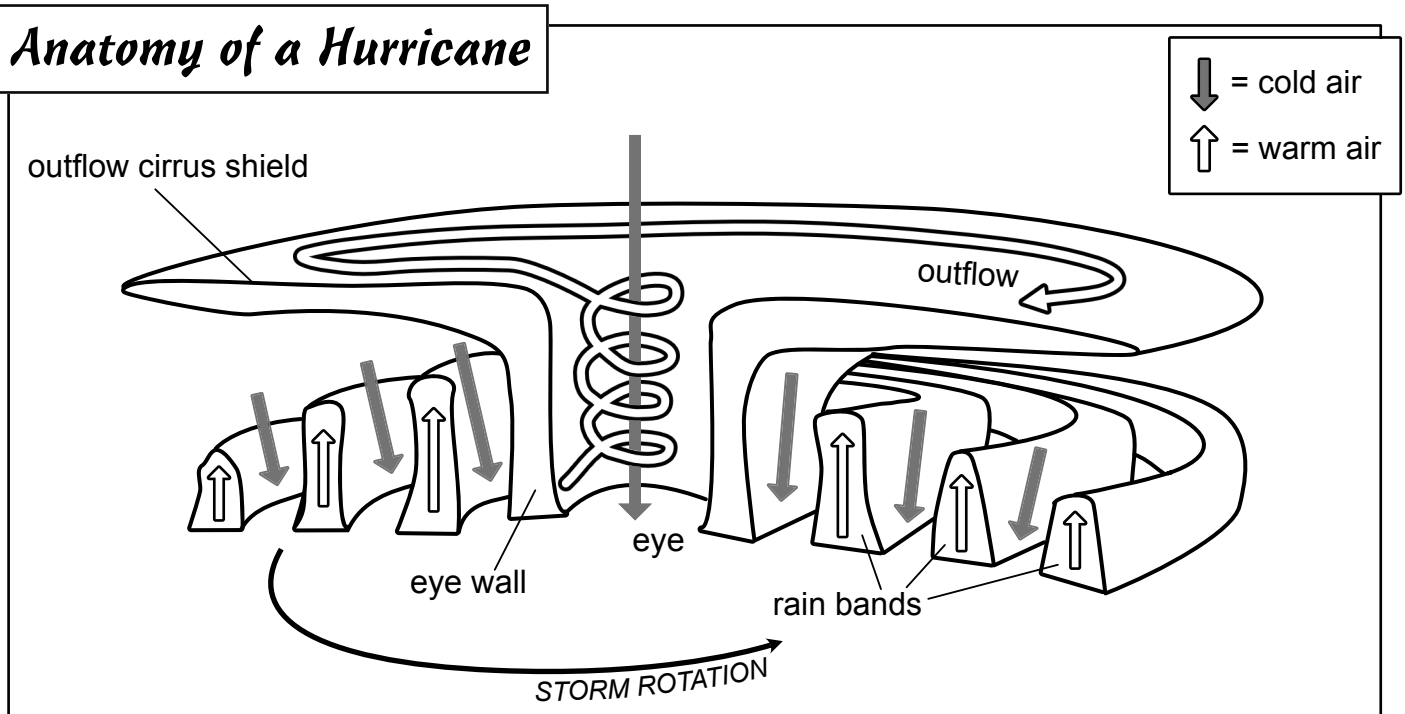


THE SAFFIR-SIMPSON SCALE

Describes how severe a storm is expected to be.

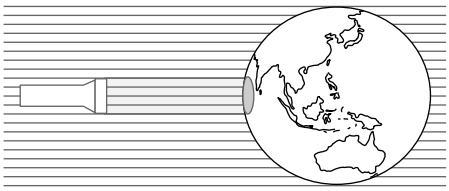
63-118 km/h	119-153 km/h	154-177 km/h	178-208 km/h	209-251 km/h	252+ km/h
34-73 mph	74-95 mph	96-110 mph	111-129 mph	130-156 mph	157+ mph
TROPICAL STORM	1	2	3	4	5
	HURRICANE				

Anatomy of a Hurricane

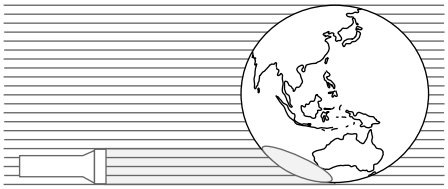


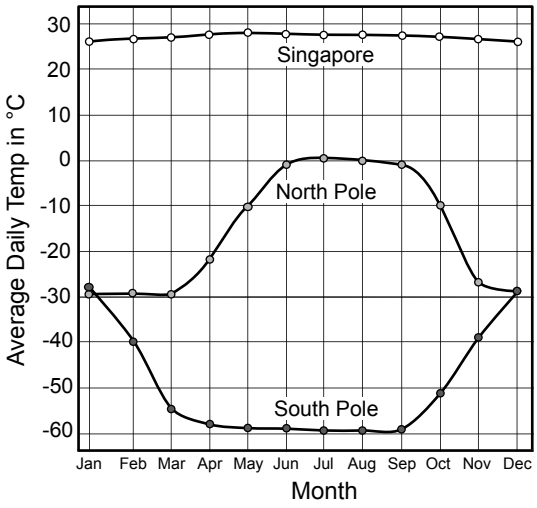
Global weather patterns

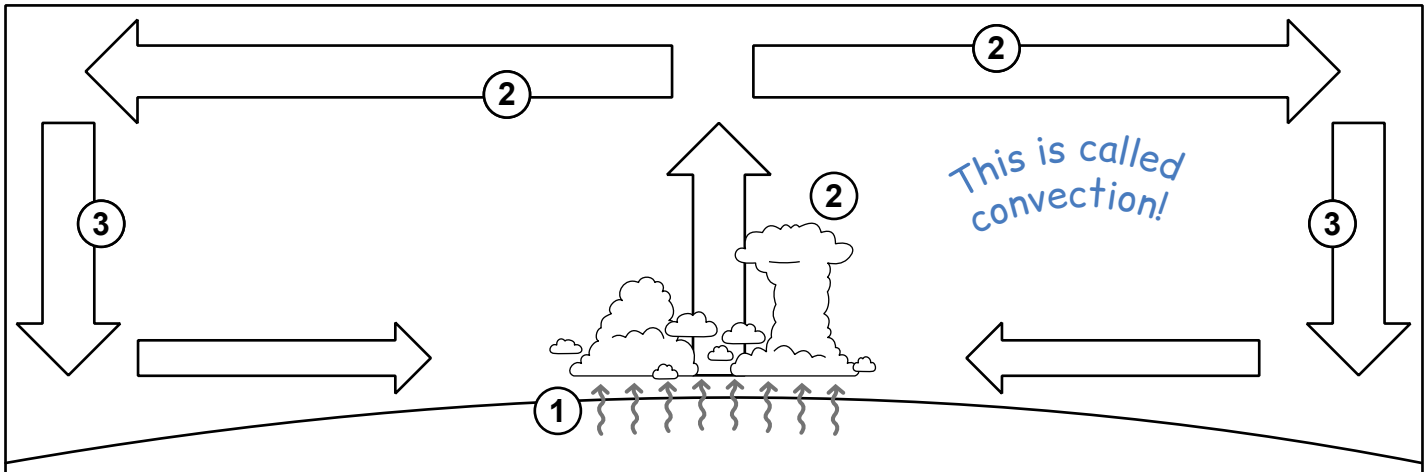
Because the Earth is round, light from the sun is more intense over the equator than the poles. Notice how the "flashlight" here highlights the globe differently?



The intense equatorial heat from the sun warms the water in the tropics, and this rising moist air is the one of the main driving forces for global weather systems on our planet.







1. The intense equatorial heat from the sun warms the water in the tropics, and this rising moist air is the main force driving enormous loops of air known as the Hadley cells.

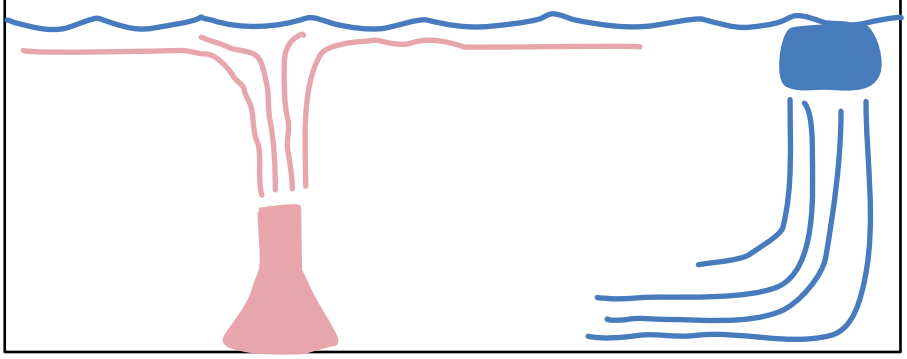
2. As the air rises it cools and forms clouds and then rain. The air drifts away from the equator because more warm air is pushing up from underneath.

3. By the time the air has cooled enough to sink, it has lost almost all of it's water. This is why there are deserts at 30° latitude all over the world.

Your notes: The South Pole is WAY colder than the North Pole because wind and water currents around Antarctica isolate it.

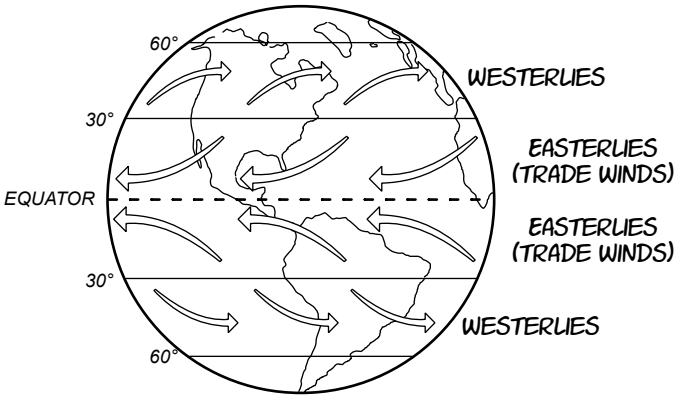
TRY IT YOURSELF!

Explore convection by filling up a large container with room temperature water. Then place two smaller containers inside it, one with blue cold water, the other with hot water colored yellow or red. You can also freeze blue water to make colored ice cubes. Draw what you observe!



PREVAILING WINDS

THE GLOBAL WIND BELTS THAT CIRCLE OUR PLANET



Because our planet is rotating, the Hadley and Ferrel cells create PREVAILING WINDS. These winds are named for the direction the wind blows FROM.

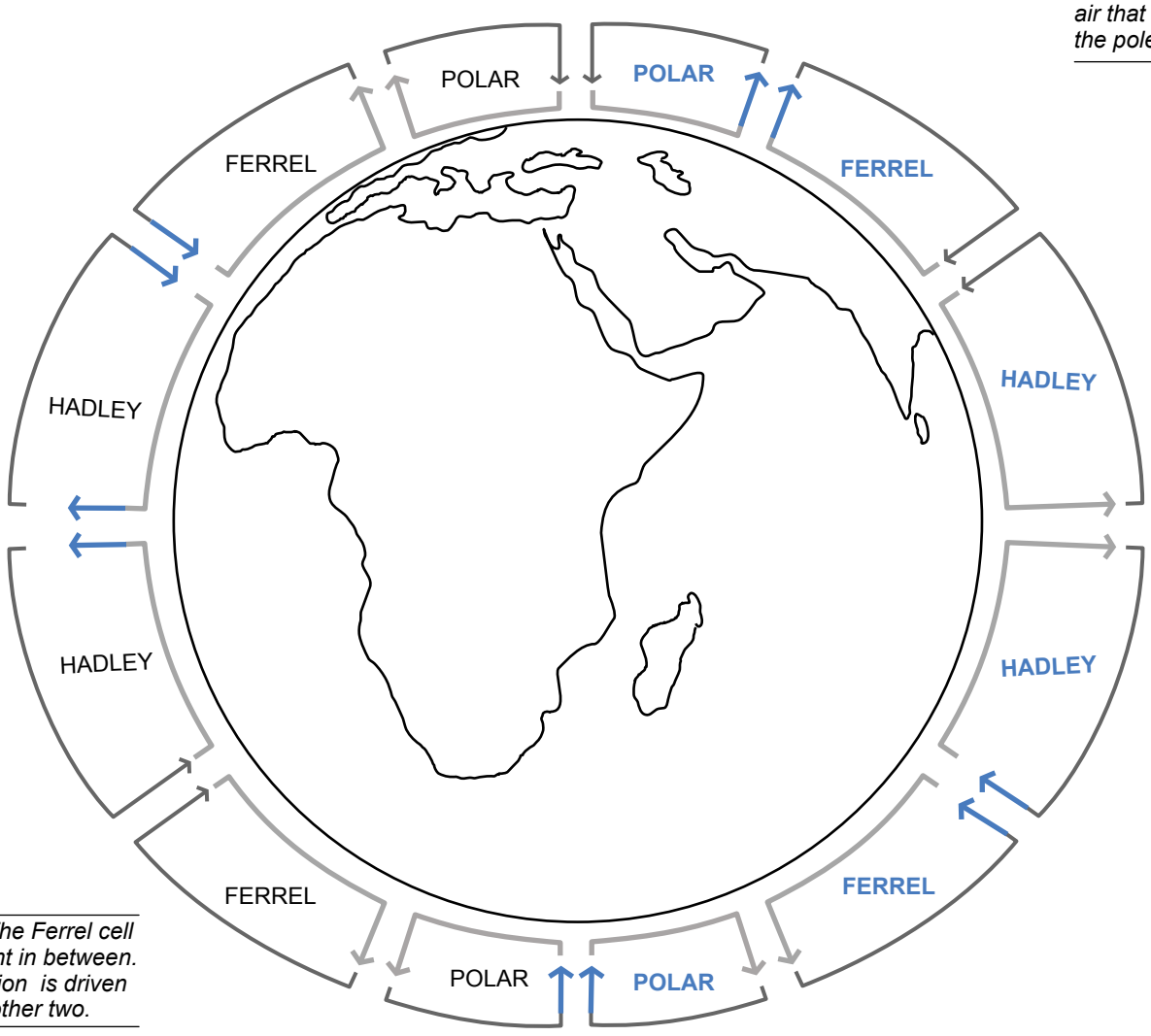
In Nevada, the wind usually blows from the west. Whatever big weather systems California is experiencing, Nevada gets the same thing a couple days later.

But in Hawaii or Florida, it's the opposite! In these locations, people look to the East to know what kind of weather is coming their way - all because of the prevailing winds.

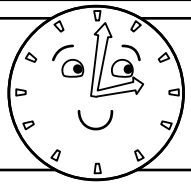
Which way does the wind usually blow where YOU live?

Draw in the missing arrows to show which way the air is moving!

HINT: The Polar cells are driven by the very cold air that sinks at the poles.



HINT: The Ferrel cell is caught in between. Its rotation is driven by the other two.



Quiz Time!

ANSWER THE QUESTIONS TO SEE WHAT YOU LEARNED!

① Which of these gases accounts for approximately 21% of the atmosphere?

A. Nitrogen
B. Oxygen
C. Carbon dioxide
D. Helium
E. Argon

② Name three greenhouse gases:

Carbon dioxide, Methane, Water vapor

③ Which of these statements are true? Select all that apply.

A. Rainclouds, hurricanes, and tornadoes form in the troposphere.
B. The tops of the tallest mountains are in the stratosphere.
C. The ozone layer is in the mesosphere.
D. The stratosphere is warmer than the mesosphere.

④ How far in advance can we accurately predict the weather?

A. 10 months
B. 1 month
C. 10 days
D. 10 hours

⑤ _____ specifies a location's difference north or south of the equator.

A. Latitude
B. Longitude

⑥ What is the elevation of the "death zone?" (The death zone is the elevation above which there is not enough oxygen to sustain human life for more than a day.)

A. 3,000 meters (9,842 feet)
B. 5,000 meters (16,404 feet)
C. 8,000 meters (26,246 feet)
D. 10,000 meters (32,808 feet)

⑦ True or False: A hurricane generally has faster wind speeds than a tornado.

A. True
B. False

A level 5 hurricane (252+ km/h or 157+ mph) will have faster wind speeds than a level 1 tornado (117-180 km/h or 73-112 mph), but *in general*, tornadoes have faster wind speeds.

⑧ List two reasons why weather prediction is important: (Answers will vary)

Because weather impacts how crops grow.

Because predicting severe storms can save lives.

⑨ The amount of water vapor in the air is called:

A. Humidity
B. Clouds
C. Rain

⑩ A funnel cloud is not considered a tornado unless or until it touches the ground.

A. True
B. False

⑪ If the weather is sunny and calm, the barometric pressure is usually

A. High
B. Low

⑫ Which gases are needed to keep Earth warm enough to sustain life? Select all that apply.

A. CO_2
B. H_2O
C. N_2
D. CH_4
E. O_2

⑬ Which layer of the atmosphere do you live in?

A. Exosphere
B. Thermosphere
C. Stratosphere
D. Troposphere
E. Mesosphere

⑭ What percentage of the atmosphere is nitrogen gas?

78%

⑮ What layer of the atmosphere protects us from damaging ultraviolet radiation?

A. The ozone layer in the stratosphere
B. The ozone layer in the troposphere
C. The exosphere
D. The mesosphere

⑯ Which is colder, the North Pole or the South Pole?

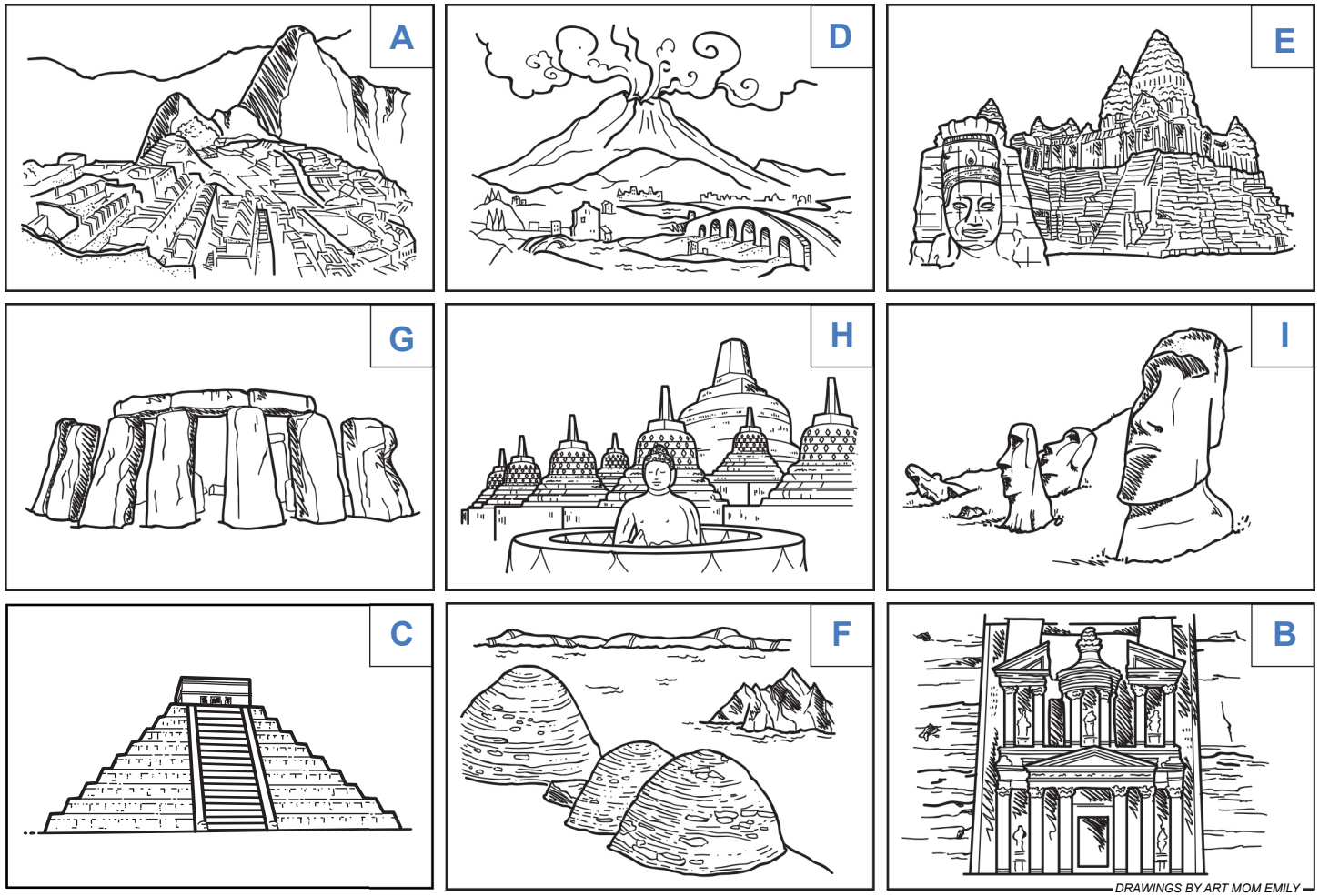
A. North Pole
B. South Pole
C. They are equally cold

⑰ What is the main driving force of the Hadley cell that creates the trade winds?

A. Dry air at high altitude cooling and sinking at 30° latitude
B. Hot air at the equator rising
C. Cold air at the poles sinking
D. The trade winds

Where in the World?

Each of these clues belongs to an abandoned place or ancient ruin. Write the letter from each clue next to the drawing it describes. Once you've matched them, place a dot on the map locating the ruin! See if you can mark all nine of them on the Winkel tripel projection map.



A 600 terraces keep this place from sliding down the mountain. Incas built it around 1450 AD and no one knows why they left.

Machu Picchu

B The Lost City of Stone in Jordan's desert is accessed through a narrow canyon. Its pink sandstone tombs contain Al-Khazneh, The Treasury.

Petra

C Built by the Mayans in Yucatán 1500+ years ago, and famous for the Temple of Warriors and Great Ball Court.

Chichén Itzá

D An eruption buried this city under several meters of ash. Forgotten for 1,500 years, it's one of the world's largest digs.

Pompeii

E Its five towers represent Mount Meru, home of the Gods. Pilgrims still visit and leave locks of hair for good fortune.

Angkor Wat

F This isolated island hosted a community of monks who fought off Viking raids from the twin-pinnacled crag.

Skellig Michael*

G This prehistoric ring of stones, each weighing more than 20 tons, was once the work of Druids and a burial ground.

Stonehenge

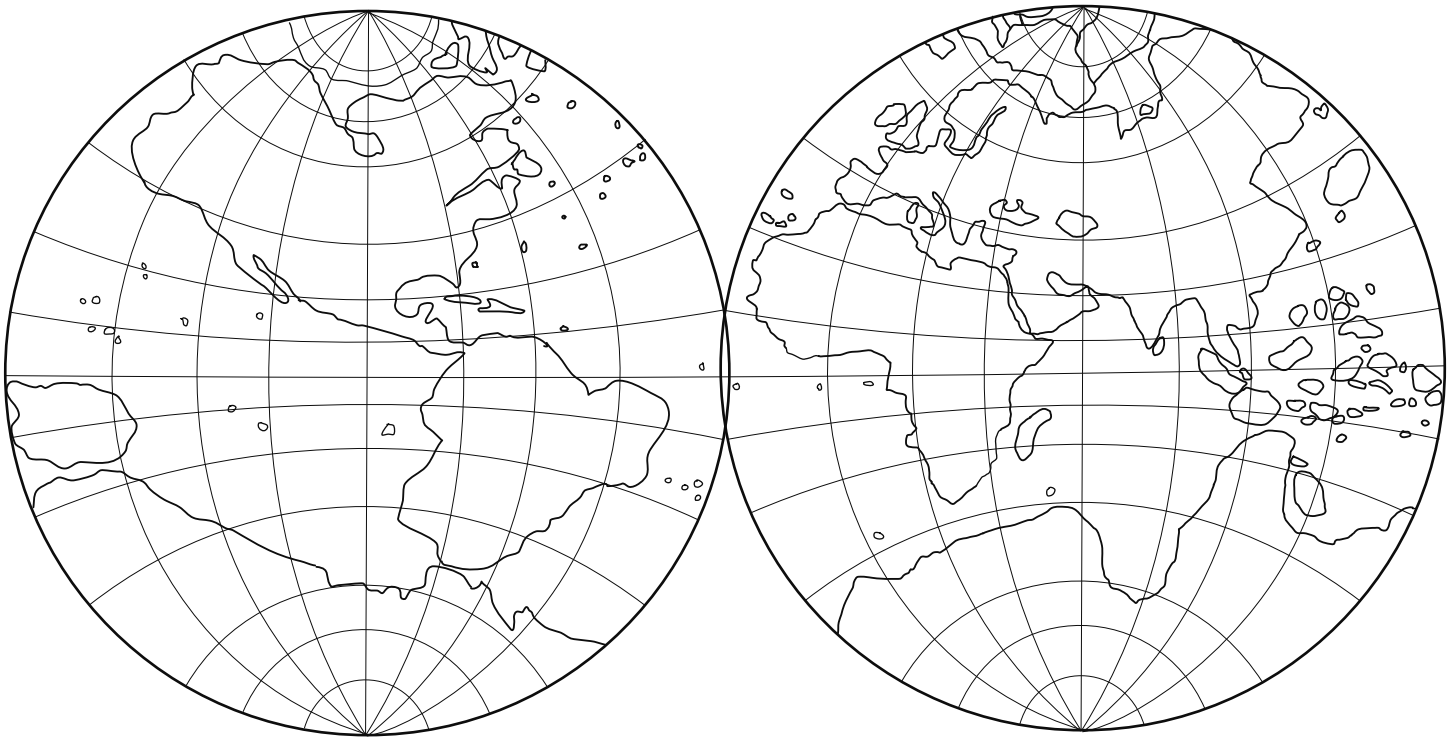
H The world's largest Buddhist temple has six squares and three circular platforms, plus 504 Buddha statues.

Borobudur

I A remote volcanic island. Its native name is Rapa Nui, the home to Moai and hundreds of big-headed statues.

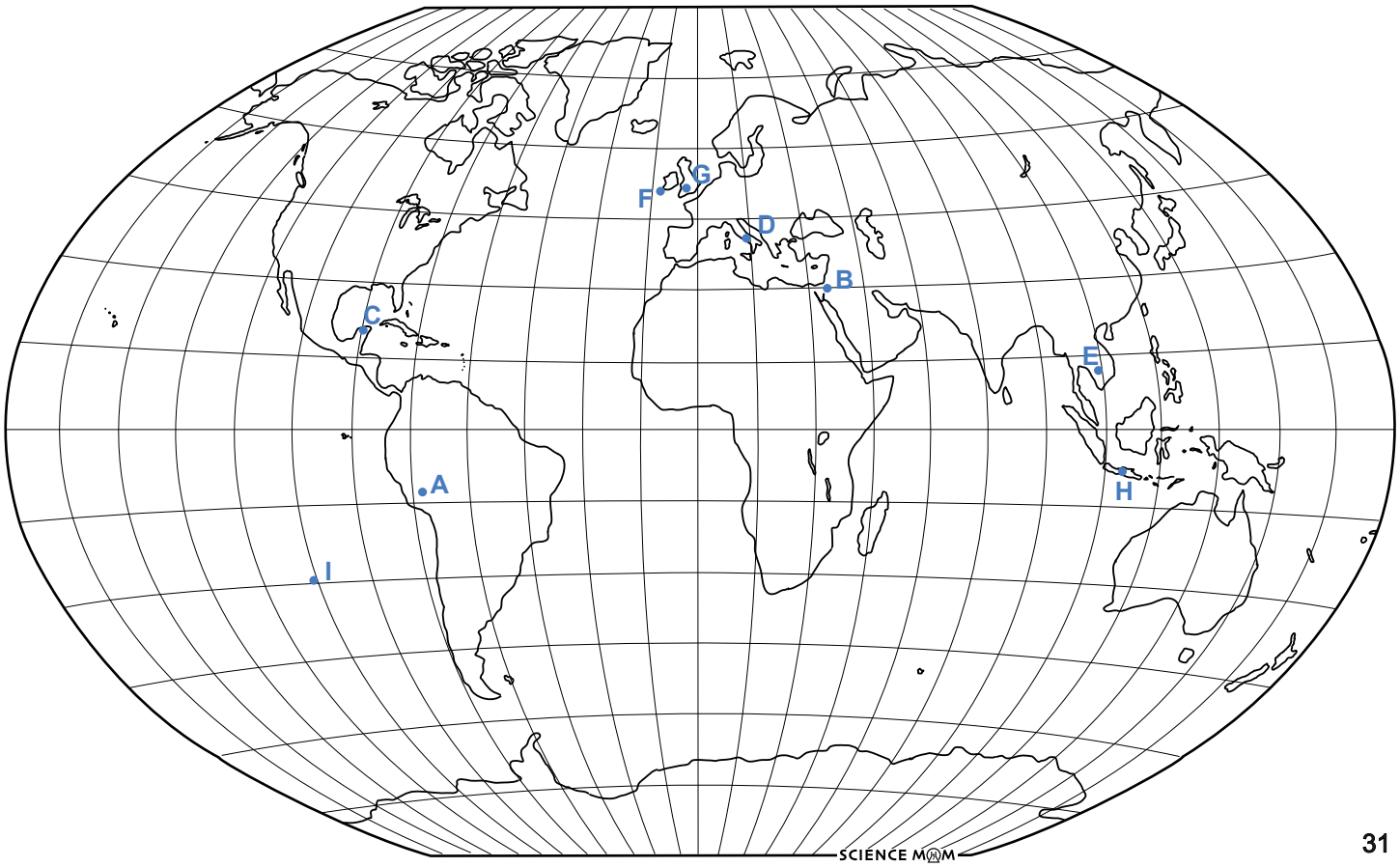
Easter Island

**Skellig Michael was also the site of Luke Skywalker's home in the Star Wars movies "The Force Awakens" and "The last Jedi."*

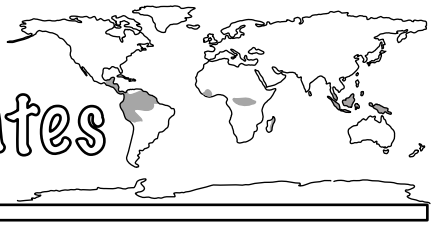


The above world map was published in 1595 and designed by Amerigo Vespucci and Gerardus Mercator. Given how much more challenging navigation and communication were in the 1500s, it's a good map. But note that some things (like New Zealand and Australia) are missing entirely, and others (like New Guinea and Antarctica) are drawn much too large!

In 1921, a cartographer named Oswald Winkel designed the Winkel tripel projection. The word "tripel" (German for triple) is in the name of this map because Oswald's goal was to minimize the three types of distortion that are common in world maps: area, direction, and distance. He did a pretty good job!



Tropical Rainforest Climates

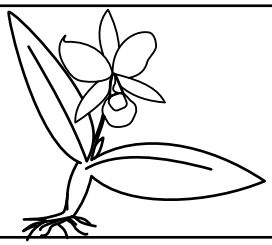


FILL IN THE BLANKS USING THESE WORDS:

soil	wettest	species	biodiversity	equator

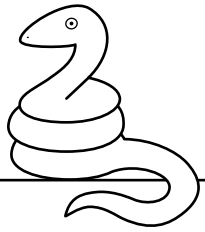
Rainforests are the world's **wettest** ecosystems. These biomes have high average temperatures, nutrient-poor **soil**, very high annual rainfall and high levels of **biodiversity**. They contain about 50% of the world's terrestrial plant and animal **species**, but cover only 6% of the world's land area. Tropical rainforests are near the **equator**. Temperate rainforests occur near oceans and experience cooler temperatures for part of the year.

DRAW LINES TO CONNECT THE CLUE WITH ITS CORRESPONDING ANIMAL OR PLANT

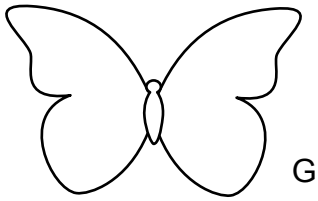


NATIONAL FLOWER OF COSTA RICA

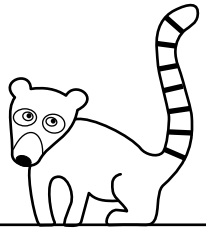
Guaria Morada
Guarianthe skinneri



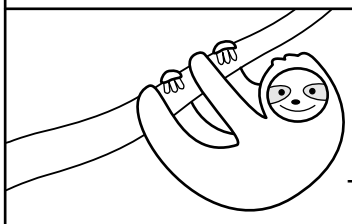
Green Vine Snake
Oxybelis fulgidus



Giant Blue Morpho
Morpho didius



White-nosed coati
Nasua narica



Three-toed Sloth
Bradypus variegatus

I have a long green tongue and hide in the trees to catch hummingbirds for prey.

I live in the trees and get water from the air. I'm said to bring good luck and fortune!

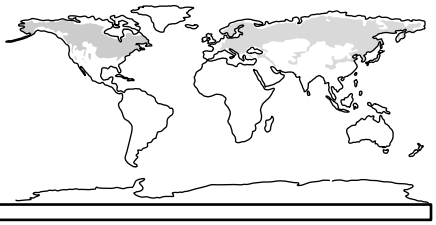
A whole community lives on me, including moths, beetles, cockroaches, fungi, and algae!

My scales appear colorful because they refract light, just like a prism.

I have double-jointed ankles and can descend from trees headfirst.

Corcovado National Park in Costa Rice is the most diverse area of its size of any place on Earth! The park has 13 different ecosystems, including the only remaining old growth forests of Central America's Pacific Coast.

Continental Climates

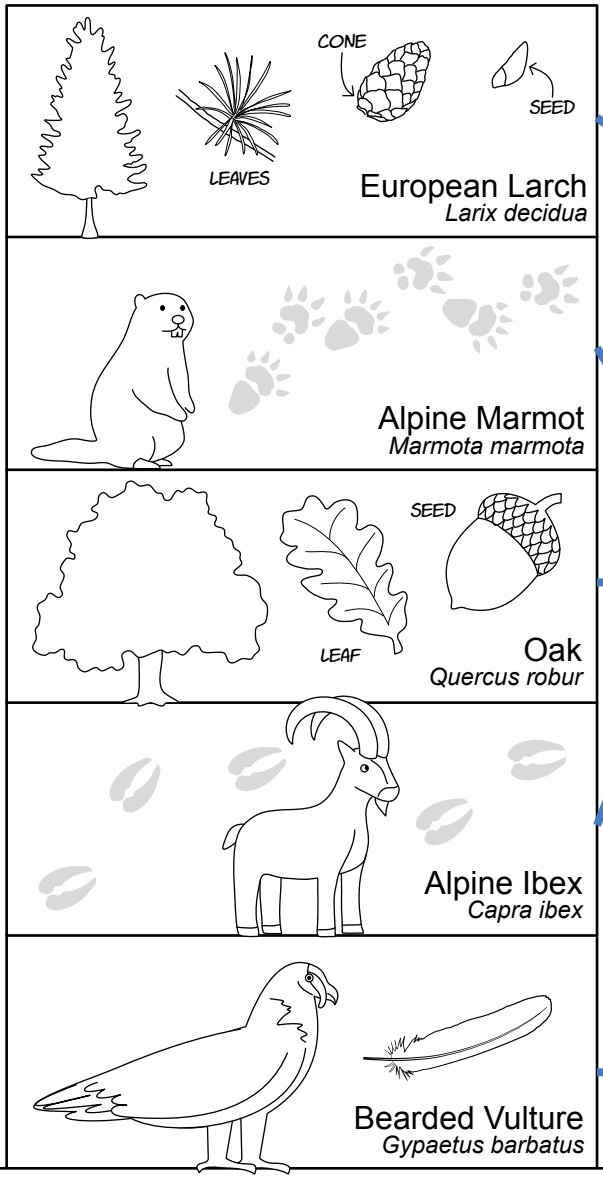


FILL IN THE BLANKS USING THESE WORDS:

snow	seasons	climate	Moscow	Oslo
moderated	continent	Toronto	Mumbai	

A continental climate has four ___seasons___. It is hot in the summer months and very cold in the winter. These climates receive ___snow___ each winter. If it doesn't snow, then it's not a continental ___climate___! This type of climate usually forms on a large landmass or ___continent___ where the temperature is not ___moderated___ by an ocean. Famous cities that experience a continental climate include: ___Toronto___, ___Moscow___ and ___Oslo___. The city of ___Mumbai___ does *not* have this climate!

DRAW LINES TO CONNECT THE CLUE WITH ITS CORRESPONDING ANIMAL OR PLANT



I am an herbivore and an excellent climber. I like high elevations.

I am a conifer, but I am also deciduous. My foliage turns a beautiful yellow each autumn.

My seeds are called acorns. My wood is resistant to insects and fungus.

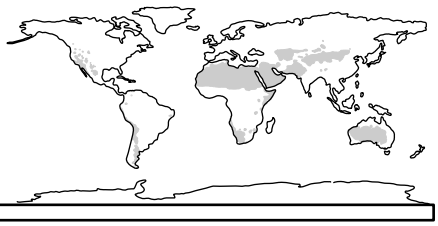
I love to eat leaves and grass, and sometimes insects too! I hibernate during the winter.

70%-90% of my diet is bone. I can live to be 45 years old.

SCIENCE MOM

Each of the above animals and plants can be found in the Swiss National Park, which was founded in 1914. It covers 174 square kilometers of land, of which 28% is forests, 21% is alpine grasslands, and 51% is rock.

Desert climates

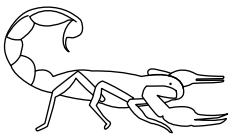


FILL IN THE BLANKS USING THESE WORDS:

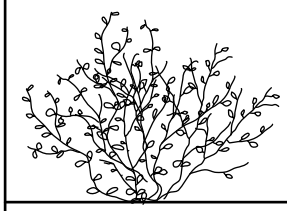
rocky	adaptations	cold	Cairo	Las Vegas
plants	year	Seattle	water	

A desert climate is defined by a lack of **water**. Hot deserts are the most common type, but deserts can be **cold** as well. Most deserts get less than 200 mm (8 in) of rain each **year**. Their landscapes are often **rocky** or sandy. Animals and **plants** living in this climate have special **adaptations** to help them conserve water. Famous cities that experience this climate include **Cairo** and **Las Vegas**. The city of **Seattle** does NOT have a desert climate!

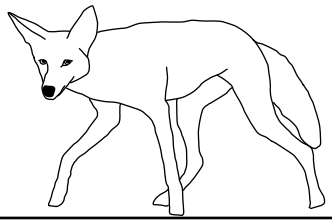
DRAW LINES TO CONNECT THE CLUE WITH ITS CORRESPONDING ANIMAL OR PLANT



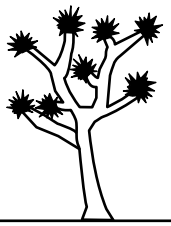
Giant Desert Hairy Scorpion
Hadrurus arizonensis



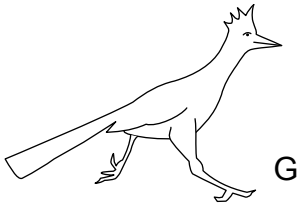
Creosote Bush
Larrea tridentata



Coyote
Canis latrans



Joshua Tree
Yucca brevifolia



Greater Roadrunner
Geococcyx californianus

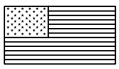
I am monogamous.

I only grow 2-3 inches per year, but I can live to be thousands of years old.

I only "breathe" (open my stomata) in the mornings, when the air is more humid.

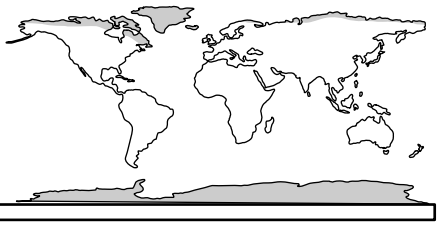
I prey upon rattlesnakes.

I grow fluorescent green under UV light.



Death Valley is the hottest, driest, and lowest national park in North America. It only receives 5 cm (2 inches) of rain a year!

Polar Climates

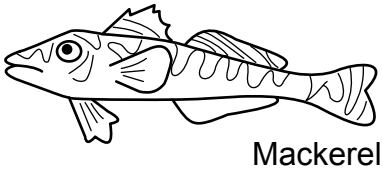


FILL IN THE BLANKS USING THESE WORDS:

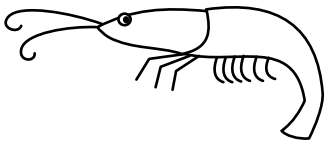
Antarctic	ice	penguins	heat	driest
important	solar	largest	aquatic	

Antarctica is the coldest, windiest, and **driest** continent on Earth. Many species of large and small **aquatic** animals live in the waters, while **penguins** are the most recognizable land animal. Antarctica contains the **largest** single sheet of **ice** in the world, known as the **Antarctic** Ice Sheet, which reflects a large amount of **heat** radiation. This results in it playing an important role in maintaining the Earth's **solar** balance. Antarctica is a very dangerous, beautiful, and **important** climate on our planet.

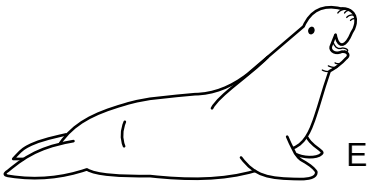
DRAW LINES TO CONNECT THE CLUE WITH ITS CORRESPONDING ANIMAL OR PLANT



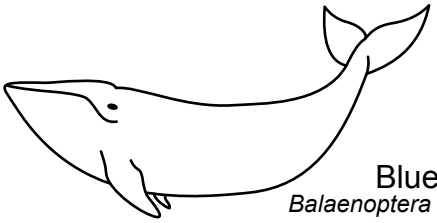
Mackerel icefish
Champsocephalus gunnari



Antarctic Krill
Euphausia superba



Elephant Seal
Mirounga



Blue Whale
Balaenoptera musculus

Macaroni Penguin
Eudyptes chrysolophus

I can survive starvation for up to 200 days! I also molt throughout my entire life.

I can dive over 220 meters deep, and my name means "good diver with a golden crest".

I am the largest animal ever known to have lived on Earth.

I'm known for being "white blooded"! My blood cells lack the red pigment haemoglobin.

I can hold my breath for up to two hours, thanks to all my red blood cells.

SCIENCE MOM

Greenland's Northeast National Park is the largest in the world! It was created in 1974 and covers 972,000 square kilometers. That's larger than most countries! This park contains 40% of the world population of musk ox.

Climate Zone QUADRAMAS ART PROJECT

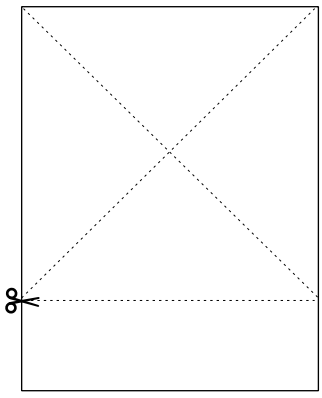
A “diorama” is a miniature model. In this art project, we are going to make four climate models which can be put together to make a “quad” of climate zones, hence the name “quad-rama.”

To begin, either print the climate zone quadrama templates (pages 125-137) OR create your own. Cut a piece of cardstock into a square, then fold it along both diagonal lines.

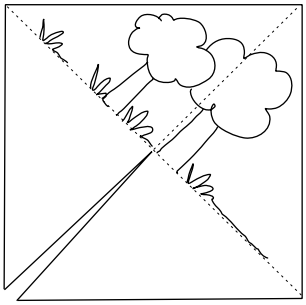
Color the background along the top half of the quadrama. Then cut the diagonal that is opposite the background and fold the two bottom quadrants together, securing them with glue or tape.

Next, draw animals and plants, leaving a square of paper attached to the bottom of each one. By cutting the square vertically and bending half of it backward and half of it forward, you create a “stand” that can support your creations!

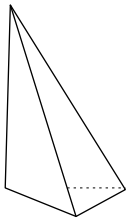
BUILD YOUR OWN



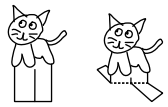
1. FOLD PAPER INTO A SQUARE AND CUT OFF THE EDGE



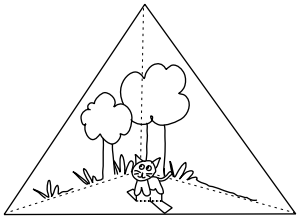
2. DRAW AND COLOR THE BACKGROUND AND CUT THE OPPOSITE DIAGONAL



3. FOLD AND GLUE THE TWO BOTTOM QUADRANTS TOGETHER

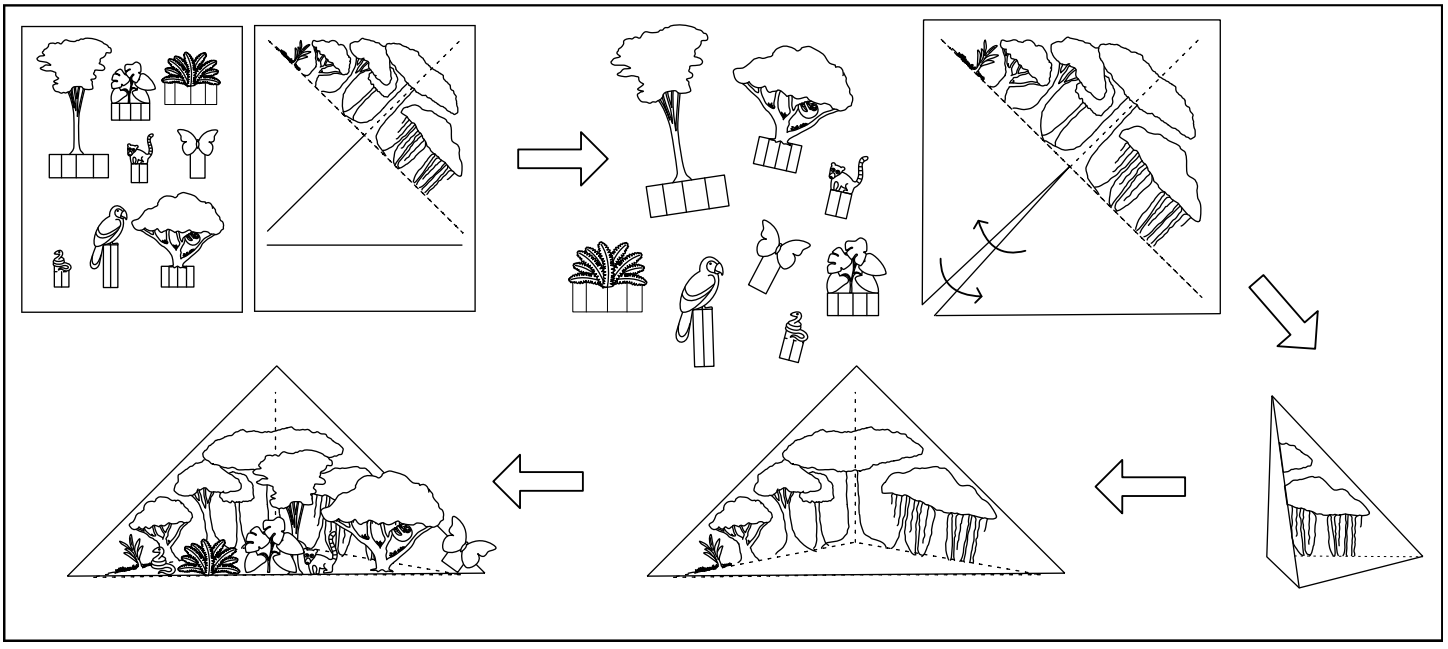


4. DRAW OR COLOR THE ANIMALS AND PLANTS FOR THE FOREGROUND



5. ARRANGE THE ANIMALS AND PLANTS AND GLUE THEM IN TO COMPLETE YOUR SCENE

OR USE THE TEMPLATES FROM THE APPENDIX!



Fill in the blanks for each of your models:

RAINFOREST BIOME:

Abiotic (temperature): Always warm (no frost or snow)

Abiotic (amount of water): Daily rain

Primary producers: Trees, orchids, ferns, bromeliads

Primary consumers: Certain insects, birds (Macaw), sloths

Secondary consumers: Snakes, coatis, jaguars, monkeys

CONTINENTAL BIOME:

Abiotic (temperature): Warm summers, cold winters

Abiotic (amount of water): Variable, rain in summer snow in winter

Primary producers: Deciduous and coniferous trees, grass, shrubs

Primary consumers: Certain insects, deer, ibex

Secondary consumers: Bearded vulture, bear, marmot

DESERT BIOME:

Abiotic (temperature): Variable, can be hot or cold

Abiotic (amount of water): Very little

Primary producers: Cacti, creosote bush or Joshua tree

Primary consumers: Certain insects, bighorn sheep, chuckwalla

Secondary consumers: Coyote, scorpion, roadrunner, gila monster

POLAR BIOME:

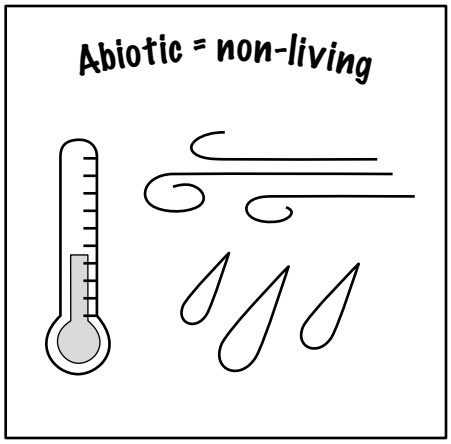
Abiotic (temperature): Always cold

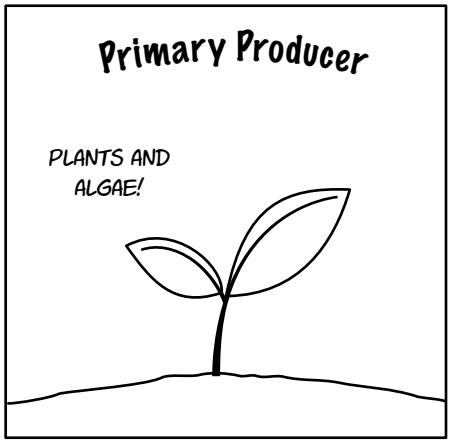
Abiotic (amount of water): Most receive less than 25 cm (10 in).

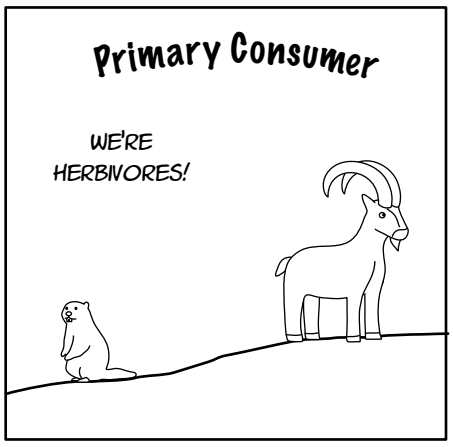
Primary producers: Algae, seaweed or kelp

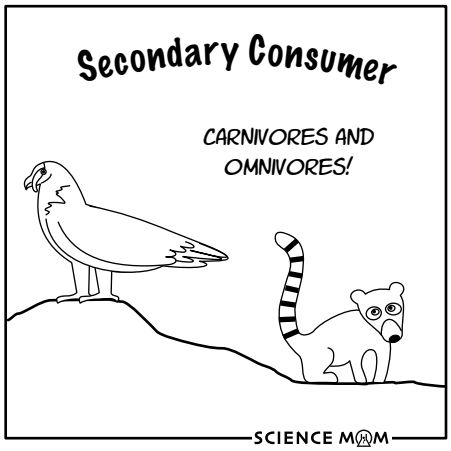
Primary consumers: Amphipod, krill

Secondary consumers: Seal, penguin, whale, nemertean worm, starfish, icefish









What is an Ice Age?

GLACIAL
22,000 years ago

VS.

INTERGLACIAL
Today

FILL IN THE BLANKS USING THESE WORDS:

Antarctica

glacial

interglacial

glaciers

An ice age is a long period of time where global temperatures drop low enough for __glaciers__ to form. Because there are glaciers on earth right now, we are currently in an ice age! This ice age started almost 2.6 million years ago when __Antarctica__ became covered in ice. But during an ice age, the amount of ice changes between __glacial__ periods (when almost 1/3 of the land is covered in ice) and __interglacial__ periods (like now). The last glacial period ended approximately 22,000 years ago.

DRAW A LINE TO MATCH THE ANIMAL TO THE CORRECT FACT BOX

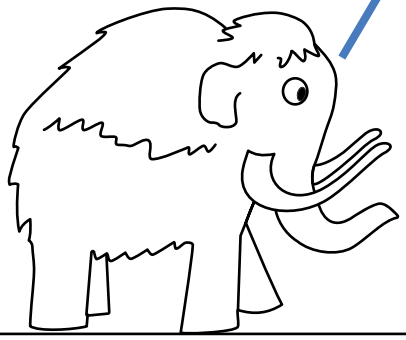
These animals survived by using inventiveness and creativity.

Scientists can tell the age of this animal by the rings in its teeth, just like a tree!

This animal looked soft, but it had small hard discs under its skin for protection.

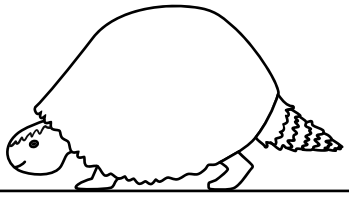
This animal was about the same size and weight of a VW Beetle car!

Woolly Mammoth
Mammuthus primigenius

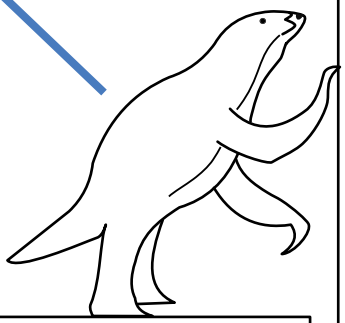


Human
Homo sapiens

Glyptodon
Glyptodon clavipes

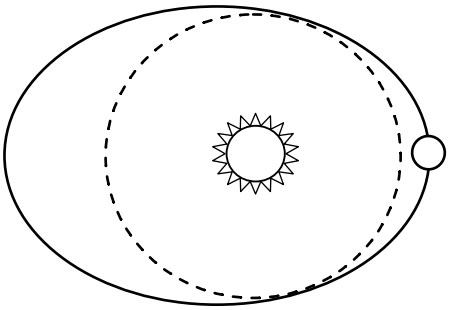


Giant Ground Sloth
Megatherium americanum

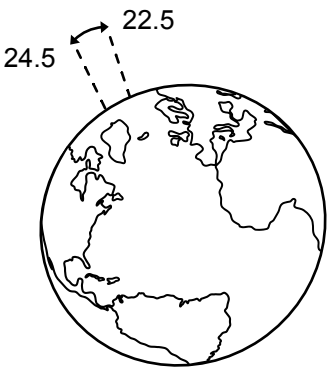


Milankovitch Cycles

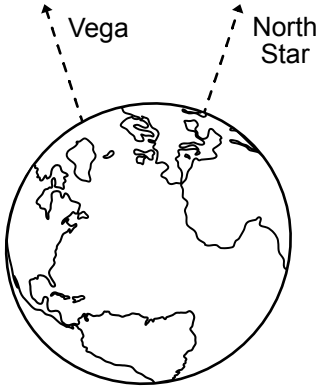
Earth's orbit is not exactly circular, and the angle of its tilt changes slightly about every 40,000 years. Changes in each of these contribute to different amounts of solar radiation reaching earth and are thought to effect the start and stop of glacial periods.



Eccentricity



Obliquity

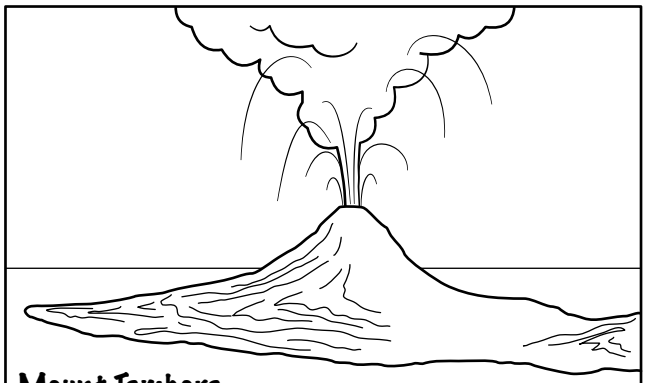


Precession

SCIENCE M@M

The year 1816 is known as the *Year Without a Summer*. It was possibly the coldest year in the last 500 years. Overall, the average temperature drop was only about 0.4-0.7 °C, but that was enough to cause an agricultural disaster. The entire Northern hemisphere experienced famines due to the erratic weather.

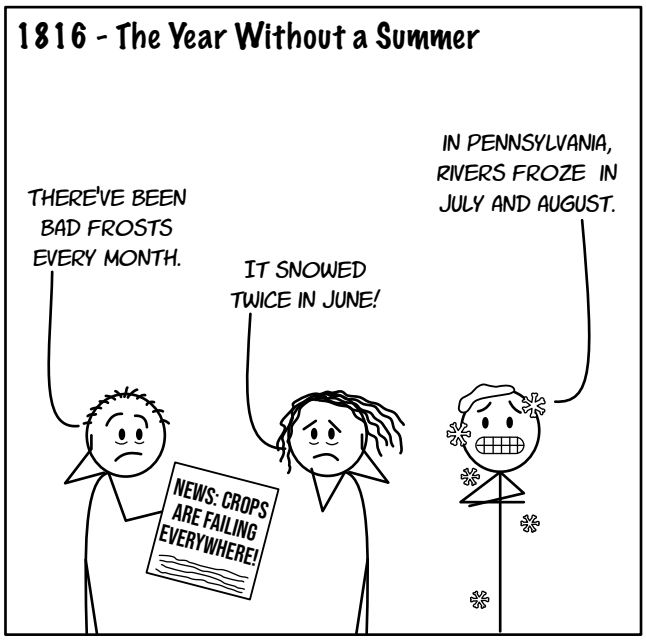
What caused such a large shift in the climate? Earth experienced a *volcanic winter* event that resulted from the eruption of Mount Tambora in Indonesia the previous year. This eruption was the most powerful volcanic eruption in recorded human history. Hundreds of cubic kilometers of material were ejected high into the stratosphere, where it reflected out much of the sun's light.



Mount Tambora

What can we learn from the Year Without a Summer?

Small changes in the overall temperature of the planet make a BIG difference to how well human beings can grow food.



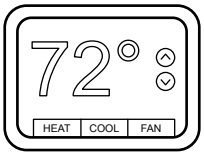
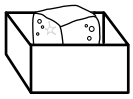
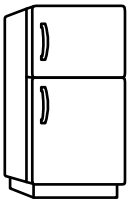
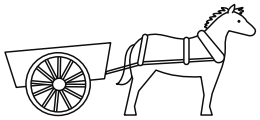
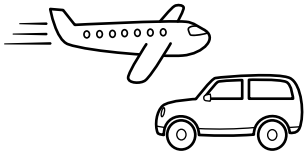
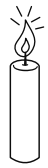
INDUSTRIAL INVENTIONS

The development of engines and power grids of electricity allowed human beings to travel, communicate, and invent as never before.

It also changed how people heated, cooled, and moved things. Instead of a fireplace, modern people use a furnace or electric heating unit for heat. Instead of an ice box to cool food (literally, a box with ice in it), people now use the power of electricity to circulate gas and transfer heat from the inside of a fridge to the outside. Instead of transportation powered by animals, people now use airplanes, cars, and trains. Instead of a room lit by a flickering candle, now bright electric lights are used to illuminate homes, streets, and buildings.

Places with access to these modern tools and resources are called *developed* countries. One of the biggest differences between developed and undeveloped nations is how much energy they use and the sources of that energy.

If energy is coming from burning fuel, then carbon dioxide gas is being produced and released into the atmosphere.

	UNDEVELOPED	***DEVELOPED***
HEAT	 *FIRE FOR HEAT*	 *FURNACE OR THERMOSTAT*
COOLING	 *ICE BOX - LITERALLY*	*REFRIGERATOR* 
TRANSPORTATION	 *HORSE AND CART*	 *CARS AND PLANES*
LIGHT	 *CANDLE OR TORCH*	 *ELECTRIC LIGHTS*

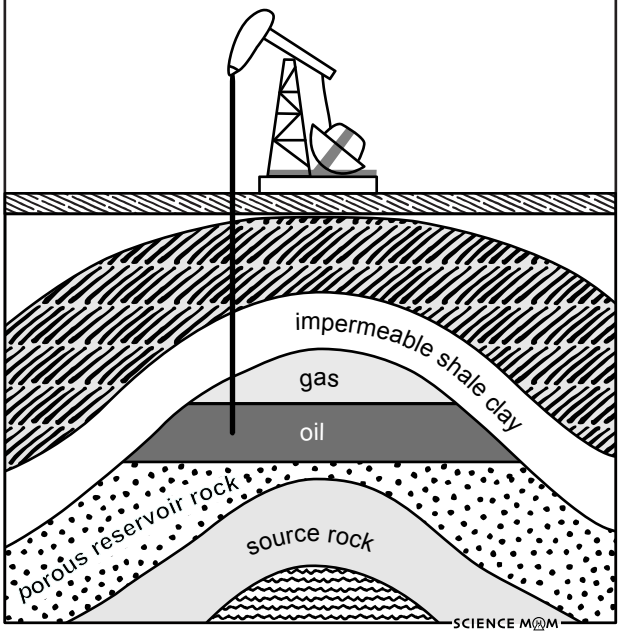
CAN YOU INVENT A NEW ENERGY SOURCE? DRAW AND DESCRIBE IT HERE.

We can't wait to see what you invent!
If you aren't sure where to begin, take a few minutes to research alternative energy sources. Don't forget to check out fusion or "cold energy" too. You can use one of these as inspiration for your invention!

Fossil Fuels

How we get petroleum (crude oil)

An oil rig or well drills down through layers of rock to access an oil deposit.



Gasoline, natural gas, diesel fuel, and kerosene are all produced from petroleum or crude oil. But oil is used for much more than fuel! Petroleum products are used to make fabric (polyester), waxes, plastics, asphalt, and even certain medicines and food additives.

Oil is a complicated mixture of different molecules containing hydrogen and carbon called "hydrocarbons." This mixture and other fuels like coal are called fossil fuels because they were formed millions of years ago – before the dinosaurs existed!

When oil is burned, energy is released and carbon dioxide is produced.

UNSCRAMBLE THE MIXED UP WORDS TO DISCOVER WHAT TIME PERIOD OIL CAME FROM:

NILESAGO → G A S O L I N E (9)

BANROC → C A R B O N (1 2 3 5)

ILO → O I L (4) LUFE → F U E L (6 8 7)

C A R B O N I F E R O U S (1 2 3 4 5 6 7 8 9)

DRAW A LINE TO MATCH THE ENERGY SOURCE WITH THE CORRECT ADVANTAGES AND DISADVANTAGES

Pros: Cost-efficient, easy to build. Completely renewable.

Cons: Contribute to noise pollution, effective locations are limited.

Pros: Little environmental impact. Produces high-energy with very low risk.

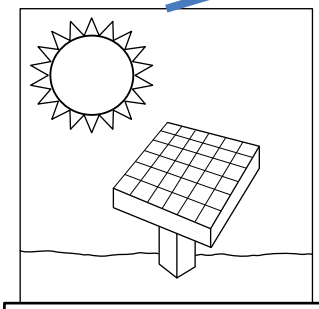
Cons: Leaves nasty waste, a meltdown could be catastrophic.

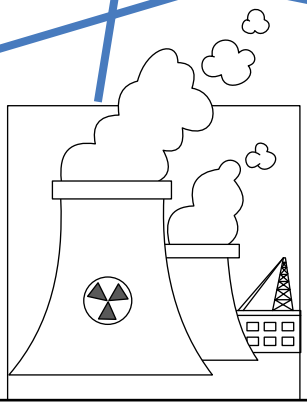
Pros: Little pollution, Renewable. Works in lots of climates.

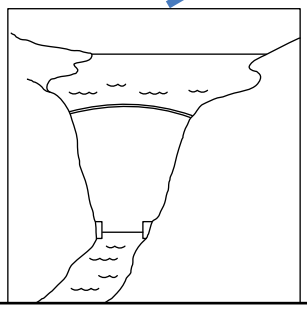
Cons: Low efficiency, Doesn't work at night.

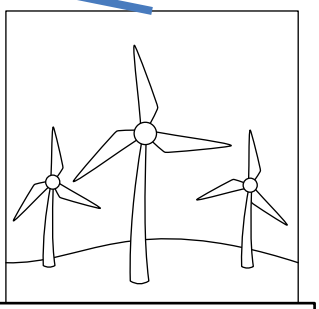
Pros: Over 90% efficiency. No waste is produced.

Cons: Environmental impact, rivers and lakes are disrupted, and there is risk of flooding.





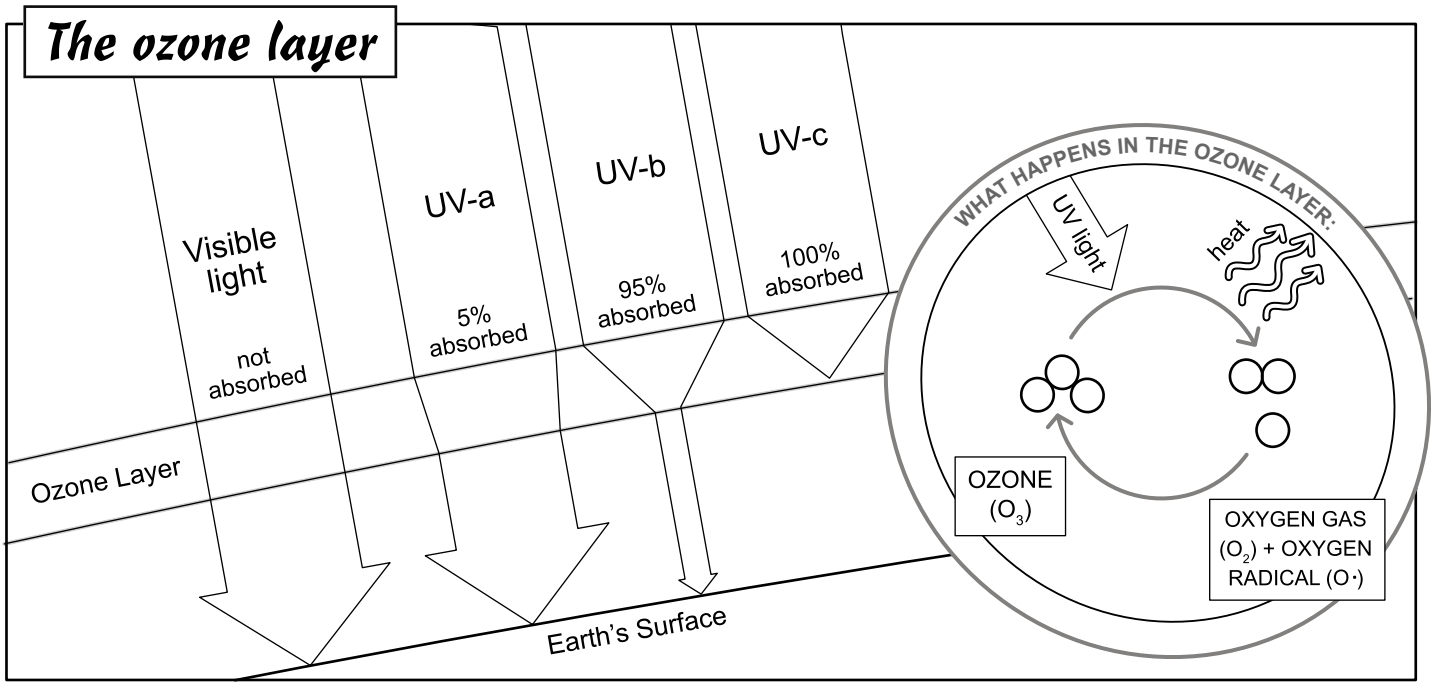




Solar | Nuclear | Hydroelectric | Wind

The Ozone Hole

AND HOW WE'RE FIXING IT



FILL IN THE BLANKS USING THESE WORDS:

ozone

UV

absorbing

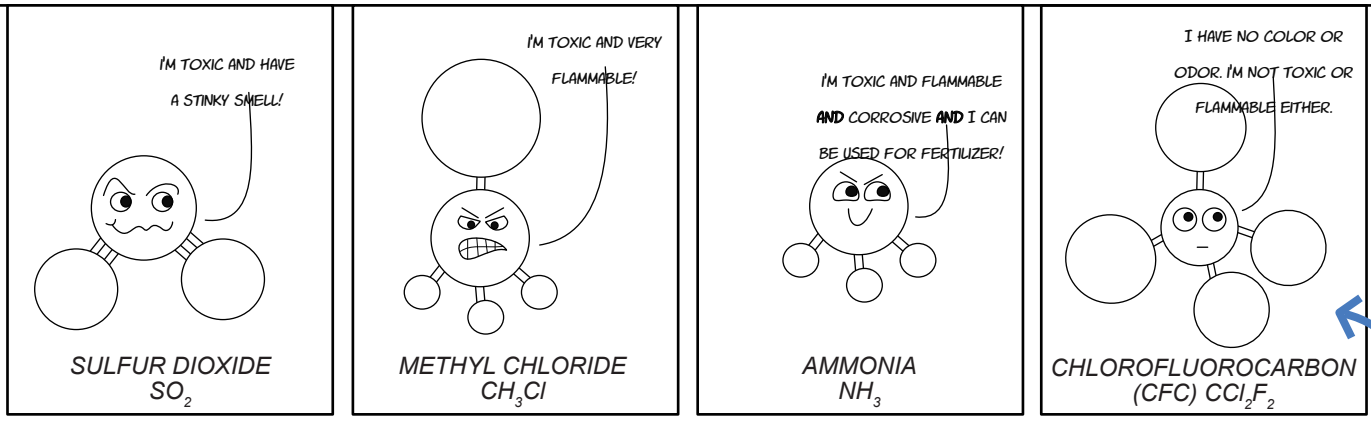
heat

radiation

protecting

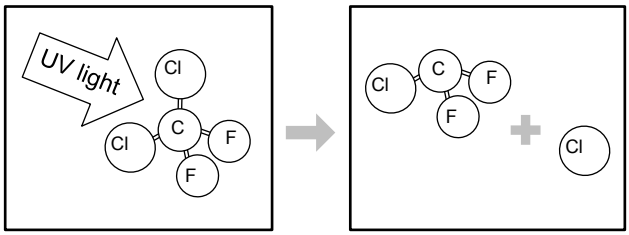
The ozone layer formed naturally from oxygen gas reacting with **radiation** from the sun. High energy **UV** light splits apart oxygen gas (O_2) in the upper atmosphere. A single oxygen atom is called an oxygen radical, and it combines with other oxygen gas to form **ozone** (O_3). Once ozone is formed, it is constantly being blown apart and reformed. As it goes through this cycle, it is constantly **absorbing** UV light and giving off **heat**. This incredible layer of gas is essential for life on Earth. It acts like a shield, **protecting** plants and animals from harmful radiation.

CHECK OUT THIS ART GALLERY OF GASES THAT CAN BE USED TO RUN A FRIDGE AND KEEP YOUR FOOD COOL. WHICH REFRIGERANT WOULD YOU RATHER USE IN YOUR HOME?

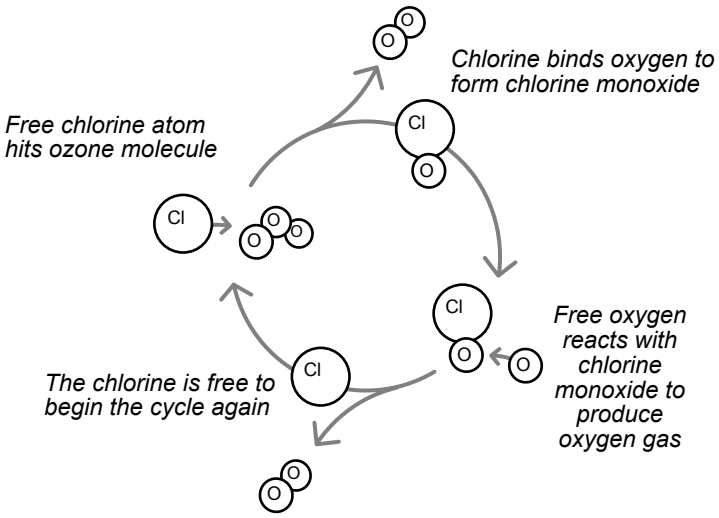


If the gas leaks in the house, this is the safest one by far

CFC's were a good choice for refrigerants because they were safer than the gases used at the time. But they were also a bad choice because they were VERY long lasting, and once they drifted up into the stratosphere, they reacted with UV light to form chlorine gas, which then started destroying the ozone layer.

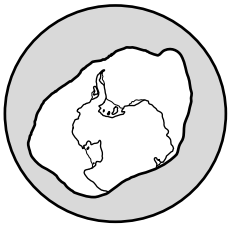


In 1987, more than 100 countries agreed to the Montreal Protocol, which banned the use of CFCs.



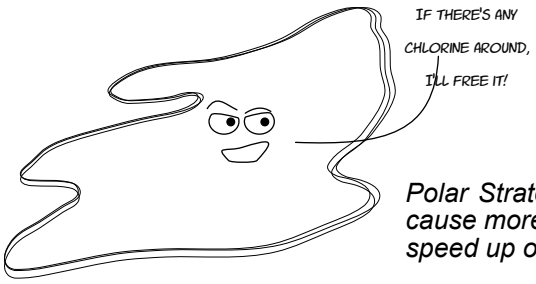
ONE CHLORINE ATOM CAN DESTROY MORE THAN 100,000 OZONE MOLECULES

Why Antarctica?



*The ozone hole appears each spring over Antarctica. The largest size ever measured was **28.3 million kilometers**^{2} (11 million miles^2) on Sept 3, 2000.*

Because it is surrounded by strong wind and water currents, Antarctica has the coldest air on the planet. During winter months, this causes the formation of Polar Stratospheric Clouds.



Polar Stratospheric Clouds (PSC's) cause more free chlorine atoms and speed up ozone depletion.

What if?

What if we *hadn't* banned CFCs? NASA recently studied that question, and discovered that if we had NOT banned CFCs, then by the year 2050, most of the ozone layer would have disappeared.

In this ozone-poor world, being outside causes a severe sunburn in less than 5 minutes. Skin cancer is incredibly common (every family loses at least one person), and crops are failing worldwide, causing famines and food shortages.

Figure out how old you will be in the year 2050 and then draw a picture of the "world we avoided" and a picture of the "world you hope to build."

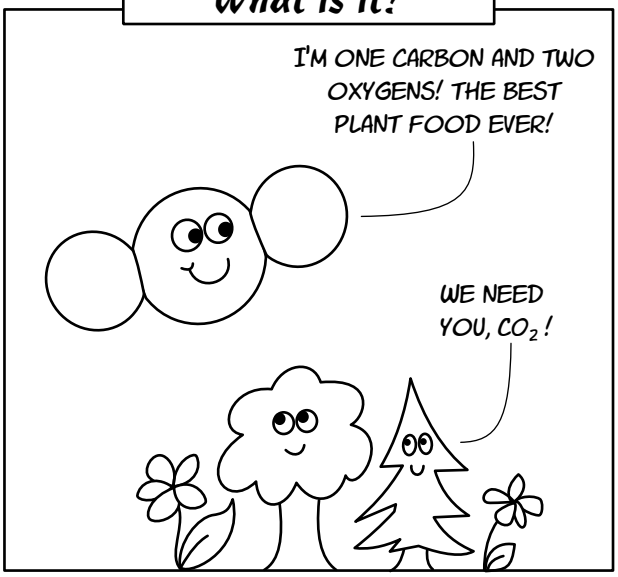
2050 - the world we hope to build.

In the year 2050, Math Dad will turn 70 and Science Mom will turn 69.

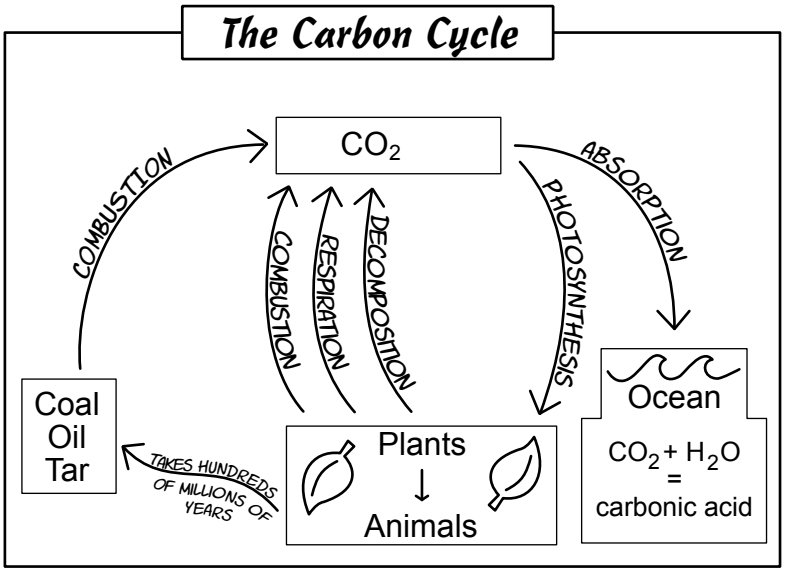
2050 - the world we avoided

Carbon Dioxide, aka CO_2

What is it?



The Carbon Cycle



FILL IN THE BLANKS USING THESE WORDS:

atmosphere

carbon

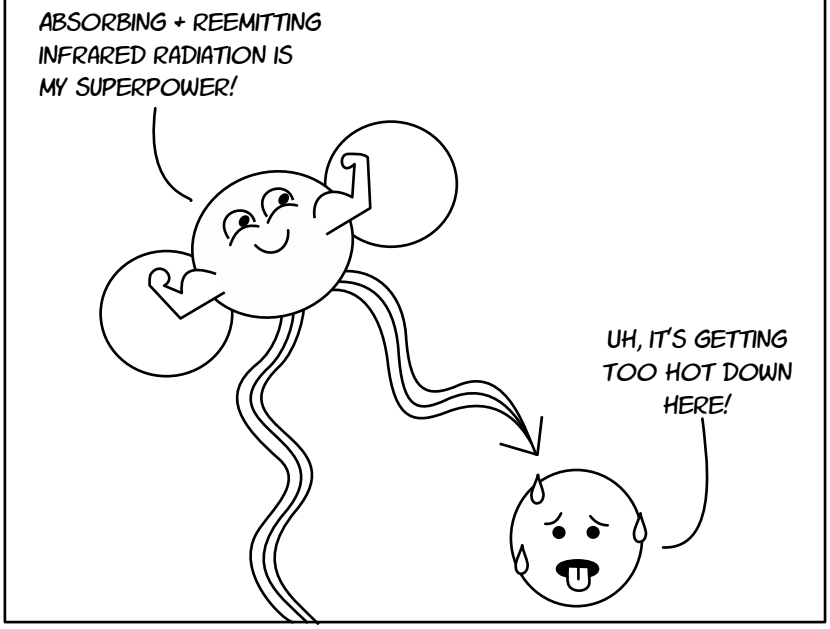
eat

greenhouse

heat

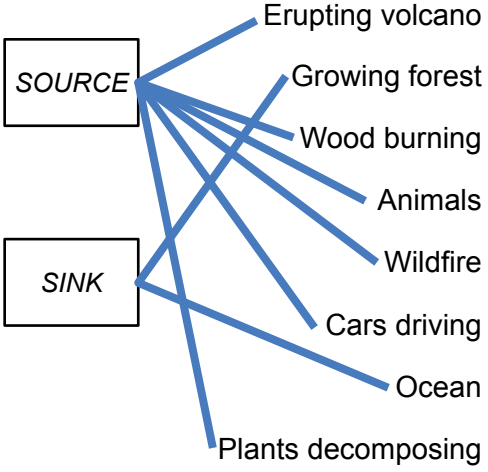
Carbon dioxide is a gas made of one **carbon** atom and two oxygen atoms. This is why it's called CO_2. It is an essential part of our **atmosphere**. Without CO_2, not only would Earth be way too cold, but plants and algae would starve! Carbon is the building block of life. Every food that we **eat** contains carbon, and the source of that carbon is the carbon dioxide in our air. Carbon dioxide is also a **greenhouse** gas. It warms Earth by absorbing and then reflecting **heat**. We need some greenhouse gases in our atmosphere, but too much can be a problem!

Can you have too much of a good thing?



SINK or SOURCE?

Draw lines to match each item or activity to whether it adds carbon (source) or subtracts it (sink) from the atmosphere.

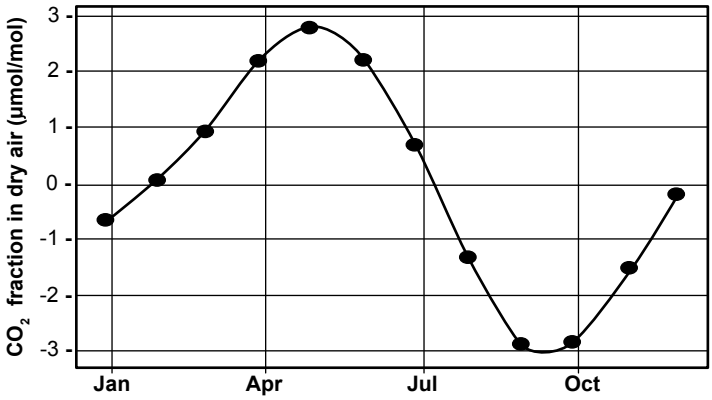


Because most of the Earth's landmasses are in the northern hemisphere, there is a distinct yearly change in the amount of CO_2 in the atmosphere.

Concentrations decrease each June-August because photosynthesis increases in the Northern Hemisphere.

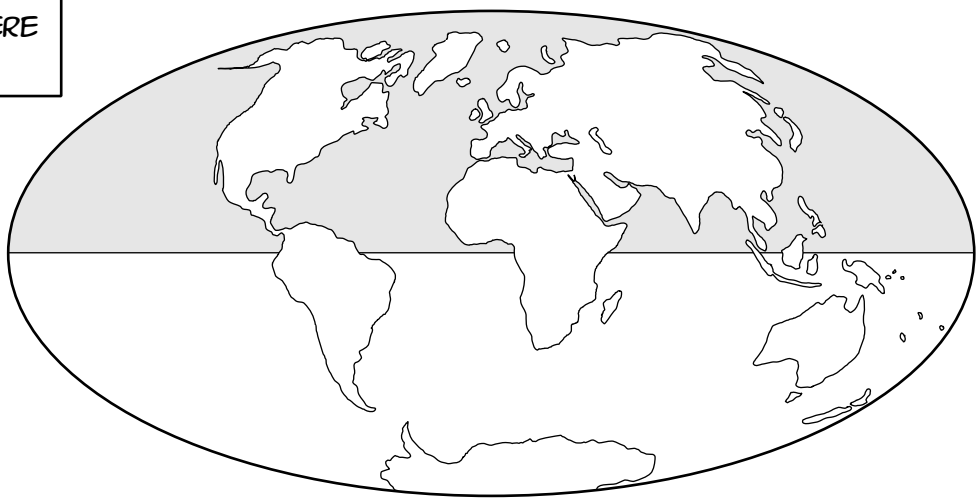
From October to late April, lower photosynthesis combined with higher levels of decomposition, respiration, and combustion cause CO_2 levels to increase.

SEASONAL VARIATION IN CARBON DIOXIDE

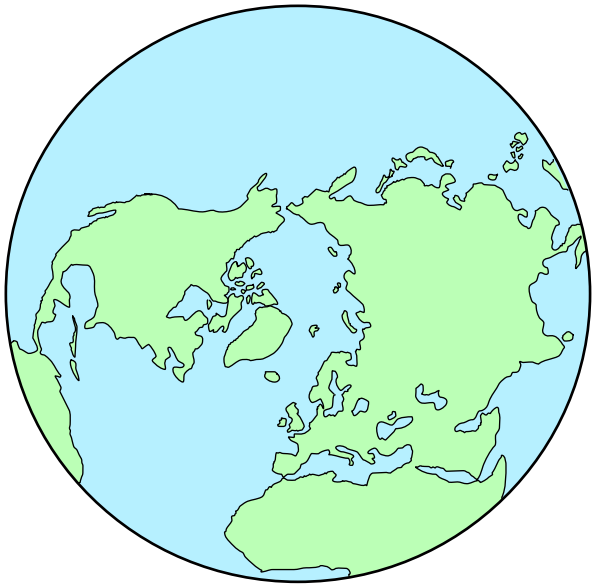


Data from NOAA & the Scripps Institution of Oceanography

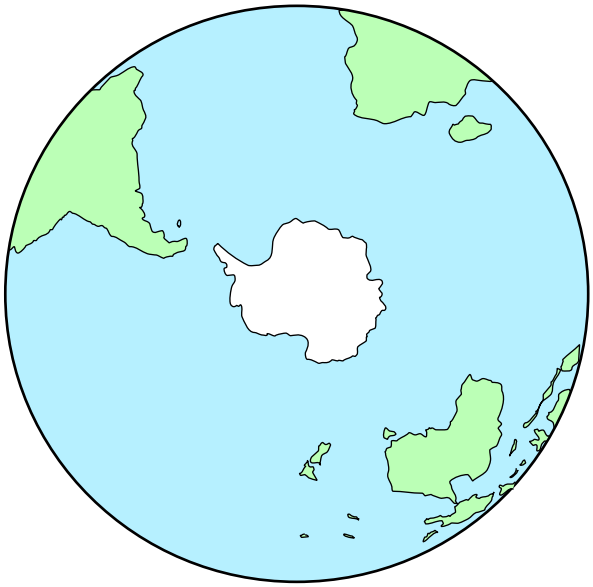
THERE'S A LOT MORE LAND IN THE NORTHERN HEMISPHERE THAN THE SOUTHERN!



COLOR THE OCEAN AND LAND IN EACH HEMISPHERE. THEN DRAW A DOT SHOWING WHERE YOU LIVE!



NORTHERN HEMISPHERE



SOUTHERN HEMISPHERE

SCIENCE MOM

Hands-on Activity

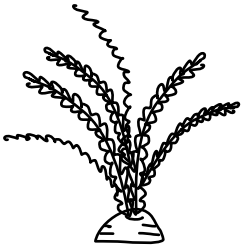
MASON JAR BIOMES

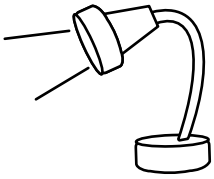
MATERIALS:


2 mason jars and lids

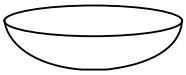

Discs of compressed coconut coir OR 2 cups of potting soil

Clover, thyme, alfalfa, grass, or chia seeds


Optional: food scraps from the kitchen


1 bright light that can be placed over one of the jars


½ cup gravel marbles, or pebbles


A bowl for hydrating the coconut fiber or potting soil

CHOOSE YOUR OWN SCIENCE ADVENTURE!

BRIGHT LIGHT vs LOW LIGHT

Plants need light to grow. What happens if they have low light or no light? Will they grow shorter or taller or even be a different color than plants with bright light? Try this experiment and find out!

Set up your jars so that everything is the same (or as similar as possible). Use the same amount of gravel, the same amount of coconut fiber or potting soil, and the same type and amount of seeds.

One of the most important details in your biome is to be sure that the soil is damp but not too wet. There should be some standing water visible in the gravel/marble/pebble layer, but NOT in the soil layer.

OR

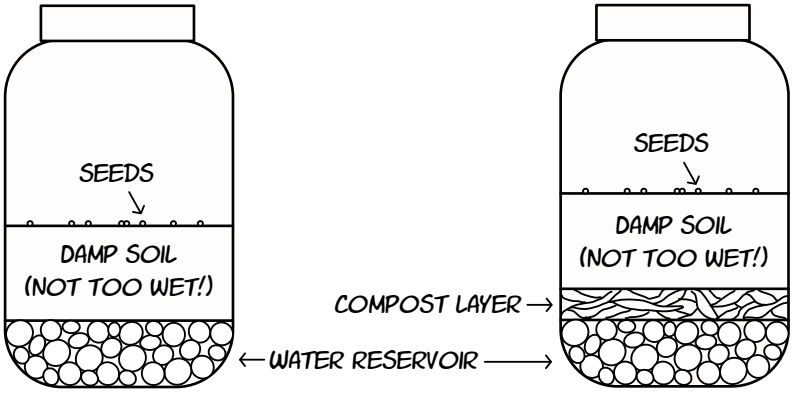
COMPOST LAYER vs NONE

Plants get their energy from sunlight, and they use water and carbon dioxide to grow bigger. But they also need nutrients like nitrogen, potassium, and phosphorus.

A compost or trash or “midden” layer can provide those nutrients. But fungi will also grow in a compost layer, and if there is too much fungus, the plants won’t grow as well.

To create a good midden or compost layer, mix dead leaves or shredded newspaper with food scraps such as the peels from carrots, bananas, or apples.

Place the compost layer on top of the gravel layer and be sure that it’s not more than 3 centimeters (about 1 inch) thick.

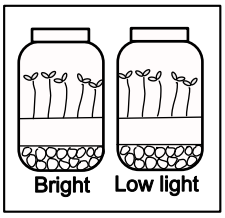


If you notice a lot of condensation inside your jar, you may have watered it too much. Just open the lid for a day and let some of the water evaporate.

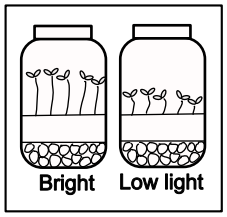
Bright light vs low light

1. Put the compressed coconut fiber into a bowl and add ¼ cup of water. Wait a minute until the fiber has absorbed the water. Then continue to add water a tablespoon at a time until the fiber is fully hydrated.
2. Make the drainage layer in both jars by adding an equal amount of gravel, pebbles, or marbles.
3. Place the coconut fiber or damp potting soil over top of the drainage layer. Check to be sure that the height of the drainage layer and soil layers are the same between the two jars.
4. Place the seeds on top of the soil and add a small amount of water. The seeds and soil should be damp, but there should only be standing water in the drainage layer.
5. Set up the jars so that one of them has a very bright light and one of them has dim light.
6. Place both lids loosely on top of the jars to maintain humidity. Check the jars daily and record your observations. Water only as needed (if the soil begins to dry on top).

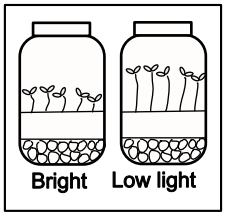
Make a prediction! How will your biomes compare?



Stay the same?



Taller with bright light?



Taller with low light?

Record your observations:

Day 5

Day 10

Day 15

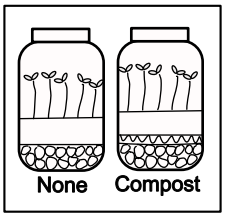
Day 20

Day 25

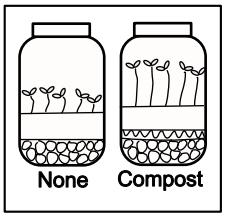
Compost layer vs none

1. Put the compressed coconut fiber into a bowl and add ¼ cup of water. Wait a minute until the fiber has absorbed the water. Then continue to add water a tablespoon at a time until the fiber is fully hydrated.
2. Make the drainage layer in both jars by adding an equal amount of gravel, pebbles, or marbles.
3. Shred your food scraps and leaves or newspaper and place it on top of the drainage layer in your compost jar. Cover it with the coconut fiber or damp potting soil, making the height of the soil layers the same between the two jars.
4. Place the seeds on top of the soil and add a small amount of water. The seeds and soil should be damp, but there should only be standing water in the drainage layer.
5. Set up the jars so that they have the same light conditions.
6. Place both lids loosely on top of the jars to maintain humidity. Check the jars daily and record your observations. Water only as needed (if the soil begins to dry on top).

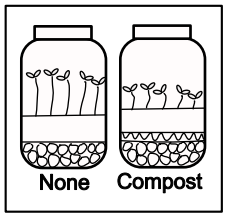
Make a prediction! How will your biomes compare?



Stay the same?



Taller with compost?



Taller without?

Record your observations:

Day 5

Day 10

Day 15

Day 20

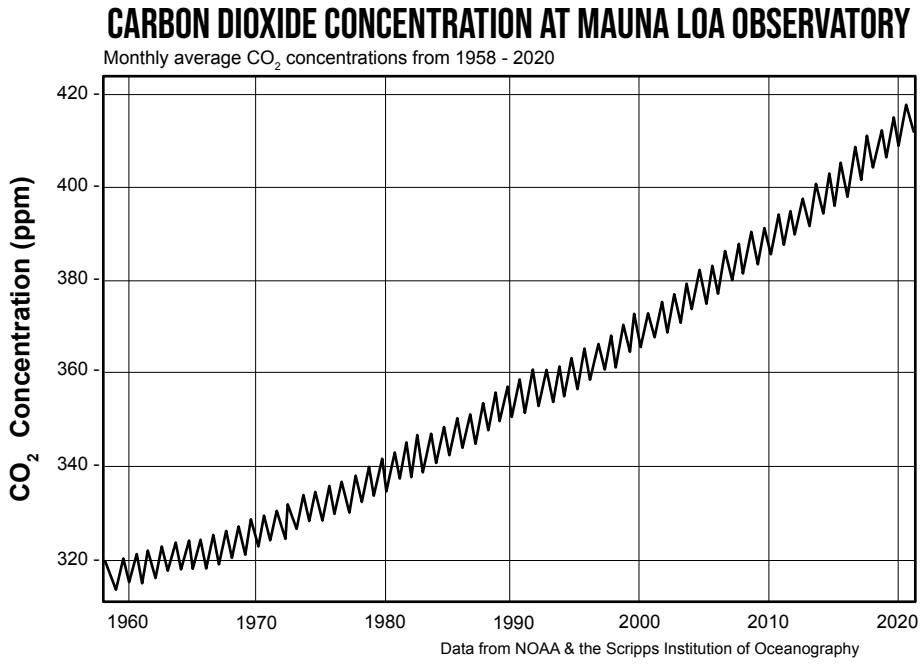
Day 25

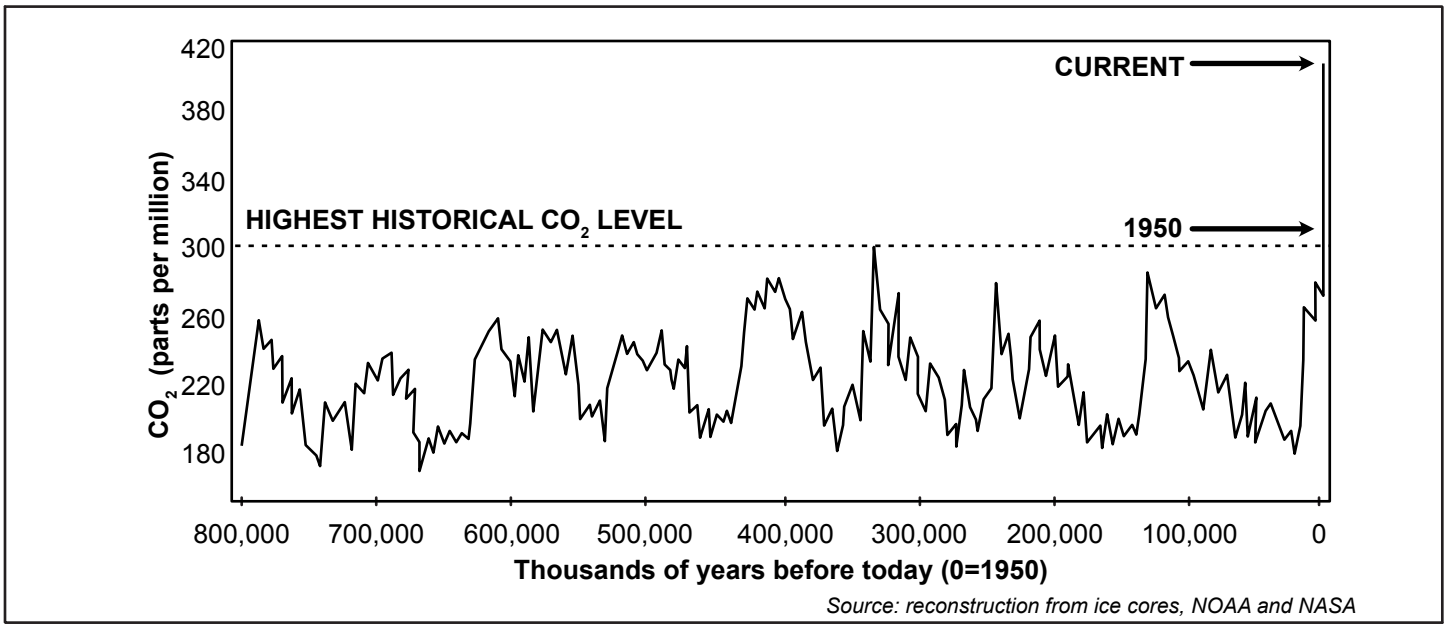
The last 100,000 years

In 1858, a scientist named Charles David Keeling started measuring CO_2 levels in Hawaii at the Mauna Loa research station.

Since Dr. Keeling started his work in the late 1950s, more and more stations around the world have started measuring daily levels of carbon dioxide. The global average shows the same trend as this data from Mauna Loa: there is a dip each summer in the Northern Hemisphere, but overall, levels are steadily and relentlessly increasing.

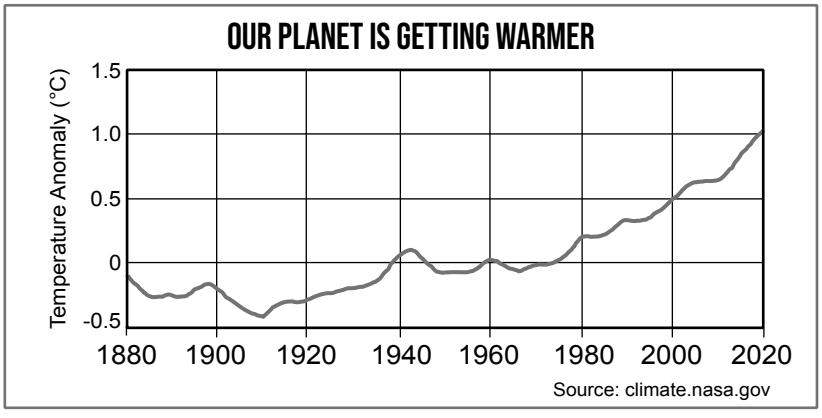
But how do these numbers of 400 parts per million compare to historic levels? Well, take a look at this next graph:





For about 10,000 years, carbon dioxide levels on Earth were stable at about 280 parts per million (ppm). That's just 0.02% of the Earth's atmosphere.

During the industrial revolution, people began burning more fuel. Since the 1800s, carbon dioxide levels have more than doubled, reaching over 415 ppm. This is much higher than any levels recorded in the past 800,000 years. The higher levels of CO_2 are causing worldwide warming and climate change.



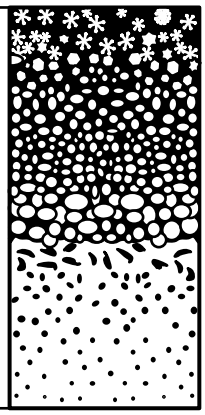
How do we know carbon dioxide levels from 100,000 years ago?

Answer: From ICE CORES!

Recent Snow

Trapped recent air

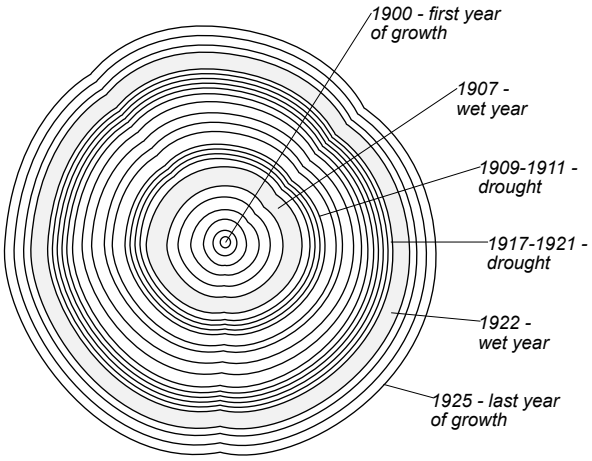
Ice with air bubbles that are hundred to thousands of years old



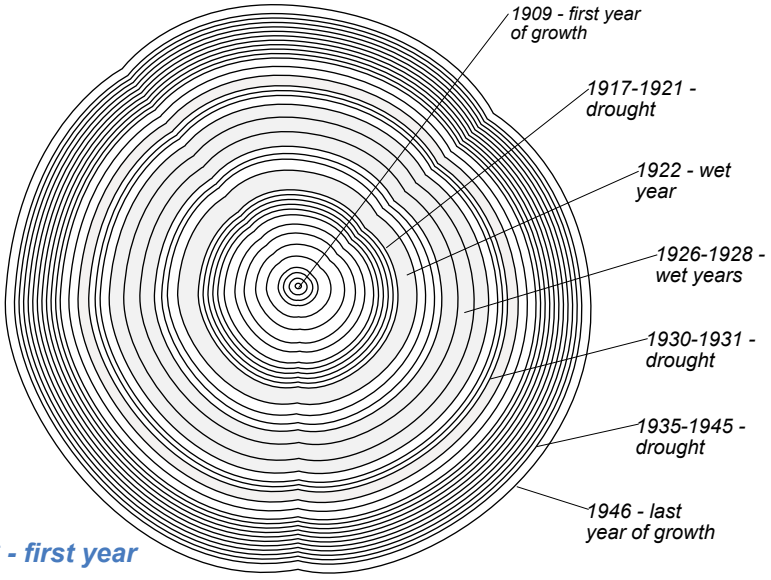
Each snowfall creates a layer, and over time those layers are compacted into ice with small bubbles of air, From ice cores in Greenland and Antarctica (some of them several miles long!) Scientists have been able to piece together climate data for hundreds of thousands of years. The layers in ice cores are similar to the layers in tree rings:

DROUGHTS CREATE THIN GROWTH RINGS

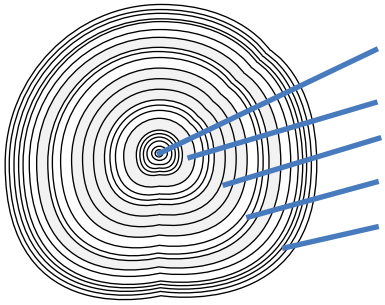
WET YEARS CREATE THICK GROWTH RINGS



TREE 1



TREE 2



TREE 3

Which drought(s) did TREE 3 experience? ☐ *1909* ☑ *1917* ☑ *1930* ☑ *1935*

Part of the 1935-1945 drought

When TREE 3 was 12 years old did it have: ☑ *A wet year* ☐ *A "normal" year* ☐ *A drought year*

What year did TREE 3 sprout? ***1916***

Did TREE 3 experience mostly average or wet years or mostly drought years? ***Mostly drought. It experienced 12 dry years, 6 average years, and 5 wet years.***

The FUTURE of our Climate

In 2015, 195 nations agreed to a goal of limiting the average temperature increase to 1.5°C. Swift action today can make a large difference for the future. Limiting the global warming to 1.5°C instead of 2° is projected to limit the damage of climate change in the following ways:

- Keeping the hottest days only 3°C warmer instead of 4°C
- Keeping deadly heatwaves from becoming annual events
- Decreasing the severity and frequency of flooding due to heavier rainfall events
- Cutting the loss of geographic range of plants, insects and vertebrates by half
- Reducing deforestation and wildfires
- Reducing food scarcity, economic damages, droughts, heat-related illness, polar ice sheet depletion

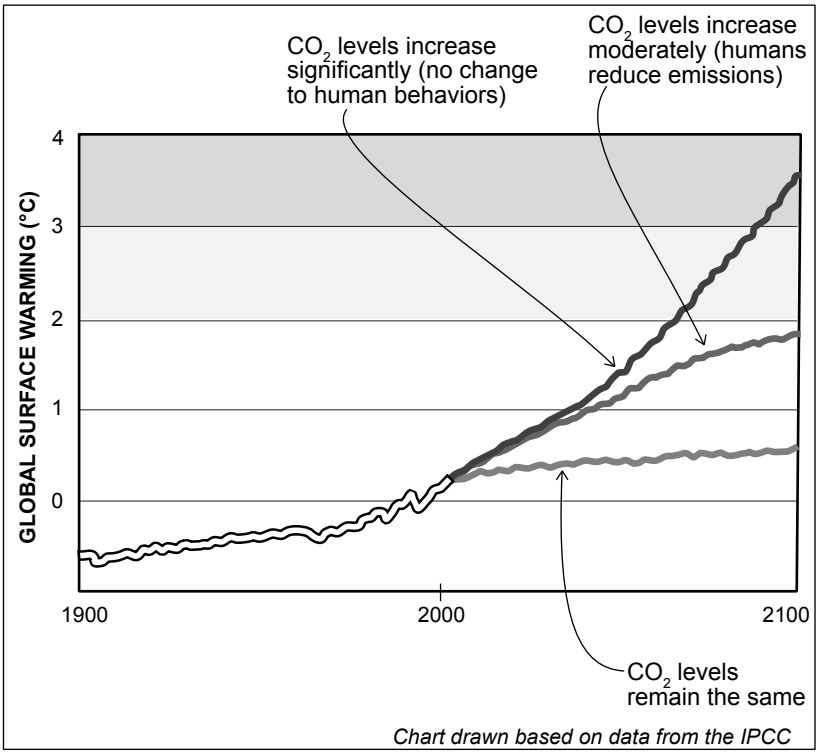
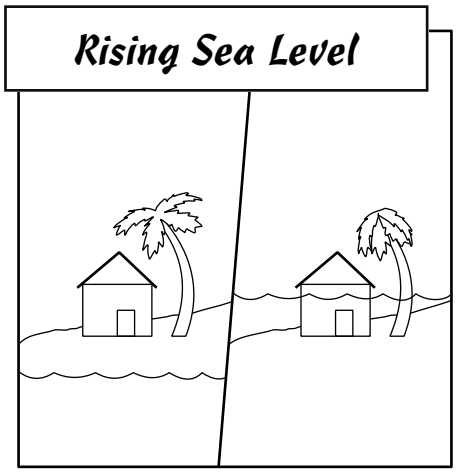
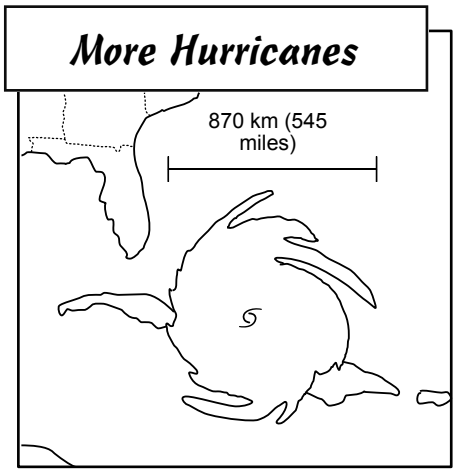
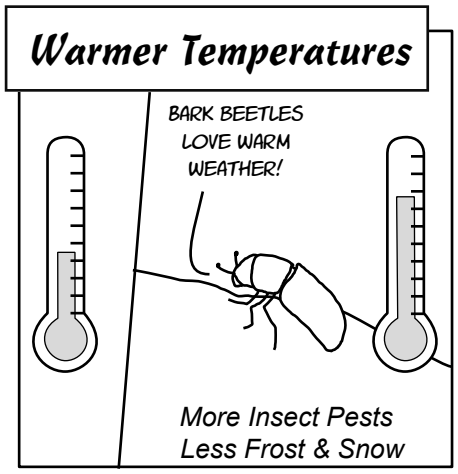
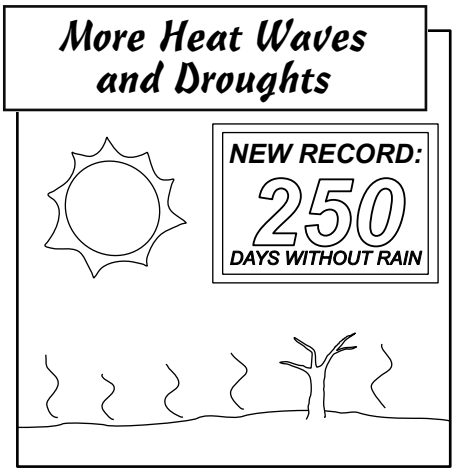


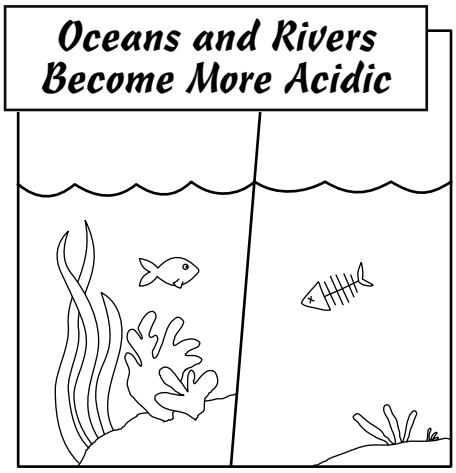
Chart drawn based on data from the IPCC

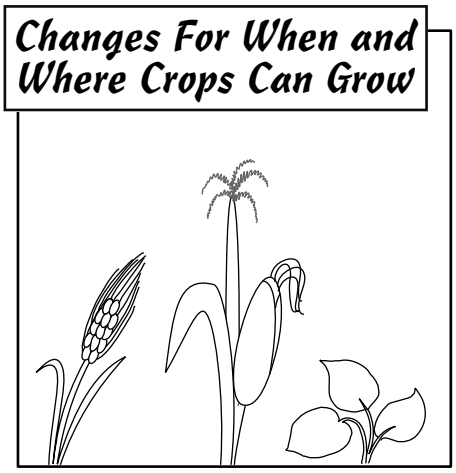


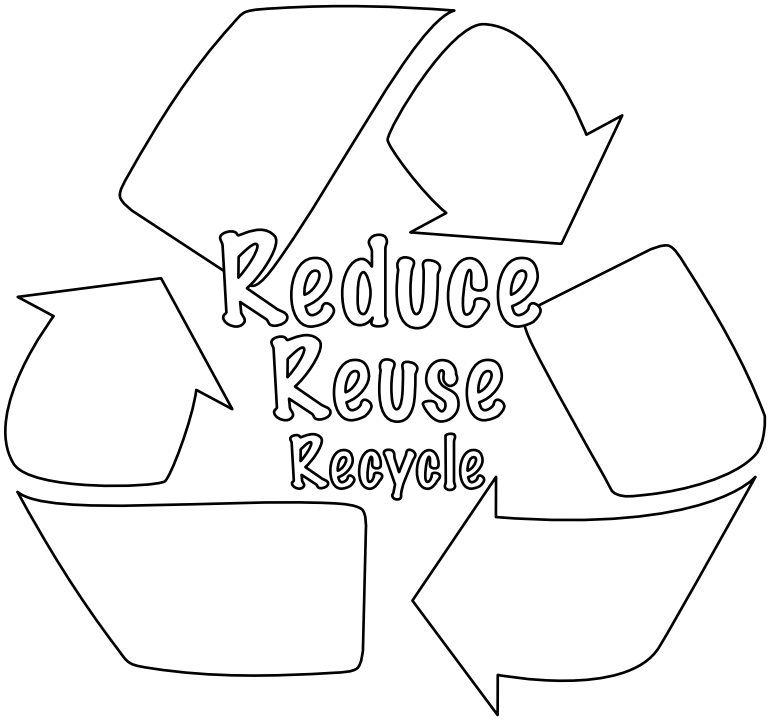












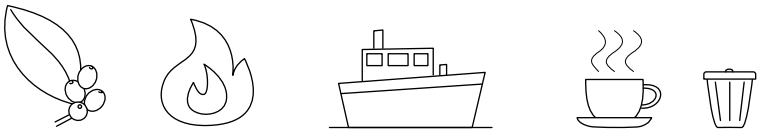
FILL IN THE BLANKS USING THESE WORDS:

steel	effective	reduce	disposable

The best way to lower our greenhouse gas emissions is to **reduce**, reuse, and recycle. Reducing is the most important and **effective** of these three "R's." Reducing means lowering the amount of energy used and products consumed. Reusing means to extend the life or use of things we use, like bringing your own utensils rather than using **disposable** plastic ones. Glass, plastic, **steel**, paper, and aluminum are all materials that can be recycled.

A carbon footprint is the ***total amount*** of carbon dioxide gas produced by a product, service, or person.

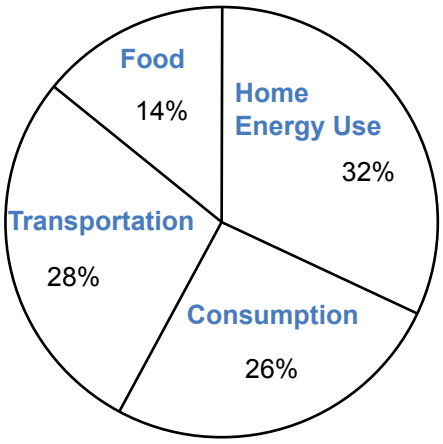
CARBON FOOTPRINT FOR A CUP OF COFFEE INCLUDES:



FARM > MILL > ROASTING > PACKAGING > SHIPPING > GRINDING > CONSUMPTION > DISPOSAL

Where's the carbon coming from?

What produces most of the average person's carbon footprint in developed countries like the United States and Canada? Fill in the chart with *your guess* for which things contribute each percentage of the average carbon footprint. Then write down an idea for how you could reduce carbon emissions in each category.

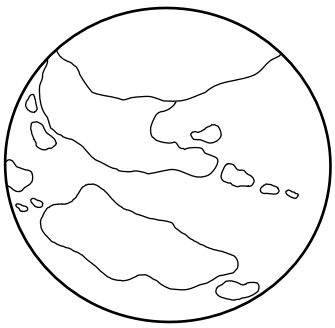


Ideas to reduce my carbon footprint:

1. Adjust the thermostat to be closer to the outside temperatures (cooler in winter, warmer in summer)
2. Instead of driving, walk or bike when possible.
3. Consume less (own fewer clothes and toys).
4. Plant a garden and grow some of the food you eat.

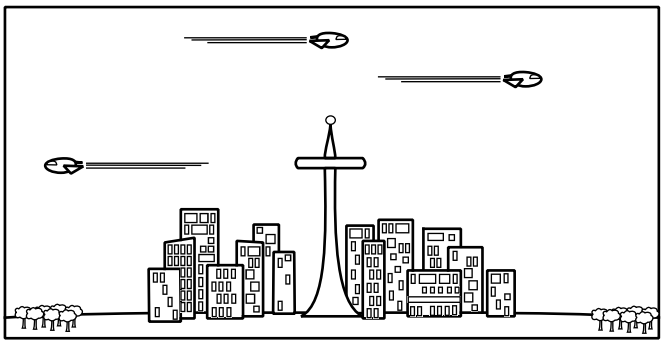
- ☐ **Transportation** (Driving or flying places)
- ☐ **Home Energy Use** (Heating and cooling, running appliances, etc.)
- ☐ **Food** (Includes energy used to grow, transport, and cook food crops)
- ☐ **Consumption** (The stuff you buy that was made using fossil fuels, such as cars or clothes)

A "What If?" Experiment

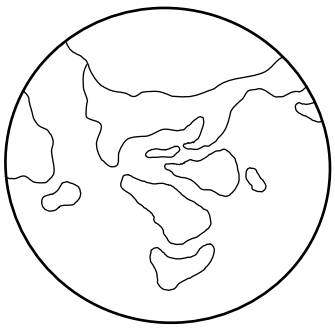


Planet Zork

70% ocean, 30% land. Nitrogen-Oxygen atmosphere. Ice cap at Northern pole.



Planet Zork and Planet Ooka have very similar atmospheres, but very different ideas about how to take care of them. Read about their history here, then complete the graphs on the opposite page to see what happens!

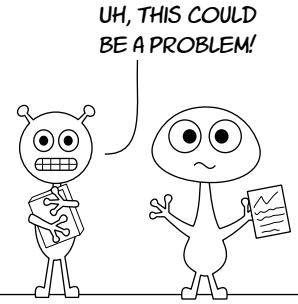


Planet Ooka

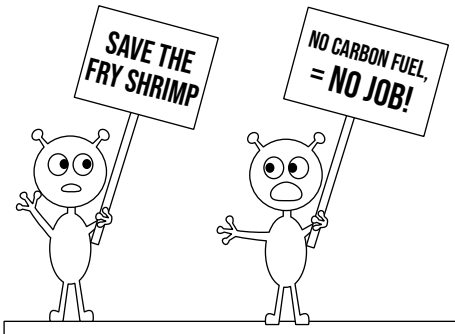
70% ocean, 30% land. Nitrogen-Oxygen atmosphere. Ice cap at Northern pole.

The age of Discovery

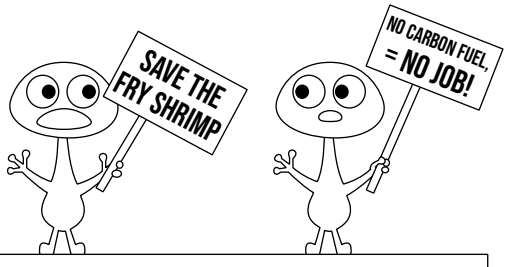
The Zorkians and Ookians both discover technology at the same time. They build hospitals and universities, invent factories and airplanes. It's an age of travel and new discoveries!



In the year 300, scientists on both planets realize that increased carbon dioxide levels are causing climate change.

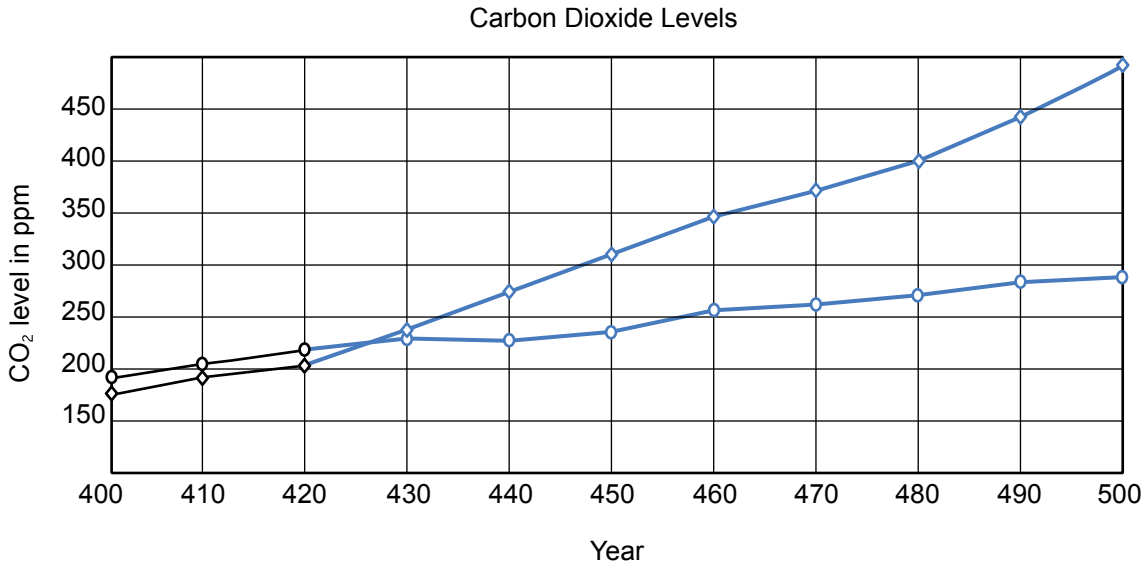


In the year 400, some scientists on planet Zork predict that the North ice sheet will disappear if Zorkians keep burning carbon fuel which will harm the fry shrimp that lay eggs under the ice. Most governments ignore this prediction and some people are upset, but the factories run on carbon fuel. The Zorkians know that without the factories, they won't be able to produce sweaters or pickled seagrass. And sea grass is one of the Zorkian's main foods.

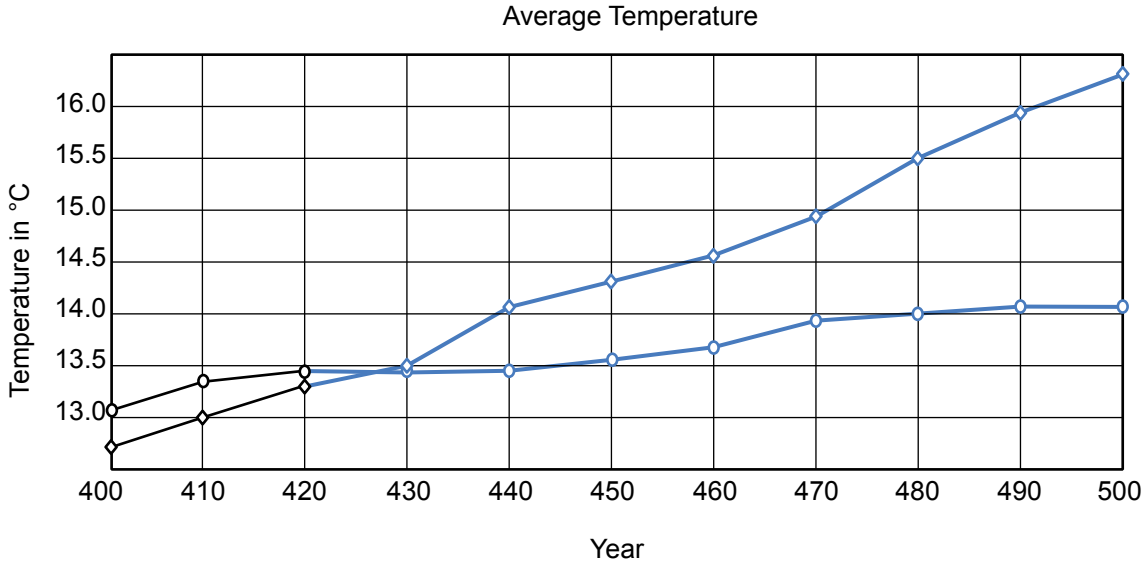


In the year 400, the Ookians decide to dramatically reduce their carbon dioxide output. This isn't easy and some people are upset, but the North ice sheet is already melting more than it ever has before. The Ookians know that if the ice sheet melts completely, the fry shrimp will go extinct. If the fry shrimp go extinct, then so will the seagrass which is one of the Ookian's main foods.

Complete the graphs to find out what happens to planets Zork and Ooka



	Year	400	410	420	430	440	450	460	470	480	490	500
o	Zork	175	191	206	238	266	310	346	370	400	441	490
◇	Ooka	191	205	220	230	228	237	255	260	270	282	288

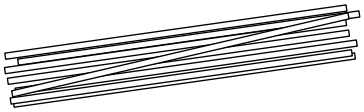


	Year	400	410	420	430	440	450	460	470	480	490	500
o	Zork	12.7	13.0	13.3	13.5	14.1	14.3	14.6	14.9	15.5	15.9	16.3
◇	Ooka	13.1	13.3	13.4	13.4	13.4	13.6	13.7	13.9	14	14.1	14.1

Hands-on Activity

SPAGHETTI BRIDGE

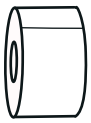
MATERIALS:


50 strands of spaghetti

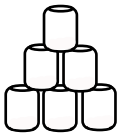

String


Cup

Weight
Can use marbles, coins, beans, or even water


Tape

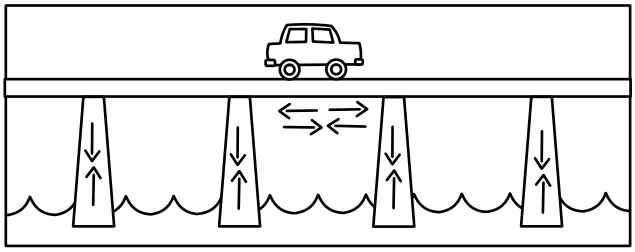
OR


Marshmallows

What holds up a bridge?

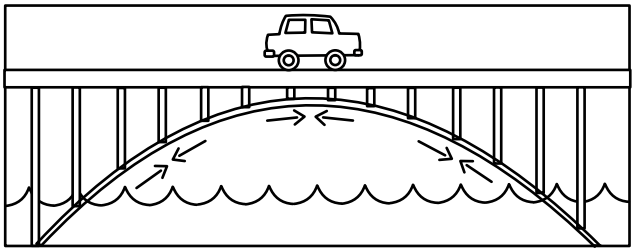
Compression, the force that pushes inward, is balanced by **tension**, the force that stretches and pulls outward. Each type of bridge uses tension and compression in different ways!

Beam



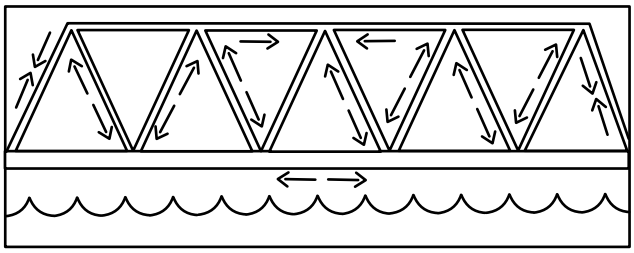
The deck or beam is in both tension and compression. The abutments are in compression.

Arch



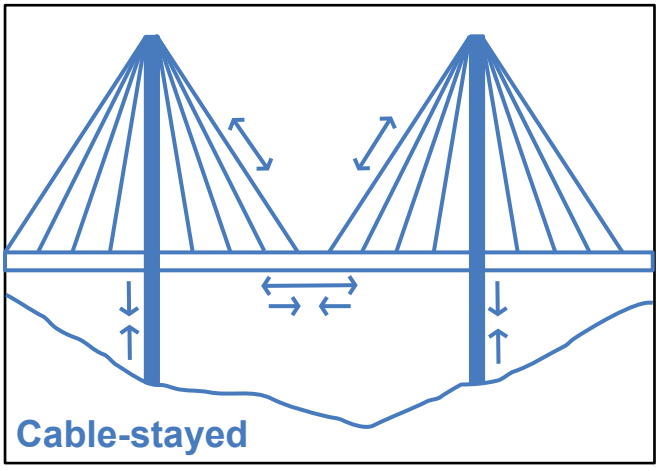
Compression forces are conveyed along the curve of the arch to the supports at the end. The structure is always pushing in on itself.

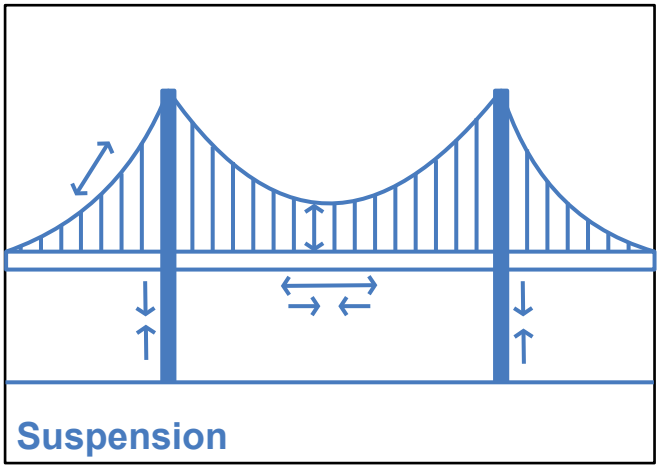
Truss



The deck is in tension. Both compression and tension are distributed through the truss.

There are many other types of bridges, such as suspension bridges, cable-stayed bridges and cantilever bridges. Pick two kinds of bridges to research. Then draw and label the bridge and fill in the tension and compression forces.

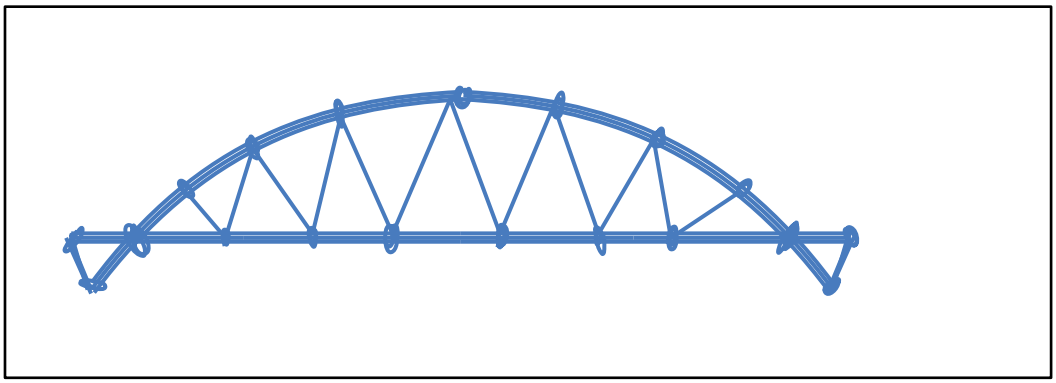

Cable-stayed


Suspension

Build your Spaghetti Bridge

1. Make a plan for the bridge you want to build. It may be helpful to draw it at full size and lay the pieces out before you connect them.
2. Put your bridge together using tape or marshmallows to connect the pieces. Don't be afraid to break the spaghetti into smaller pieces!
3. When your bridge is finished, make a prediction for how much weight your bridge will be able to hold.
4. Use string to attach some weight to your bridge. It may be helpful to tie a paper cup to the bridge and slowly add coins for weight.
5. When your bridge breaks, record the weight. If using coins for weight, record the number of coins added to the cup. If using water, add the water a tablespoon at a time and record how many tablespoons were added.

Draw your bridge!



Predicted weight:

30 marbles

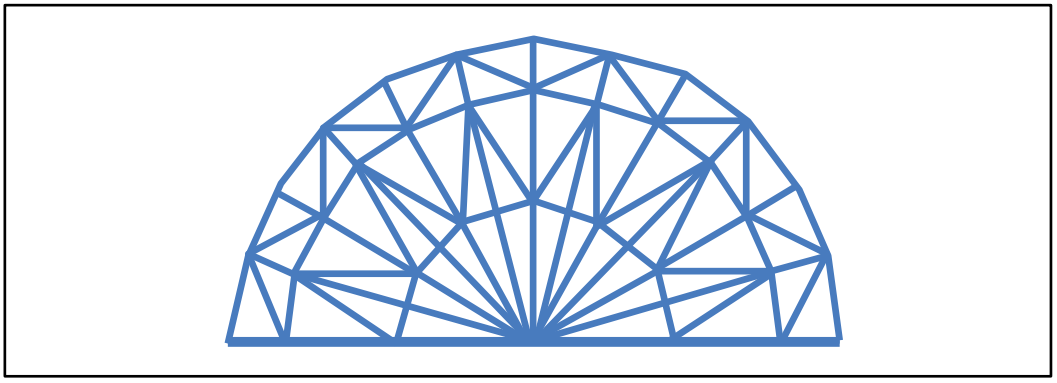
The actual weight:

17 marbles

How would you change your bridge so that it could hold more weight?

1. Make a plan and build a second bridge
2. How much weight do you predict it will hold?
3. Attach the weight and keep adding weight until it breaks.
4. Record the weight.

Draw your bridge!



Predicted weight:

25 marbles

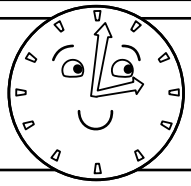
The actual weight:

45 marbles

Did your second bridge hold more or less weight? Why?

The second bridge had more trusses to offer support and a thicker base.

This made it much stronger.



Quiz Time!

ANSWER THE QUESTIONS TO SEE WHAT YOU LEARNED!

① What fraction of Earth's land is "dry land," meaning it loses more water through evaporation than it gains by precipitation?

A 1/2
B 1/3
C 1/4
D 1/5
E 1/6

According to the United Nations and the International Fund for Agricultural Development, the following "dry lands" occupy this percentage of Earth's total land:

Desert (hyper-arid)	6.6%
Semi-desert (arid)	10.6%
Grassland (semi-arid)	15.2%
Total:	***32.4%***

② Name two examples of areas that experience a rainforest climate:

Answers could include: Amazon (parts of Brazil, Bolivia, Peru, Ecuador, Columbia...), Thailand, Malaysia, Indonesia, the Philippines, Papua New Guinea, Costa Rica, Panama, Madagascar, Burundi, Congo, Ethiopia, Gabon, Burkina Faso ...

_____, _____

③ True or False: Polar climates don't receive direct sunlight.

A True
B False

④ Which of these are *consumers* in an ecosystem? Select all that apply.

A Algae
B Herbivores
C Plants
D Carnivores
E Fungi

⑤ Rainforests cover less than _____% of Earth's land but are home to _____% of Earth's plant and animal species.

A 1, 10
B 6, 50
C 10, 20
D 16, 70

Source: World Wildlife Fund and publications from Caltech and Columbia University

⑥ What harmful rays does the ozone layer protect us from? Select all that apply.

A UV-A
B UV-B
C UV-C
D X-rays

One could argue that the ozone layer also protects us from UV-A radiation, but because it only absorbs 5% of UV-A and lets the other 95% through, it doesn't offer much protection from UV-A.

X-rays are absorbed in a region of the thermosphere known as the ionosphere. By the time sunlight reaches the ozone layer, the x-rays have all been absorbed/removed.

⑦ What is ozone gas?

A Three oxygen molecules (O_3)
B One ozone atom
C Oxygen chloride
D Two oxygen molecules (O_2)

⑧ What would life on Earth be like in the year 2050 if the Montreal Protocol had NOT been signed and chlorofluorocarbons had continued being produced?

Answers will vary, but the results would have been really bad! Without the ban on CFCs, by 2050 the ozone layer would have virtually collapsed worldwide. Crops would only grow in greenhouses, and going outside for less than 5 minutes would result in severe sunburns.

⑨ What are organisms that get their energy from eating other organisms called?

A Producers
B Consumers
C Directors
D Hungry

⑩ Ecology is the study of the relationship between _____ and their _____ environment.

A Plants/Living
B Sediments/Physical
C Living organisms/Physical
D Abiotic/Three dimensional

⑪ Approximately what percent of the Earth's land was covered in ice during the last glacial period.

A 10%
B 20%
C 30% Source: National Snow and Ice Data Center (NSIDC) and National Oceanic and Atmospheric Administration (NOAA)
D 40%
E 50%

⑫ True or False: The ozone hole is a literal hole in the atmosphere.

A True
B False The ozone hole is a region located over Antarctica where the ozone layer is severely thinned or depleted.

⑬ In this simple food chain (Algae > Krill > Whales), which organism is the primary consumer?

A Algae
B Krill
C Whales

⑭ List two examples of decomposers:

Answers will vary, but decomposers can include fungi (mushrooms), bacteria. Insects and invertebrates such as millipedes, slugs, snails, earthworms, and beetles.

⑮ True or False: The North Pole is colder than the South Pole.

A True
B False The South Pole is much colder!

⑯ Which of the following are made from or with petroleum? Select all that apply.

A Gasoline
B Plastic
C Polyester clothing
D Rubbing alcohol (hand sanitizer)
E Vaseline

It's possible to find plastics and rubbing alcohol made from biofuel sources (such as ethanol from corn) but most often, each of the products in this list are made or derived from petroleum.

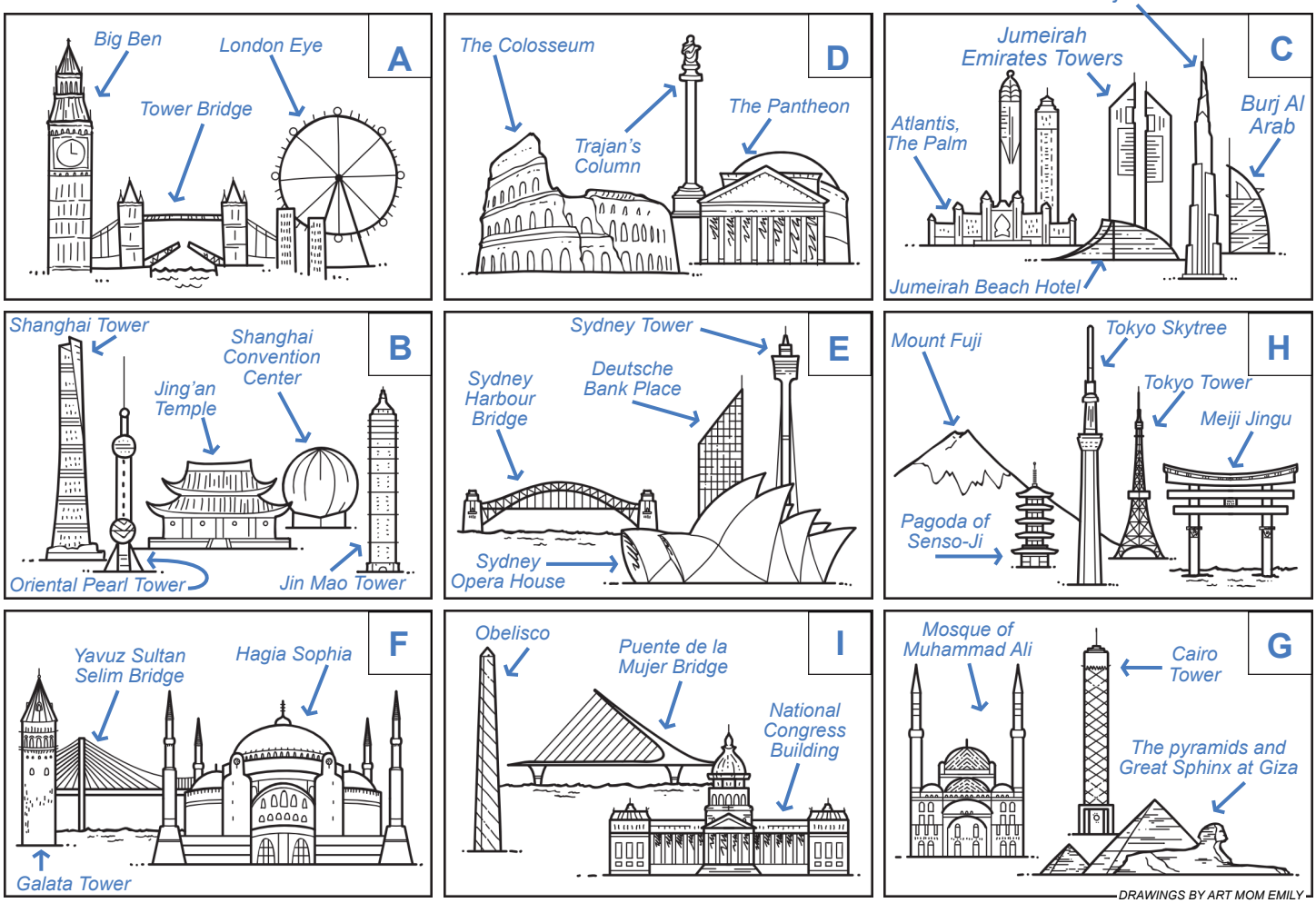
⑰ Fossil fuels like petroleum take _____ years to form.

A 100
B 1,000
C 1,000,000
D 100,000,000
E More than 150,000,000

Some oil reserves can be as young as 100 million years old, but MOST fossil fuels like petroleum and coal are more than 150 million years old.

Where in the World?

Can you match the clue to its drawing and discover the location of each famous city? Once you've matched them, see if you can mark all nine locations on the Peirce quincuncial world map.



A The smallest English city, technically a forest, has an Eye in the sky, and six ravens in its tower.

London*

D Founded in 753 BCE, 50,000 people once cheered its gladiators, and men often wore togas.

Rome

G The "Mother of the World" - or Um al-Dunya - has the world's Second oldest university And the Giza Pyramid.

Cairo

B China's largest city hosts 27 million people and the 2nd longest metro system with 282 stations!

Shanghai

E The deadly funnel-web spider hangs here with 5 million people who play cricket and rugby and listen to opera.

Sydney

H Near an enormous volcano, a city famous for cherry blossoms and its 36 million people who live across 845 square miles.

Tokyo

C A once-small fishing village with a thriving pearl-diving industry, now home to the Burj Khalifa, the world's tallest building.

Dubai

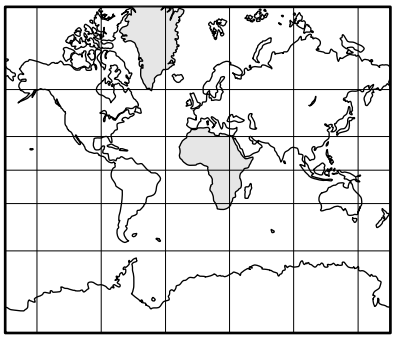
F Home to a church that was once the world's largest. This is the only city located on two different continents.

Istanbul

I Argentina's capital has the tango for its native dance. It's the birthplace of Pope Francis and its name means "Good Air."

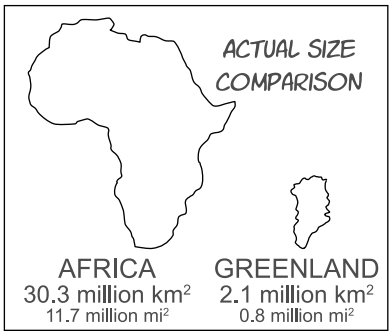
Buenos Aires

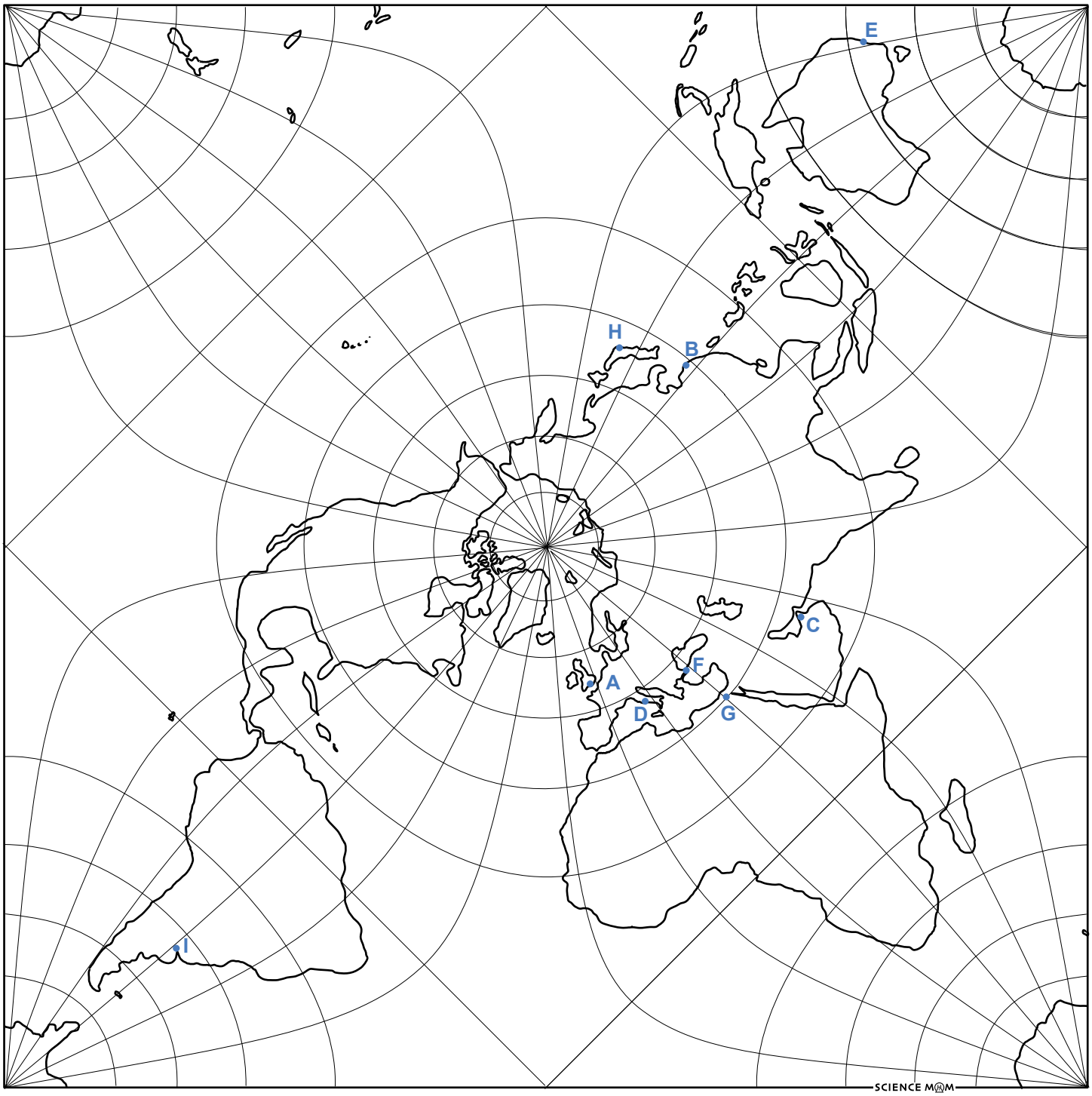
**The actual city of London is only 2.1 square kilometers, which makes it officially the smallest city in England by land area. The Greater London Urban Area, with a population of more than 9 million people, is the largest urban area within the United Kingdom.*



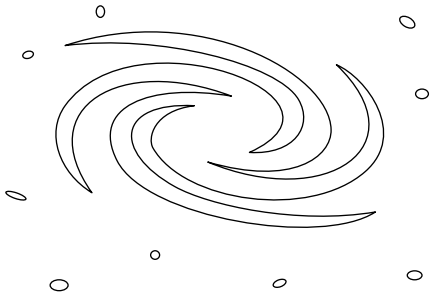
The Mercator map was designed in 1569 and is one of the more common world maps. Its main drawback is that it dramatically inflates the size of objects that are further away from the equator. On the Mercator map, Greenland appears to be as large as Africa. But it's not!

The map below is called the Peirce quincuncial projection and it does a much better job at preserving the relative sizes of the continents.

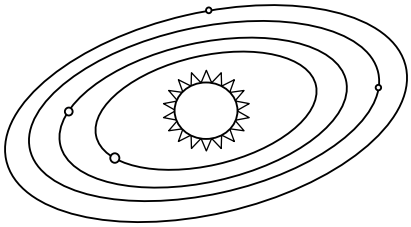




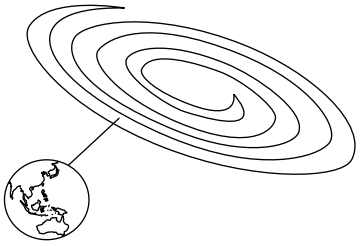
Where do planets come from?



A **GALAXY** can have millions or billions of solar systems as well as dust, gas, and nebulas.



A **SOLAR SYSTEM** is the objects orbiting a sun. It includes things like planets, dwarf planets, and asteroids.



EARTH is the third planet in our solar system, which is in the MILKY WAY GALAXY.

FILL IN THE BLANKS USING THESE WORDS:

nebula

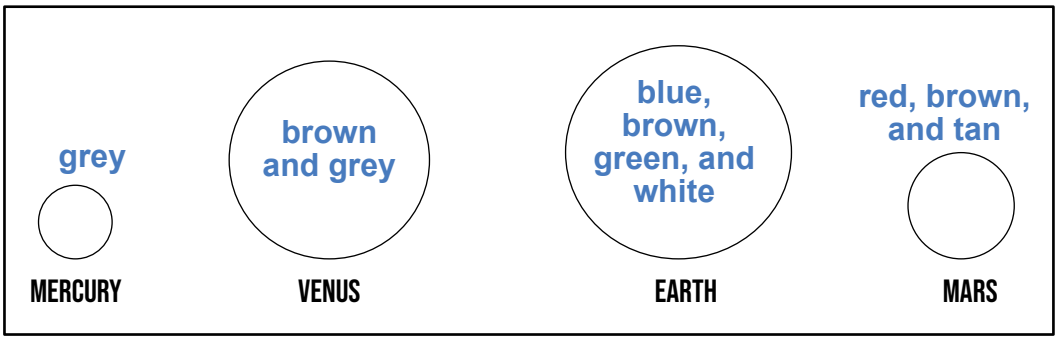
outer

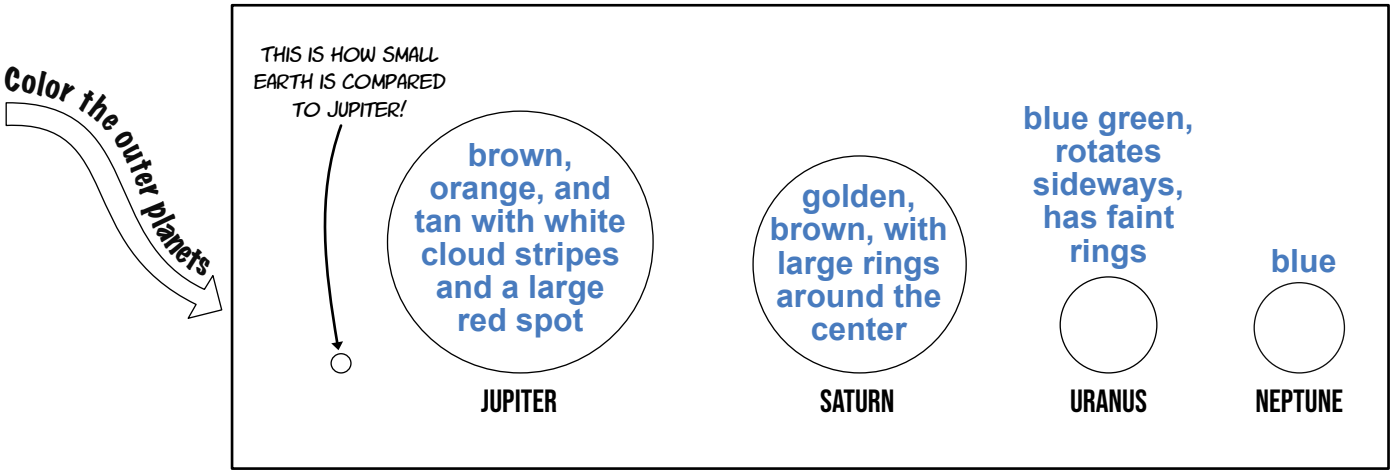
gases

gaseous

asteroid

A stellar nursery or ___**nebula**___ is a cloud of gas that becomes thick and dense enough to condense into a star and planets. In the inner solar system, temperatures are so hot while the planets are forming that most of the ___**gases**___ are boiled away, leaving behind rocky planets. In the ___**outer**___ solar system, temperatures are cooler and gas giants form. Our solar system has 4 rocky planets (the inner planets), an ___**asteroid**___ belt, and 4 ___**gaseous**___ planets (the outer planets).





A mnemonic (pronounced “new-MAH-nick”) is a pattern of letters or ideas that helps you remember something. To remember the order of the planets, you could say a sentence like “**M**y **V**ery **E**xcited **M**onster **J**ust **S**naps **U**p **N**achos.” Invent your own mnemonic for the order of the planets here!

M _____

V _____

E _____

M _____

J _____

S _____

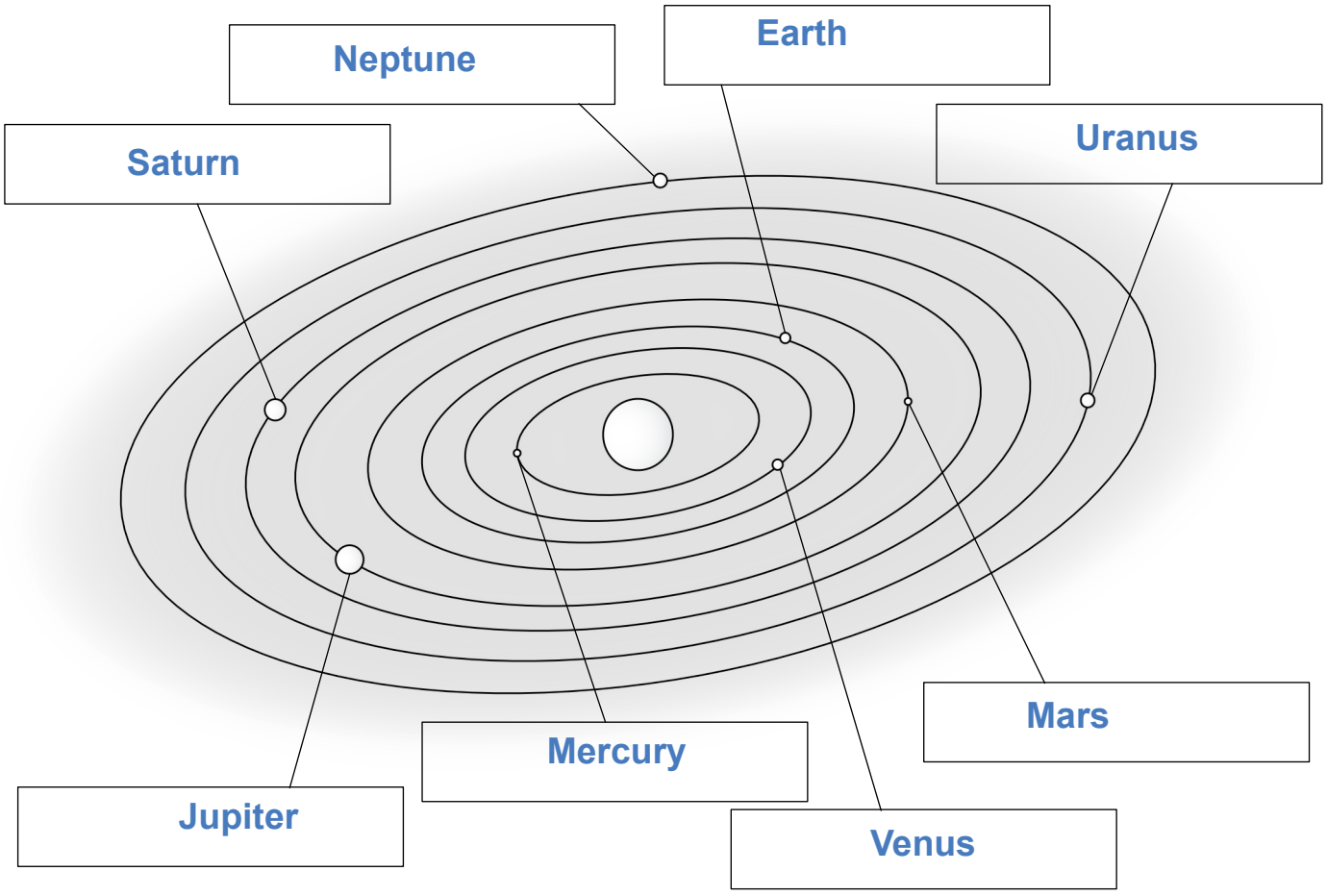
U _____

N _____

Draw a picture of your mnemonic!

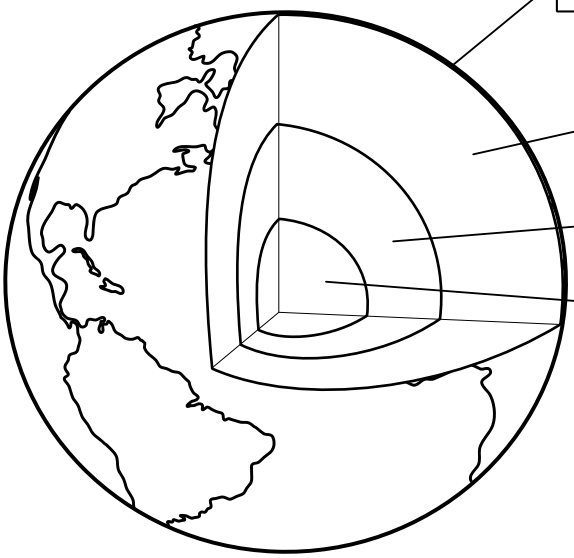
Name the planets in our solar system

All the planets orbit the Sun in the same plane called the Ecliptic Plane. Each planet also orbits in the same direction. Our word "planet" comes from a Greek word meaning "wanderer." Can you label each of the 8 planets orbiting the Sun?



What is Earth made of?

INSIDE OUR PLANET EARTH



CRUST

MANTLE

OUTER CORE

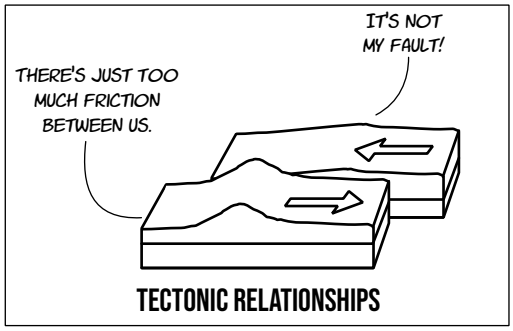
INNER CORE

FILL IN THE LABELS ABOVE USING THESE WORDS:

CRUST MANTLE

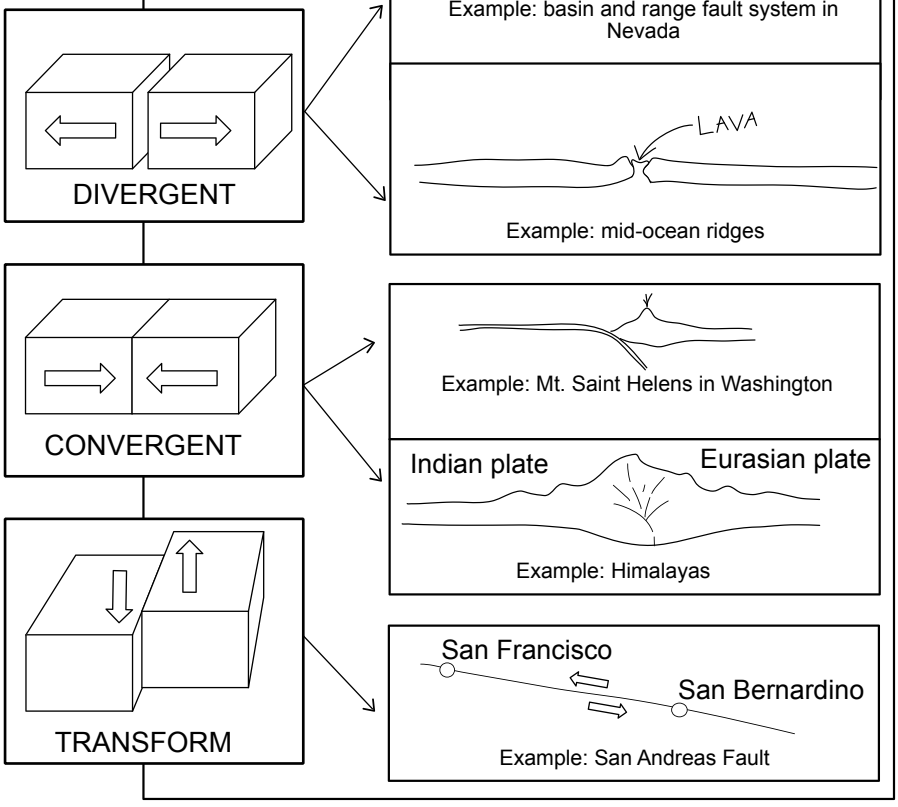
OUTER CORE INNER CORE

The hot ***core*** of our Earth is made mostly of iron and nickel. The inner core is solid while the outer core is liquid. The next layer (the ***mantle***) is like super thick and super hot syrup. It moves about as fast as your fingernails grow, but when it does move, it pushes parts of the ***crust*** around! We call these pieces of crust "continental plates," and when they meet, they can slide past each other (called a TRANSFORM boundary), smash into each other (a CONVERGENT boundary), or pull apart from each other (called a DIVERGENT boundary). All of this pressure and movement creates things like earthquakes and ***faults*** – which is any broken area between two blocks of rock.



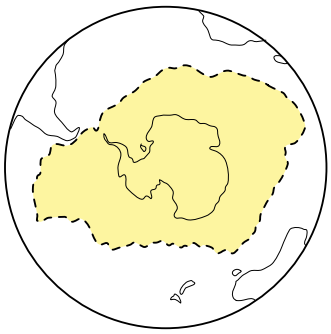
TECTONIC RELATIONSHIPS

TYPES OF PLATE BOUNDARIES:



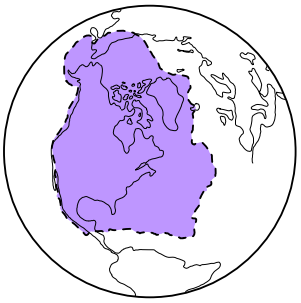
COLOR THE PLATES

Use the clues below to identify and then color each of the tectonic plates shown on the maps:

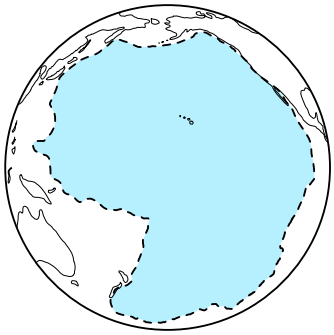


Antarctic Plate

Eurasian Plate



North American Plate



Pacific Plate

GREEN — ***Juan De Fuca Plate*** - This plate slides underneath North America producing volcanoes like Mt. St. Helens!

GREEN — ***South American Plate*** - Home of the Amazon rainforest!

GREEN — ***Philippine Sea Plate*** - The Mariana Trench (deepest part of the ocean) is on the border of this oceanic plate.

YELLOW — ***Indian Plate*** - Home to more than 1 billion people and the tallest mountains in the world.

YELLOW — ***Cocos and Caribbean Plates*** - There are tropical rainforests on these plates.

YELLOW — ***Antarctic Plate*** - This large plate contains the coldest, driest, and windiest land on Earth! Home to several species of penguins.

RED — ***Eurasian Plate*** - Contains the countries of England, Russia, China, and many more!

RED — ***Nazca Plate*** - The pressure of this plate running into South America is responsible for the formation of the Andes mountains.

PURPLE — ***North American Plate*** - This plate has Greenland and most of North America.

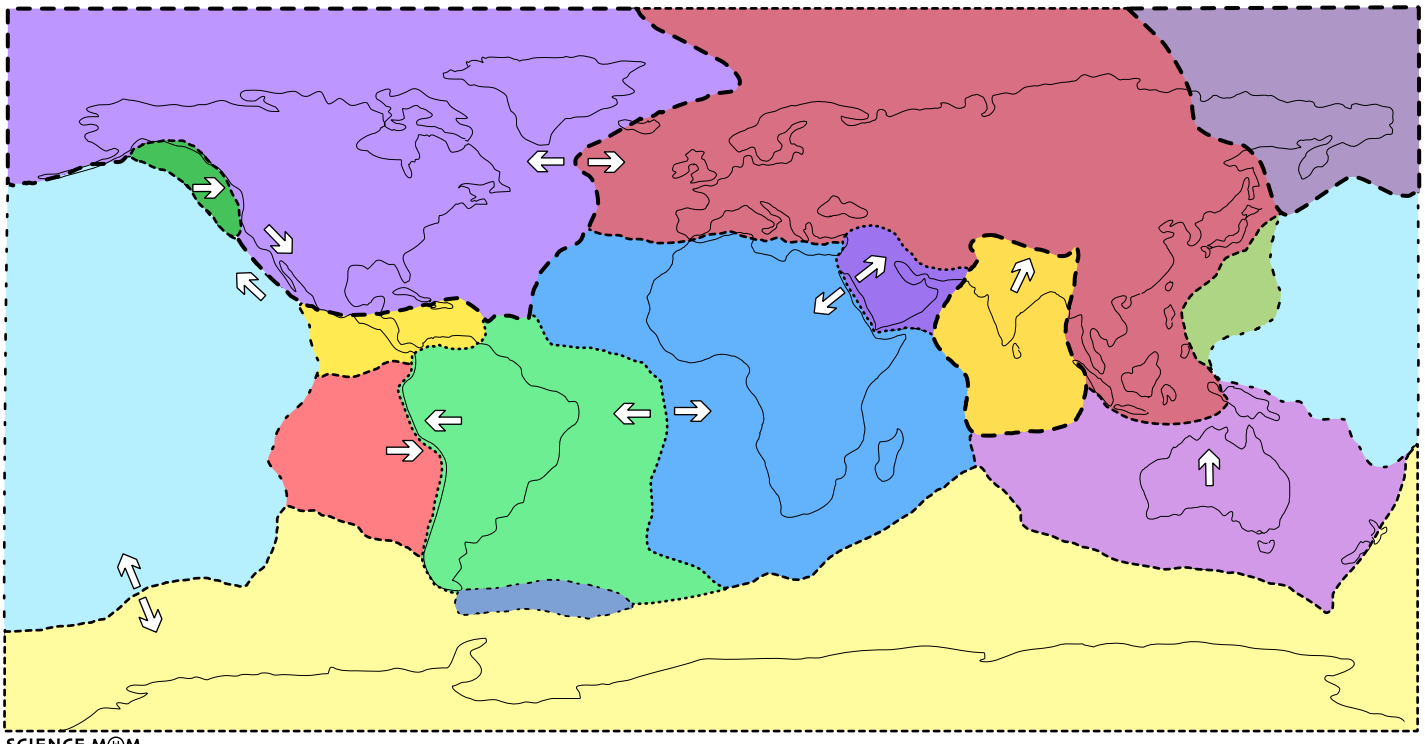
BLUE — ***African Plate*** - Contains the world's largest desert, the Sahara, and the longest river in the world, the Nile.

PURPLE — ***Australian Plate*** - Contains Australia, New Zealand, and parts of New Guinea!

PURPLE — ***Arabian Plate*** - Contains the countries of Saudi Arabia, Oman, Yemen, and more.

BLUE — ***Pacific Plate*** - The largest tectonic plate and responsible for a lot of volcanoes. It's border is sometimes called "The ring of fire!"

BLUE — ***Scotia Plate*** - Most of this plate is underwater!



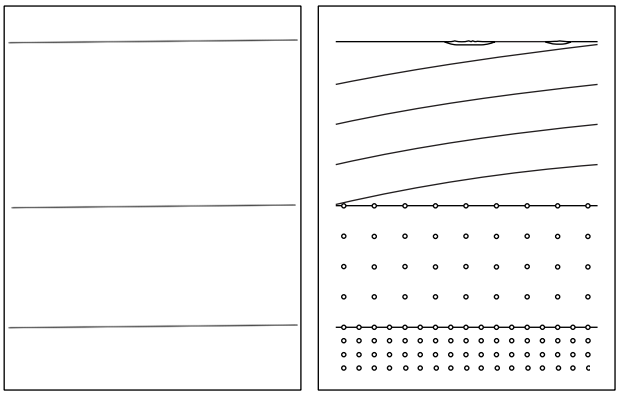
Layers of the Earth ART PROJECT

Print the Layers of Earth template (page 119) OR create your own using a ruler by marking straight lines across the paper at the following heights:

25.4 cm or 10” from bottom (crust)

13.3 cm or 5 ¼ inches from bottom (boundary of outer core)

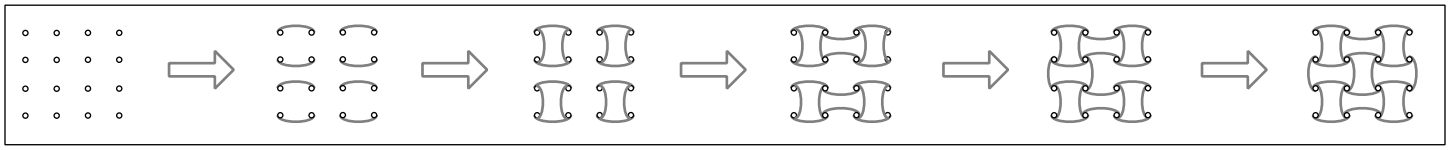
4.4 cm or 1 6/8 inches from bottom (boundary of inner core)



DRAW YOUR OWN OR USE THE TEMPLATE

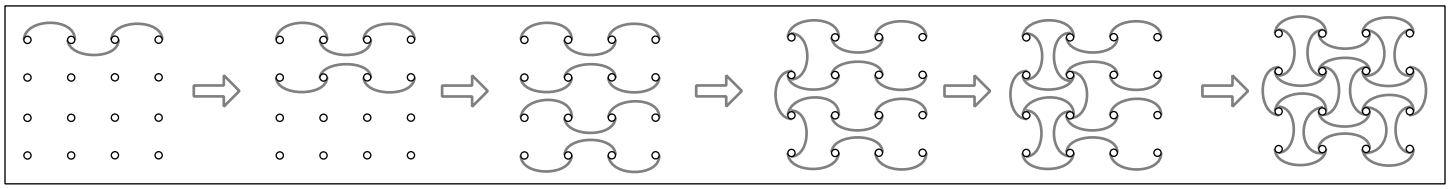
INNER CORE LAYER

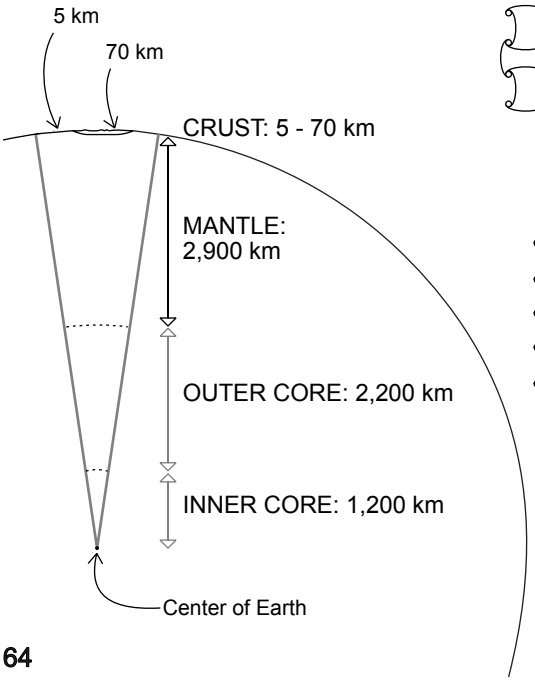
Create a grid of circles or dots and then draw the curve of a letter “c” to link them in a pattern like this:

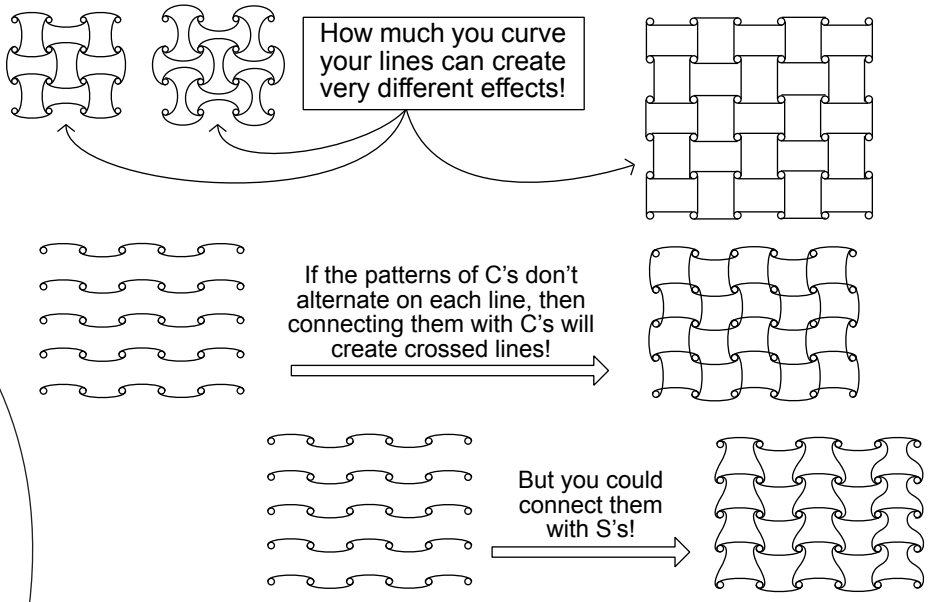


OUTER CORE LAYER

Same pattern as above, just bigger! Create a grid of circles or dots, then curve lines to link them in a pattern like this:

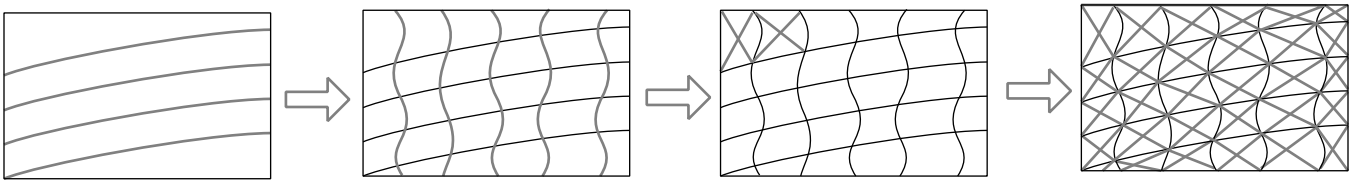






DON'T WORRY IF SOME OF YOUR LINES CURVE MORE THAN OTHERS OR IF YOU HAVE AN "OOPS!" WITH YOUR PATTERN. VARIETY IN ART IS GREAT!

MANTLE LAYER



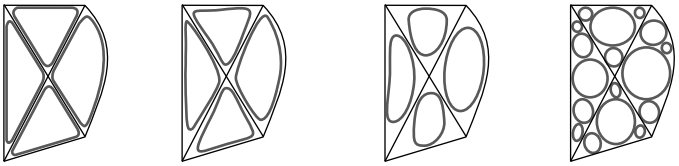
Draw some diagonal or curved lines.

Draw curvy vertical lines.

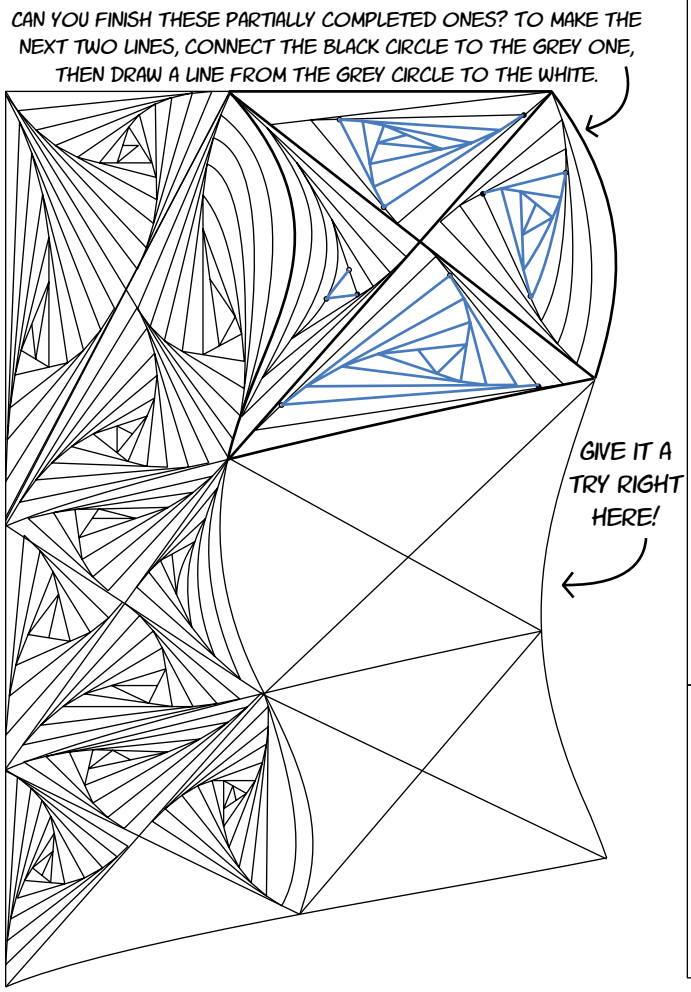
Make an “x” in each box.

Color it in as it is or choose a doodle design pattern (or invent your own!)

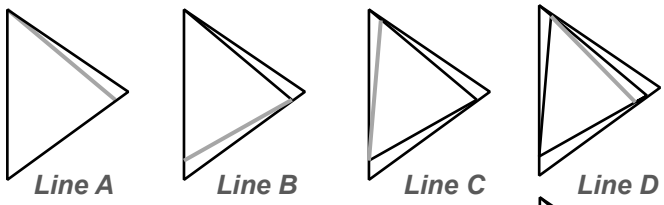
Doodle 1: Stained glass bubbles.



Draw “bubbles” in each shape. They can be super round, or fill in as much of the space as possible. Either one is fine! There are no “rules” in this art. Enjoy doodling and discovering the design. Each time you do it, it will look different!

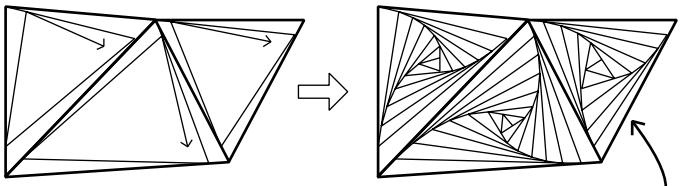


Doodle 2: telescoping triangles!

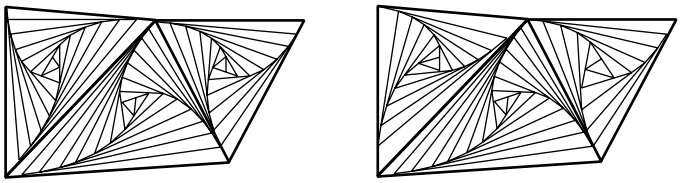


This one can be a little tricky! Don’t worry if it takes some practice. Start at one corner of your triangle and draw from that corner to just below the opposite corner (line A). Keeping your pencil at that point, draw a new line to the opposite side of the triangle, hitting just a little bit “up” from the corner (line B). Repeat that step (line C) and keep going until you close your triangle.

If you think this looks cool, just wait until you see what happens if you do three triangles that are next to each other!

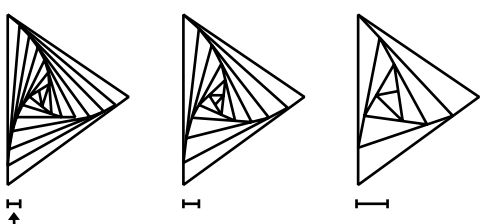


These three are all filled in with a clockwise direction.



Counter clockwise.

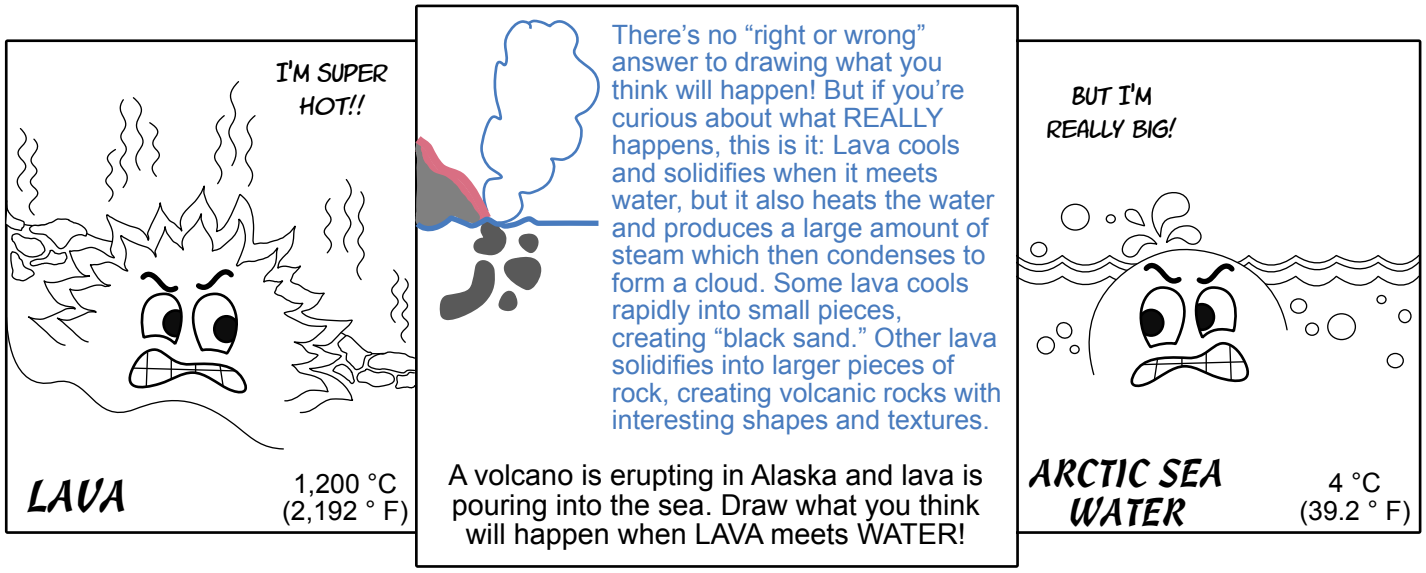
Alternating.



What happens if the distance varies.

Igneous Rocks

ALL ABOUT LAVA!



FILL IN THE BLANKS USING THESE WORDS:

magma

igneous

lava

chocolate

What happens if you heat a rock to more than 1,000 degrees Celsius? It melts! Just like a piece of ___chocolate___ turns to liquid in a hot car, solid rock melts into lava. Melted rock *inside* Earth is usually called ___magma___, and melted rock *on Earth's surface* is called ___lava___. When lava cools down, it solidifies back into rock. What type of rock? Well that depends on how much gas the lava contained, how much silica it has, and how quickly it cools. Any type of rock that comes from lava is called an ___igneous___rock.

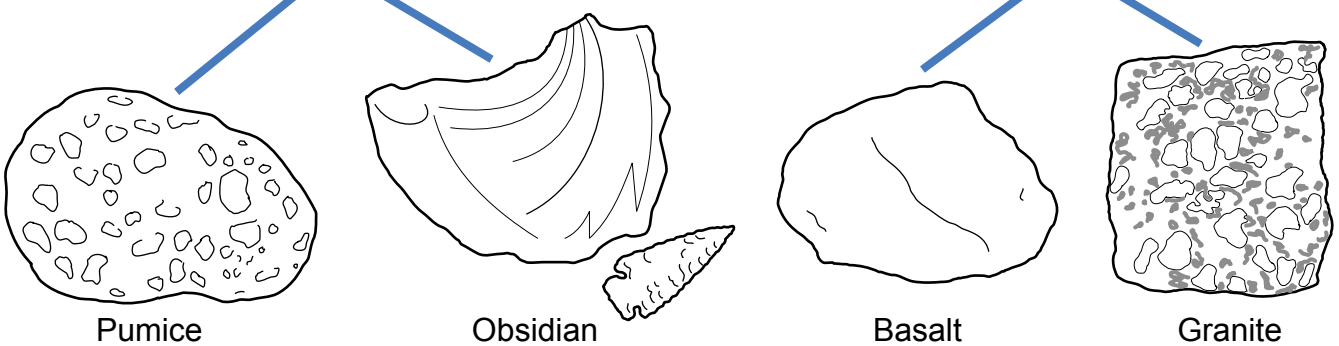
DRAW A LINE TO MATCH THE IGNEOUS ROCK TO THE CORRECT FACT BOX

This rock was used to make knives and tools and can be sharper than a steel razor.

This rock contains so many little pockets of air that it often floats on water!

This rock is very popular in construction, from Egyptian pyramids to modern kitchen countertops.

More than 90% of all volcanic rock on Earth is this type of rock!



Pumice

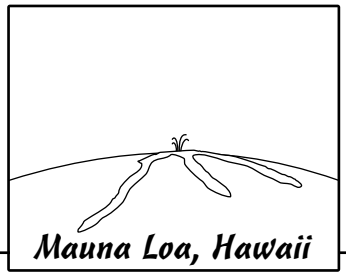
Obsidian

Basalt

Granite

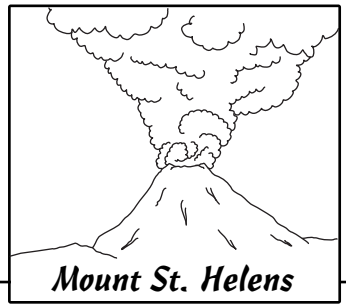
Anatomy of a Volcano

Three ACTIVE VOLCANOES:



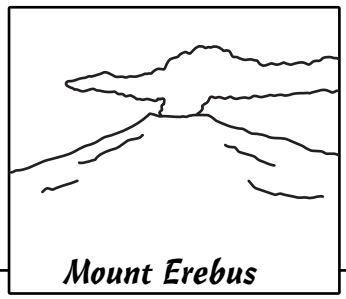
Mauna Loa, Hawaii

This is the largest volcano on Earth. It's a shield volcano, which means it has a gentle slope and eruptions that are almost always fluid or "runny" lava.



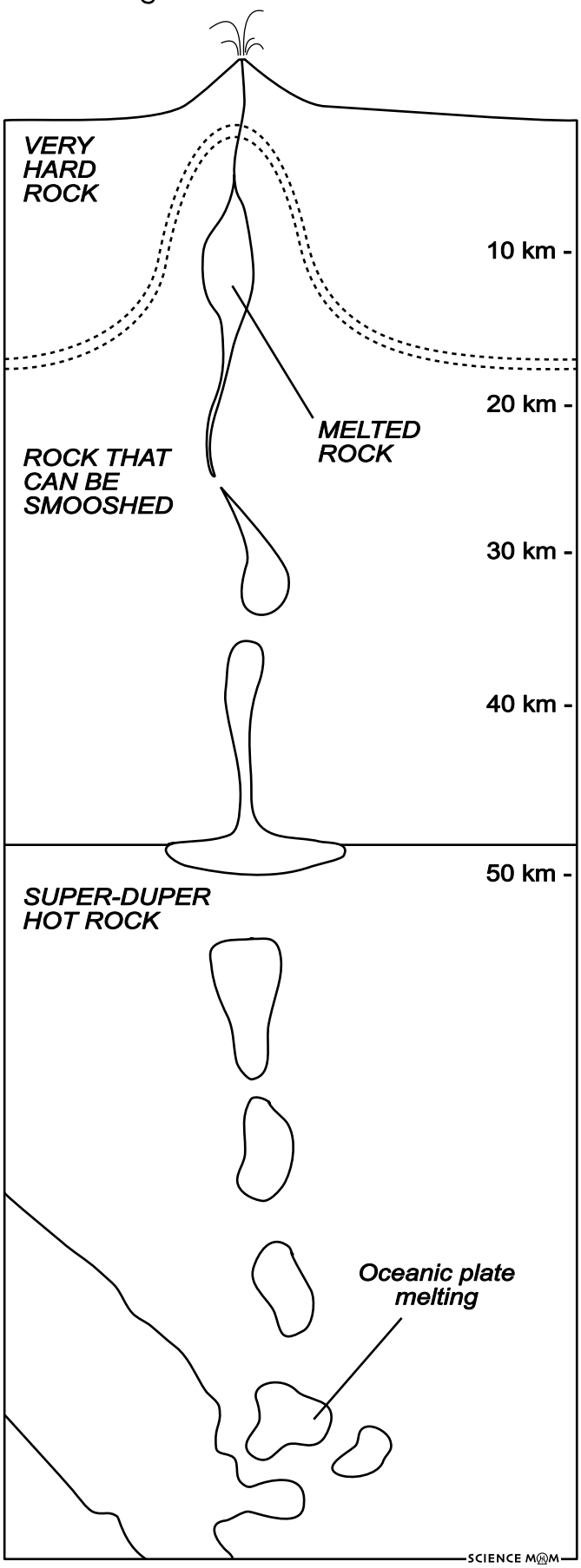
Mount St. Helens

This stratovolcano had an enormous eruption on March 20, 1980 and several smaller ones in the decades afterward. Instead of runny lava, this volcano sends clouds of superheated ash into the sky.



Mount Erebus

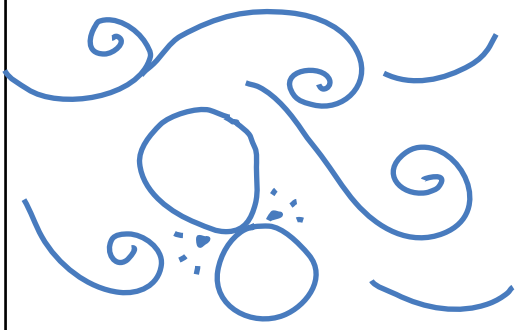
Mount Erebus is the most active volcano in Antarctica and contains a lava lake! There are only 4 long-lasting lava lakes on Earth. The other 3 are located in the Congo, Ethiopia, and Vanuatu.



EROSION

Wind and water are the most powerful forces of erosion and weathering on our planet. But they aren't the only things that cause rocks to break down and move around! Animals, plants, and chemical reactions play a role too. Draw a picture of each event in the boxes on the left. You can choose from one of the examples below or make your own!

Swiftly moving water picks up rocks and smashes them into other rocks, breaking off pieces.



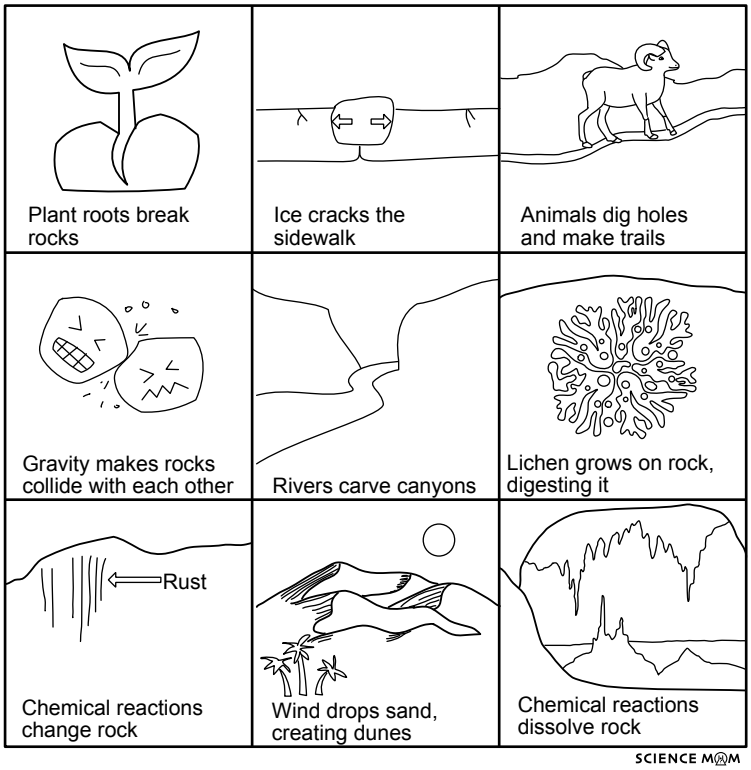
WEATHERING breaks down rocks into smaller pieces

Wind and water slowly remove pieces of rock, forming an arch.

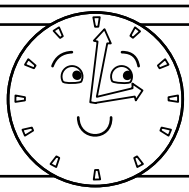
EROSION moves pieces of rock or sediment to another place

Beaches are an example of deposition! The sand was all brought in and dropped by the water.

DEPOSITION drops sediment into a new location



SCIENCE MOM



Quiz Time!

ANSWER THE QUESTIONS TO SEE WHAT YOU LEARNED!

1 The Earth's inner core is up to _____ times hotter than our atmosphere.

A. 60
B. 600
C. 6,000
D. 60,000

The temperature of the inner core of the Earth is estimated to be over 5,200 °C, which is as hot as the surface of the sun! The temperature of the atmosphere all depends on elevation, but most of it is well below 0 °C.

2 What are the two main types of tectonic plates?

Oceanic , Continental

3 What is the name of the transform boundary in California that causes many earthquakes each year?

A. San Andreas Fault
B. The Ring of Fire
C. Pacific Subduction Zone
D. Cascadia Subduction Zone

4 True or False: on average, continents move toward or away from each other at the same rate that human fingernails grow.

A. True
B. False

Mostly true. The "fingernail growth" speed of ~ 2.5 cm (1 inch) per year is actually quite fast - rift valleys and Australia move this quickly. Other continents move more slowly.

5 What kind of volcanoes tend to form over subduction zones?

A. Stratovolcanoes
B. Cinder cones
C. Shield volcanoes

6 Seasons are caused by:

Earth's tilt of about 23°

7 The universe is mostly made of which two elements?

A. Iron and Silicon
B. Carbon and Oxygen
C. Hydrogen and Helium
D. Plutonium and Uranium

8 Which of the following are gaseous planets?

A. Jupiter
B. Venus
C. Neptune
D. Mercury

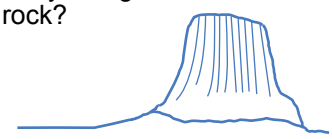
The definition of a gas giant depends slightly on who you ask! Some scientists and educational websites classify Neptune and Uranus as gas giants. Others argue that Neptune and Uranus are different enough from Jupiter and Saturn that they should be in a third category: ice giants. In my opinion, the latter argument (Neptune is an ice giant) is best.

9 True or False: Earth's inner core is as hot as the surface of the sun.

A. True
B. False

10 Which national monument in Wyoming is a well-known example of igneous rock?

Devil's Tower National Monument



11 Which of these can erode and transport rock? Select all that apply.

A. Water
B. Wind
C. Gravity
D. Freezing temperatures

When water freezes it expands and pieces of rock can be moved. It works on a smaller scale than water or wind, but it's still moving sediment.

12 Which type of rock most often has layers?

A. Igneous
B. Sedimentary
C. Metamorphic

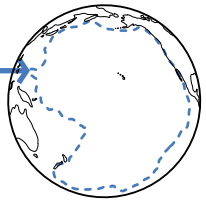
Since we hadn't yet covered sedimentary rocks in the notes or in class, this was an extra tricky question. Don't worry if you didn't know the answer!

13 When an oceanic and continental plate collide, what usually happens?

A. The continental plate covers the oceanic plate, forming a subduction zone.
B. The oceanic plate covers the continental plate, forming a subduction zone.
C. The plates push together, forming a tall mountain.

14 What is the name of the most volcanically active region or zone on Earth?

The Ring of Fire!



The Ring of Fire contains more than 450 volcanoes!

15 How deep is the Earth's crust?

A. Between 5-70 kilometers
B. Between 75 - 200 kilometers
C. Exactly 347 kilometers
D. Approximately 500 kilometers

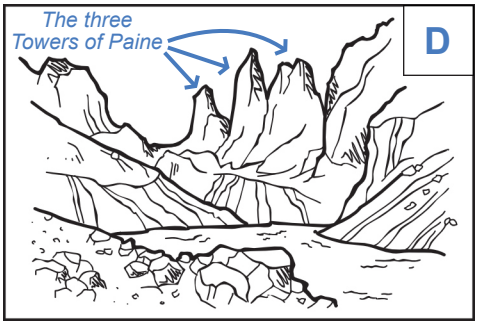
16 Which is larger, a solar system or a galaxy?

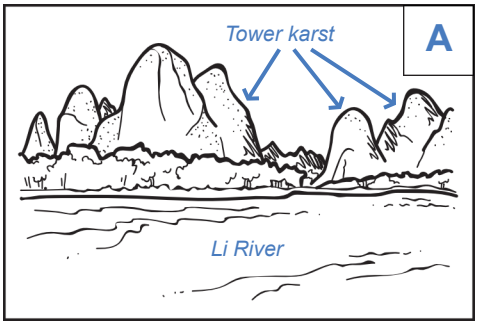
A. Solar system
B. Galaxy

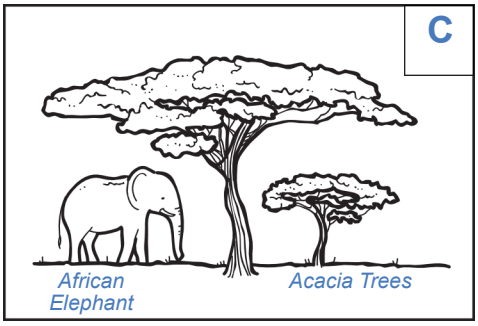
A galaxy can contain BILLIONS of solar systems.

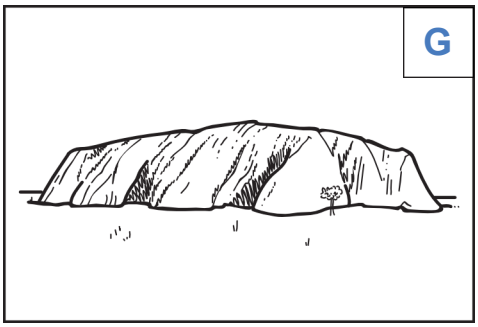
Where in the World?

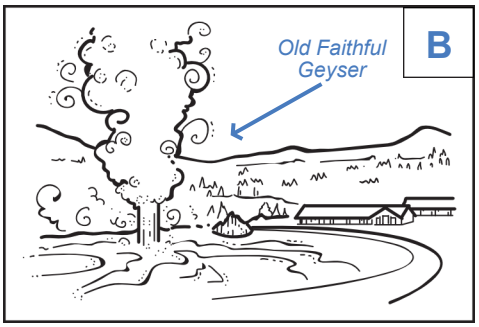
Each of these clues belongs to a National Park or nature preserve. Can you match the letter of the clue with each drawing? Then, once you've matched them, place a dot on the map locating the park! See if you can mark all nine of them on the Cahill-Keyes world map.

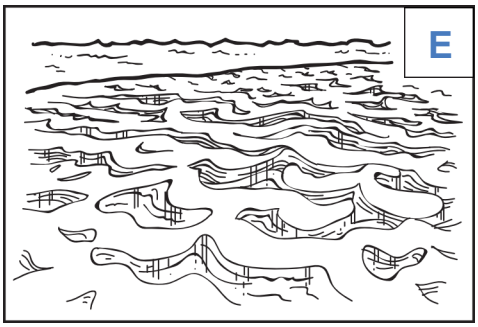


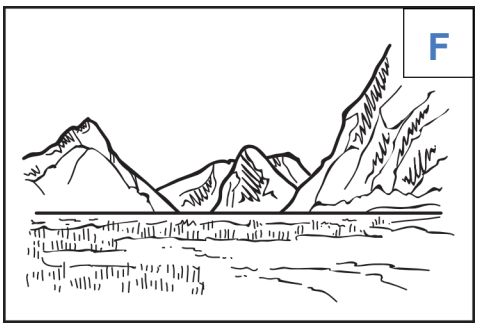


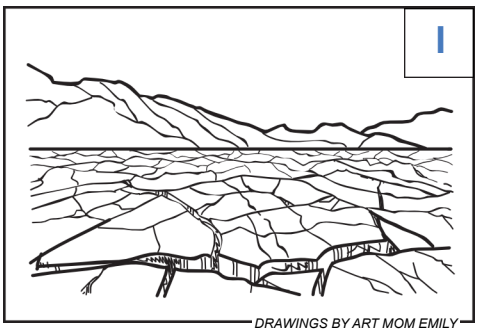












DRAWINGS BY ART MOM EMILY

A This dramatic landscape of karst towers covered with trees has hundreds of dolines and caves surrounding the River Li.

Guilin Lijiang

B Over 67 species of mammals wander a land of 10,000 geysers, hot springs, and fumaroles. The world's first national park.

Yellowstone

C Here near the equator one can see rhinos and 500 bird species, thunderous wildebeest migrations, lions, leopards, and cheetahs too.

Serengeti

D A park with lakes and rivers, forests and fiords, glaciers fed by a Patagonian ice field, plus steppe, shrub, and desert.

Torres del Paine

E Imagine white sweeping dunes, yet not a desert - these dunes transform into blue lagoons during seasonal monsoons.

Lençóis Maranhenses

F Narrow fiords between steep cliffs were carved by giant glaciers. Islands here protect the kakapo and kiwi, endangered flightless birds.

Fiordland

G Taller than the Burj Khalifa, this sandstone rock extends 1.6 miles underground and takes 3 ½ hours to walk around.

Uluru

H In the "Land of Beautiful Horses," underground homes, tunnels and churches are carved in rock from ancient volcanic ash.

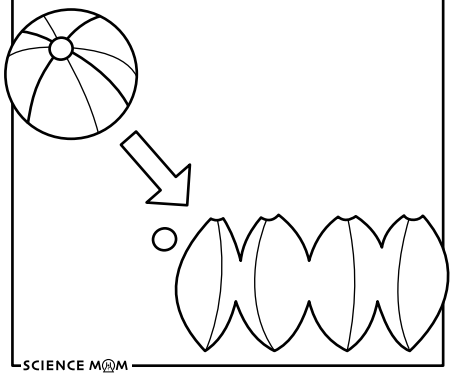
Göreme National Park

I Deadly hot with sand dunes and salt flats 85 m below sea level. This desert park also has fossils from an ancient lake and mountains covered with winter snow.

Death Valley

Imagine you had a beach ball with a treasure map printed around the sides. How could you lay it on table with all parts visible at once?

You'd have to cut it up! These two maps do exactly that. Because of that, they both have very little or no distortion.



SCIENCE MOM

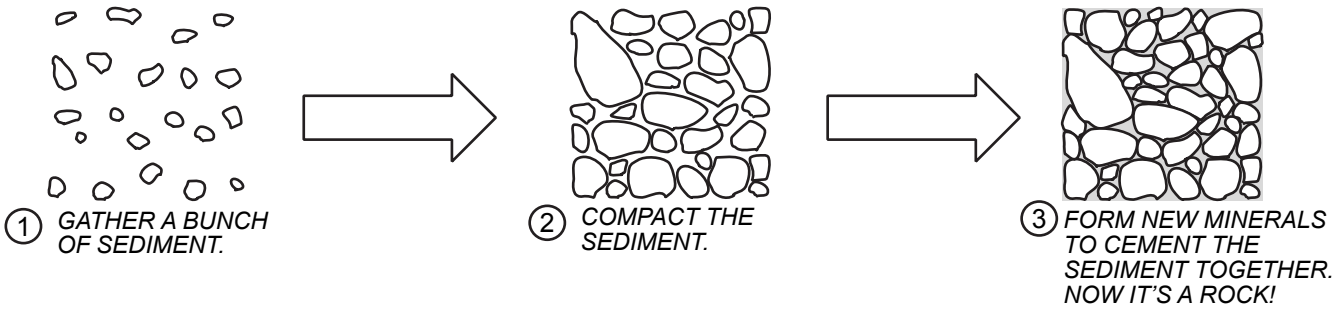
Cahill-Keyes projection
Designed in 1975

Goode homolosine projection
Designed in 1923

Sedimentary Rocks

ALL ABOUT EROSION AND SEDIMENTS!

HOW TO MAKE A SEDIMENTARY ROCK:



1. GATHER A BUNCH OF SEDIMENT.
2. COMPACT THE SEDIMENT.
3. FORM NEW MINERALS TO CEMENT THE SEDIMENT TOGETHER. NOW IT'S A ROCK!

Most of the rocks we see on land are SEDIMENTARY rocks. They are formed from sediments like clay or sand that get cemented together. Sediments can come from lots of different places, but erosion is one of the most common sources!

Unscramble the words in the above boxes to discover all of the different things that can cause erosion.

DIWN	W	I	N	D					
			6	3					
WETRA	W	A	T	E	R				
				2					
SAVEW	W	A	V	E	S				
					1				

RISRVE	R	I	V	E	R	S			
				5					
CEI	I	C	E						
	4								
TORFS	F	R	O	S	T				
					7				

ALL OF THE FORCES ABOVE CREATE:

S	E	D	I	M	E	N	T	S
1	2	3	4		5	6	7	

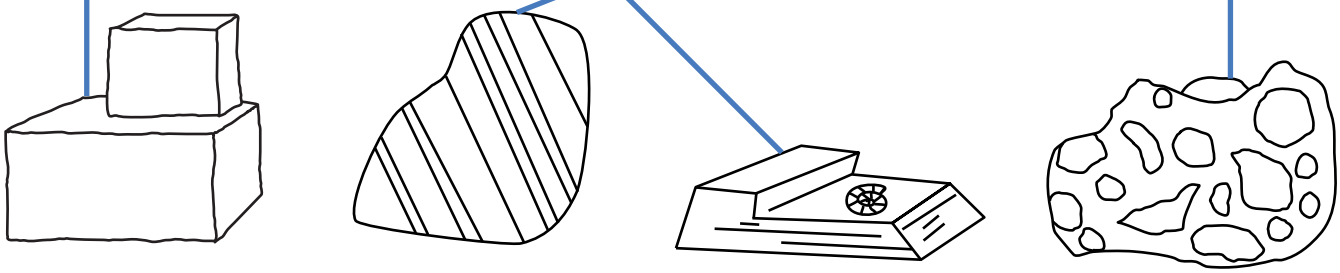
DRAW A LINE TO MATCH THE SEDIMENTARY ROCK TO THE CORRECT FACT BOX

This rock is sometimes used to make buildings or statues. Caves are formed in this kind of rock.

This is the most common sedimentary rock. It is formed from ancient mud flats. Sometimes this rock breaks into thin layers, and in between the layers, fossils are found!

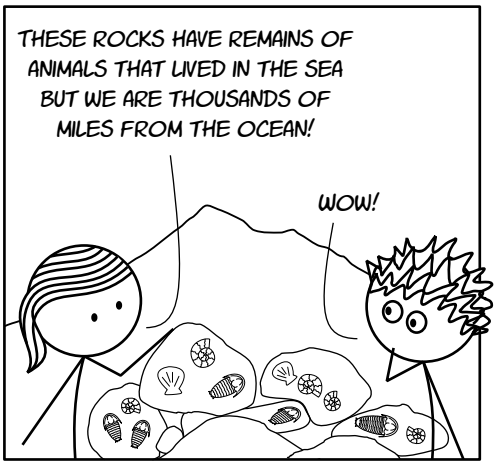
This rock is made from sand. Sometimes these rocks have beautiful orange and red stripes.

Ancient river beds turn into this type of rock, which looks a bit like a bunch of pebbles smooshed into playdough.



Limestone Sandstone Shale Conglomerate

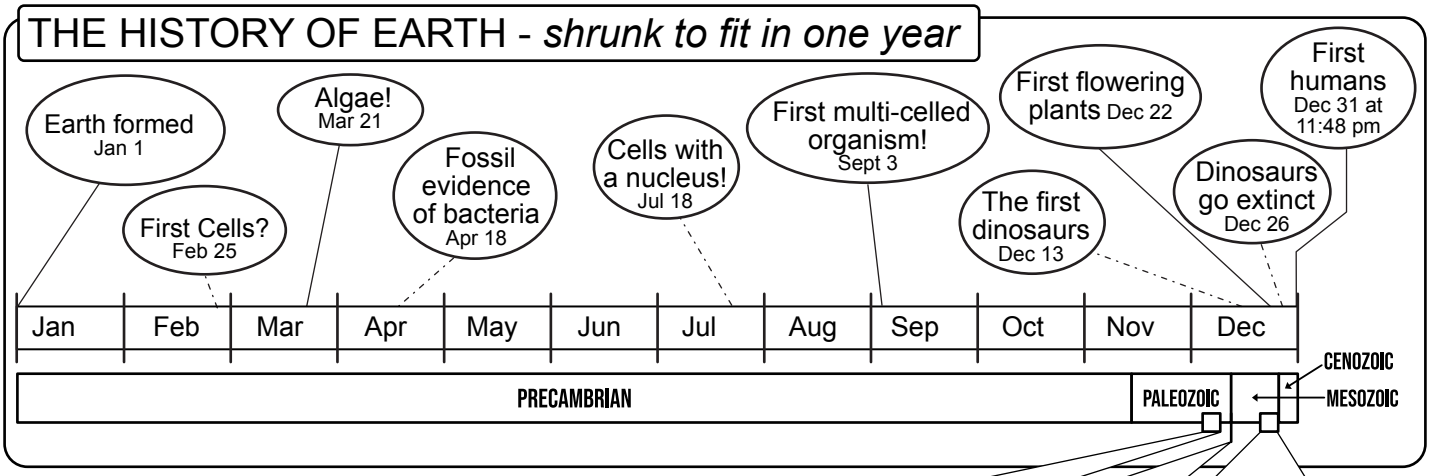
Geologic TIME



How do fossils of animals that live under water end up on top of mountains? The answer is time - and LOTS of it! Scientists have divided Earth's history into ERAS and PERIODS.

Each *era* has different conditions and fossil records. The first three eras of Earth's history are often called the "Precambrian," because the Cambrian *period* (the first part of the Paleozoic era) is when Earth first had abundant animals. The next three eras could be nicknamed the age of insects and plants (Paleozoic), the age of reptiles (Mesozoic), and the age of mammals (Cenozoic).

To appreciate just how long these eras are, it helps to match them to a calendar year. If all of Earth's history were squished to fit in one calendar year, this is what it would look like:

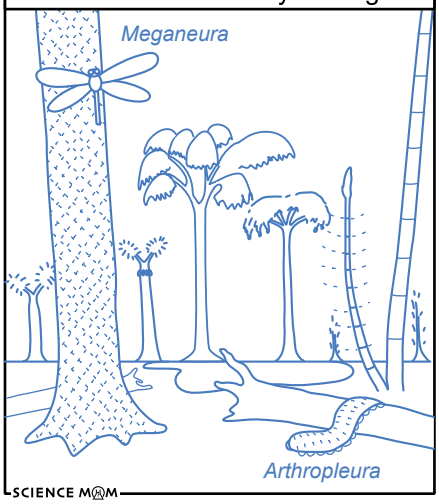


Tropical climate worldwide with abundant plants (ferns, cycads, and lycopsids), huge insects, and much higher levels of both oxygen and carbon dioxide in the atmosphere.

Flowering plants developed and dinosaurs roamed the Earth!

CARBONIFEROUS PERIOD

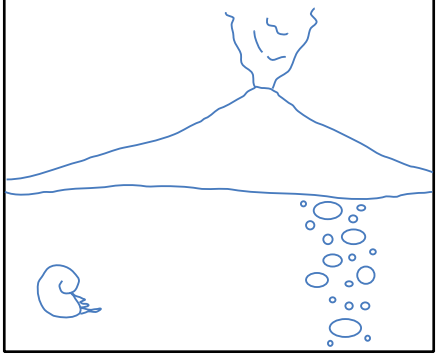
358.9-298.9 million years ago



P-T EXTINCTION EVENT

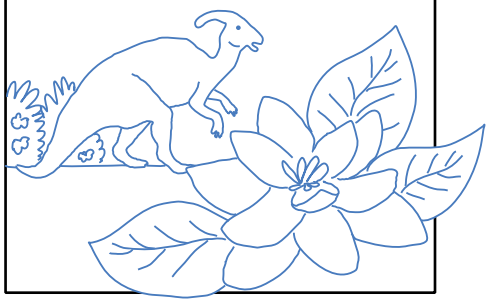
252 million years ago

Known as "The Great Dying," Nearly 90% of marine life and 70% of terrestrial species became extinct. One cause of this event was climate change brought on by large releases of underwater methane.



CRETACEOUS PERIOD

145-66 million years ago

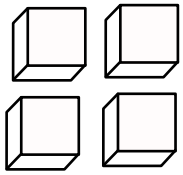


SCIENCE MOM

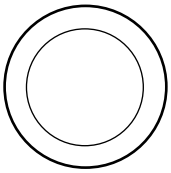
Hands-on Activity

CANDY ROCK CYCLE

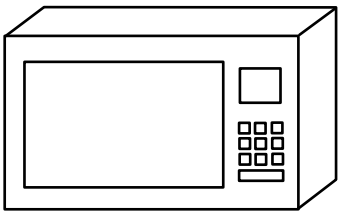
MATERIALS:



4 Starburst candies



Paper plate



Microwave

Lets make some candy rocks!

1. Unwrap 4 Starburst candies.

2. Tear (or cut with scissors) each candy into small pieces. You may need to soften the candy in your hand first.

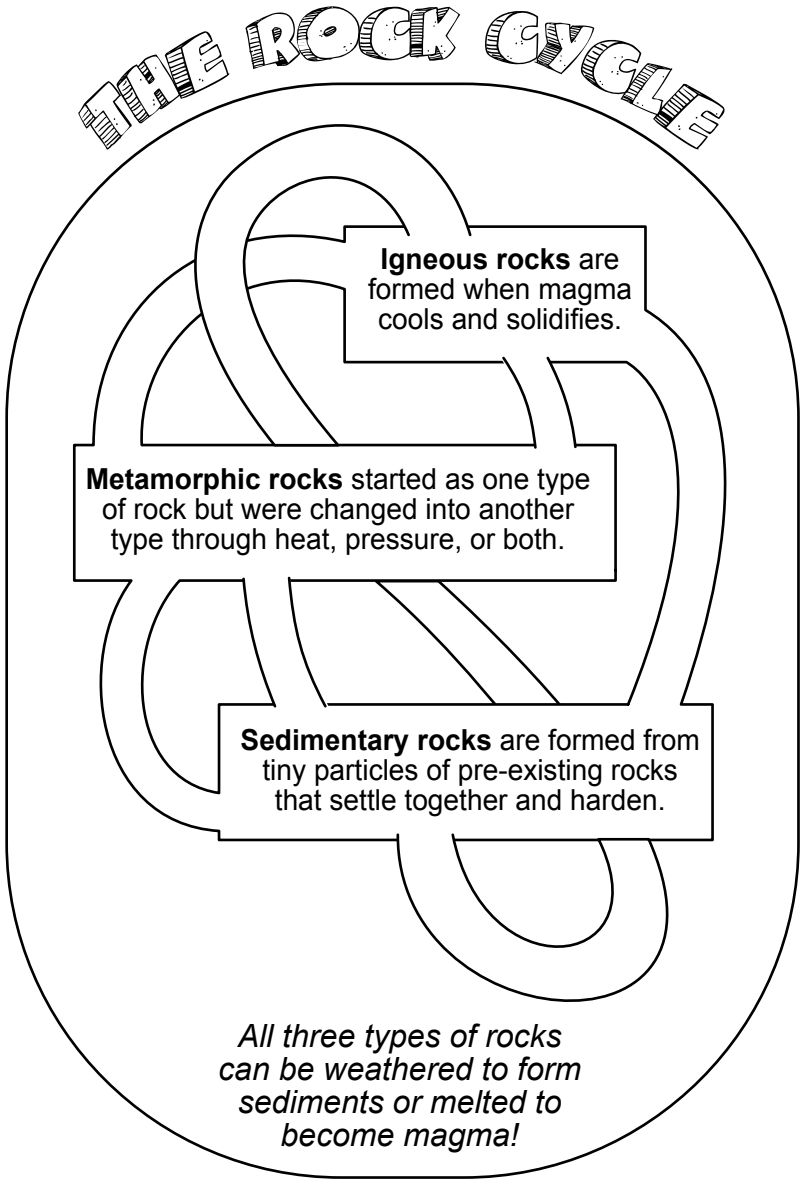
3. Hold the pieces in your hand and smash them together into a lumpy ball. This is your sedimentary rock.

4. Next, use the warmth of your hand and pressure to turn your sedimentary rock into metamorphic rock. You may also try using books and your feet. Put your "rock" into a plastic bag if you don't want to get sticky.

5. Now it's time to make some magma! Place your metamorphic rock on a paper plate and microwave for 15 to 20 seconds. Stop the microwave as soon as it begins to melt and bubble. The longer it cooks, the harder your candy will end up.

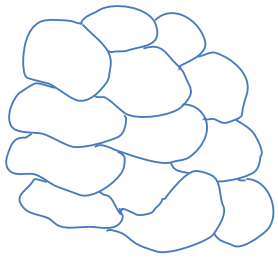
6. Don't touch! The magma is very hot and may need up to 10 min to harden and cool. Try putting it in the refrigerator if you want it to cool faster.

7. When the magma hardens and cools, the igneous rock is formed. It is safe to eat, but may be tough and chewy!

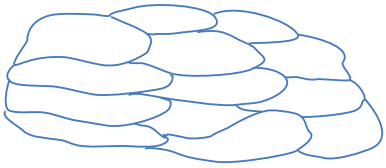


Draw a picture of your rock and then describe it! Which was your favorite?

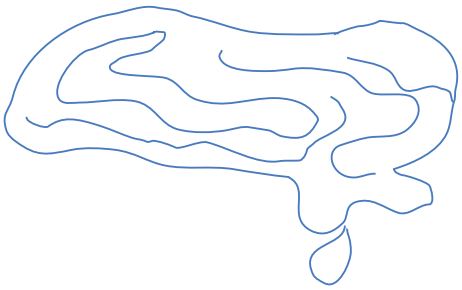
Sedimentary



Metamorphic



Igneous



How these turn out all depends on how soft and warm the candy is and how much pressure is applied.

Hopefully you observed that the sedimentary rock has more distinct colors and could almost be “pulled apart” to separate it back into the original Starburst flavors.

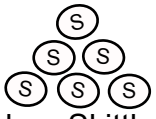
The metamorphic rock should have been much more compact and solid, with some colors running together, and the igneous rock should have melted to the point that colors mixed entirely. Some bubbles may have formed too, depending on how long it was heated.

Hands-on Activity

CARBON DATING WITH CANDY

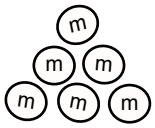
MATERIALS:

Cup



1 bag Skittles

IF YOU DON'T HAVE SKITTLES, THAT'S NO PROBLEM! YOU CAN ALSO USE:



About 50 m&m candies

OR

About 50 pennies

OR

Any other small item that has two distinct sides

Calculating half-life

1. Count out 50 Skittles and place them in the cup. Record your starting number of Skittles in your table.

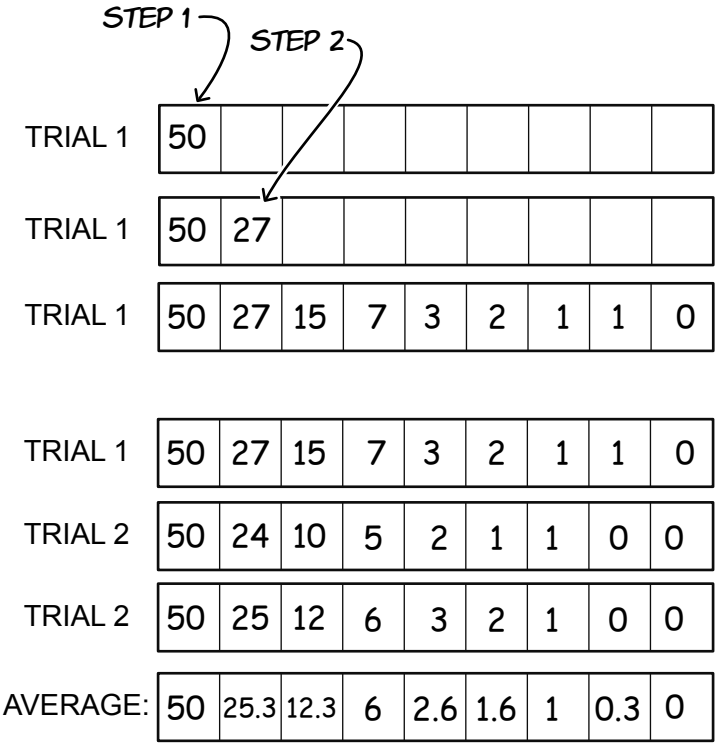
2. Shake the cup and pour the candy out on the table. The Skittles that landed S-side up are radioactive and the candies that landed S-side down have decayed. Count the number of decayed isotopes and record it in your table. Set them aside.

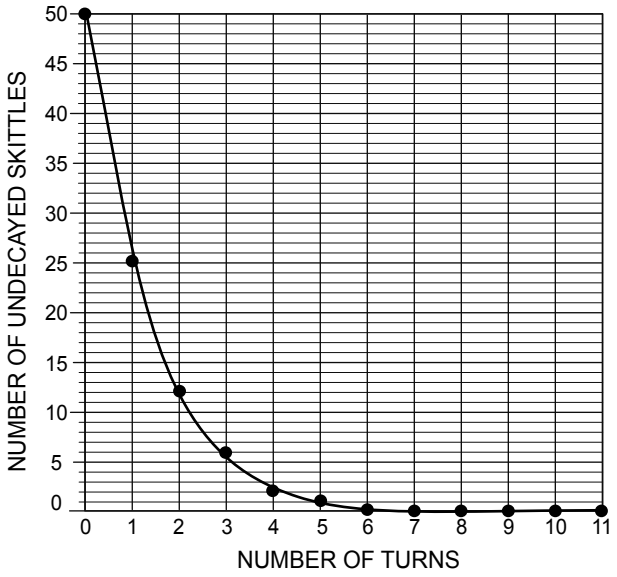
3. Place your radioactive isotopes back in the cup and shake them up. Pour them out on the table and count your decayed isotopes, recording the number in the table. Set them aside.

4. Collect the radioactive isotopes and put them back in the cup. Repeat the process until no more radioactive isotopes remain. Don't forget to record the number of decayed isotopes for each pour in your table!

5. After the first trial, repeat the experiment two more times. On the third trial, you can start eating the decayed isotopes. But make sure you wait until the third trial!

6. After the three trials, average your data for each pour so you can plot it on the graph! Make a dot for each data point on your average chart. Then draw a line to connect them.





HOW TO FIND THE AVERAGE?

Add up the number of skittles measured on a turn and then divide by the number of measurements.

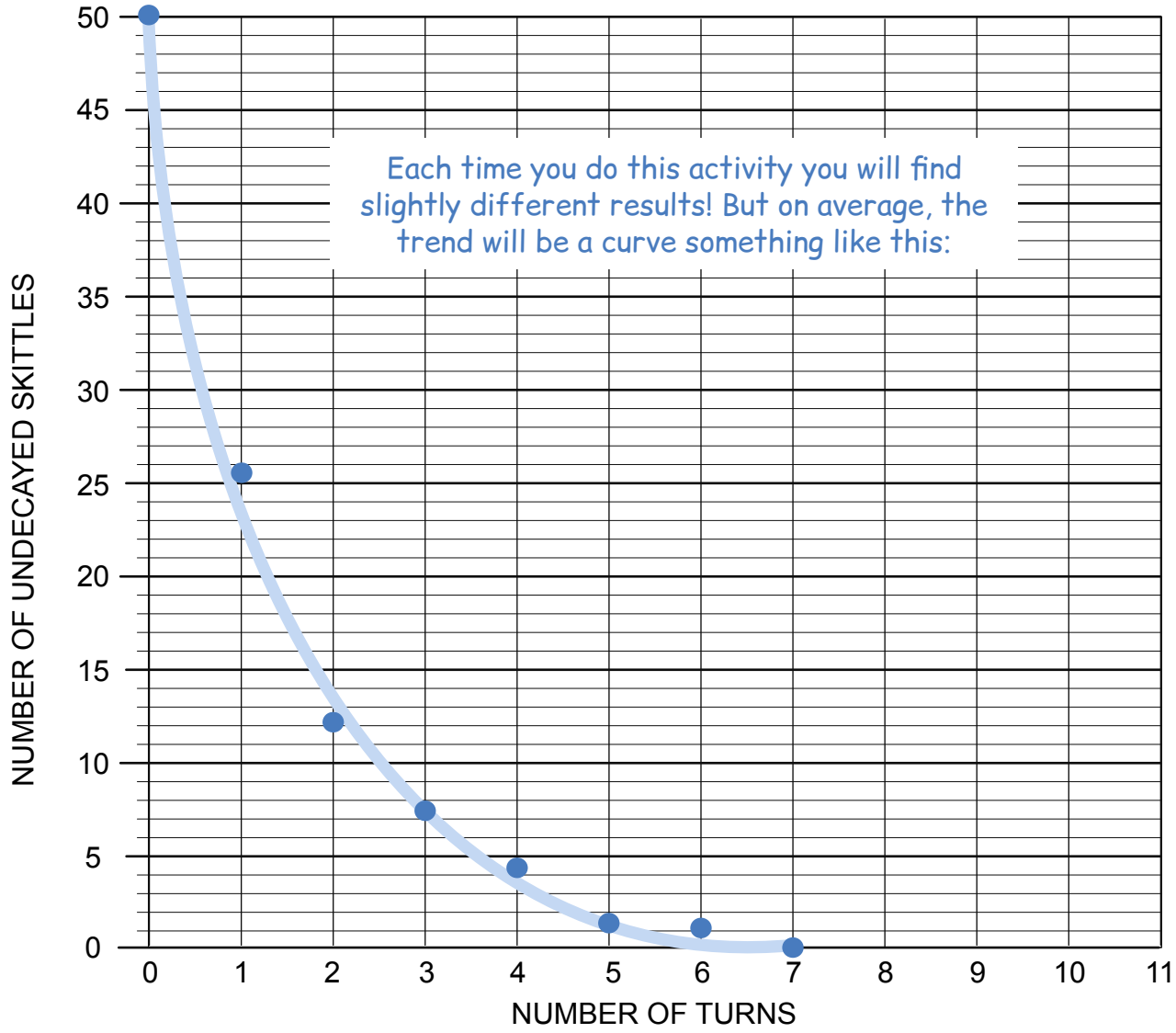
50 + 50 + 50 = 150 150/3 = 50

27 + 24 + 30 = 81 81/3 = 27

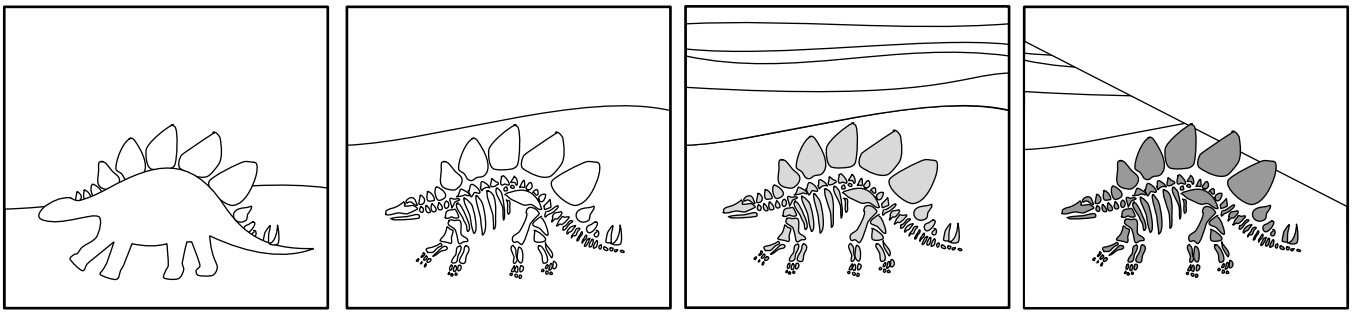
Carbon is found in all living things. Once an organism dies, it is no longer taking in carbon-14 in the form of food and the carbon in its body begins to decay. Scientists can measure the amount of carbon to determine how long ago the organism died. The older the sample is, the less carbon-14 there is to be detected. The half-life (the period of time in which half the sample has decayed) for carbon-14 is 5,730 years. Carbon-14 dating can be used to figure out the age of organic material up to 50,000 years old!

YOUR DATA

TRIAL 1	50	28	15	8	6	1	0	0	0	
TRIAL 2	50	24	8	6	2	1	1	0	0	
TRIAL 3	50	25	14	9	6	4	3	1	0	
THE AVERAGE:	50	25.6	12.3	7.6	4.6	1.6	1.3	0.3	0	



How Fossils are Formed



Fossilization is rare! Scientists estimate that less than one in a million make it into the fossil record. To become a fossil, a dead plant or animal needs to be buried and then preserved. There are many different ways that burial and preservation can happen. Unscramble the words below to discover some of the different types of burial. Then use the numbers to spell the most common and famous way a fossil can be preserved.

A fossil can be BURIED by being:

Covered in DUM M(4) U D from a VIRER R I V E R(3)

Swallowed by a NASD NEDU S A N D(10) D U N E(2)

Buried in SHA A(7) S H from a NALOCVO V O L C A N O(8,6)

Sink in a PAWSM S W A M P(1)

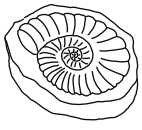
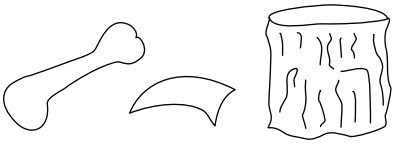
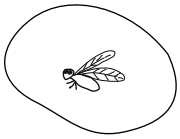
A storm at sea moves TIMESEND S E(9) D I(5) M E N T

SCIENCE MOM

A fossil can be PRESERVED by being:

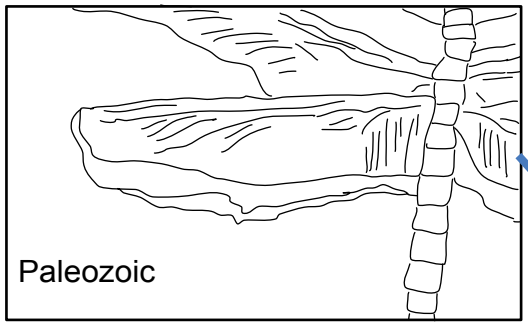
P	E	R	M	I	N	E	R	A	L	I	Z	E	D
1	2	3	4	5	6			7	8			9	10

Types of fossils:

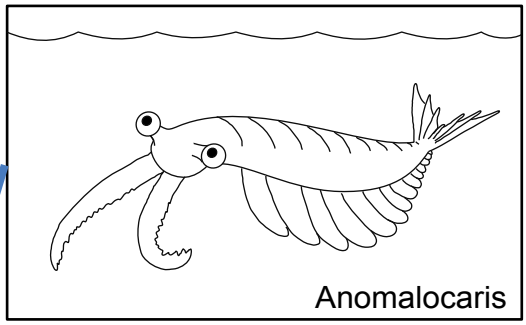
TRACE	MOLDS CASTS	PERMINERALIZED (FOSSILIZED)	ACTUAL SPECIMEN
Evidence of the organism, but NOT the actual plant/animal.	The animal/plant has dissolved away, but the impression remained.	Tissue has been replaced with minerals! Most dinosaur bones and petrified wood fossils have been permineralized.	The rarest type. The actual animal or plant is preserved by being frozen or encased in amber.
			
footprints	seashell mold	Bone, T-rex claw, petrified wood	insect in amber

Mixed up Fossils

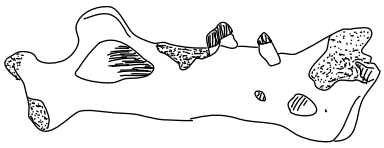
The animals and plants have gotten mixed up! Match the drawing of each animal and plant with its correct fossil evidence and time period.



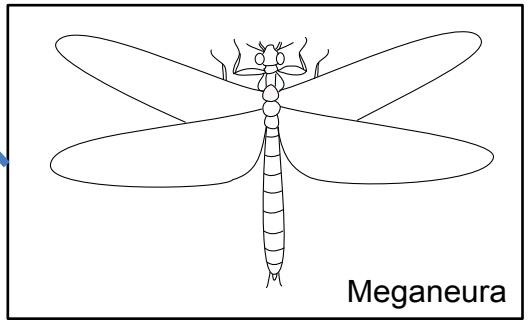
Paleozoic



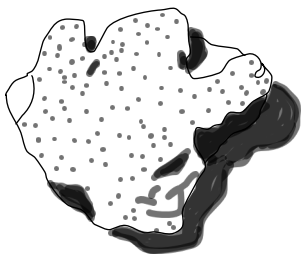
Anomalocaris



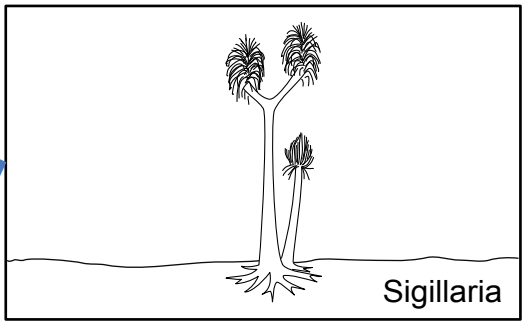
Pleistocene



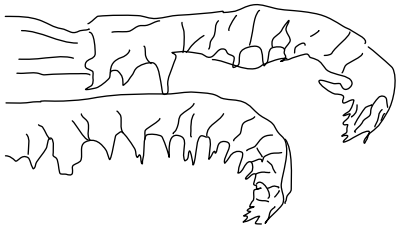
Meganeura



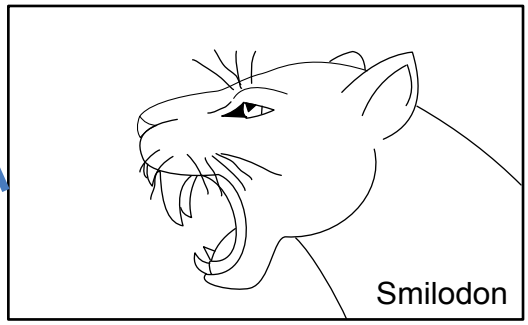
Jurassic



Sigillaria

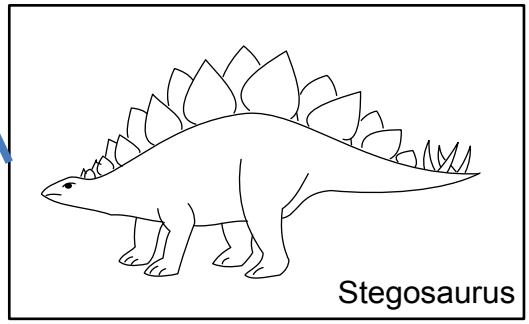


Cambrian



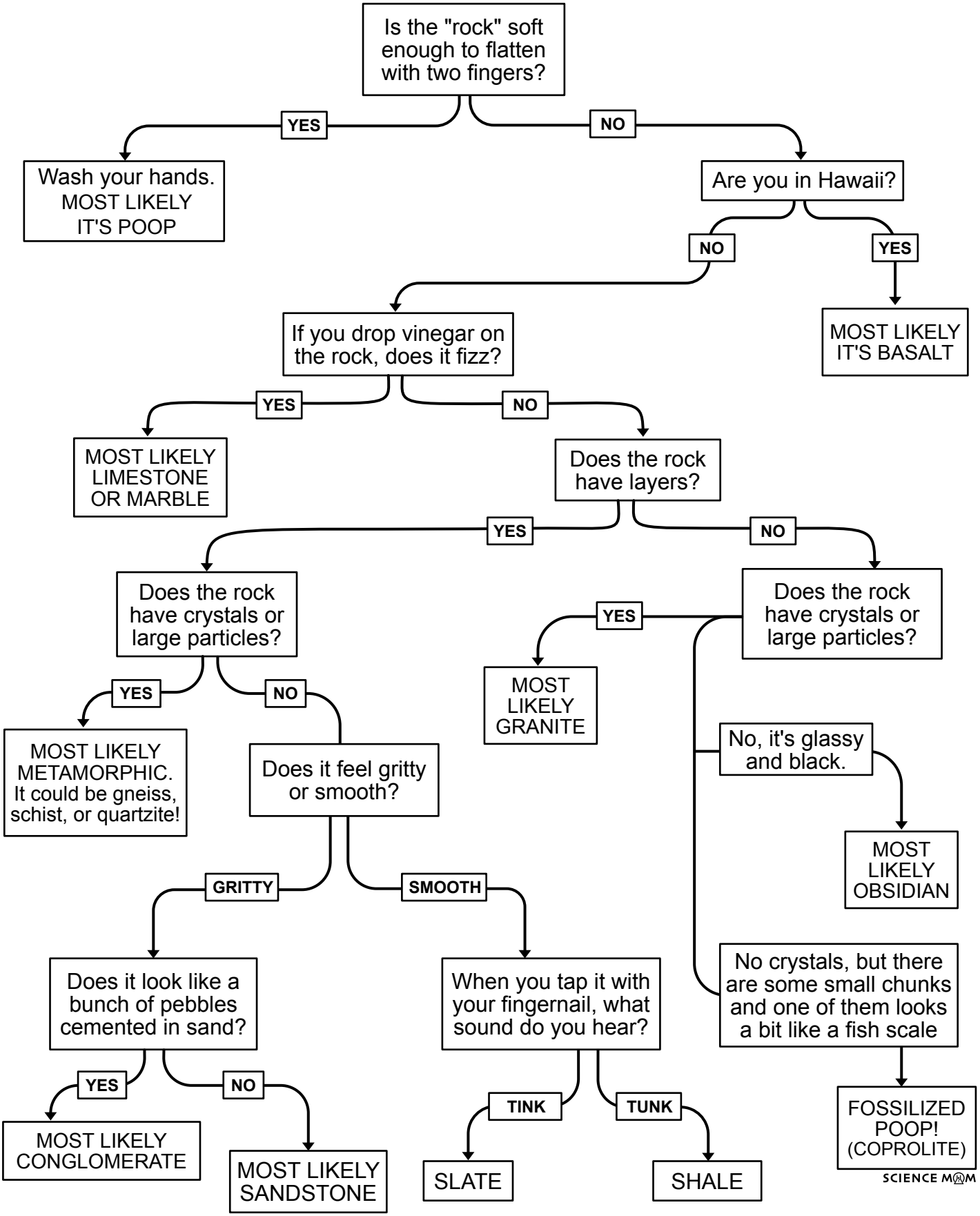
Smilodon

Carboniferous



Stegosaurus

ROCK IDENTIFICATION FLOWCHART

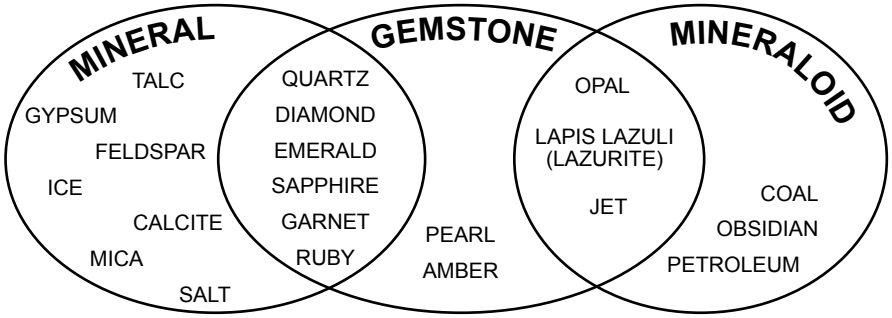


What is a rock?

You might think the answer to this question is easy, but "rock" is both a common word and a scientific term, and this sometimes causes confusion over whether or not certain things should be called rocks.

In geology, a rock is defined to be:

- a solid mass
- naturally occurring
- made of either minerals or mineraloid matter.

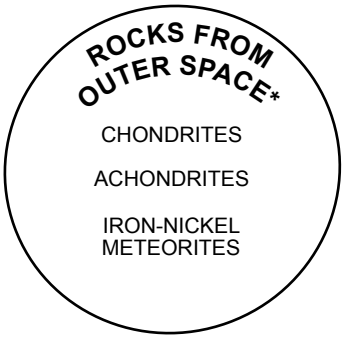


MINERAL: A solid with both a specific chemical formula and crystal structure.

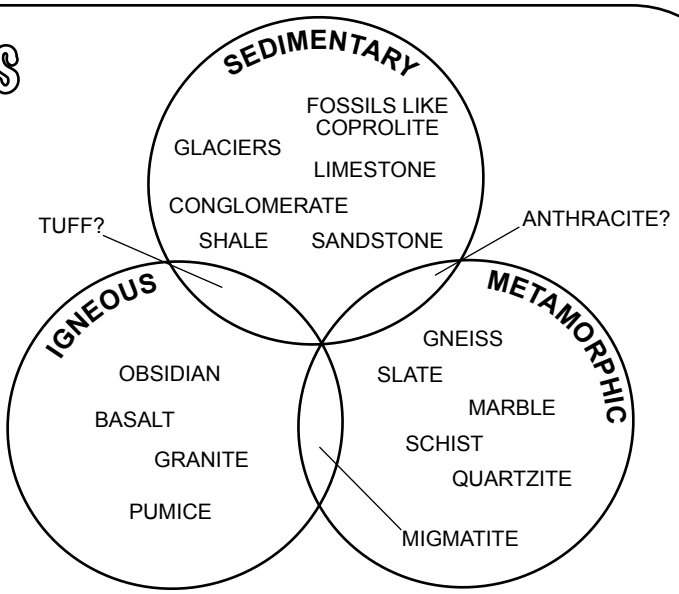
GEMSTONE: A mineral, rock, or organic material used to make jewelry or other adornments.

MINERALOID: A mineral-like substance that does not have a crystal structure.

Types of Rocks

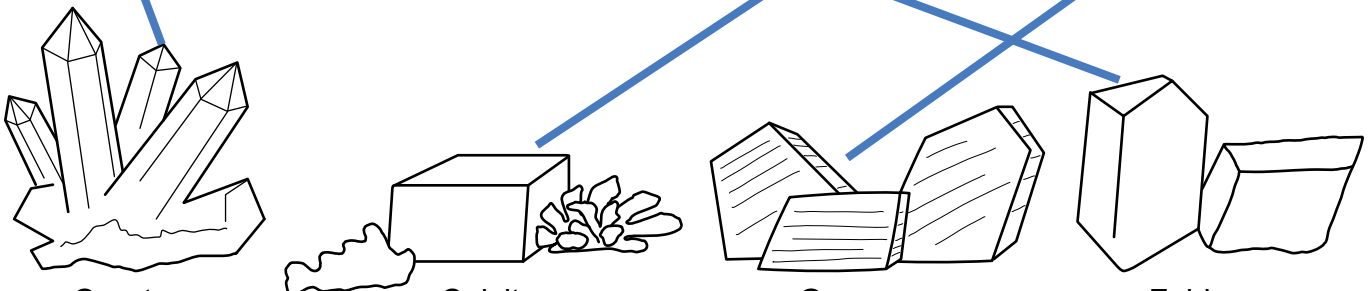


*Are meteorites igneous, sedimentary, or metamorphic? One could argue that they fall into all three categories! It all depends on where they formed and how they traveled to Earth.



DRAW A LINE TO MATCH THE MINERAL TO THE CORRECT FACT BOX

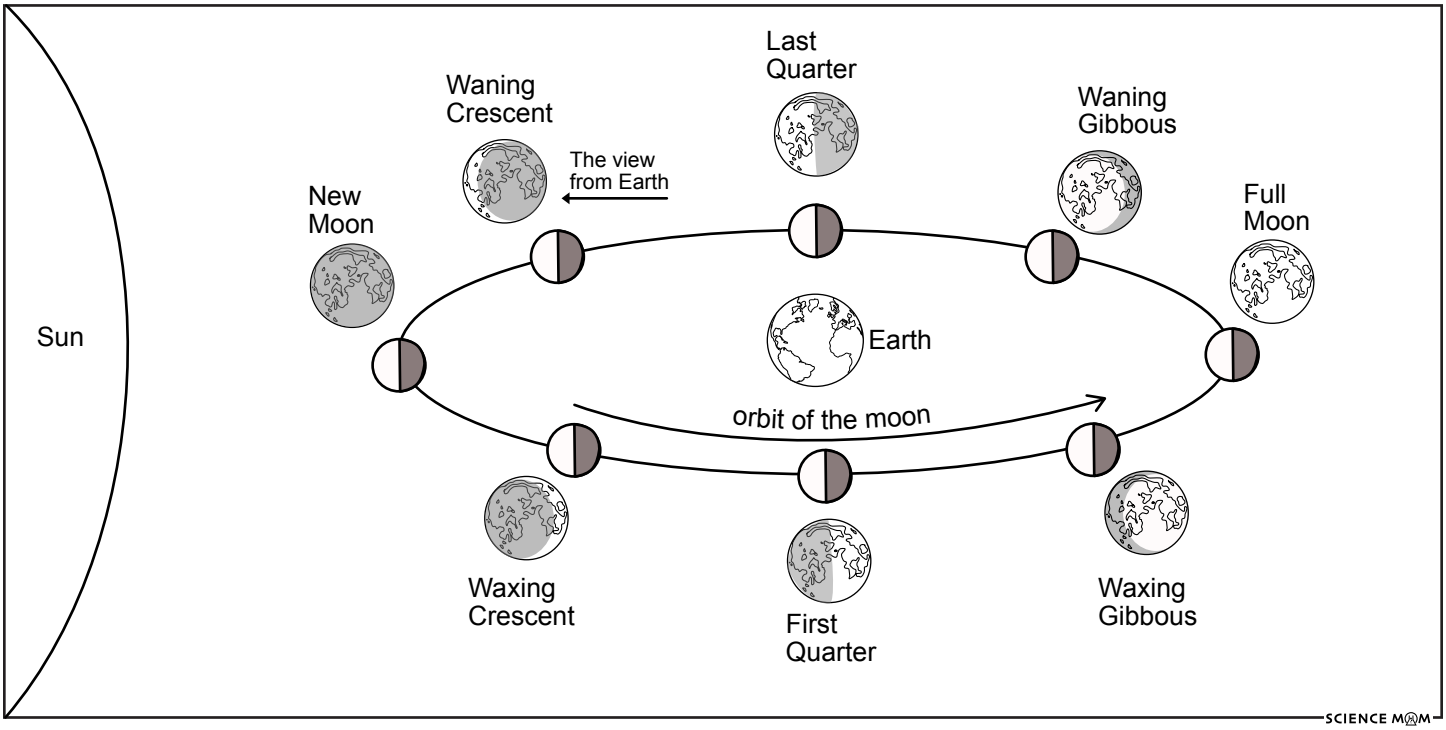
This hard mineral is found in igneous rocks like granite. It's a main ingredient of sand and, when purple, is called amethyst.	These minerals are the most common on Earth's surface. They come in three main varieties: potassium, sodium, and calcium. Used in making ceramics and glass.	This mineral will dissolve if placed in vinegar. It is a main ingredient of stalactites, and animals use it to create shells.	This mineral is so soft, you can scratch it with your fingernail. Used to make plaster.



Quartz Calcite Gypsum Feldspar

Moons and Shadows ART PROJECT

The moon is “locked” with Earth so that we always see the same side. But as it rotates around our planet, different parts of the moon’s surface are receiving sunlight. The shape of the Moon's directly sunlit portion as viewed from Earth is called the moon’s phase. These are the 8 phases:



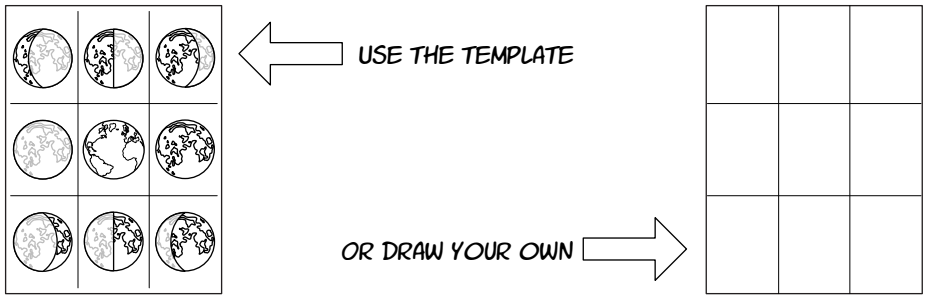
EARTH'S MOON WATERCOLOR PAINTING

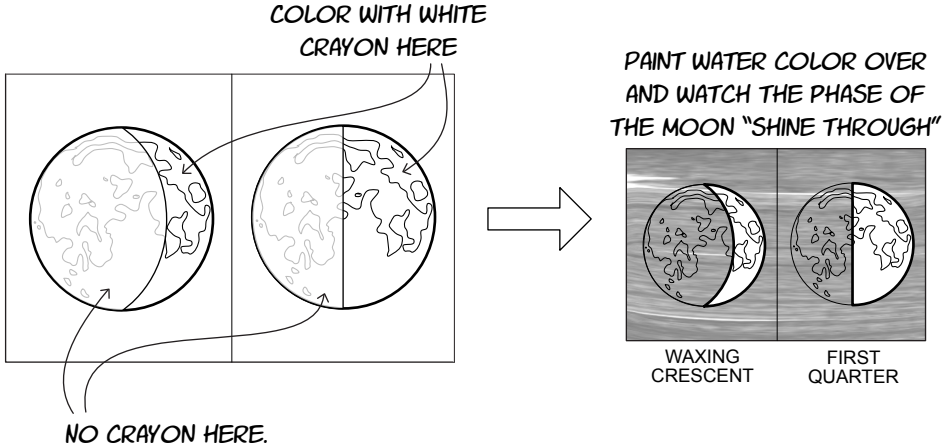
1. Print the Phases of the Moon template (page 121) OR create your own using a ruler by marking straight lines across the paper in a 3x3 grid.

2. Use a white crayon to color each phase of the moon. Be sure to press down hard as you color. Do 2 or 3 coats of crayon for a brighter white. Use other colors of crayon for the Earth.

3. Use water color paints to paint a dark background behind the moon. The more water you use, the lighter the color will be. Use less water for brighter, more vivid color.

4. Don't be afraid to paint right over your moon, the crayon wax is hydrophobic! Use a tissue to blot any paint that beads over the moon.





OTHER MOONS IN THE SOLAR SYSTEM

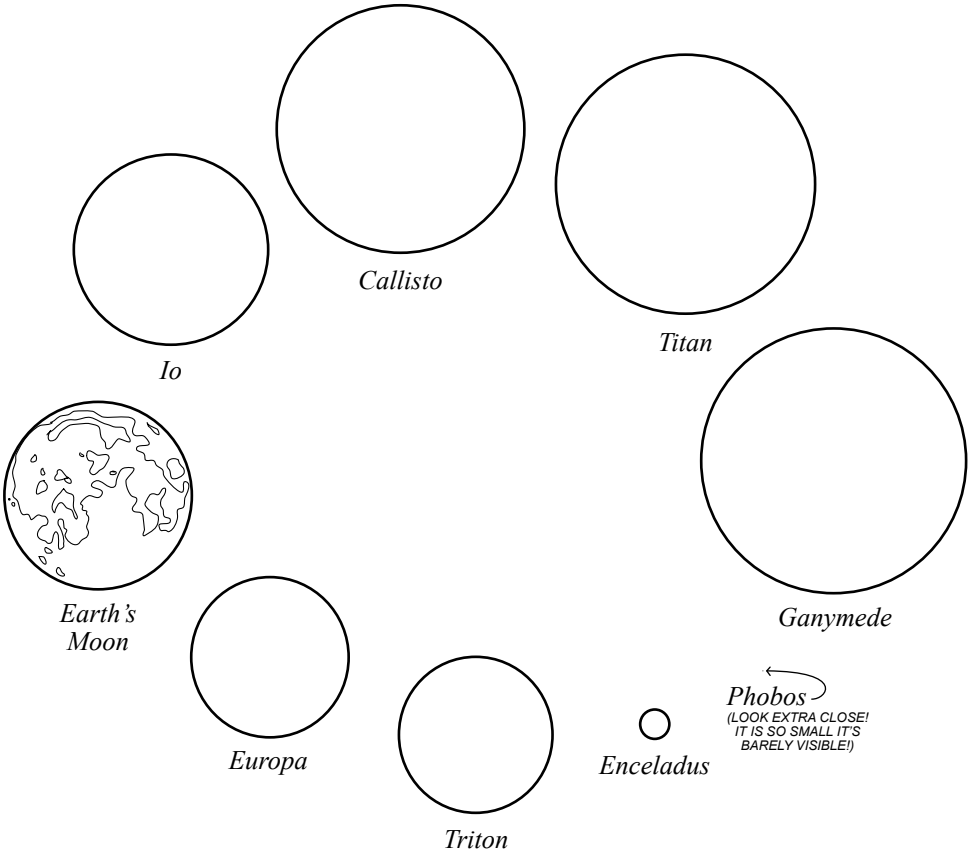
Print the Other Moons in the Solar System template (page 123) OR create your own drawings by making circles for each of these 9 moons.

Your moon art can be realistic and researched or fanciful and fun. You choose!

If you want to color them with realistic colors, first read the descriptions in the template and then look up photos online. The NASA website has some great pages on each moon!

If you would like to create a more fanciful or imaginative set, blend different combinations of crayon and water colors, or draw alien settlements or space stations on each moon!

**Note: The moons on this page are drawn to scale so Phobos (which is 239 times smaller than Ganymede) looks like a tiny dot. The moons in the template are not drawn to scale.*



SIDEWALK CHALK SUNDIAL

Option A:

1. On a day forecast to be sunny, go to a flat, paved area that gets good sun exposure most of the day. Trace the shadow of a friend or object such as a chair or lamp post. Mark the spot where they were standing and write down the time next to the shadow or in a journal

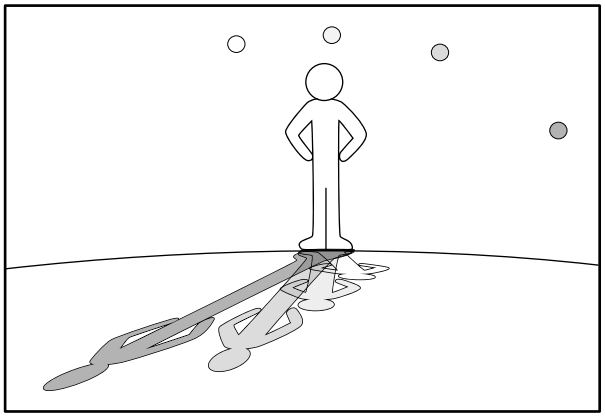
2. Set a timer for an hour. When it goes off, head to the same spot and trace the shadow again in a different color

3. Repeat several times during the day to record how the shadow's position and shape shifts.

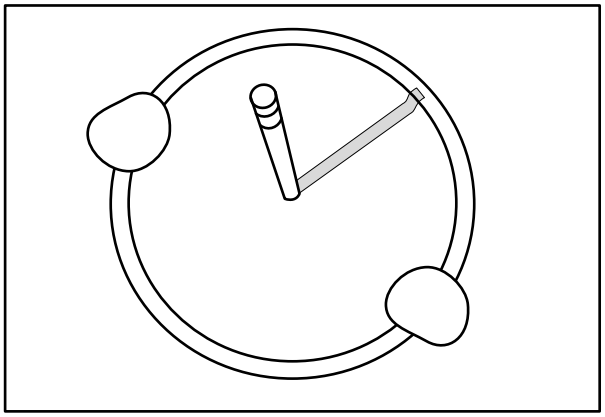
Option B:

1. Place a stick or pencil in the center of a paper plate. Tape the plate to the ground or place rocks on the plate to secure it.

2. Trace the shadow and make a note of the time. Set the timer for an hour and return regularly to the plate to trace the shadow again.



OPTION A



OPTION B

The Inverse Square Law

To square a number, you multiply it by itself. For example, the number 6 squared is $6 \times 6 = 6^2 = 36$. Fill in the table below by squaring each number.

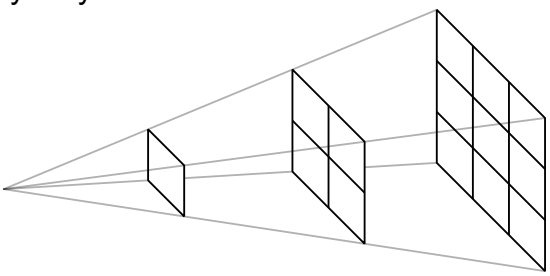
n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
n^2	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225	256	289	324	361	400

We call the numbers 1, 4, 9, 16,... square numbers. Why do you think we would give them that name?

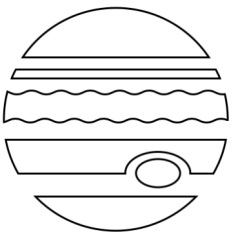
When we make a squares with side lengths equal to 1, 2, 3, 4,... the area of the square (length x width) is 1x1=1, 2x2=4, 3x3=9, 4x4=16, and so on. Each 2D figure has area measured in square units.

The Inverse Square Law. Moving an object 2× as far away makes the intensity only 1/4 of what it used to be. Moving an object 3× as far away makes the intensity only 1/9 of what it used to be. In general, moving an object n× as far away makes the intensity only $1/n^2$ times what it used to be.

The image to the right demonstrates the inverse square law. The same light that would hit a single square would be spread across 4 squares at twice the distance. The light that would hit a single square would be spread across 9 squares at three times the distance.



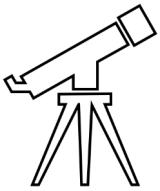
Jupiter is 5 times further from the Sun than Earth. How many times brighter is the Sun's light from Earth than it is on Jupiter?



Jupiter is 5 times as far from the sun, so the Sun's light is only 1/25 times as intense on Jupiter as on Earth. That means, the light will seem 25 times brighter on Earth than Jupiter.

Stars don't seem very bright to us. Why do you think that is?

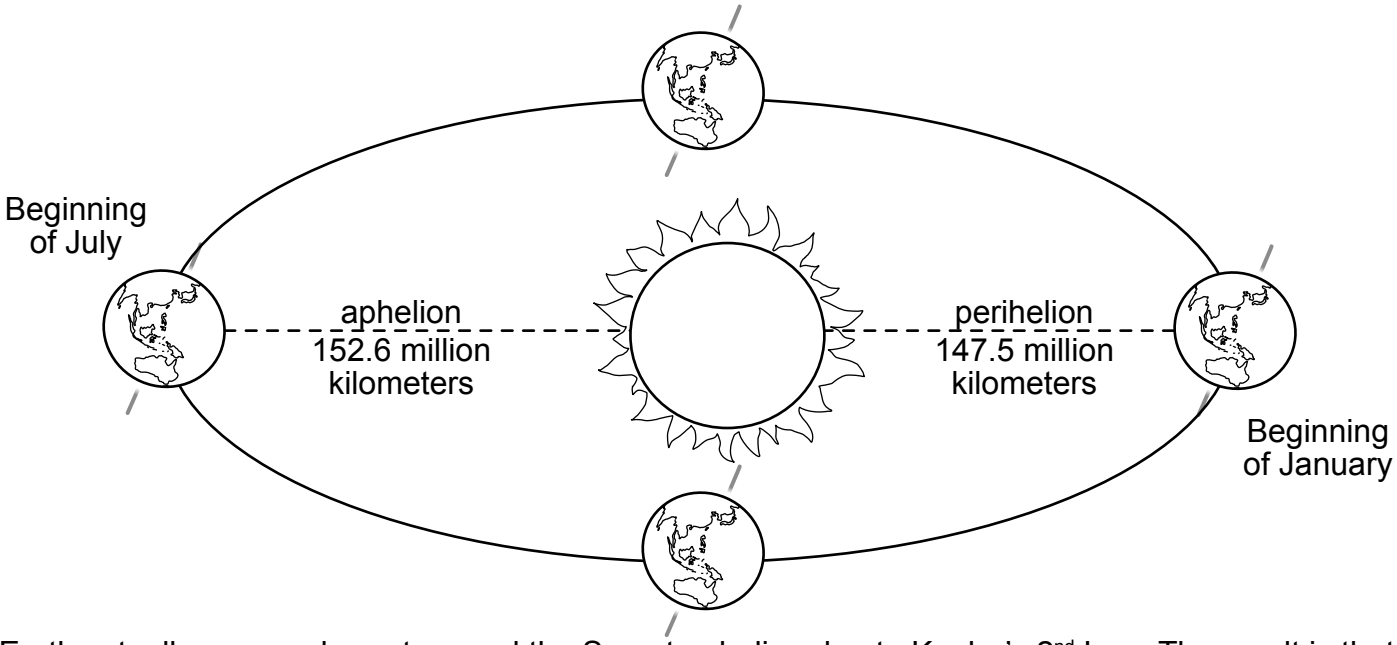
Only a small portion of a star's light actually reaches Earth. The rest of the star's light is spread out through space.



Earth's Orbit

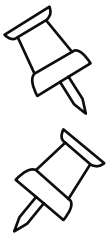
Earth has an axial tilt of 23.4° relative to the plane of rotation (ecliptic plane). That means that different parts of the Earth are directly facing the Sun at different times of the year. Explain in your own words how this axial tilt causes the seasons.

In December, the Northern hemisphere is tilted away from the sun, so it gets less light and heat. In June, the Northern hemisphere is tilted toward the sun so it gets extra light and heat.

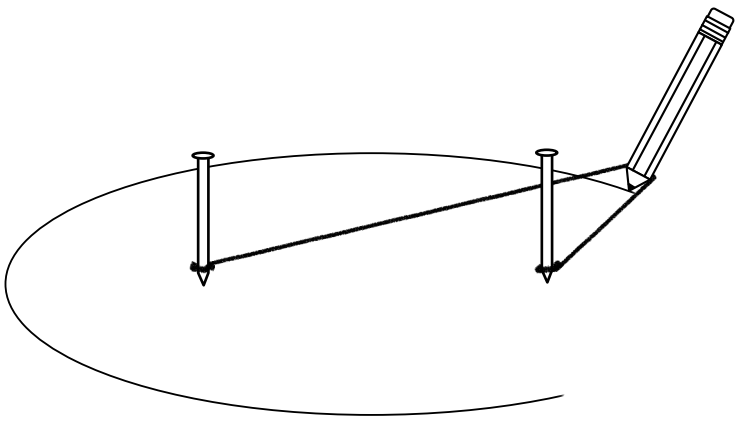


Earth actually moves slowest around the Sun at aphelion due to Kepler's 2nd Law. The result is that summer is 2-3 days longer in the Northern hemisphere than the Southern hemisphere.

Surprisingly, the Earth is actually colder at perihelion because the Southern hemisphere's oceans are facing the sun and they don't heat up as easily as land because water has high heat capacity.

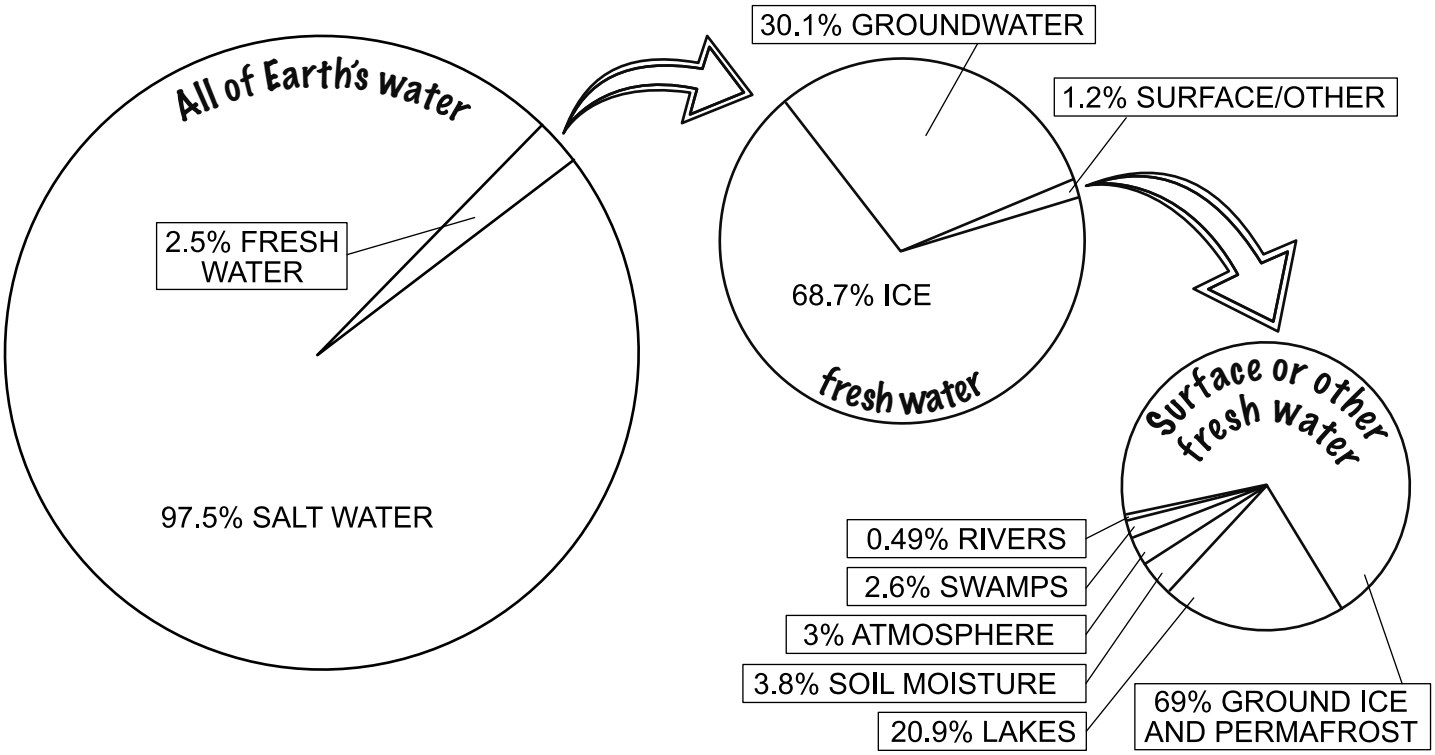


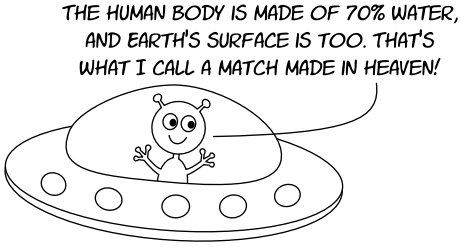
Make your own ellipse! Tie a piece of string between two nails or pins in a piece of paper. Place your pencil inside the string and trace out the widest curve that the string will allow.

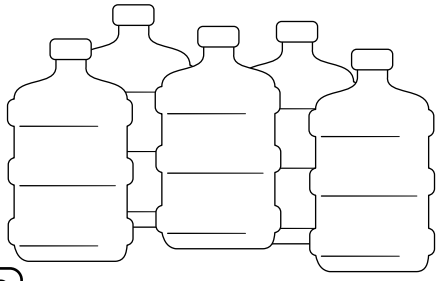


The location of each nail is called a focus of the ellipse. For each planet's orbit, the Sun is located at a focus of the ellipse. For some planets the elliptical orbit is more oblong, while other planets have a nearly circular orbit.

Where is Earth's water?







If the world's water supply were 100 liters (26 gallons), our usable water supply would be only 3 milliliters (one-half teaspoon)!

CAN SALT WATER BE MADE FRESH?

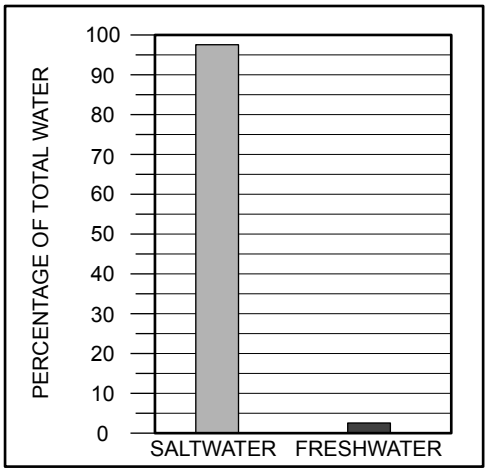
Draw and describe a machine or natural process that turns salty water into drinkable freshwater. If you don't think such machines or processes exist, then explain why not!

The water cycle turns salty water from oceans into fresh water (rain). Desalination machines can also convert salt water into fresh water.

	Percentage of total water
SALTWATER	97.47
FRESHWATER	2.53

97% of all the water on earth is salty. If we graph the percentage of saltwater and freshwater, it looks like this:

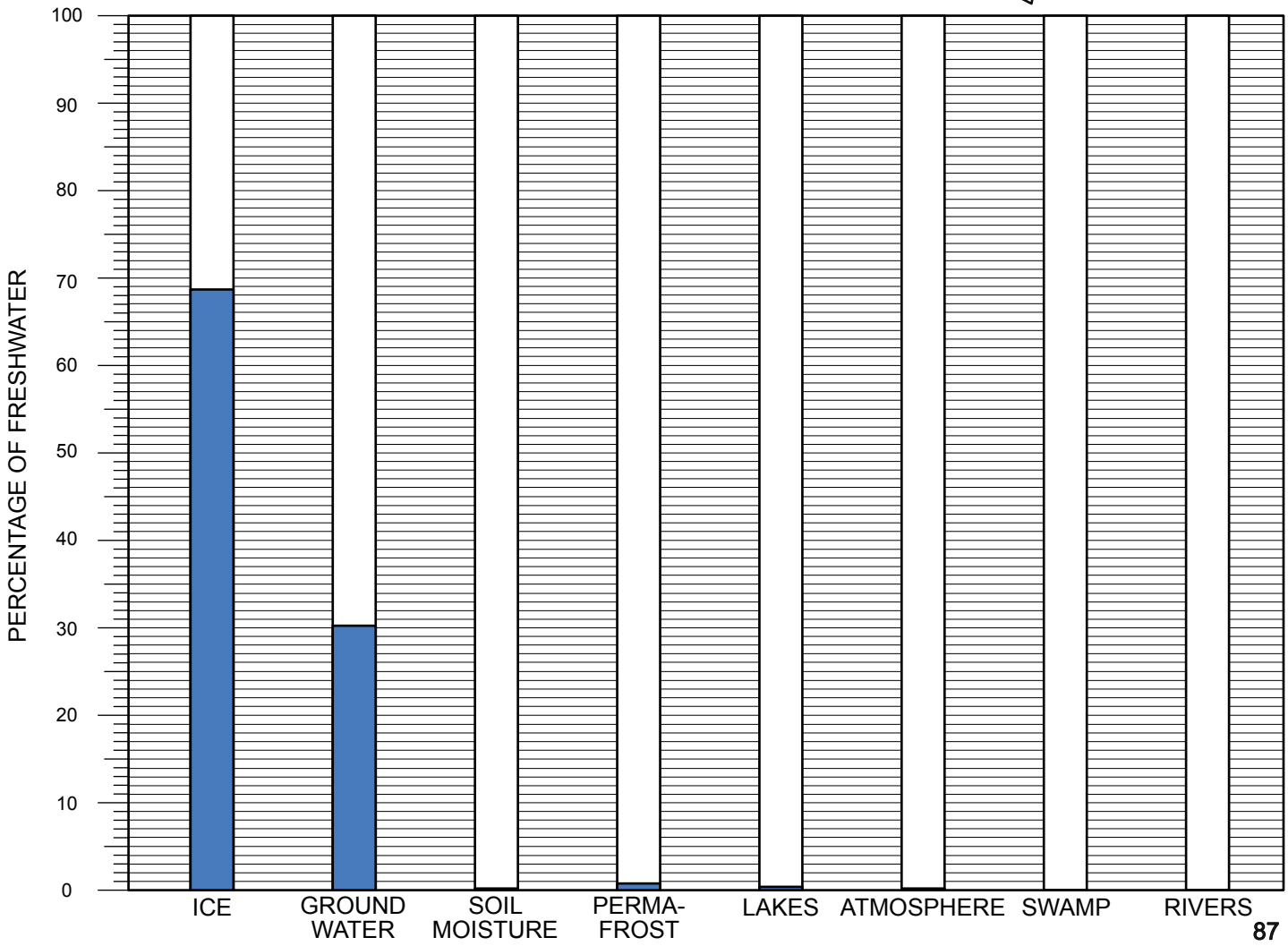
The percentages displayed in a bar chart!



	% freshwater
ICE	68.7
GROUNDWATER	30.1
PERMAFROST	0.86
LAKES	0.26

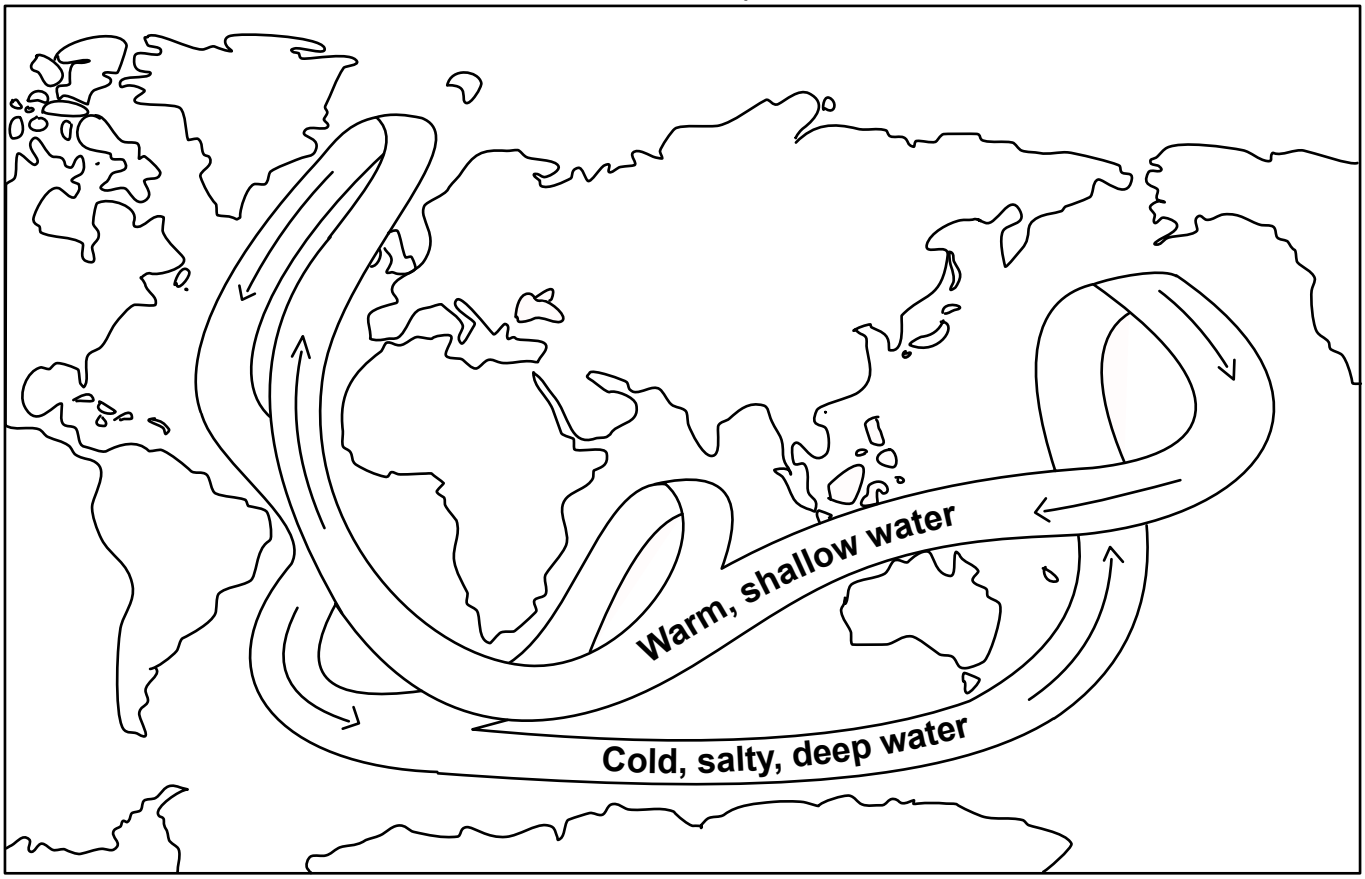
	% freshwater
SOIL MOISTURE	0.05
ATMOSPHERE	0.04
SWAMP WATER	0.03
RIVERS	0.006

Can you use this data to graph Earth's freshwater?



The Thermohaline Circulation

Color the warm surface waters red and the cold deep water blue:



How long do you think it takes for water to travel around the ENTIRE thermohaline current?

Your guess:

What scientists have measured:

1,000 years (source: www.noaa.gov)

The movement of the ocean on the surface layer is mostly driven by the wind. But in certain areas near the polar oceans, the colder surface water also gets saltier due to evaporation or sea ice formation. This water then sinks to the ocean depths. This sinking force is the main drive of a giant current which is called the thermohaline circulation.

After sinking, the water moves horizontally through the ocean depths. If the current hits an island, this can cause some of the water to rise, but most of it won't resurface until it reaches the warm waters of the Pacific and Indian Oceans.

It is called the thermohaline circulation because this "ocean conveyor belt" is caused by variations in temperature (thermo) and salinity (haline).

COULD CLIMATE CHANGE ALTER THE THERMOHALINE CIRCULATION SYSTEM? WHY OR WHY NOT?

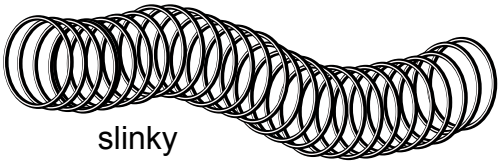
Yes. Sea ice is the main driving force behind the Thermohaline Circulation. The formation of sea ice requires very cold temperatures. If less sea ice is forming, then the current will slow down or could even stop or change its flow.

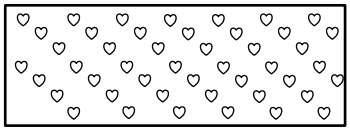
SCIENCE MOM

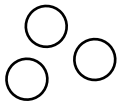
Hands-on Activity

EXPLORING WAVES

MATERIALS:


slinky


Lightweight blanket or sheet


ping pong balls

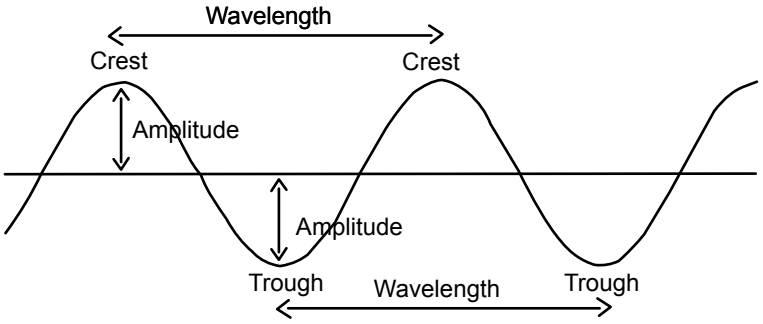
What is a wave?

Waves cause a disturbance in the medium they are traveling through, which allows them to carry energy. The amount of energy they carry is tied to the amplitude of the wave.

The **amplitude** of the wave is the distance from the center line, or still position, to the top of the crest or bottom of the trough. The greater the amplitude of a wave, the more energy it has.

The **wavelength** of a wave is the distance from a point on one wave to the same point on the next wave.

The **frequency** of a wave is the number of waves passing through a point in one second. One hertz is equal to one wave per second.



Blanket activity

1. If you have two people, have each partner hold one end of the blanket. Alternatively, hold 2 corners down with books while one person holds the blanket.

2. Shake the blanket in a wave pattern. Can you make waves with an amplitude of 4 inches?

3. Place the three ping pong balls on the blanket and pick an identifiable point on the blanket.

4. Can you change the wavelength and amplitude to make the balls go to that point on the blanket?

If you increase the frequency of the blanket waves, how does the wavelength change?

The wavelength should get shorter. Is this what you observed?

Slinky activity

1. Hold the slinky in two hands. If you move the slinky up and down to make waves, these are called **transverse** waves.

2. Now, stretch the slinky out on a flat surface but bunch up the slinky so you are holding most of the coils in one hand. When you let go, the wave moves horizontally between your hands. By pushing and pulling on the slinky, you can keep the wave going. This type of wave is called a **longitudinal** or compression wave.

What is the largest number of transverse waves you can make with the Slinky? What is the smallest?

There's no right or wrong answer here! Just experiment and see what types of waves and patterns you are able to make!

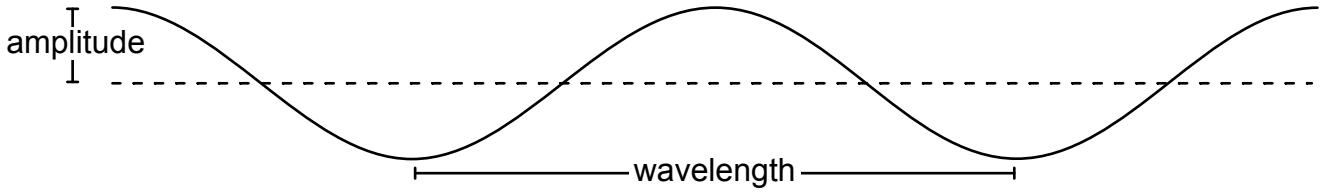
What are some examples of longitudinal waves?

Sound is a longitudinal wave. So are seismic P-waves that cause earthquakes.

Wave Functions

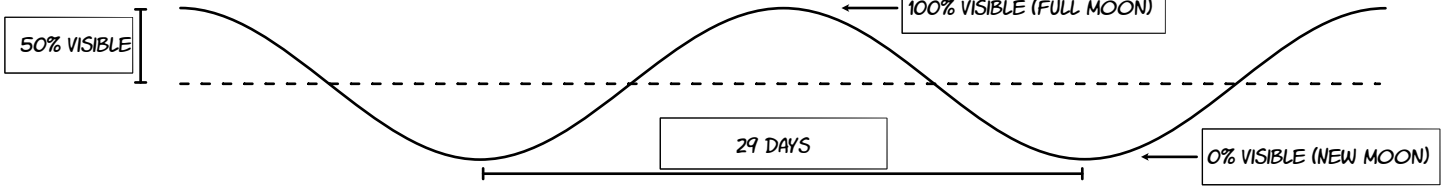
Wave functions occur naturally in lots of contexts. Each wave has (at least) 4 characteristics that we care about:

Amplitude: The height of the wave from the baseline.
Wavelength: The distance between repeating parts of the wave.
Maximum: The highest part (or peak) of the curve.
Minimum: The lowest part (or trough) of the curve.

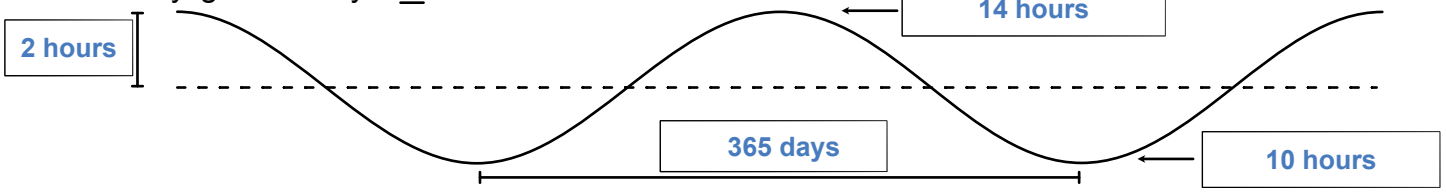


For each scenario below, identify possible values for the amplitude, wavelength, maximum, and minimum of the wave function. (Your answers should be realistic guesses with units.) The first one is completed as an example.

Phases of the moon

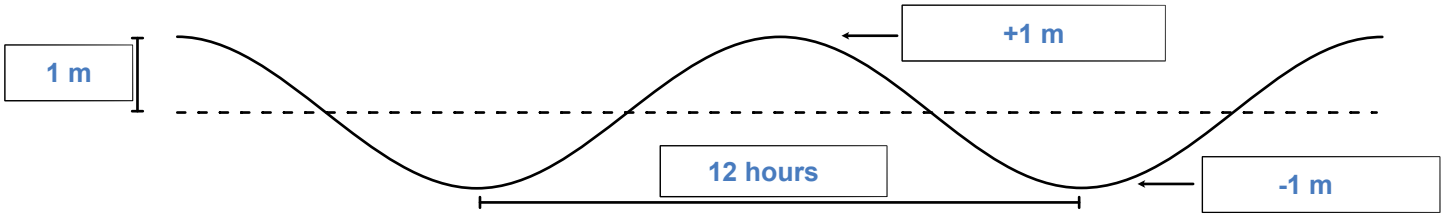


Hours of daylight in a day



The numbers will vary a lot based on location. You're just estimating how much things change and how often.

High Tide



Predator-Prey Models

A predator is an animal that eats other animals. A prey is an animal that is eaten by a predator. A predator-prey model is a way of showing how the population of a predator and its prey grow in an ecosystem.

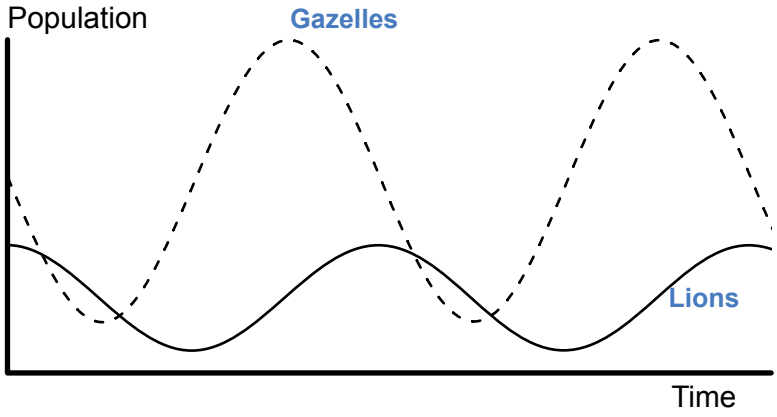
The lion pride was so large that the gazelle population dropped.

Once the gazelle population dropped, there wasn't enough food, so the lion population dropped.

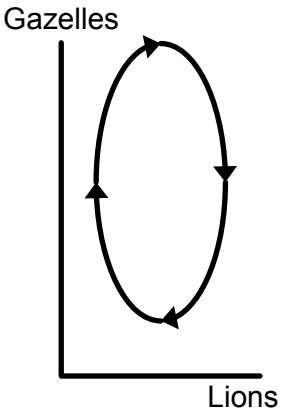
Fewer lions meant that more gazelles could live, so the gazelle population climbed.

A large gazelle population provided food for the lions, so the lion population grew again.

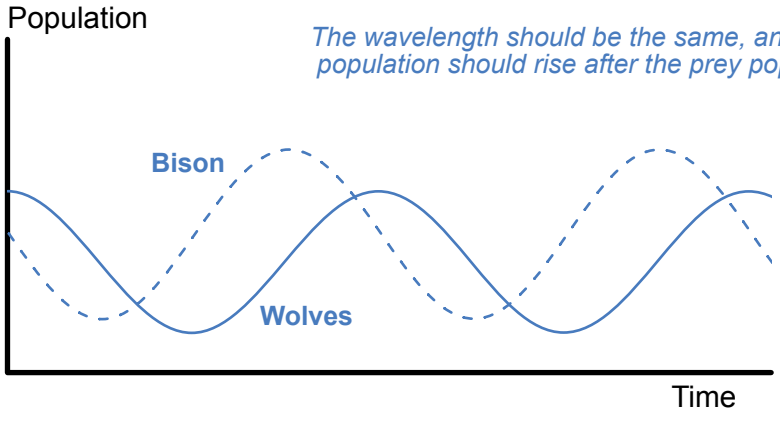
One of the curves below represents the lion population, and the other represents the gazelle population. Label each curve correctly.



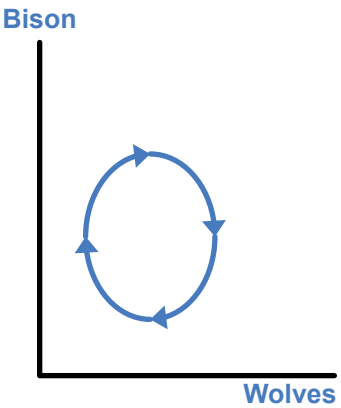
It's possible to plot both populations on the same graph if you use one axis for lions and one axis for gazelles.



Make up your own predator-prey model below by choosing a predator and a prey and then plotting their populations over time.



The wavelength should be the same, and the predator population should rise after the prey population rises.



Water Underground!

Ground water fills up the space between rocks and soil particles. As it percolates through the earth, it can dissolve minerals, forming sinkholes and caves. Layers of rock that water cannot pass through are called impermeable. These impermeable layers can trap ground water and form aquifers or they can force it to the surface, creating springs or rivers.

T	T	S	E	B	S	I	H	T	A	M	L
N	R	E	T	I	M	G	A	L	A	T	S
E	E	J	I	S	I	N	K	H	O	L	E
N	F	O	K	E	P	G	E	E	A	L	L
O	I	A	T	T	E	N	V	T	G	V	B
P	U	S	S	A	R	A	T	N	L	R	A
X	Q	R	R	C	C	S	A	R	A	B	E
E	A	E	G	E	O	M	E	T	R	Y	M
K	K	Y	S	U	L	U	C	L	A	C	R
M	S	T	A	L	A	C	T	I	T	E	E
O	G	B	N	O	T	R	M	C	R	A	P
P	H	A	L	G	E	B	R	A	T	B	I

WORD SEARCH

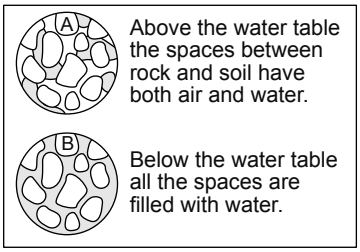
All the words below (except for one!) are hidden in the grid forwards, backwards, or diagonally. Can you find them?

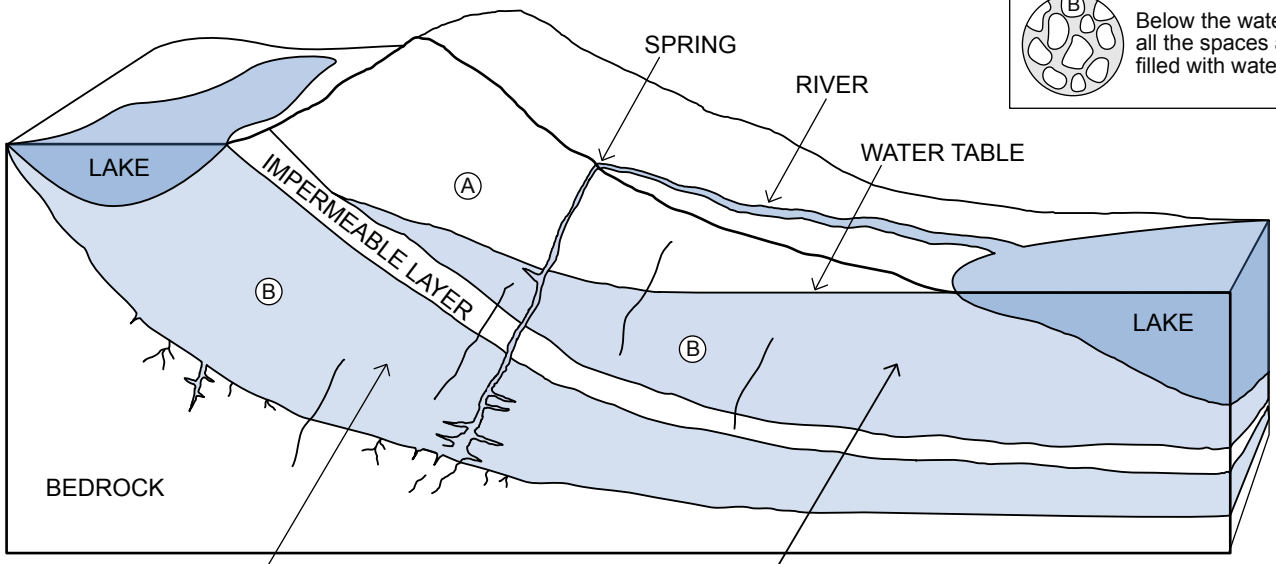
- ✔ **Stalactite**: structure of calcium deposits formed on the roof of a cave
- ✔ **Stalagmite**: structure of calcium deposits formed on the floor of a cave
- ✔ **Aquifer**: an area of permeable rock or earth that contains ground water
- ✔ **Karst**: a limestone landscape with water-eroded towers, sinkholes and caves
- ✔ **Cave**: a natural underground chamber or cavern
- ✔ **Sinkhole**: a hole or collapsed area caused by underground water erosion
- ✔ **Permeable**: something that allows water or air to pass through
- **Limestone**: a rock made mostly of calcium carbonate This one is not in the grid!
- ✔ **Percolate**: to gradually filter through something

Did you see the bonus math words?

Where's the water?

Can you label the unconfined aquifer (above the impermeable layer) and confined aquifer (between the bedrock and impermeable layer). After filling in the labels, color the aquifers, spring, and lakes blue.

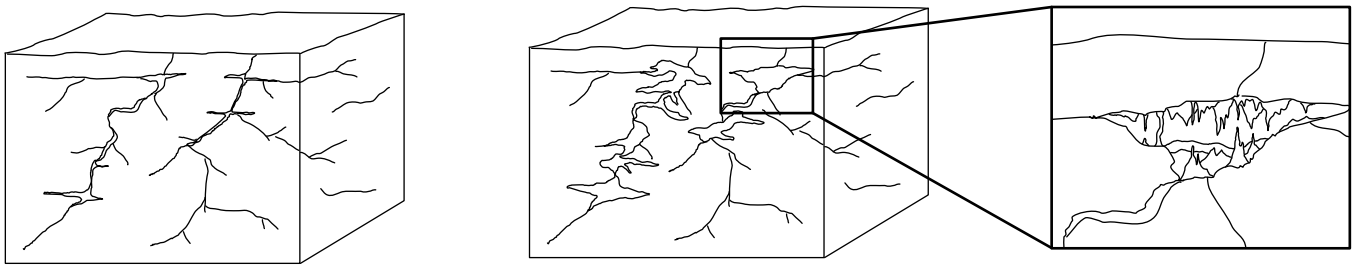




Confined aquifer

Unconfined aquifer

How Caves Form



1. Water seeps into cracks in the ground. Because it contains dissolved carbon dioxide and minerals, it becomes acidic.
2. Water dissolves calcium carbonate in the rocks. As long as the water is flowing, the cave grows larger and larger.
3. The water level drops and air fills the cave. Dripping water deposits calcium carbonate, creating cool formations like stalactites and stalagmites.

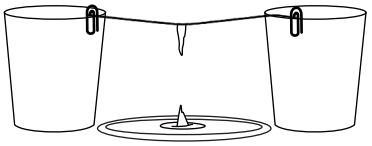
Going Spelunking...

If you were exploring a cave (spelunking!) What would you most like to discover? A neat formation, a rare crystal, an animal, or something else? Draw it and describe it below!

We can't wait to see what you invent!

Bonus activity!

Make your own stalactites/stalagmites.



Materials:

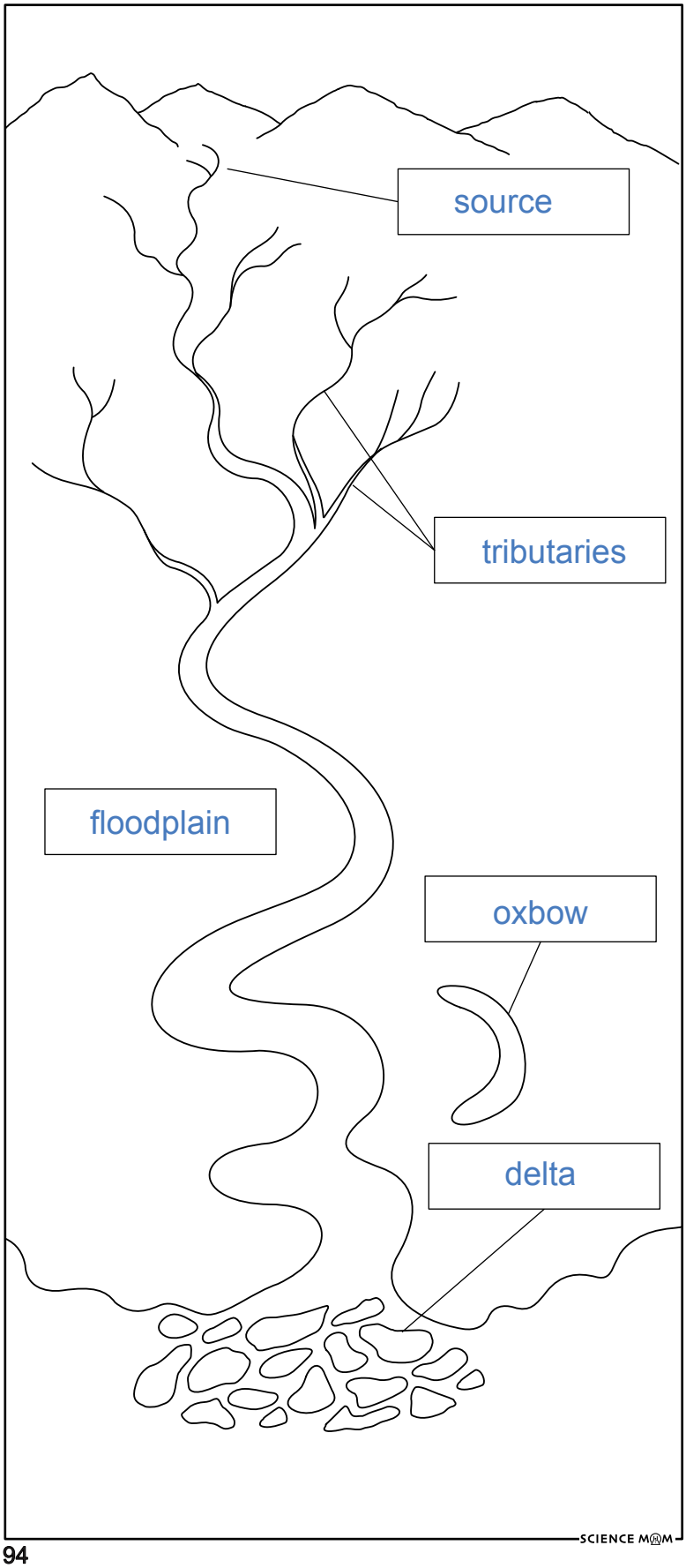
- Epsom salt
- Water
- Food coloring
- 2 identical sized cups
- Yarn or string
- 2 paperclips
- A plate and bowl

1. Fill two glasses to the brim with water. Then carefully pour the water in a bowl or pan.
2. Heat the water in the microwave or on the stove until it is very hot.
3. Add an equal volume of epsom salt a spoonful at a time, stirring well. Continue adding salt until it won't dissolve any more.
4. Add food coloring if desired and pour the solution into both glasses. Place the glasses on either side of a plate and use the paperclips to suspend the string between them. The middle of the string should be slightly lower than the level of the water. The key to good stalactite formation is for the drips to happen very slowly.
5. Reserve the extra solution and replenish the two cups as needed over several days.

About Rivers

FILL IN THE BLANKS BELOW USING THESE WORDS, THEN LABEL THEM ON THE DIAGRAM TOO:

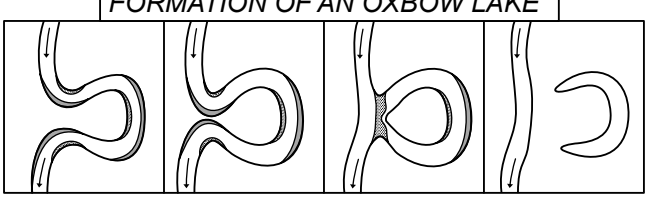
delta	tributaries	source	floodplain	oxbow



A river is a channel of water that flows into a lake, ocean, or another river. The __source__ of a river can be a spring, runoff from rain in mountains, or small streams that form the "headwaters." As a river flows downhill, it's likely to be joined by other streams and rivers, which are called __tributaries__. When the river reaches a mostly flat area of land, sand and other particles in the water begin to drop.

Over many years these sediments form the __floodplain__, an area of land around the river that is subject to flooding. Rivers tend to meander, and since the water moves fastest on the outside of the curve, it erodes more of that riverbank, which can eventually form an __oxbow__ lake. When the river meets a lake or ocean it drops the sediment, forming a fan-shaped piece of land and marsh called a river __delta__.

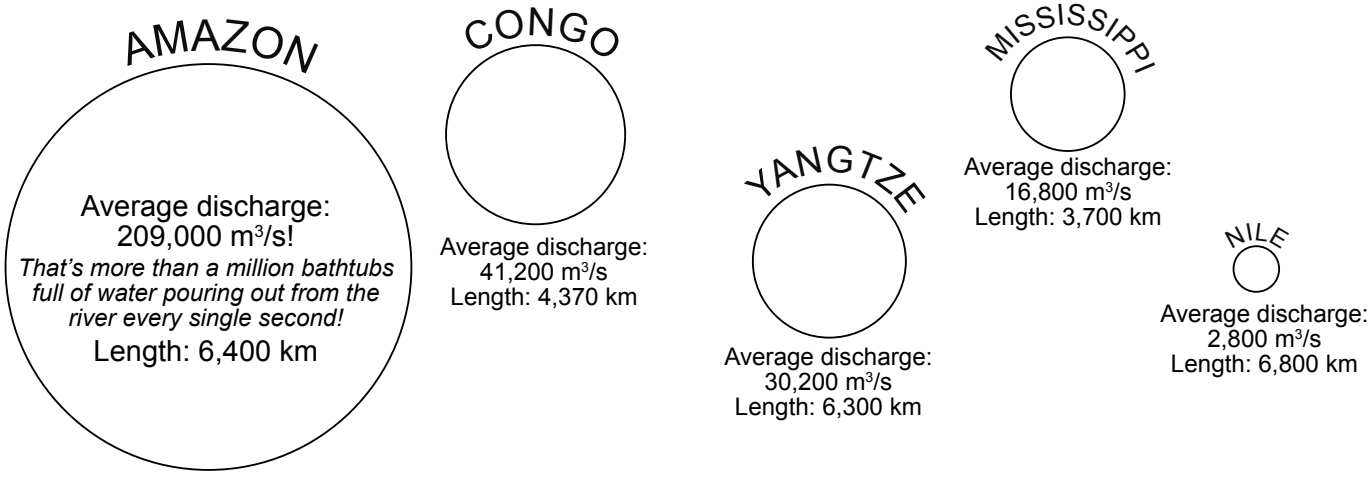
FORMATION OF AN OXBOW LAKE



SLOWER MOVING WATER DEPOSITS SEDIMENT
FASTER MOVING WATER ERODES THE RIVER BANK

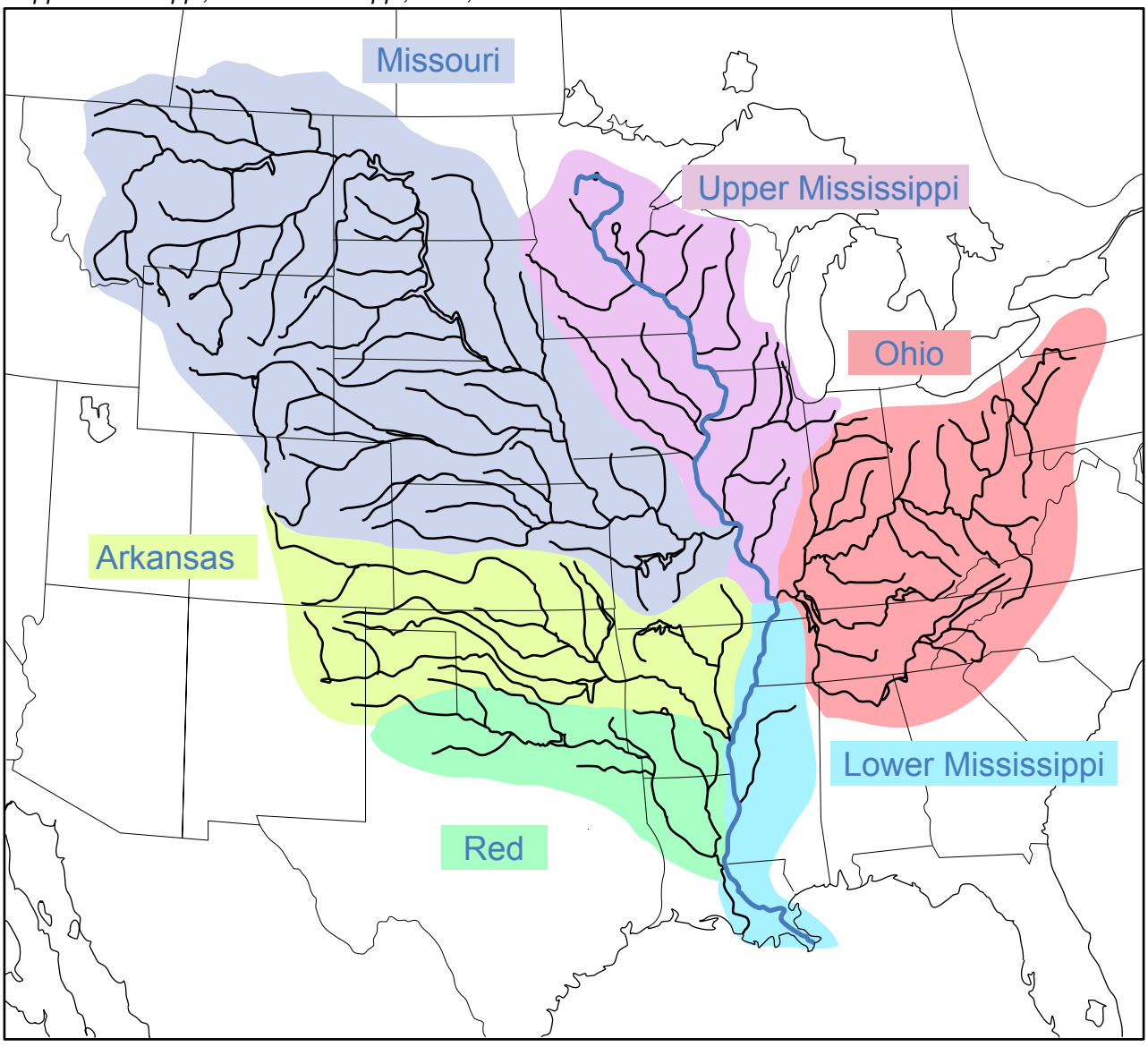
Famous Rivers

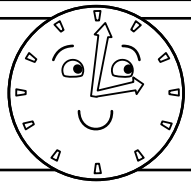
Five of the biggest and longest



Average discharge *is how many cubic meters of water are coming out of the river every second.*

All of the rivers below are part of the Mississippi watershed. Trace a line along which path YOU think should be called the Mississippi river. Then look it up! For a bonus activity, color the Missouri, Arkansas, Upper Mississippi, Lower Mississippi, Ohio, and Red river basins.





Quiz Time!

ANSWER THE QUESTIONS TO SEE WHAT YOU LEARNED!

① Why is the sky blue?

A Blue has the longest wavelength of visible light, so it stays around the longest in the upper atmosphere.
B Because outer space is dark blue.
C Blue light has the shortest wavelength of visible light and is scattered by the gases in the atmosphere.

② What is the name of formations that hang down from the roof of a cave?

Stalactites

③ What is the typical speed of the thermohaline circulation system?

A 1 cm per second (0.0006 kilometers per hour or 0.00037 mph)
B 1 meter per second (3.6 kilometers per hour or 2.24 mph)
C 10 meters per second (26 kilometers per hour or 22 mph)

④ Caves most commonly form in which type of rock?

A Basalt
B Sandstone
C Shale
D Limestone

⑤ What type of rock is made of the fossilized remains of ocean life that died millions of years ago?

A Basalt
B Sandstone
C Shale
D Limestone

⑥ What factors contribute to forming a metamorphic rock? (Select all that apply)

A High heat
B Low pressure
C Mineral-rich fluids
D Accumulation of sediment

⑦ True or False: Dragonflies grew to be the size of seagulls during the Carboniferous period.

A True
B False

⑧ What are the three main types of rocks?

Sedimentary, **Metamorphic**, **Igneous**

⑨ What is the most common mineral in sand?

A Quartz
B Calcite
C Gypsum
D Feldspar

⑩ True or False: All gemstones are minerals.

A True
B False

⑪ Which moons in our solar system are the most likely places we could find bacteria or other living organisms?

A Phobos
B Earth's moon
C Europa
D Enceladus

⑫ When did flowering plants first develop?

A During the Cambrian Period
B During the Carboniferous Period
C During the Cretaceous Period

⑬ If the star SPARK was the same size and brightness as our sun but 100 times further from Earth, how much dimmer would the light from SPARK appear to us?

A 100 times dimmer
B 1,000 times dimmer
C 10,000 times dimmer
D 100,000 times dimmer

⑭ Most of the world's liquid fresh water is contained in:

A Rivers
B Swamps
C Lakes
D Groundwater

⑮ How much of Earth's water is saltwater?

A 97%
B 74%
C 47%
D 24%

⑯ In a wave, what is the distance from crest to crest called?

A Amplitude
B Wavelength
C Frequency

⑰ What is the name of the number of waves passing through a point each second?

A Amplitude
B Wavelength
C Frequency

⑱ The thermohaline circulation system is important because (select all that apply)

A It absorbs heat and moderates Earth's temperature
B It cycles nutrients through the ocean
C It provides a fast path for ships between Europe and North America

⑲ What is the main reason Earth experiences the seasons of spring, summer, fall, and winter?

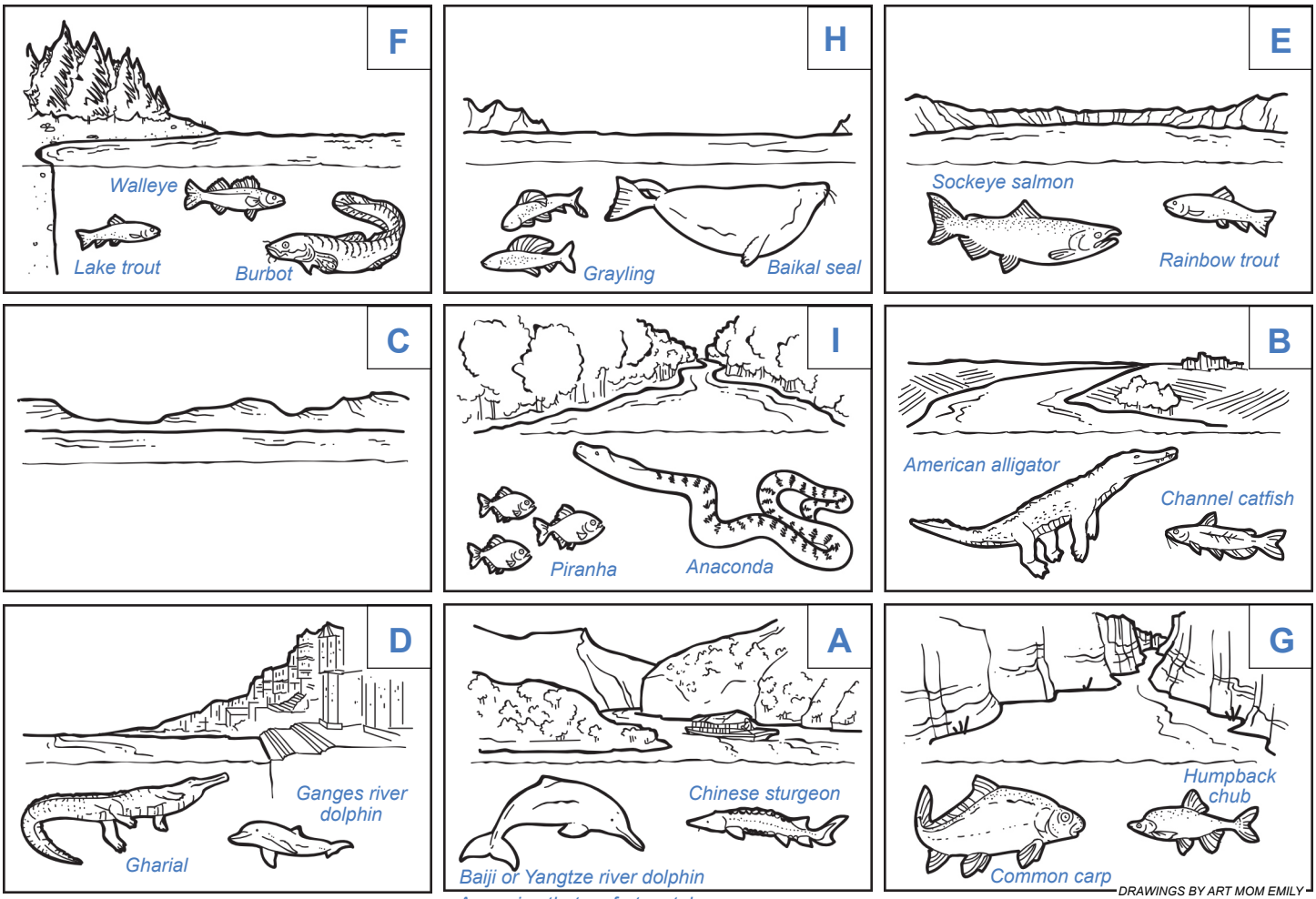
A Earth is tilted at 23°
B Earth orbits the sun in an elliptical motion
C There is more land above the equator than below

⑳ How long is a day on the moon?

A 24 hours
B 29 Earth days (708 hours)
C The moon doesn't have days because one side is always facing the sun and the other is always dark.

Where in the World?

Each of these clues belongs to a river or lake. Once you've matched the clue with its picture, place a dot on the map locating the river or lake! See if you can mark all nine of them on the map of the world's rivers.



A Asia's longest river is fed by 700 tributaries. Its drainage basin covers 20% of China's total land mass.

Yangtze

B A drop of water travels 3,700 kilometers in 90 days meandering through 10 states to reach the Gulf of Mexico.

Mississippi

C The Jordan River flows in but not a single river flows out. Ten times saltier than the ocean, this is a lake without any fish.

The Dead Sea

D India's longest river hosts 400 million people who live near its banks and is also home to gharials and dolphins.

Ganges

E A basin that once held lava is now home to salmon and trout. Its crystal blue waters are more than 500 meters deep.

Crater Lake

F Fed by 300 streams and rivers, it holds hundreds of shipwrecks and has a surface area as large as the country of Austria.

Lake Superior

G Wild for whitewater rafting, it travels through 15 dams and a giant, deep canyon. Then after flowing more than 2,000 km, it often doesn't reach the ocean.

Colorado River

H The world's oldest lake holds 20% of Earth's fresh water. Geophysicists think it's on its way to becoming an ocean.

Lake Baikal

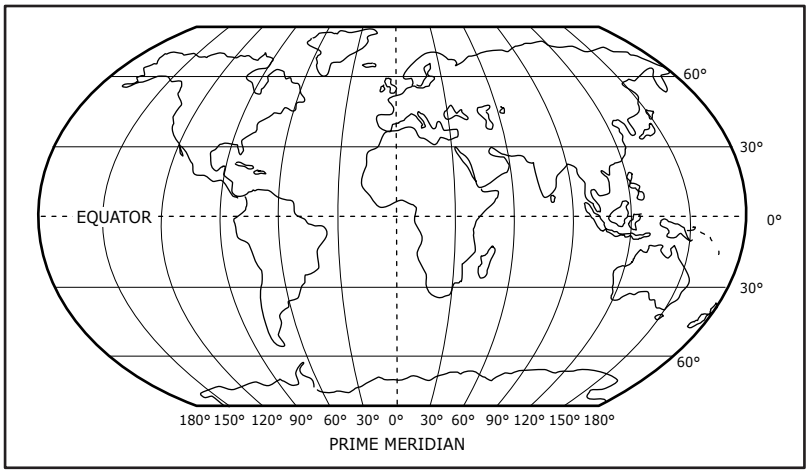
I Flowing through nine countries, it holds 20% of world's river water and more than 3,000 species of fish, including giant arapaima and sharp-toothed piranhas.

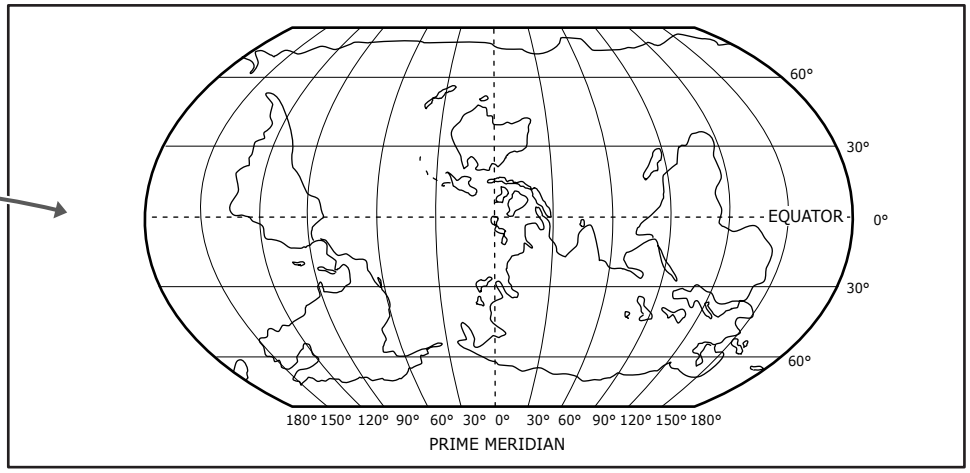
Amazon

If you live in Europe, or a country that was settled by a European nation, your world map likely has the Atlantic Ocean in the middle.

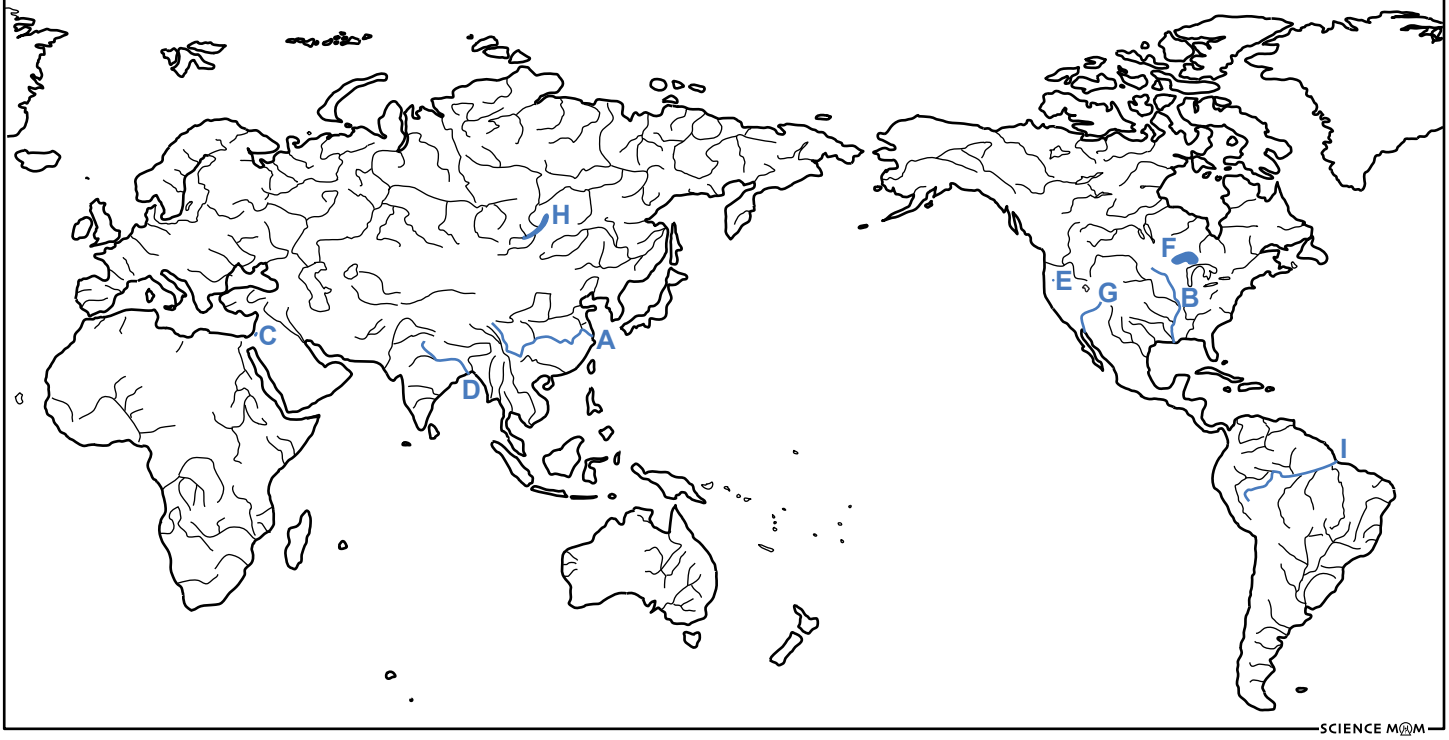
But if you live in Asia, it's more likely that your map is arranged with the Pacific Ocean at its center, like the map of the world's rivers shown below. People like to see their home in the center of the map.

By tradition, North is at the top of our maps, but there is no reason north should be "up" and south should be "down." If the first world map makers had been Australian instead of European, our standard world maps could have easily looked more like this.





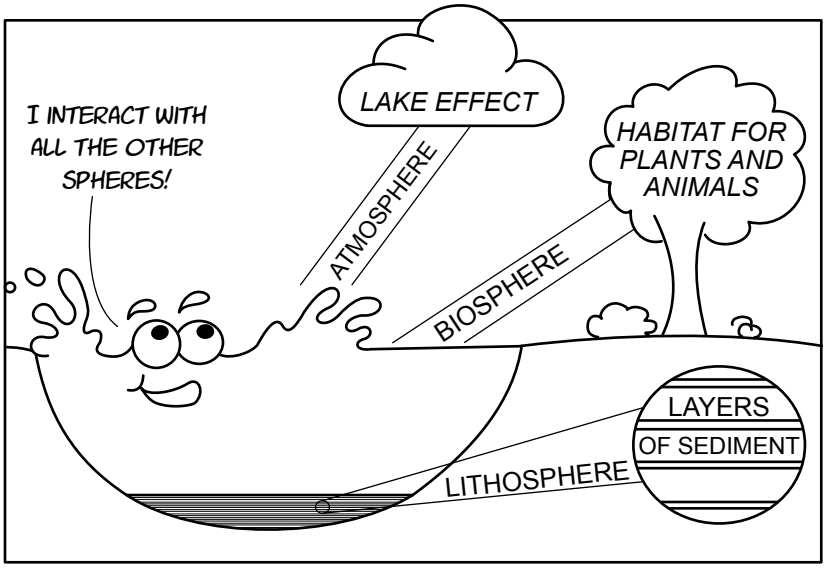
MAP OF THE WORLD'S RIVERS



Once upon a Lake...

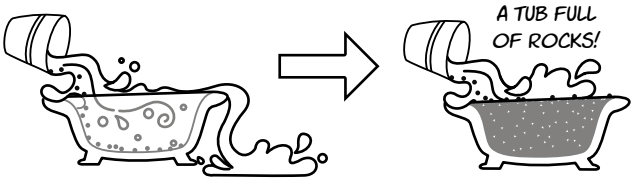
FILL IN THE BLANKS USING THESE WORDS:

sea	water	glacial	land	basin

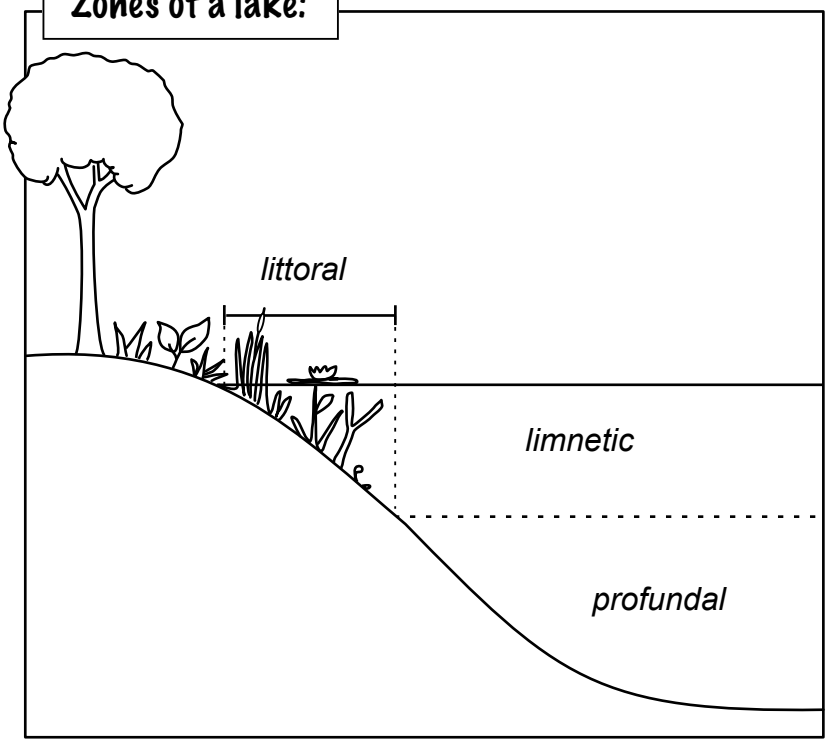


A lake is a large body of ___water___ that is surrounded on all sides by ___land___. It can be fed and drained by rivers, and those rivers often travel into the ___sea___. A lake fills a ___basin___, and how that basin was formed tells you what type of lake it is. It might be ___glacial___ (carved by ice from ancient glaciers), tectonic (filling a rift between two plates in Earth's crust), or fluvial (formed by a river).

Geologically, all lakes are temporary. It can take hundreds of millions of years, but eventually they'll fill up with sediment, just like a bathtub would if you constantly dumped dirty, gravelly water into it.



Zones of a lake:



WRITE IN THE NAME OF THE LAKE ZONE BEING DESCRIBED:

limnetic

Sunlit water located far away from the shore.

littoral

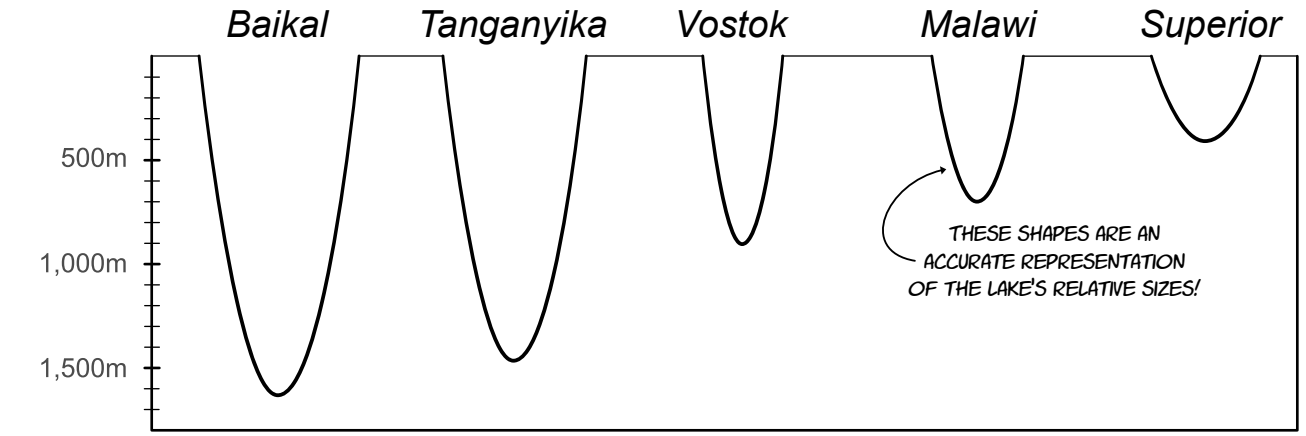
Sunlit water located close to the shore.

profundal

Water with no sunlight located deep in the lake.

The BIG

The five largest freshwater lakes in the world!



	Baikal	Tanganyika	Vostok	Malawi	Superior
Max depth:	1,637m	1,637m	900m	706m	406m
Volume:	23,615 km^3	18,900 km^3	5400 km^3	8,400 km^3	12,000 km^3

SCIENCE M@M

The STRANGE

Imagine a strange lake. Then draw and describe it here! What unusual features will you invent? Would any new animals or plants live there?

For inspiration, you can check out some of Earth's strange lakes: 5 Jellyfish Lake in Palau, Boiling Lake in Dominica, the soda lakes in Africa that are home to flamingos, Lake Hillier in Australia (it's pink!) or Khiluk or Spotted Lake in Canada.

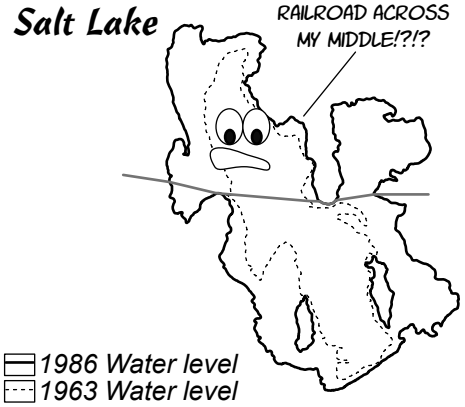
And the SALTY

Lakes that do NOT drain into the ocean.

The Caspian Sea

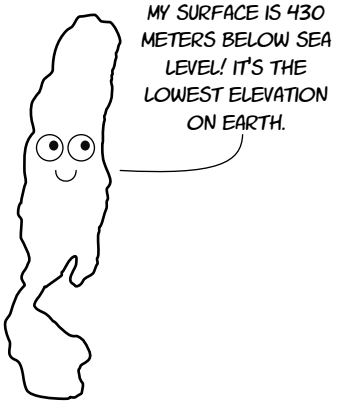
Volume: 78,200 km^3
Salinity: 1.2%
Maximum Depth: 1,025 meters

The Great Salt Lake



Volume: 19 km^3
Salinity: 5 - 27%
Maximum Depth: 10 meters

The Dead Sea

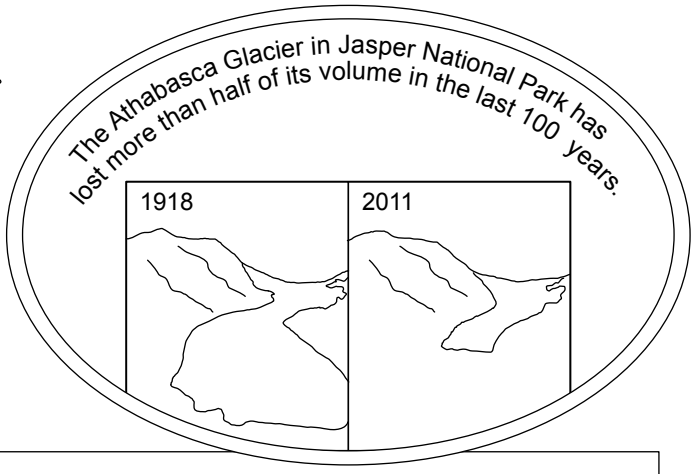


Volume: 114 km^3
Salinity: 34%
Maximum Depth: 304 meters

Glaciers

Glaciers are formed by snow accumulating over many years. Over time, the layers of snow become compacted into ice. Glaciers slowly move downhill, carving sediment and rock as they go.

Most glaciers move just a few cm per day, but the world's fastest moving glacier (Jakobshavn Isbrae in Greenland) moves up to 40 meters (131 feet) in a day. Most glaciers are receding and melting faster today than they ever have before.



WORD SEARCH

The bolded words are hidden in the grid forwards, backwards, or diagonally. Can you find them all?

N	A	C	O	N	G	N	I	T	L	E	M
L	O	B	R	P	R	E	I	C	A	L	G
A	L	I	M	T	E	N	A	L	P	L	E
I	F	G	T	I	G	I	N	A	O	M	C
C	Q	U	B	A	B	L	A	T	I	O	N
A	W	S	S	U	L	M	A	H	Y	R	E
L	R	T	A	I	C	U	T	C	T	A	I
G	E	A	T	E	G	R	M	R	H	I	C
B	B	M	I	X	A	D	I	U	A	N	S
U	M	A	H	E	S	E	R	A	C	E	T
S	U	T	E	S	S	A	V	E	R	C	H
A	N	H	B	N	R	A	E	L	T	S	A

Till: sediment formed from the movement of a glacier. It's often deposited when a glacier melts.

Moraine: mounds of till ranging in size from sand grains to large boulders. Formed by the deposition of material from a glacier.

Drumlin: a canoe-shaped hill made of glacial till.

Firn: partially compacted snow from several seasons that is not yet as firm or solid as ice.

Accumulation zone: the area above the firn line where snowfall accumulation is greater than losses from evaporation, melting, or sublimation.

Ablation zone: the area of a glacier where more ice is lost than gained due to melting, evaporation, and ice calving.

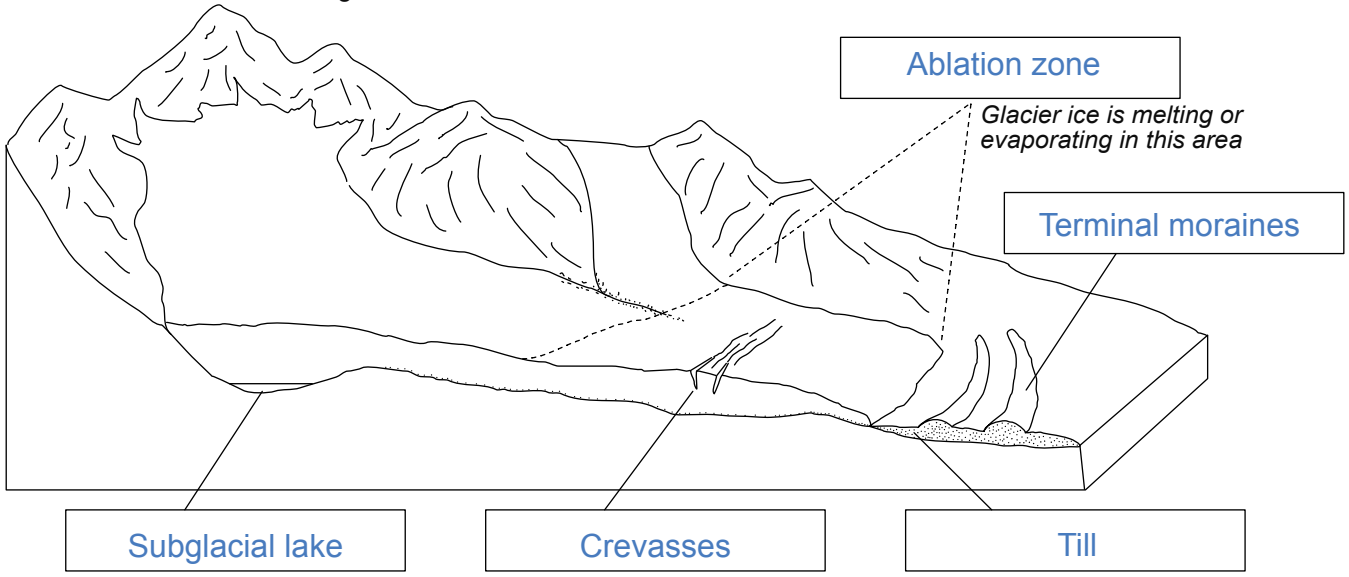
Crevasse: a deep open crack in a glacier.

Subglacial lake: a lake underneath a glacier.

Did you see the bonus words too?
(Melting, glacier, science, math, learn, number)

Ice on the move...

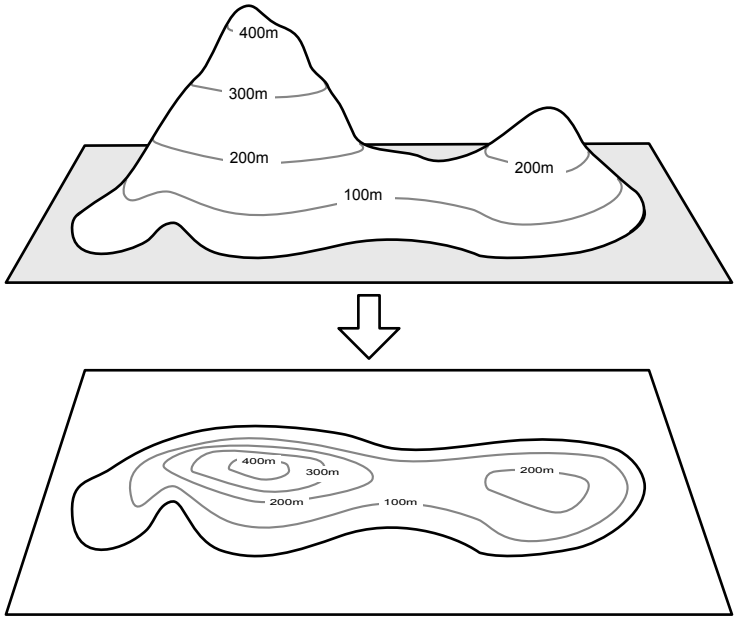
Use the definitions above to label the terminal moraines, crevasses, ablation zone, subglacial lake, and till:



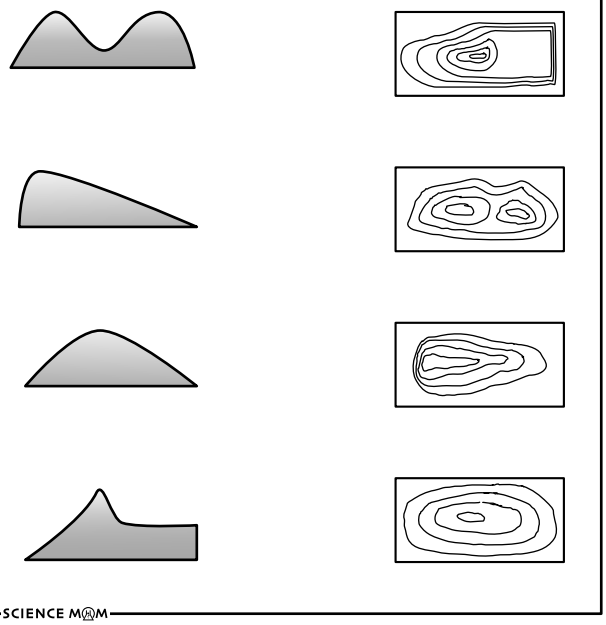
Build A Map ART PROJECT

A contour map is a 2-dimensional plot of a 3-dimensional figure that tracks all the locations of specific heights.

In the image to the right, you can imagine what the lines on the hill would look like from above. That's a contour map.

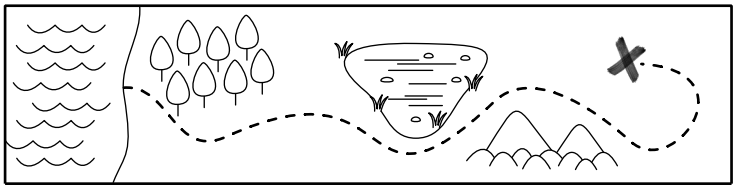


Draw lines to map the shape to it's corresponding topographical map!



SCIENCE MOM

IF YOU'D LIKE, YOU CAN MAKE A KEY FOR YOUR MAP AND ADD IN SYMBOLS TO GIVE IT MORE DETAILS!

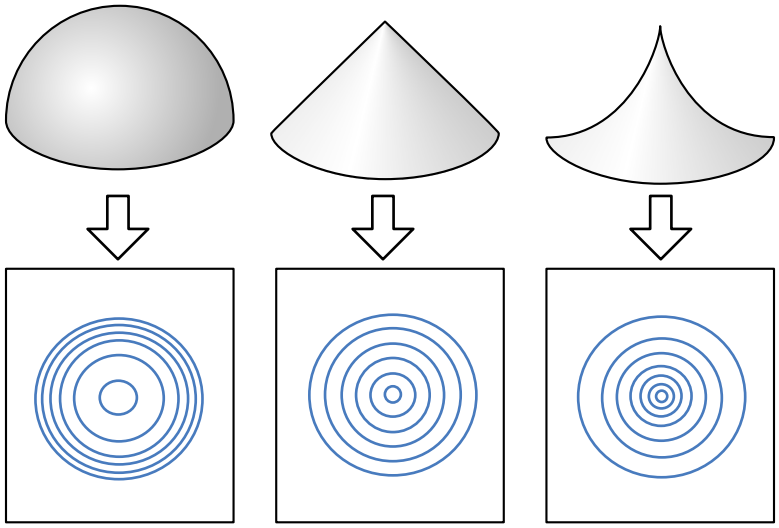


Contour Challenge: Form a shape using playdough, and draw the corresponding contour map. If you want, use a ruler and a marker to draw parallel lines around your shape to help map it.

Reverse Challenge: Make up a contour map and then create the corresponding 3D shape.

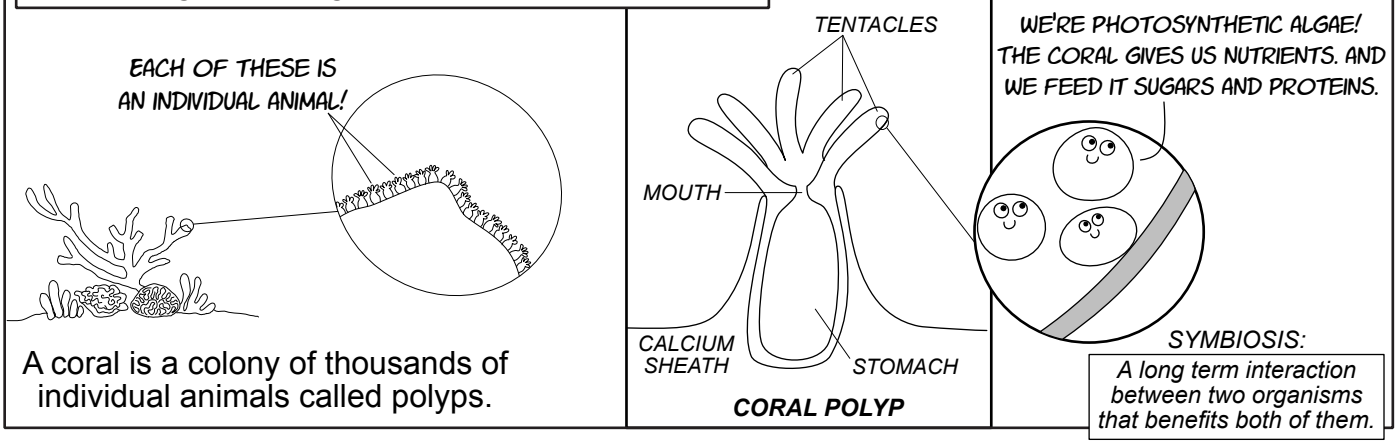
Team Challenge: Teammate 1 draws a contour map, and Teammate 2 molds it into a 3D figure. Teammate 3 is then tasked with drawing a contour map from the 3D figure. Compare it with the original contour map to see how well it translated back and forth.

For each shape below, draw the contour map that describes the shape below it.



Coral Reefs

CORAL: Algae-farming animals that turn into rocks!



A coral is a colony of thousands of individual animals called polyps.

Coral reefs are some of the most diverse ecosystems on Earth. They protect shorelines from erosion and provide habitat for thousands of different species of animals.

Most coral are photosynthetic and grow in shallow waters. But they are not plants! A coral is a colony of identical individual animals called polyps.

Hard corals form a support structure of calcium carbonate. Over millions of years, a coral reef will turn into limestone.

MALICCU

C	A	L	C	I	U	M
		9	8			

TAREH

E	A	R	T	H
6	3		4	5

WORG

G	R	O	W
		1	

ORCLA

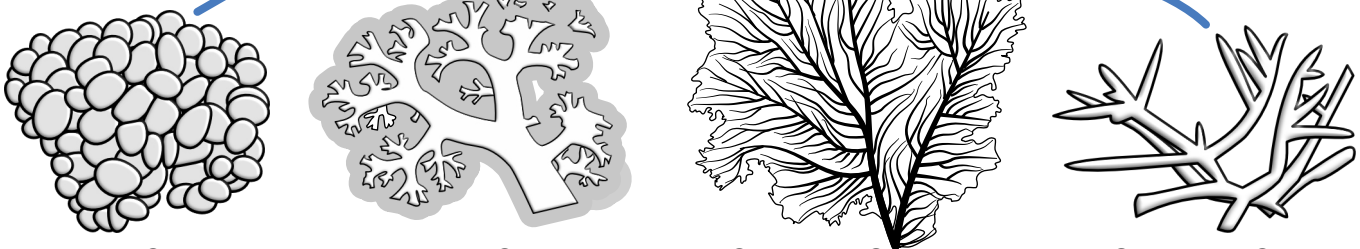
C	O	R	A	L
	2			7

THE FOUR WORDS ABOVE ARE FROM THESE PARAGRAPHS. UNSCRAMBLE THEM TO UNCOVER THE NAME OF CORAL ALGAE:

Z	O	O	X	A	N	T	H	E	L	L	A	E
1	2			3		4	5	6	7	8	9	

DRAW A LINE TO MATCH THE CORAL TO THE CORRECT FACT BOX

One of the most important corals in the Caribbean. Forms thickets in shallow water and is an important habitat for fish.	This coral looks like a bunch of grapes!	These soft corals are often seen on shorelines. They attach to strong rock and have a rubbery feel.	This soft coral grows in a flat fan-like shape. It has no calcium carbonate skeleton.



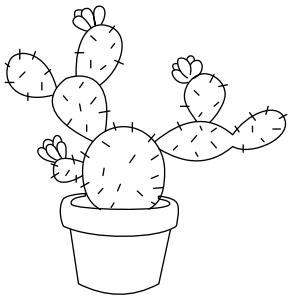
Bubble Coral
Pleregyra Sinuosa

Tree Coral
Capnella species

Common Sea Fan
Gorgonia Ventalina

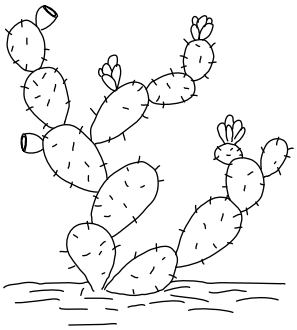
Staghorn Coral
Acropora cervicornis

SCIENCE MOM



A prickly problem

The prickly pear was brought to Australia in 1787. These cacti were great homes for macerated cochineal bugs which were used to make red dye for British soldiers' coats. They were then used in gardens as a hedge. This led to cacti slowly spreading and taking over land. In 1901, a drought caused farmers to plant even more of it to help feed their cattle after many of their crops were destroyed. By 1925 prickly pear had spread to over 25 million acres!



The land it grew on became unusable. It was so expensive to remove the troublesome plant that farmers would just abandon their land. The government tried crushing it, burning it, digging it up, and even poisoning it without much success.

After a reward equaling $1.3 million dollars for a solution to the problem went unclaimed, the Prickly Pear Traveling Commission was created. They searched the globe until finally, in Argentina they discovered a small brown-grey moth called *Cactoblastis cactorum*. Nine million moth eggs were brought to Australia in 1926, and by 1932 the larvae had eaten their way through the problem!

Are there invasive species in your neighborhood or country? Research two of them!

Common Name: _____

Scientific Name: _____

Where it's from.

Why it's a problem.

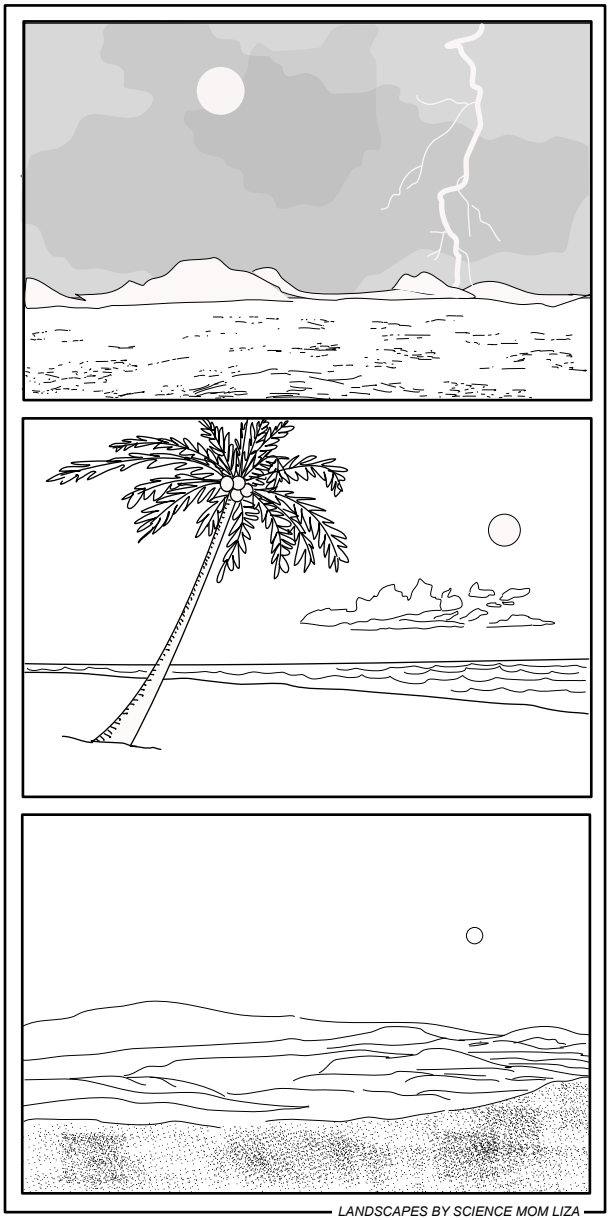
Common Name: _____

Scientific Name: _____

Where it's from.

Why it's a problem.

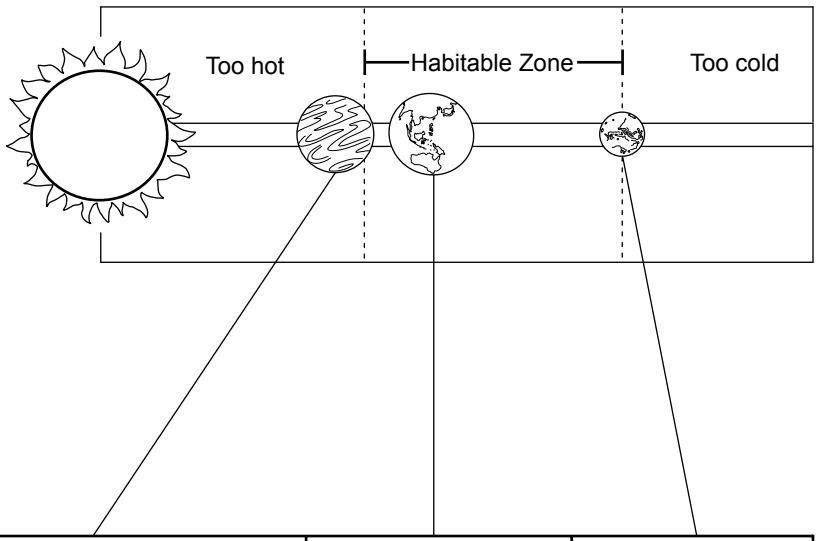
Venus, Earth, and Mars



FILL IN THE BLANKS USING THESE WORDS:

melt	water	atmospheres	sun	different

The closest planets to Earth have very different ___atmospheres___. The air on the surface of Venus is thicker than liquid ___water___ but hot enough to ___melt___ lead. The air on the surface of Mars is very thin and incredibly cold. One reason conditions on Venus, Earth, and Mars are so ___different___ has to do with their distance from the ___sun___. Venus is too close, Mars is too far, and Earth is just right.



	Venus	Earth	Mars
ATMOSPHERE	Mostly carbon dioxide, with clouds of sulfuric acid.	Mostly nitrogen with 21% oxygen.	Mostly carbon dioxide. Very thin.
AVERAGE TEMPERATURE	461° C (861° F)	15° C (59° F)	-46 ° C (-50° F)
WATER	No liquid water.	70% of surface covered by ocean.	Small amounts of ice at poles
PRESSURE ON PLANET SURFACE	9,300 millibars (like being under a kilometer of water)	1,013 millibars (feels comfortable)	6 millibars (feels deadly)
DISTANCE & RADIATION RECEIVED FROM SUN	0.723 AU (astronomical units) and 2,603 W/m^2	1 AU 1,361 W/m^2	1.52 AU 586 W/m^2

What supplies and shelter would you need to survive for three weeks on each planet?

Earth

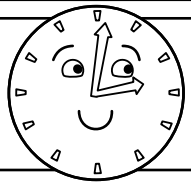
A person could survive for three weeks with no supplies as long as they were placed in a temperate or tropical climate and knew how to forage and gather edible food from their surroundings. Without hunter/gatherer skills, a large case of food (about 50 MREs (Meals Ready to Eat)), a water filter, and a tarp and blanket would be more than adequate.

Venus

A person would need the most advanced and indestructible submarine ever invented (because the pressure and temperatures on Venus are similar to diving to the bottom of a boiling hot lake), an energy supply for cooling to keep the inside of the submarine/ space station from overheating, all the air/ oxygen you'd need to breathe during 3 weeks, plus food and water.

Mars

A full space station with protection from the hostile atmosphere, equipment to keep the station warm, all the air/oxygen you'd need to breathe during 3 weeks, plus food and water.



Quiz Time!

ANSWER THE QUESTIONS TO SEE WHAT YOU LEARNED!

① What is the most common gas in the atmosphere?
- A Oxygen
- B Carbon dioxide
- **C Nitrogen**
- D Argon

② Most of the clouds in the sky are made of:
- A Solid water
- **B Liquid water**
- C Gaseous water

③ Which of these clouds will produce rain?
- **A Cumulonimbus**
- B Stratus
- C Cirrus
- D All of the above

④ When air speeds up to go over the curve of an airplane wing, what happens?
- **A The pressure decreases.**
- B The pressure increases.

⑤ Air rising at the equator drives the circulation of:
- A The Ferrel cells
- **B The Hadley cells**
- C The polar cells

⑥ Desert climates are defined by a lack of
- A Heat
- **B Water**

⑦ The layer of the atmosphere that contains the ozone layer is called the:
- A Mesosphere
- B Exosphere
- C Troposphere
- **D Stratosphere**

⑧ Which instrument is used to measure air pressure?
- A Thermometer
- B Hygrometer
- C Anemometer
- **D Barometer**

⑨ Herbivores in an ecosystem are:
- A Primary producers
- **B Primary consumers**
- C Secondary producers
- D Secondary consumers

⑩ True or False? Hurricanes transfer heat from the ocean to the atmosphere.
- **A True**
- B False

⑪ What caused the year without summer (1816)?

A A mistake by the calendar-makers guild
B A volcanic eruption
C An extreme drought
D Icebergs migrating from the Southern hemisphere

⑫ Where are most oil reserves located?

A Underground between layers of rock
B Aboveground in tar pits
C At the bottom of the ocean
D In the ozone layer

⑬ How is the ozone in the ozone layer formed?

A From pollution drifting into the sky
B From solar radiation splitting oxygen
C From a chemical reaction between hydrogen and oxygen

⑭ Why do chemicals like chlorofluorocarbons damage the ozone layer?

A They emit radiation that causes ozone to decay.
B They release chlorine atoms into the stratosphere.
C They cause acid rain in the ozone layer.
D They emit a magnetic field that repels ozone.

⑮ If an alien civilization with superior technology came to Earth and removed all the CO_2 from the atmosphere for one year, the result would be

A Beneficial - It would solve global warming.
B Neutral - CO_2 is only 0.04% of the atmosphere. Removing it wouldn't make much difference.
C Catastrophic - All plant life on Earth would die.

⑯ When two tectonic plates move away from each other they create

A A divergent boundary
B A convergent boundary
C A transform boundary

⑰ If you had a super powerful drill that could drill to any depth as long as it was drilling through rock, which of these depths would melt the drill because it would punch through the Earth's crust and encounter magma? *Note that you are drilling holes on a continental plate, not an oceanic plate.* (Select all that apply)

A 4 kilometers
B 14 kilometers
C 40 kilometers
D 400 kilometers
E 4,000 kilometers

"40 kilometers" could also be considered correct if one were drilling at the very edge of or at a thinner spot on a continental plate. Continental plates vary in thickness but are usually more than 40 km thick, so the best answers for this question are 400 and 4,000 km. Oceanic plates are much thinner than continental plates (often just 4 or 5 km thick!)

⑱ Which part of the Earth is the hottest?

A The mantle
B The inner core
C The outer core
D The crust

⑲ True or False: Erosion is breaking down something (like rocks) into smaller pieces.

A True
B False That's weathering. Erosion is moving sediment or rock from one place to another.

⑳ Which came first in Earth's history: flowers or dinosaurs?

A Flowers
B Dinosaurs

㉑ What is the main process happening in a river delta?

A Weathering
B Erosion
C Deposition

㉒ What common sedimentary rock is formed from ancient mud flats?

A Limestone
B Sandstone
C Shale
D Conglomerate

㉓ Approximately how long does would it take for half of the carbon-14 in a dead tree to decay?

A 5 years
B 50 years
C 500 years
D 5,000 years

㉔ A fossil that has evidence of an organism but is not the remains or actual organism is called:

A A trace fossil
B A cast fossil
C A permineralized fossil

㉕ Which type of rock will usually fizz and produce bubbles when placed in vinegar? Select all that apply.

A Limestone
B Granite
C Shale
D Marble
E Obsidian

㉖ Which of these is NOT a mineral? Select all that apply.

A Quartz
B Pearl
C Emerald
D Opal
E Diamond

㉗ What is an example of the lithosphere interacting with the atmosphere?

Answers will vary. One example is a volcano erupting and putting gases like carbon dioxide and sulfur dioxide into the atmosphere.

㉘ Which zone of a lake lacks sunlight?

A Limnetic
B Profundal
C Littoral

㉙ If the world's water supply was 100 liters (26 gallons), how large would the liquid fresh water be?

A 3 milliliters
B 30 milliliters
C 3 liters
D 30 liters

㉚ A hole or collapsed area caused by underground water erosion is called:

A Limestone
B An aquifer
C A sinkhole (Also called a doline)
D Karst

㉛ A meandering river will form:

A Caves
B Oxbow lakes
C A swamp
D Whitewater rapids

㉜ What is at the bottom of every lake?

A A prehistoric sea monster
B Layers of sediment
C Hydrothermal vents

㉝ Glaciers carve sediment and deposit it into _____. Select all that apply.

A Drumlins
B Moraines
C U-shaped valleys

㉞ A lake with no outlet (no river draining from it) will be:

A Large
B Salty
C Full of fish

㉟ True or false: coral are plants.

A True
B False

㊱ What is an example of the biosphere interacting with the hydrosphere?

Answers will vary. Some examples: Clams, shrimp, and other filter feeders clean water, removing sediment, algae, and other debris. Runoff from over fertilized fields adds excess nitrogen to a pond, producing an algae bloom.

㊲ In the coral reef ecosystem, what are the primary producers?

A Algae
B Coral
C Reef fish
D Sharks

㊳ What is an example of the lithosphere interacting with the biosphere?

Answers will vary. Some examples are that of soil providing nutrients for plants, a cave providing habitat for animals, a volcano erupting and lava forcing animals to move to a new home.

㊴ True or False: Obsidian and granite are both igneous rocks.

A True
B False

㊵ Why are invasive species a problem?

Answers will vary but should touch on the following concepts: Invasive species upset the balance of an ecosystem by eating or outcompeting other important species, sometimes even causing other species to go extinct.

㊶ True or False: The discharge or flow rate of a river rarely fluctuates.

A True
B False

㊷ How does the atmosphere impact the hydrosphere? Select all that apply.

A Carbon dioxide dissolves in water, changing the pH of oceans and rain.
B Volcanic vents release minerals into the air.
C Wind blows dust into the air, providing "seeds" for water droplets which increases cloud formation.
D Volcanic vents release minerals into the ocean.

Acknowledgments

I wouldn't have been able to complete this project without the help of several wonderful people. I'd like to give a special thank you to each of the following for their contributions:

Amber Chesser (Science Mom Amber) for wonderful moderating, encouraging messages, and all around sparkle-power.

Emily Austin (Science Mom Emily) for excellent fact-checking. Your candor and humor brings out the best in our team.

Emily Chen (Art Mom Emily) for amazing artwork in the "Where in the World" trivia pages. If you'd like to see more or her art, check out:

www.facebook.com/mchendraws and
www.emilychendesign.com

Jamie Hitchings (Science Mom Jamie) for outstanding moderating, the best puns, and always being willing to lend a hand.

Jodi Ireland (Science Mom Jodi) for sharing a love of history and science. Thank you for contributing the "Where in the World" clues!

Krista Frye (Science Mom Krista) for constant support (I couldn't imagine running our facebook page without you!) and the best insights for worksheets and lesson plans.

Liza Bishton (Science Mom Liza) for incredible artwork, sharp writing, and having words of encouragement at the times when I need them most.

Our Patrons - it's no exaggeration to say this class (and our Science Mom Squad) wouldn't exist without our wonderful patrons. Thank you!

Serge Ballif (Math Dad) for being the most supportive partner and my best friend. Spending every day with you is a dream come true.

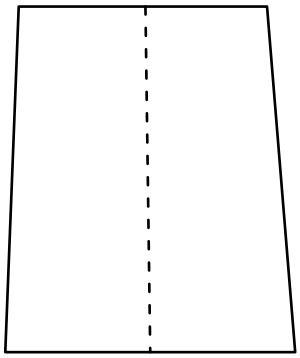
Appendix (the place with all the templates!)

Note that for the pages following 113, every other page is left blank. This is intentional so that when the notes are printed double-sided, the templates are still usable)

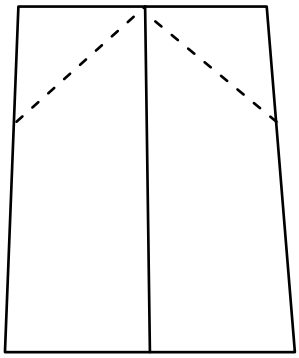
IN THE APPENDIX:

The Classic Dart

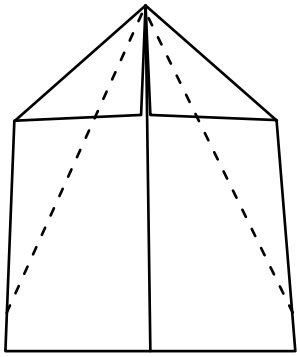
①. Fold the paper in half hotdog-style. Then open it back up.



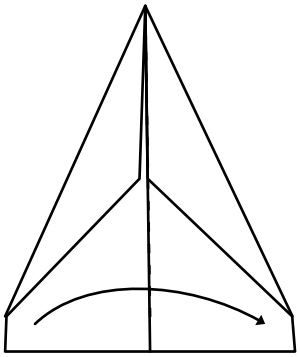
②. Fold the top two corners into the center line.



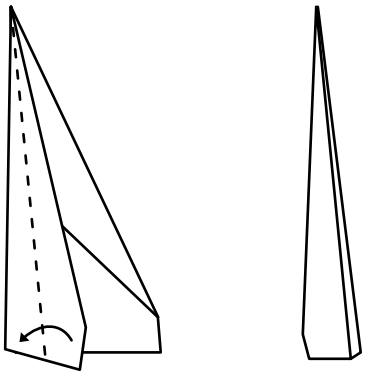
③. Fold the obtuse corners to the center line.



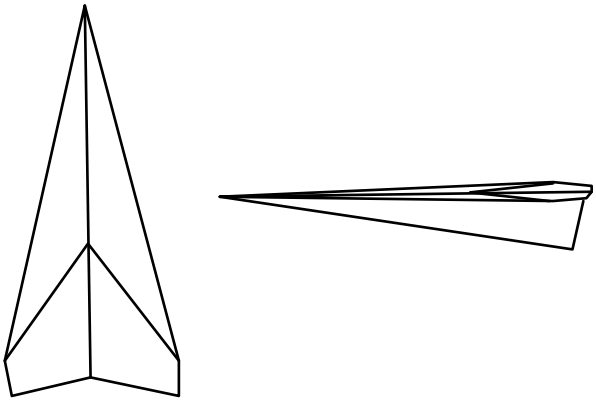
④. Fold the two wings together.



⑤. Fold each wing down so that the edges meet.

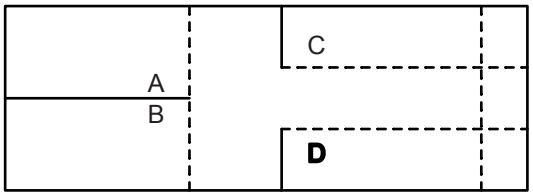


⑥. Reopen the wings by lifting them up a bit more than 90°.

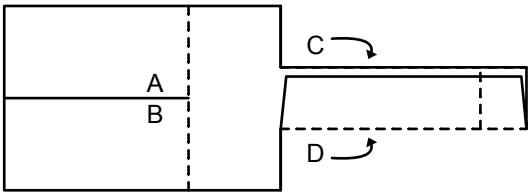


Helicopter

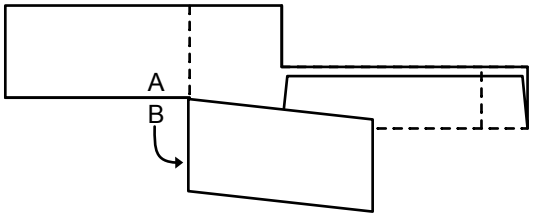
①. Cut a rectangular piece of paper (or use the templates on the following page) and cut it along all solid lines. The dashed lines are for folds.



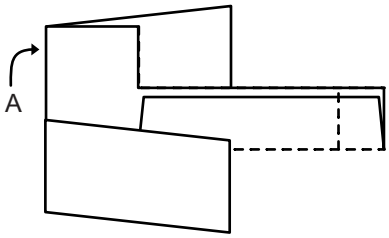
②. Fold section C and D along the dotted line.



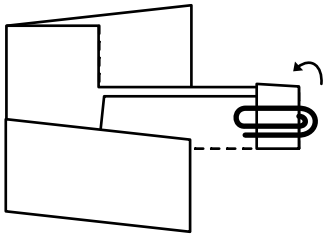
③. Fold section B up along the dotted line.



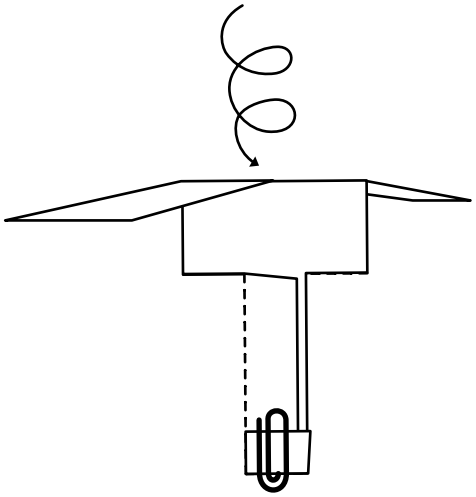
④. Fold section A along the dotted line, but on the opposite side as section B.

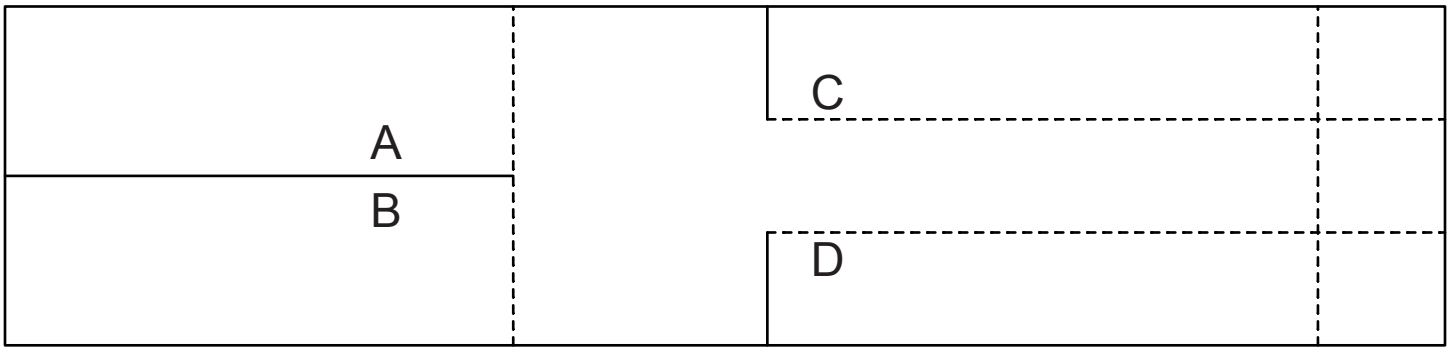


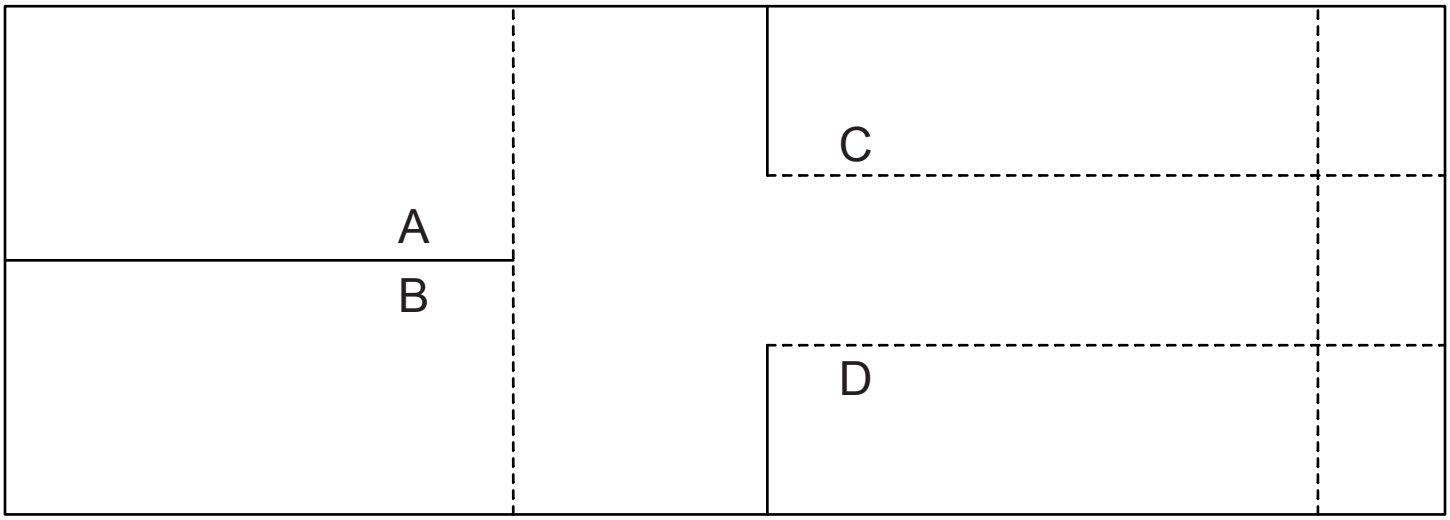
⑤. Fold the tip up and hold it in place with a paper clip.

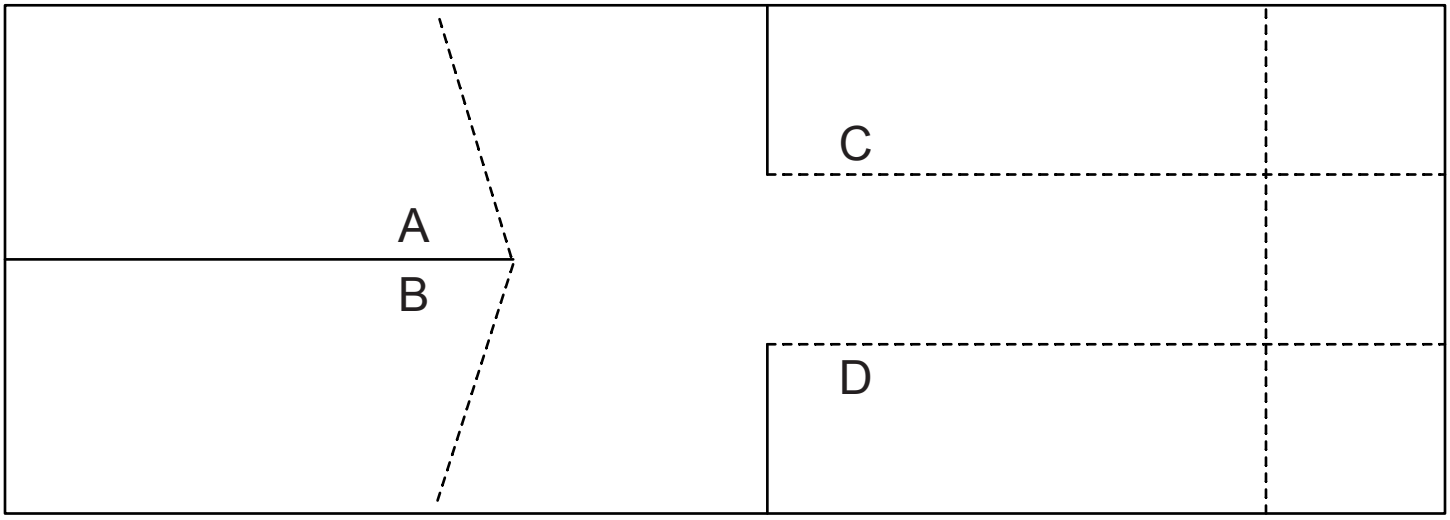


⑥. Toss the final helicopter into the air or drop it from the ceiling.




A
B
C
D


A
B
C
D


A
B
C
D

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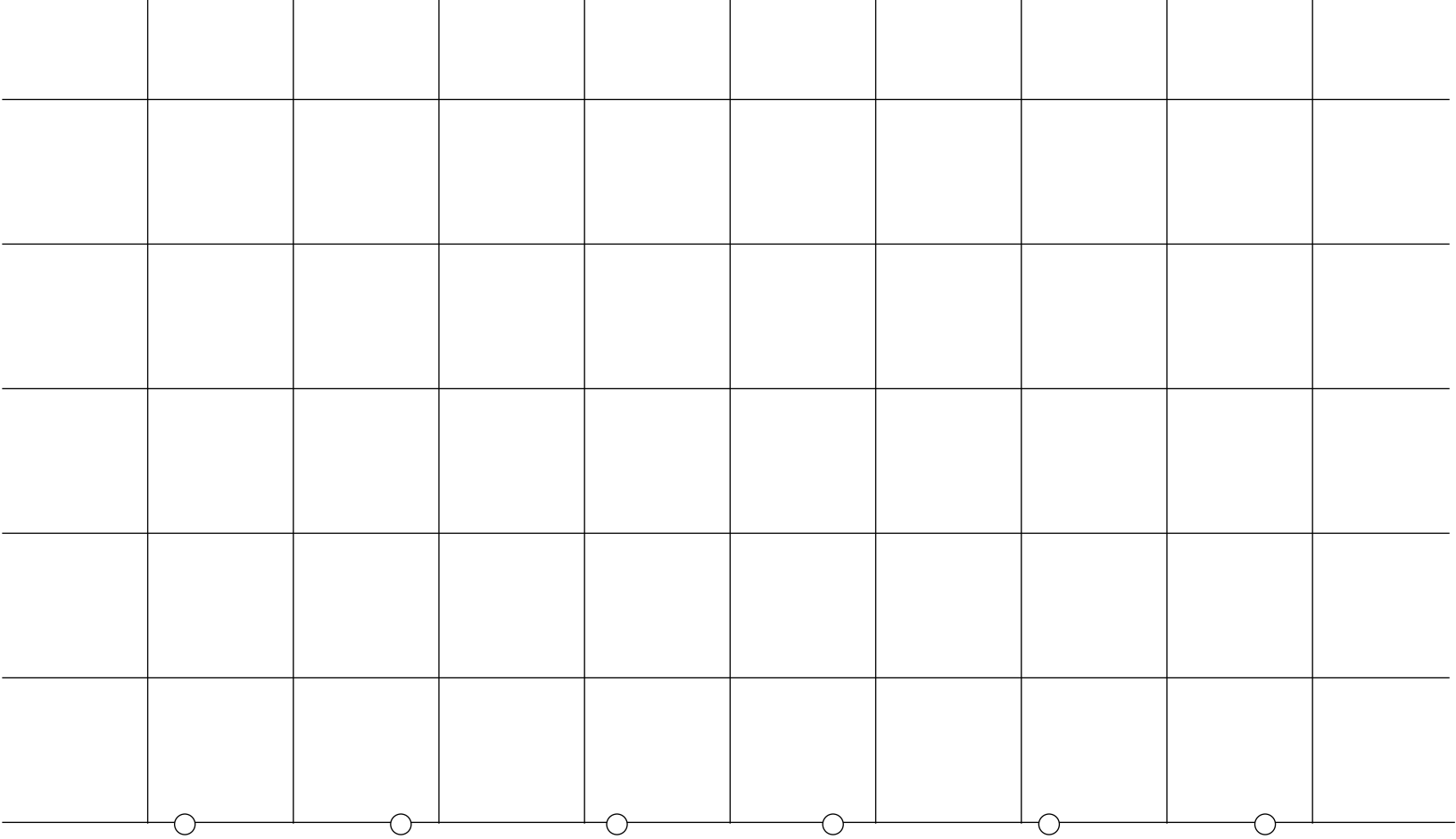

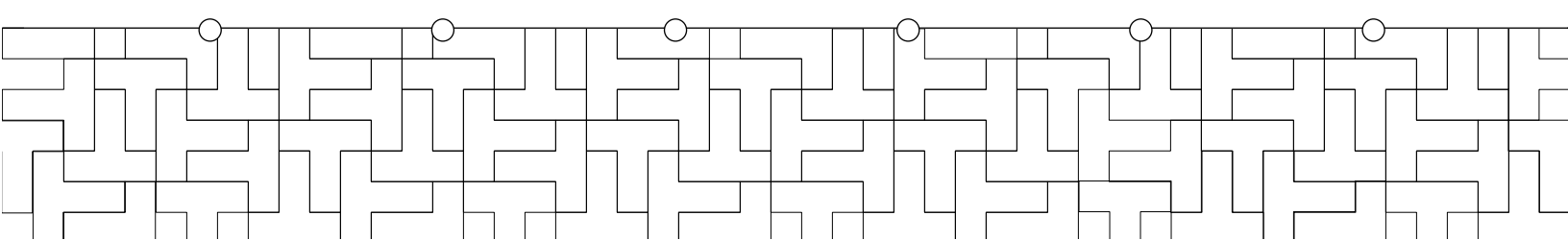

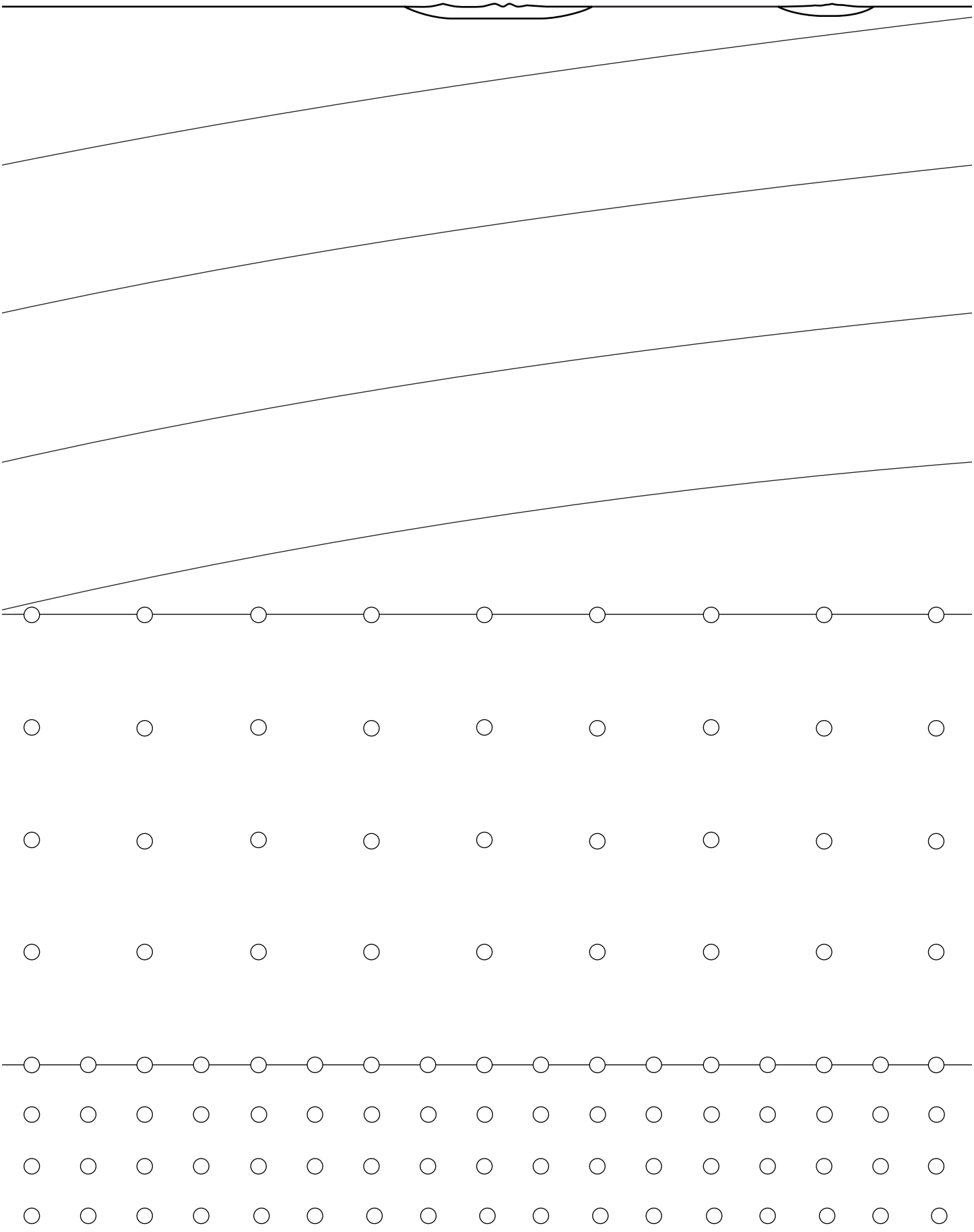

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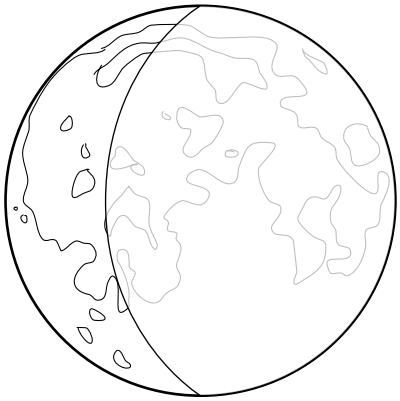

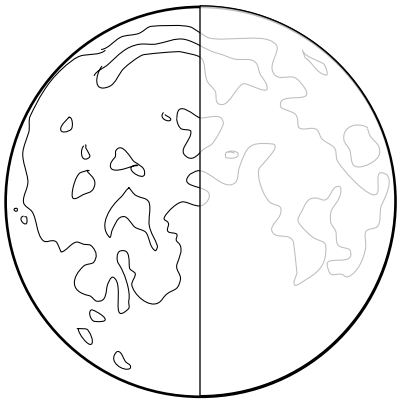

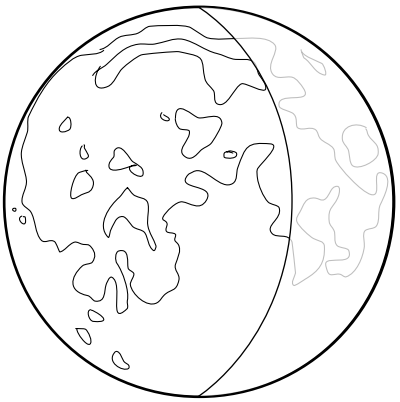

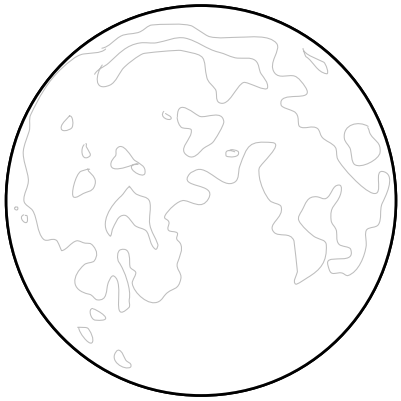

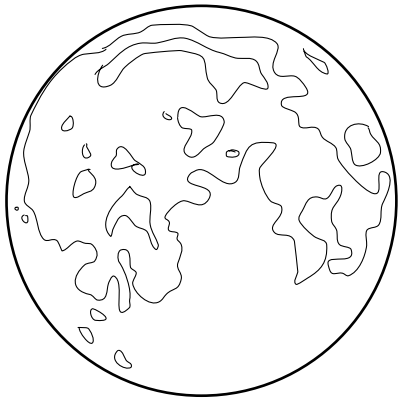

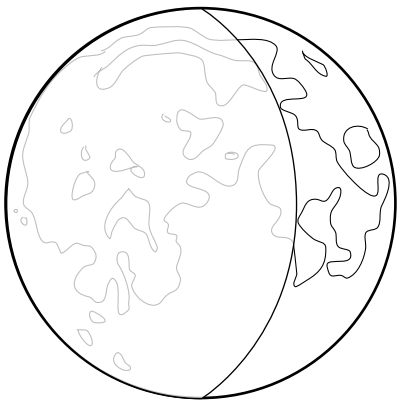

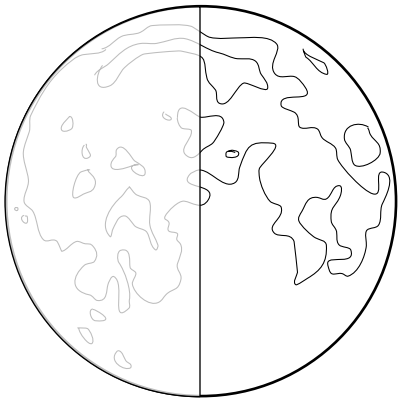

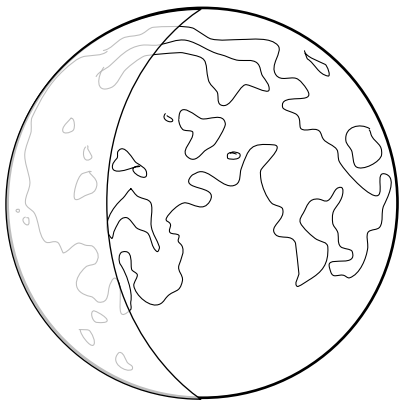

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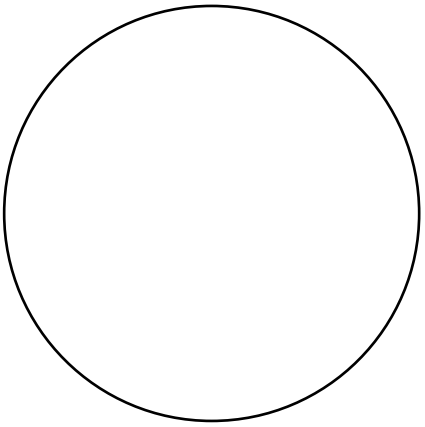
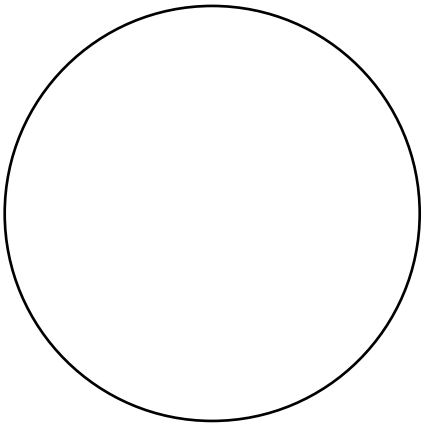
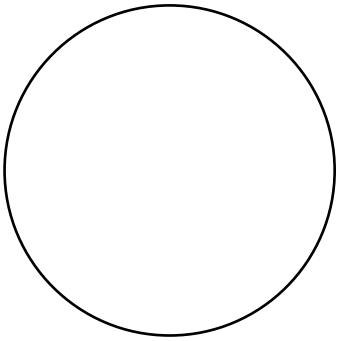


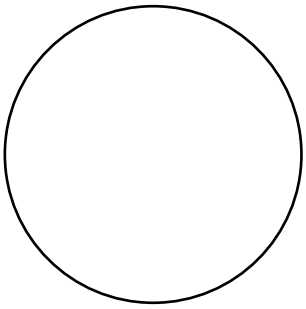
Jupiter's moon Ganymede is larger than the planet Mercury. The moon likely has a salty ocean underneath its icy surface and is the ninth-largest object in our solar system.



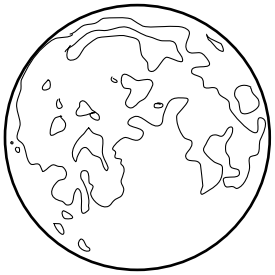
Saturn's moon Titan is the second-largest satellite in the Solar System. It is 50 percent larger than Earth's moon in diameter. It is the only moon known to have a dense atmosphere.



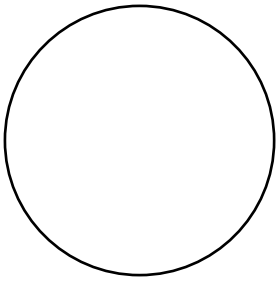
Callisto is the second-largest moon of Jupiter, after Ganymede. It is the third-largest moon in the Solar System and composed of equal parts rock and ice.



Jupiter's moon Io is the most volcanically active body in the solar system. Astronomers have mapped about 150 volcanoes on the moon, some of which blast lava 250 miles (400 km) out into space.

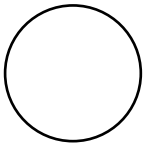


The Moon is Earth’s only natural satellite. Its presence helps stabilize our planet’s wobble, which helps stabilize our climate. The Moon has a very thin atmosphere called an exosphere.

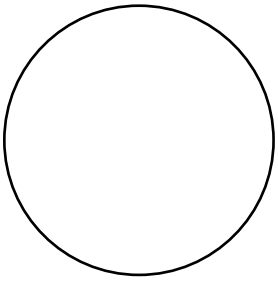


Jupiter's moon Europa is slightly smaller than Earth's Moon and is primarily made of silicate rock with a water-ice crust. It is believed to glow in the dark as Jupiter's radiation lights up Europa's icy shell.

Phobos orbits only a few thousand miles above the surface of Mars. The moon is getting closer to Mars over the centuries, and will eventually break up or be pulled into the Martian surface.



Saturn's moon Enceladus is mostly covered by ice, making it one of the most reflective bodies of the Solar System. It likely has hydrothermal vents and a liquid ocean under its layer of ice.



Neptune's moon Triton is the only moon in the solar system that orbits in a direction opposite to the rotation of its planet. It has geysers, a very thin atmosphere and cryovolcanoes.

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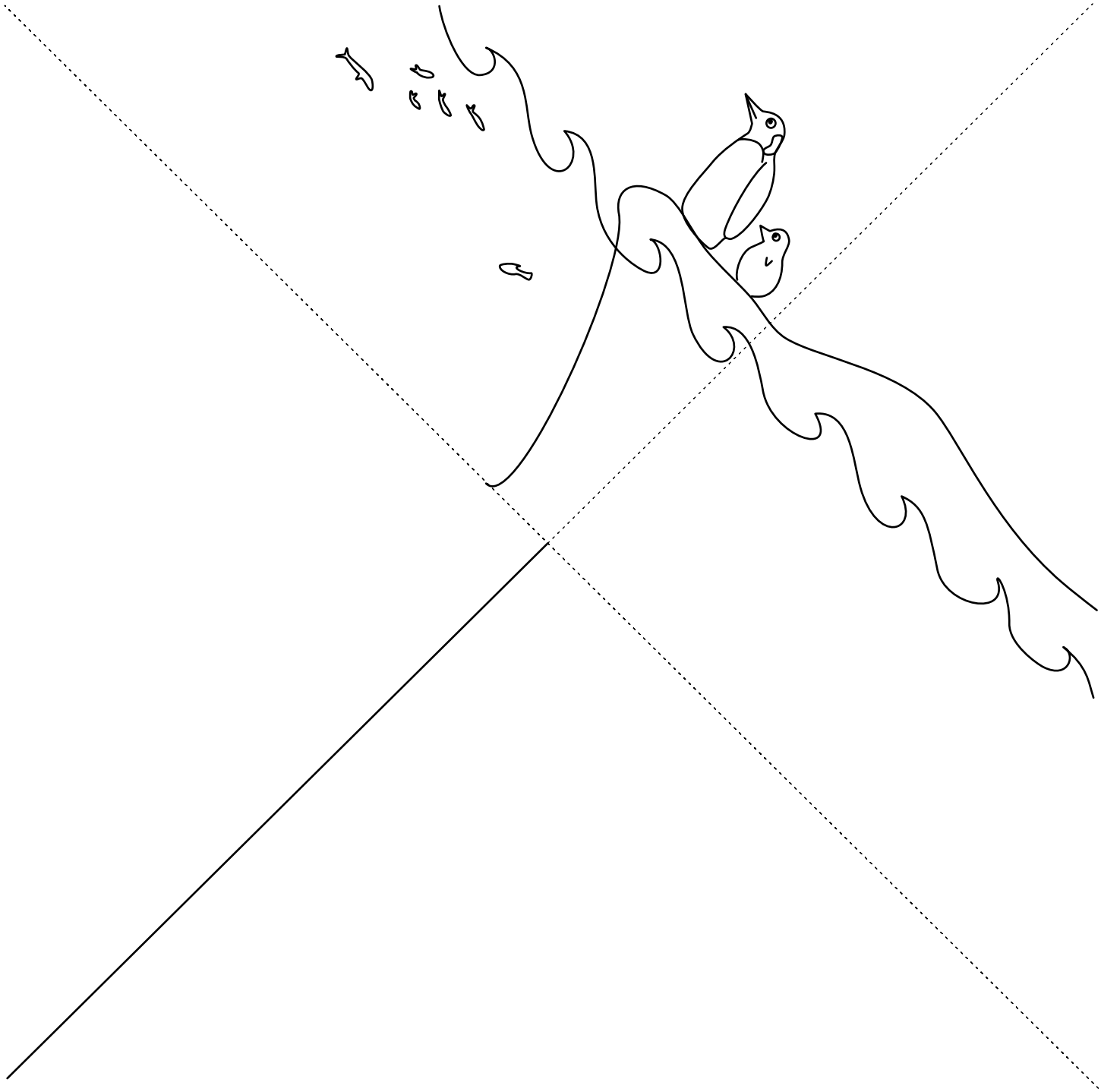
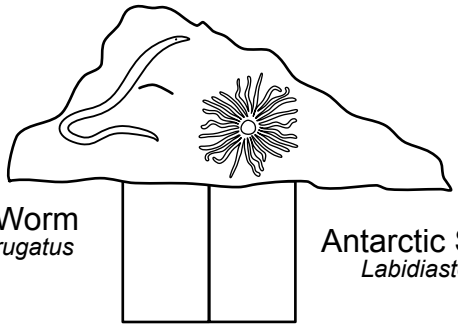
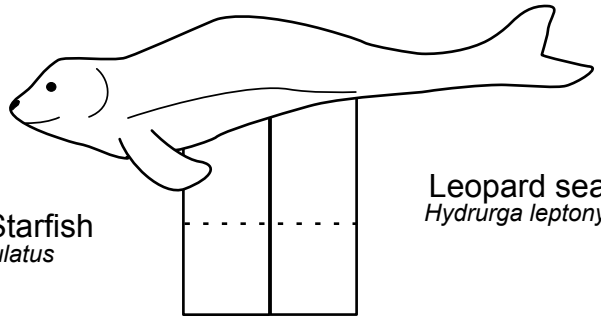




Nemertean Worm
Parborlasia corrugatus

Antarctic Sun Starfish
Labidiaster annulatus



Leopard seal
Hydrurga leptonyx

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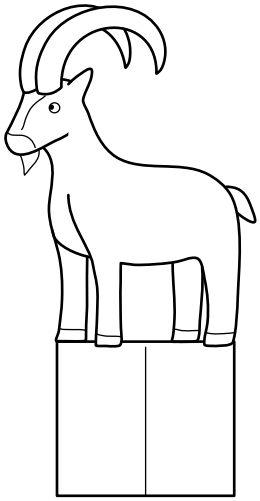
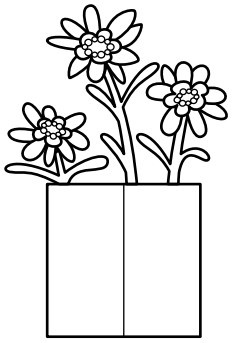
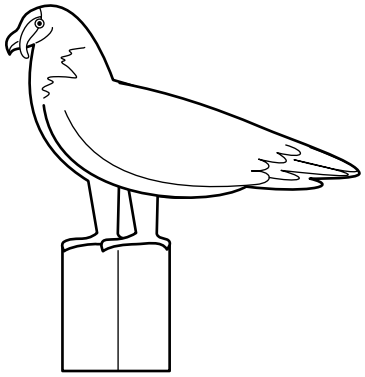


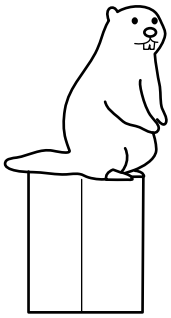
Alpine Ibex
Capra ibex



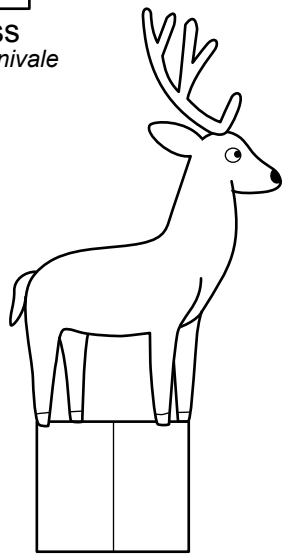
Edelweiss
Leontopodium nivale



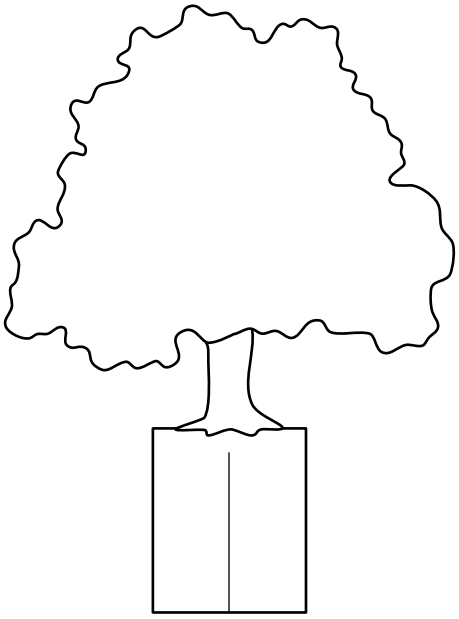
Bearded Vulture
Gypaetus barbatus



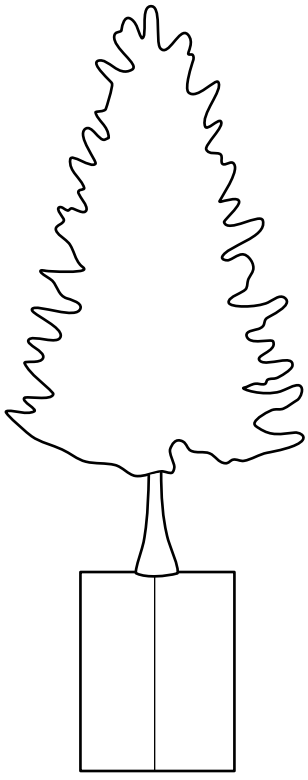
Alpine Marmot
Marmota marmota



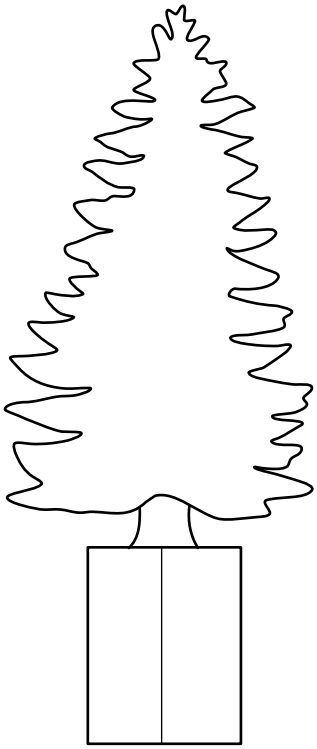
Red deer
Cervus elaphus



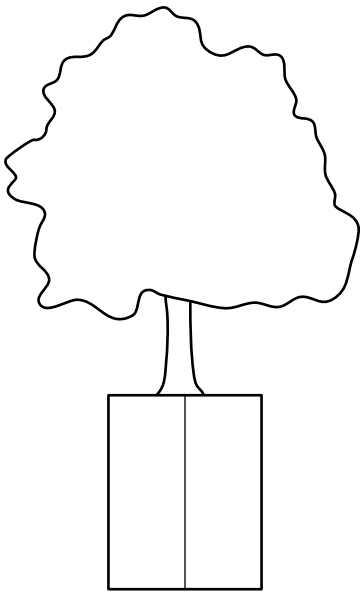
Oak
Quercus robur



European Larch
Larix decidua



Mountain Pine
Pinus mugo



European Beech
Fagus sylvatica

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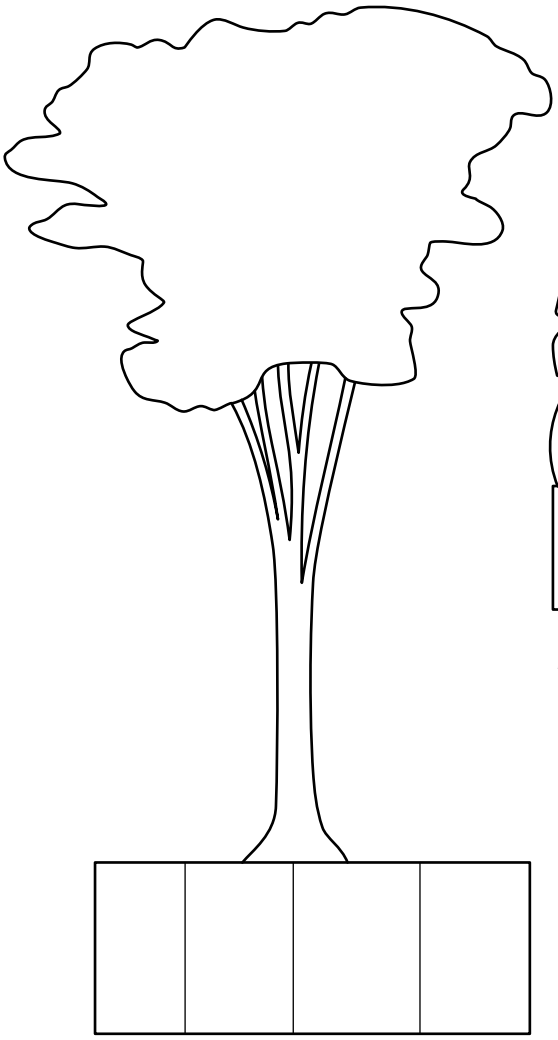
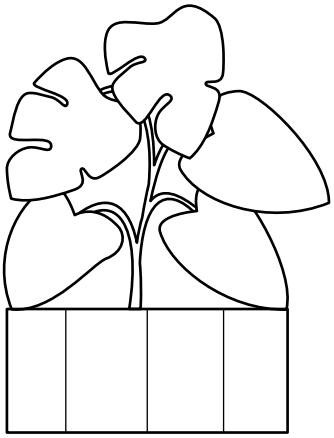
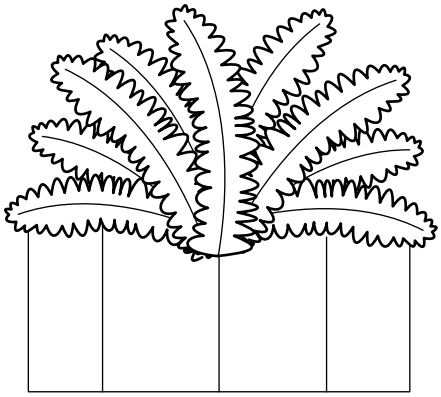


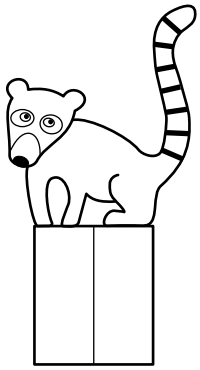
Purpleheart Tree
Peltogyne purpurea



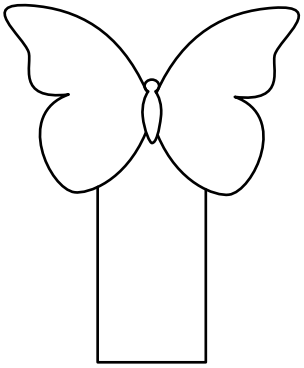
Philodendron
Philodendron verrucosum



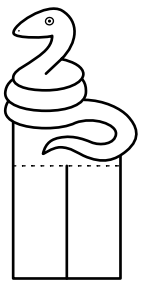
Sword Fern
Nephrolepis exaltata



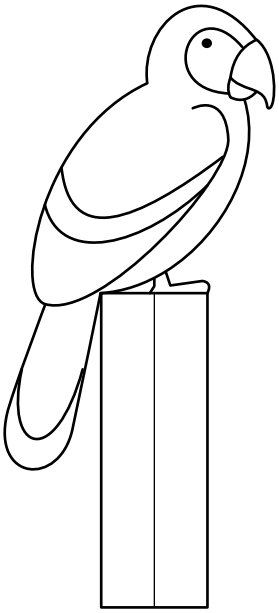
White-nosed coati
Nasua narica



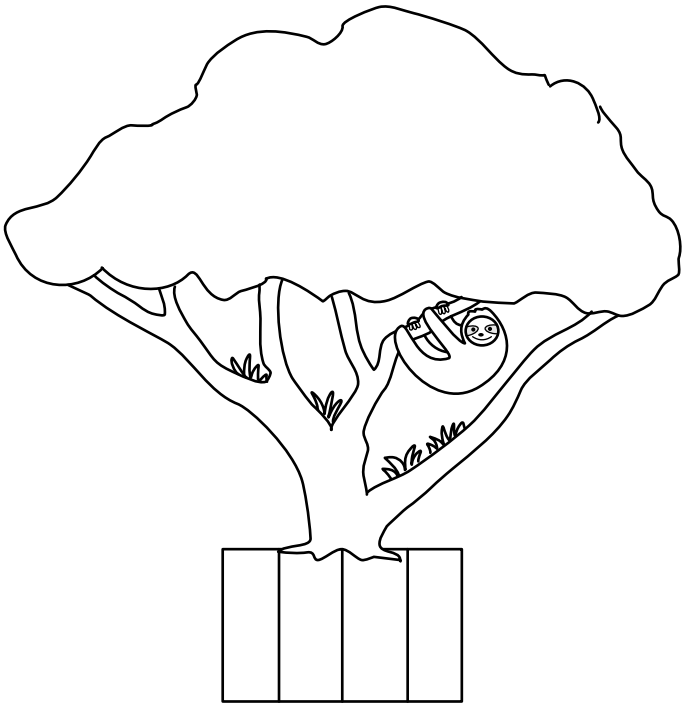
Giant Blue Morpho
Morpho didius



Green Vine Snake
Oxybelis fulgidus



Scarlet Macaw
Ara macao



Guanacaste
Enterolobium cyclocarpum

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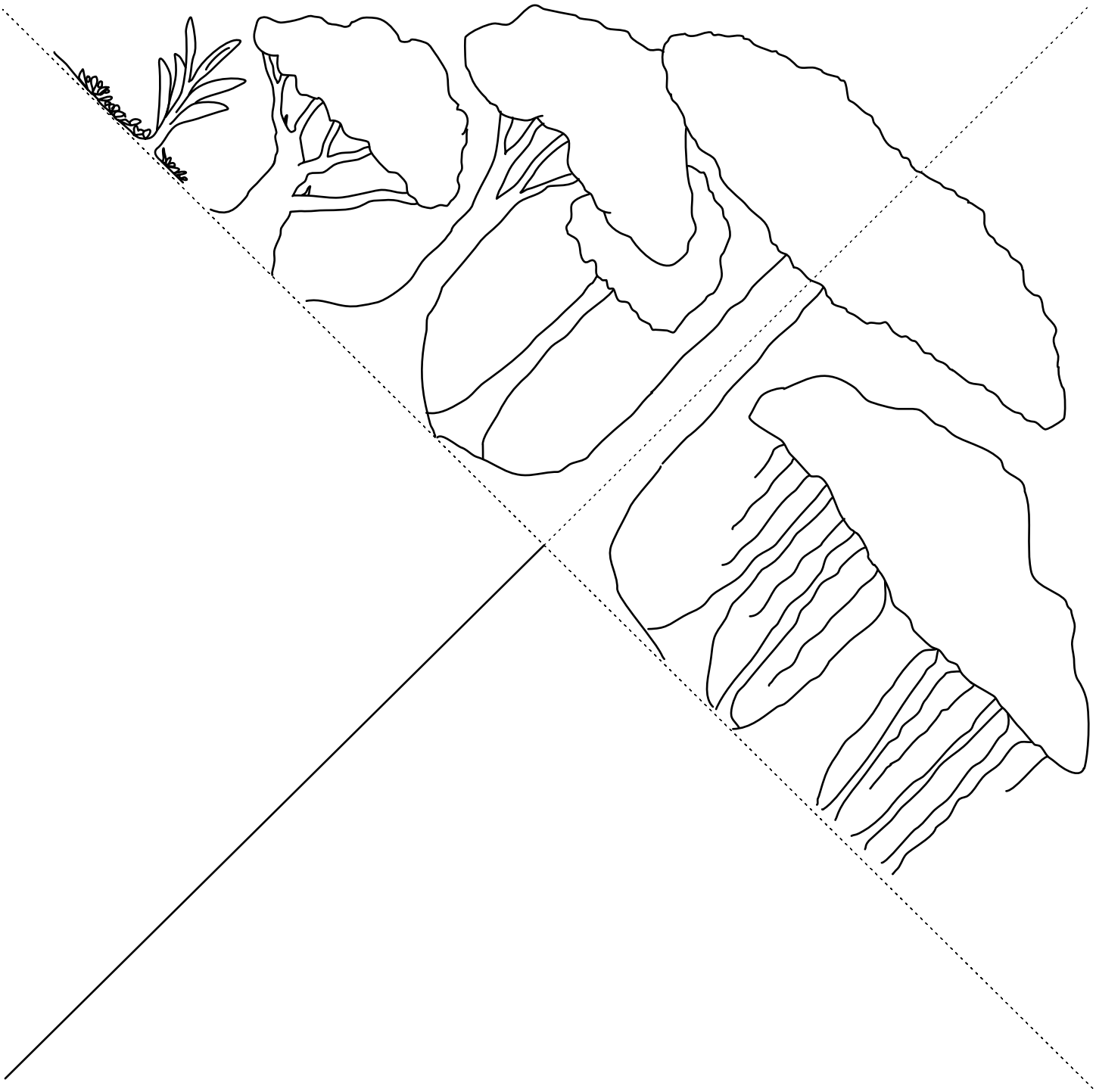

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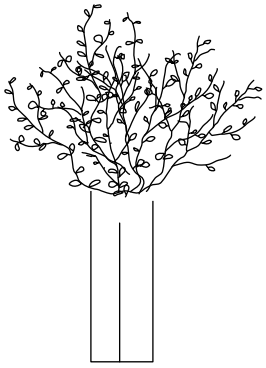
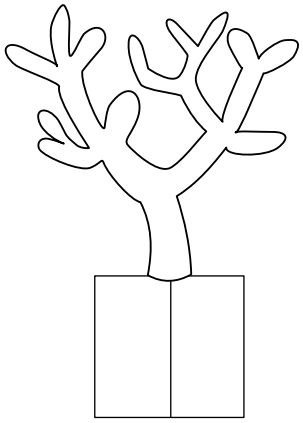
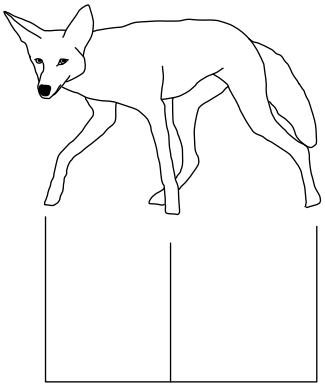


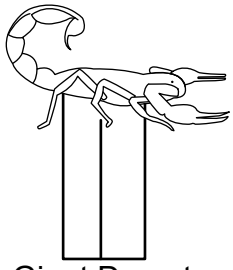
Creosote Bush
Larrea tridentata



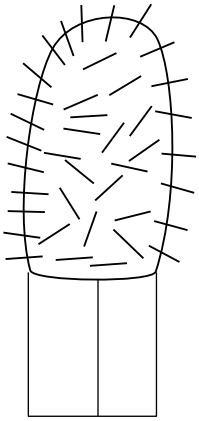
Cholla cactus
Cylindropuntia bigelovii



Coyote
Canis latrans

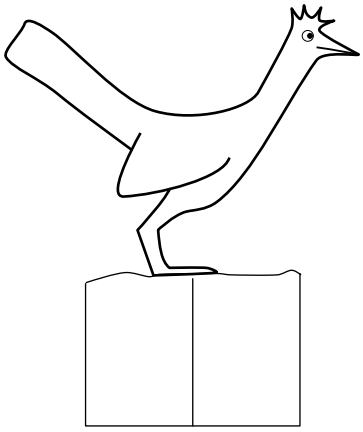


Giant Desert
Hairy Scorpion
Hadrurus arizonensis



Red barrel cacti
Ferocactus cylindraceus

Chuckwalla
Sauromalus ater



Greater Roadrunner
Geococcyx californianus

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