High School Science Enrichment

2 of 3

Wayne-Westland
COMMUNITY SCHOOLS

Name_____

DATA Nugget

A window into a tree's world

Featured scientists: Jessie K Pearl, University of Arizona and Neil Pederson, Harvard University. Written by Elicia Andrews.

Research Background:

According to National Aeronautics and Space Administration (NASA) and the National Oceanic Atmospheric Administration (NOAA), the years 2015-2018 were the warmest recorded on Earth in modern times! And it is only expected to get warmer. Temperatures in the Northeastern U.S. are projected to increase 3.6°F by 2035. Every year the weather is a bit different, and some years there are more extremes with very hot or cold temperatures. **Climate** gives us a long-term perspective and is the average weather, including temperature and precipitation, over at least 30 years.

Over thousands of years, tree species living in each part of the world have adapted to their local climate. Trees play an important role in climate change by helping cool the planet - through photosynthesis, they absorb carbon dioxide from the atmosphere and evaporate water into the air.

Scientists are very interested in learning how trees respond to rapidly warming temperatures. Luckily, trees offer us a window into their lives through their growth rings. Growth rings are found within the trunk, beneath the bark. Each year of growth has two parts that can be seen: a light ring of large cells with thin walls, which grows in the spring; and a dark layer of smaller cells with thick walls that forms later in the summer and fall. Ring thickness is used to study how much the tree has grown over the years. **Dendrochronology** is the use of these rings to study trees and their environments.

Jessie taking a tree core in the winter.

Different tree species have different ranges of temperatures and rainfall in which they grow best. When there are big changes in the environment, tree growth slows down or speeds up in response. Scientists can use these clues in tree's rings to decipher what climate was like in the past. There is slight variation in how each individual tree responds to temperature and rainfall. Because

of this, scientists need to measure growth rings of multiple individuals to observe year-to-year changes in past climate.

Neil taking a tree core from a pine.

Jessie and Neil are two scientists who use tree rings for climate research. Jessie entered the field of science because she was passionate about climate change. As a research assistant, Neil saw that warming temperatures in Mongolia accelerated growth in very old Siberian pine trees. When he later studied to become a scientist, he wanted to know if trees in the eastern U.S. responded to changes in climate in the same way as the old pine trees in Mongolia. As a result, there were two purposes for Jessie's and Neil's work. They wanted to determine if there was a species that could be used to figure out what the climate looked like in the past, and understand how it has changed over time.

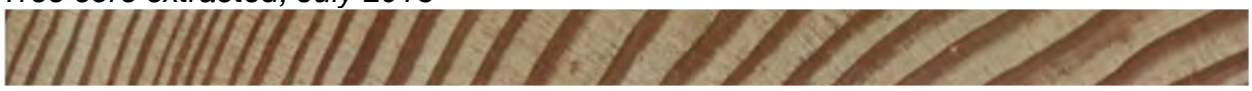
Jessie and Neil decided to focus on one particular species of tree – the Atlantic white cedar. Atlantic white cedar grow in swamps and wetlands along the Atlantic and Gulf coasts from southern Maine to northern Florida. Atlantic white cedar trees are useful in dendrochronology studies because they can live for up to 500 years and are naturally resistant to decay, so their well-preserved rings provide a long historical record. Past studies of this species led them to predict that in years when the temperature is warmer, Atlantic white cedar rings will be wider. If this pattern holds, the thickness of Atlantic white cedar rings can be used to look backwards into the past climate of the area.

To test this prediction, Jessie and Neil needed to look at tree rings from many Atlantic white cedar trees. Jessie used an increment borer, a specialized tool that drills into the center of the tree. This drill removes a wood core with a diameter about equal to that of a straw. She sampled 112 different trees from 8 sites, and counted the rings to find the age of each tree. She then crossdated the wood core samples. Crossdating is the process of comparing the ring patterns from many trees in the same area to see if they tell the same story. Jessie used a microscope linked to a computer to measure the thickness of both the early and late growth to the nearest micrometer (1 micrometer = 0.001 millimeter) for all rings in all 112 trees. From those data she then calculated the average growth of Atlantic white cedar for each year to create an Atlantic white cedar growth index for the Northeastern U.S. She combined her tree ring data with temperature data from the past 100 years.

Name_____

Let's look at a section of a tree core to see how Jessie collected her data.

Tree core extracted, July 2018



↑Year tree core taken (2018) Center of the tree ↑

Observe the tree core. Notice there are two ring colors. The dark rings are made during slower growth and the light ring is made during faster growth. Each pair of light and dark rings represent one year. Count the dark rings to **estimate the age** of the tree.

Which years are the thinnest? Which are the thickest?

What do you think could have caused the differences in tree ring sizes?

Name_____

Scientific Question: How does the Atlantic white cedar respond to changing temperature?

Scientific Data:

Use the data below to answer the scientific question:

Year	Atlantic White Cedar Growth Index	Jan-April Temperature (F)
1910	-0.24	44.29
1915	0.02	44.02
1920	-0.62	43.35
1925	-0.81	43.85
1930	-0.95	43.79
1935	0.30	44.80
1940	-0.64	44.71
1945	-0.62	45.07
1950	-0.69	44.98
1955	0.82	46.16
1960	-0.19	44.66
1965	-1.02	43.73
1970	-1.43	44.21
1975	-0.42	44.60
1980	0.54	45.01
1985	1.10	45.12
1990	1.18	45.32
1995	0.10	45.03
2000	0.86	45.89
2005	1.09	45.22
2010	1.41	46.42
Average		

**The growth index is calculated by comparing growth across a large number of individual trees to get one best estimate of tree growth. There are no units.*
**Jessie and Neil used temperature data from January to April because previous research has shown that the temperature in these months has the strongest effect on Atlantic White Cedar growth.*

Name_____

What data will you graph to answer the question?

Independent variable(s): _____

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Dependent variable(s): _____

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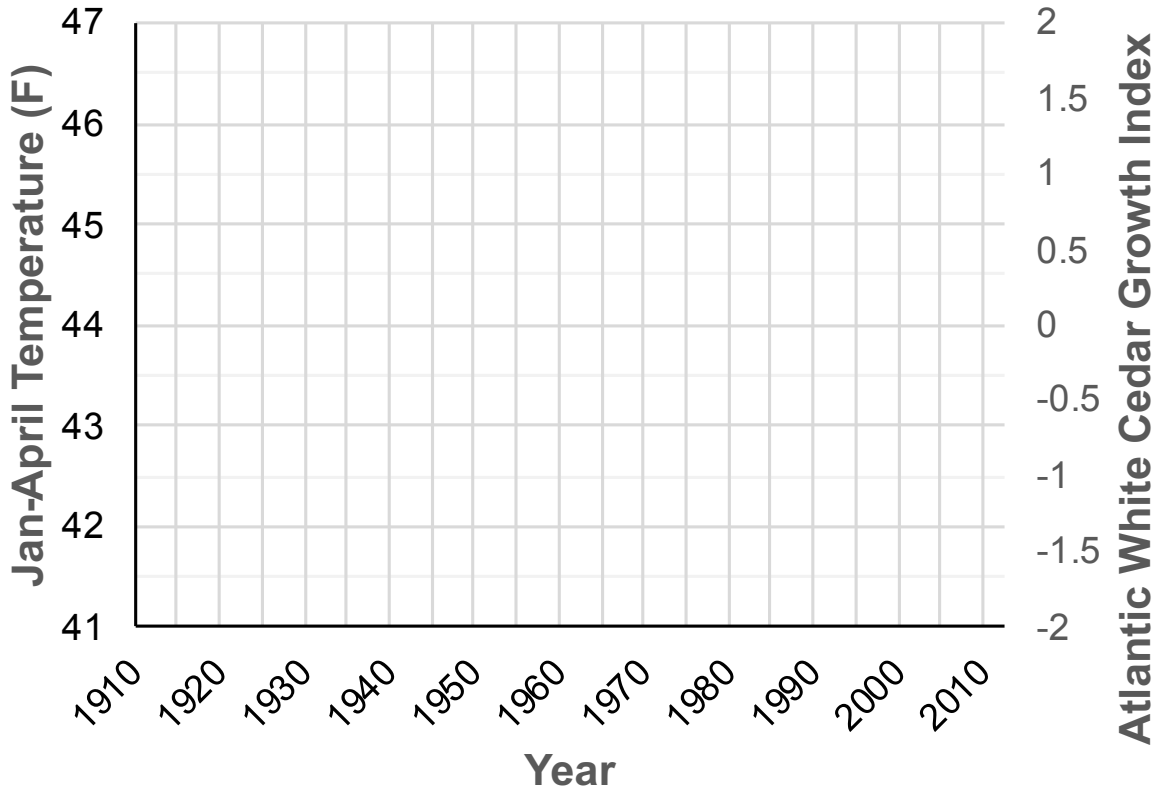
Draw your graph below: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Name_____

Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the table or graph.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about how tree rings width is related to growth.

Name_____

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Jessie and Neil's research? How do your questions build on the research that has already been done?

Name_____

DATA Nugget

Do invasive species escape their enemies?

Featured scientist: Elizabeth Schultheis from Michigan State University

Research Background:

Invasive species, like zebra mussels and garlic mustard, are species that have been introduced by humans to a new area. Where they invade they cause harm. For example, invasive species outcompete native species and reduce diversity, damage habitats, and interfere with human interests. Damage from invasive species costs the United States over $100 billion per year.

Scientists want to know, what makes an invasive species become such a problem once it is introduced? Is there something that is different for an invasive species compared to native species that have not been moved to a new area? Many things change for an invasive species when it is introduced somewhere new. For example, a plant that is moved across oceans may not bring enemies (like disease, predators, and herbivores) along for the ride. Now that the plant is in a new area with no enemies, it may do very well and become invasive.

Scientists at Michigan State University wanted to test whether invasive species are successful because they have escaped their enemies. They predicted invasive species would get less damage from enemies, compared to native species that still live near to their enemies. If native plants have tons of insects that can eat them, while an invasive plant has few or none, this would support enemy escape explaining invasiveness. However, if researchers find that native and invasive species have the same levels of herbivory, this would no support enemy escape. To test this hypothesis, a lab collected data on invasive and native plant species in Kalamazoo County. They measured how many insects were found on each species of plant, and the percent of leaves that had been damaged by insect herbivores. The data they collected is found below and can be used to test whether invasive plants are successful because they get less damage from insects compared to native plants.

Scientists at Michigan State University collecting data on invasive and native plant species, such as the number of insects found on each plant and the percent of leaves damaged by insect herbivores.

Name_____

Scientific Question: How does insect herbivore damage and insect herbivore numbers compare for native and invasive plants? Are invasive species successful because they have escaped insect herbivores?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Scientific Data:

Use the data below to answer the scientific question:

Scientific Name	Species Status	Average number of insects per plant	Percent leaves with damage from insect herbivores
Trifolium repens	invasive	0.09	67.5
Silene latifolia	invasive	0.08	33.9
Daucus carota	invasive	0	13.3
Robinia pseudoacacia	invasive	0.57	86.3
Dianthus armeria	invasive	0.03	34.7
Hieracium caespitosum	invasive	0.06	27.2
Stellaria graminea	invasive	0	8.3
Rumex acetosella	invasive	0	47.5
Chenopodium album	invasive	0	0
Phleum pratense	invasive	0.06	29.1
Danthonia spicata	native	0	10.4
Apocynum cannabinum	native	0	21.6
Hieracium gronovii	native	0	20
Lespedeza capitata	native	0.08	66.7
Ambrosia artemisiifolia	native	0	40.5
Vitis riparia	native	0	100
Monarda fistulosa	native	0	30.5
Antennaria parlinii	native	0	17.7
Euphorbia corollata	native	0	8.3
Asclepias tuberosa	native	0.8	11.6

Average for Invasive		
Average for Native		

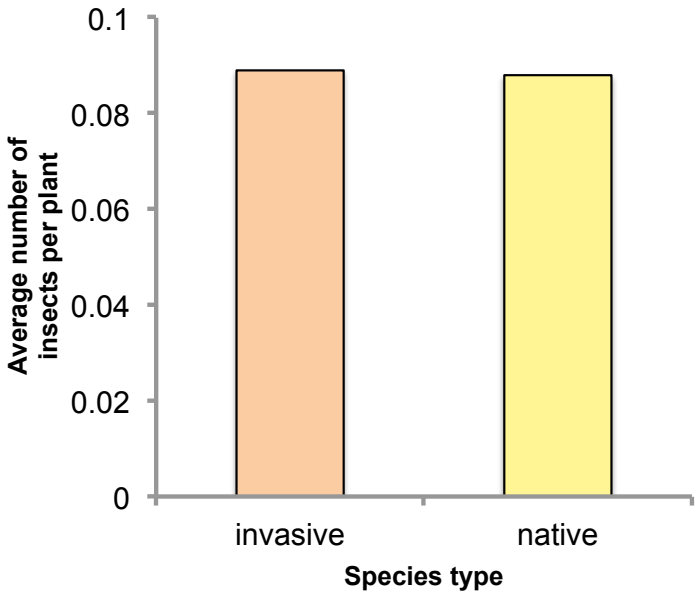
What data will you graph to answer the question?

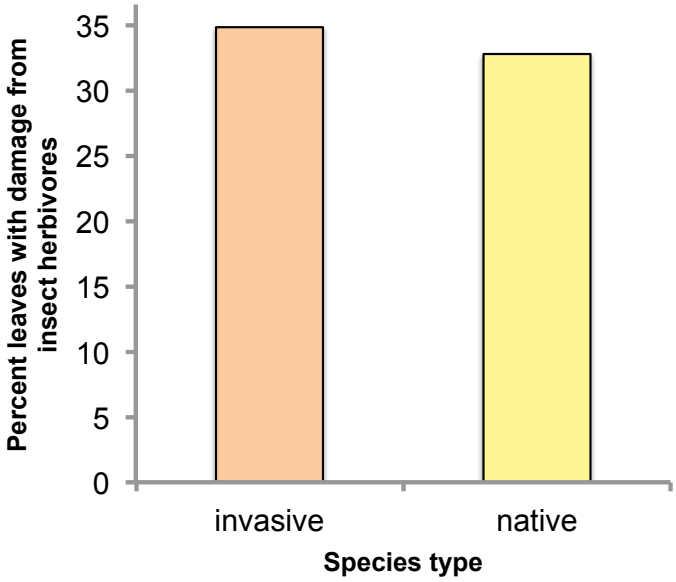
Predictor variable: _____

Response variables: _____

Name_____

Below are two graphs of the data:





Interpret the data: Make a claim based on the evidence that helps answer the original research question. Connect the pattern in the data to a pattern in the natural world. Justify your reasoning using data.

Name_____

Your next step as a scientist: Science is an ongoing process. Did this study fully answer your original question? What new questions do you think should be investigated? What future data should be collected to answer them?

Name_____

DATA Nugget

Do insects prefer local or foreign foods?

Featured scientist: Elizabeth Schultheis from Michigan State University

Research Background:

Insects that feed on plants, called **herbivores**, can have big effects on how plants grow. Herbivory can change the size and shape of plants, the number of flowers and seeds, and even which plant species can survive in a habitat. A plant with leaves eaten by insect herbivores will likely do worse than a plant that is not eaten.

Plants that naturally grow in an area without human interference are called **native** plants. When a plant is moved by humans to a new area and lives and grows outside of its natural range, it is called an **exotic** plant. Sometimes exotic plants become **invasive**, meaning they grow large and fast, take over habitats, and push out native species. What determines if an exotic species will become invasive? Scientists are very interested in this question. Understanding what makes a species become invasive could help control invasions already underway and prevent new ones in the future.

Because herbivory affects how big and fast a plant can grow, local herbivores may determine if an exotic plant thrives in its new habitat and becomes invasive. Elizabeth, a plant biologist, is fascinated by invasive species and wanted to know why they are able to grow bigger and faster than native and other exotic species. One possibility, she thought, is that invasive species are not recognized by the local insect herbivores as good food sources and thus get less damage from the insects. Escaping herbivory could allow invasive species to grow more and may explain how they become invasive.

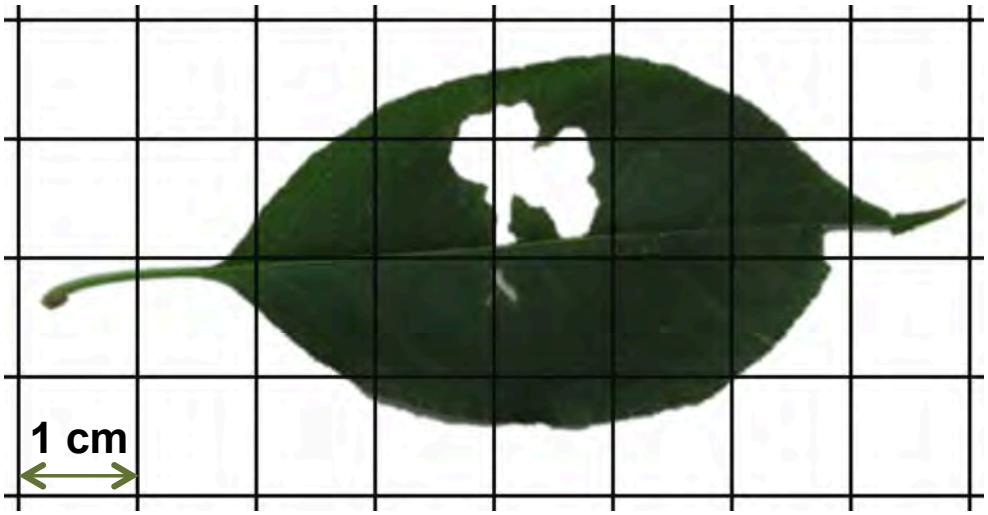
Figure 1: Undergraduate researchers Dan and Gabe checking on the 610 plants in the experiment. The experiment ran for three years, from 2011 to 2013.

Figure 2: Every year, Elizabeth measured the proportion of leaf area removed by herbivores on each of the experimental plants.

Name_____

To test this hypothesis, Elizabeth planted 25 native, 25 exotic, and 11 invasive species in a field in Michigan. This field was already full of many plants and had many insect herbivores. The experimental plants grew from 2011 to 2013. Each year, Elizabeth measured herbivory on 10 individuals of each of the 61 species, for a total of 610 plants. To measure herbivory, she looked at the leaves on each plant and determined how much of each leaf was eaten by herbivores. She then compared the area that was eaten to the total area of the leaf and calculated the proportion leaf area eaten by herbivores. Elizabeth predicted that invasive species would have a lower proportion of leaf area eaten compared to native and noninvasive exotic plants.

Let's look at one leaf to see how Elizabeth collected herbivory data. Here is an example of a leaf from an invasive plant:



Observe the shape of the leaf. Does it appear some of the leaf area is missing and has been eaten by herbivores? Estimate how many grid cells the leaf covers and how many grid cells are missing from the leaf. Each grid cell represents 1 square centimeter (cm).

Area of leaf eaten by herbivores = _____

Total area of leaf = _____

Proportion leaf area eaten by herbivores = area of leaf eaten / total area of leaf = _____

Scientific Question: How does insect herbivore damage compare for native, exotic, and invasive plant species?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Name_____

Draw Your Predictions: On the three leaves below, draw your predictions for the amount of herbivory on the three plant types. Use one color to fill in areas that the herbivores have eaten. Use another color to fill in the rest of the leaf. Remember to fill in the legend to show which colors you used.

native

exotic

invasive

☐ = eaten by herbivores

☐ = leaf remaining

Scientific Data:

Use the data below to answer the scientific question:

Average Proportion Leaf Area Eaten by Herbivores

	Year of Data Collection		
Plant Type	**2011**	**2012**	**2013**
native	0.046	0.037	0.046
exotic	0.075	0.063	0.057
invasive	0.168	0.087	0.078

What data will you graph to answer the question?

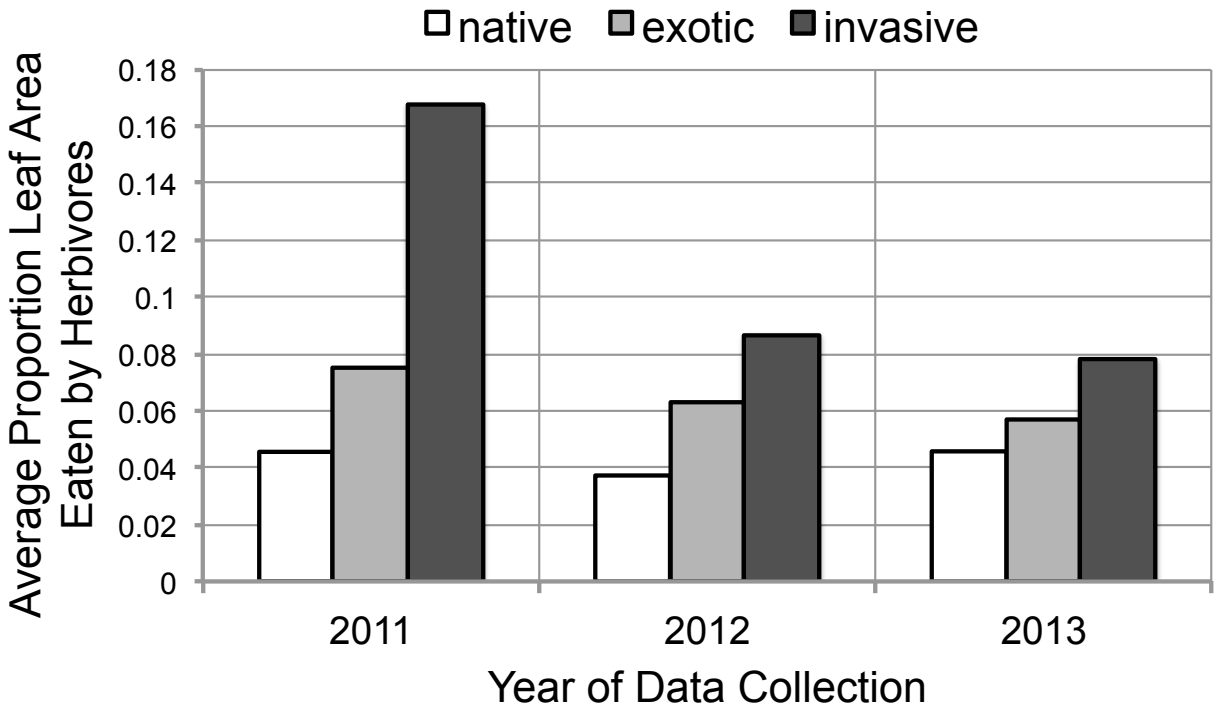
Independent variables: _____

_____

Dependent variable: _____

Name_____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the table or graph.

Name_____

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about the effects of herbivory on plant performance.

Did the data support Elizabeth's hypothesis? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Elizabeth's research? What future data should be collected to answer your question(s)?

Name_____

DATA Nugget

Where to find the hungry, hungry herbivores

Featured scientist: Carina Baskett from Michigan State University

Research Background:

When travelling to warm, tropical places you are exposed to greater risk of diseases like malaria, yellow fever, or dengue fever. The same pattern of risk is true for other species besides humans. For example, scientists have noticed that crops seem to have more problems with pests if they grow at **lower latitudes** (closer to the equator). Locations that are at lower latitudes have warm climates. We don't know exactly why there are more pests in warmer places, but it could be because pests have a hard time surviving very cold winters.

Carina and some pokeweed plants in Tennessee.

Carina is interested in figuring out more about this pest-y problem. She first got excited about plants in school, when she learned that they use photosynthesis to make their own food out of light, air, and water. She thought it was fascinating that plants have evolved so many different strategies to survive. Even though they don't have brains, plants do have adaptations that help them compete for light and mate in many different habitats. Carina continues to learn more every day, and especially enjoys researching how plants defend themselves against **herbivores**, or animals that eat plants. Herbivores pose a challenge because plants can't run away or hide!

Carina studies ways wild plants can defend themselves against herbivores. What she learns in wild plants could give us ideas of how to help crops defend against pests too. Scientists aren't sure why crops have more pest problems in warmer places, but it would help to understand if wild plants also have the same pattern.

So Carina decided to travel all across the eastern United States to measure herbivory on pokeweed, a common wild plant there. Carina drove a lot for this project! In one

summer, she visited ten patches of pokeweed spread out between Michigan and Florida. Carina thought that the pokeweed found at lower latitudes (Florida, 27° N) would have higher herbivory than pokeweed at northern latitudes (Michigan, 42° N) because pests may not be able to survive as well in places with harsh winters.

At each of the ten sites, she marked five very young leaves on 30 to 40 plants. That equals over 1,500 leaves! She then came back six weeks later to measure how much the leaves were eaten as they grew into large, mature leaves. When leaves are young, they are more tender and can be more easily eaten by herbivores (that's why we eat "baby spinach" salad). To measure herbivory she compared the area that was eaten to the total area of the leaf, and calculated the percent of the leaf area eaten by caterpillars, the main herbivores on pokeweed. She then averaged the percent eaten on leaves for each plant. Some plants died in those 6 weeks, so the sample size at the end of the study ranged from 4 to 37 depending on the site.

Scientific Question: At what latitudes do caterpillars do the most damage to pokeweed?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Pokeweed (*Phytolacca americana*) is a common wild plant that grows all over the eastern US. Pokeweed has beautiful pink stems and dark purple berries.

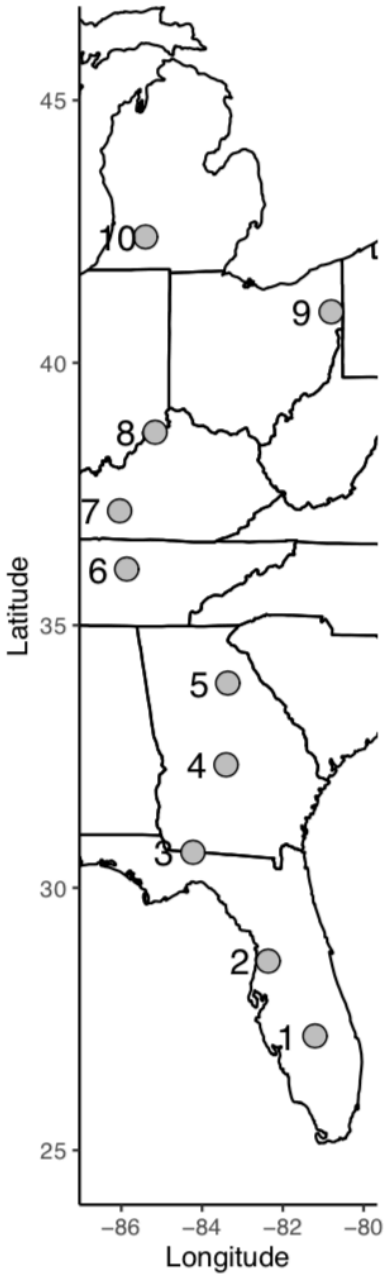
Name_____

Scientific Data:

Use the data below to answer the scientific question:

Site number	Latitude (N)	Sample size (n)	Average percent of the total leaf area eaten	SD	SE
10	42.5	30	12.80	13.77	3.85
9	41.0	28	22.28	21.78	4.61
8	38.7	27	6.46	11.23	4.42
7	37.2	24	26.59	27.49	5.33
6	36.1	20	6.45	13.81	5.44
5	33.9	26	73.30	32.89	3.84
4	32.3	26	87.01	22.37	2.40
3	30.7	17	98.46	3.44	0.35
2	28.6	4	78.10	9.87	1.12
1	27.2	37	60.35	27.15	3.49

**Standard deviation (SD) tells us about the amount of variation in the data. A large SD means there is a lot of variation around the mean, while a small SD means the data points all fall very close to the mean. Standard error (SE) tells us how confident we are in our estimate of the mean, and depends on the number of replicates in an experiment and the SD. A large SE means we are not very confident, while a small SE means we are more confident.*



What data will you graph to answer the question?

Independent variable: _____

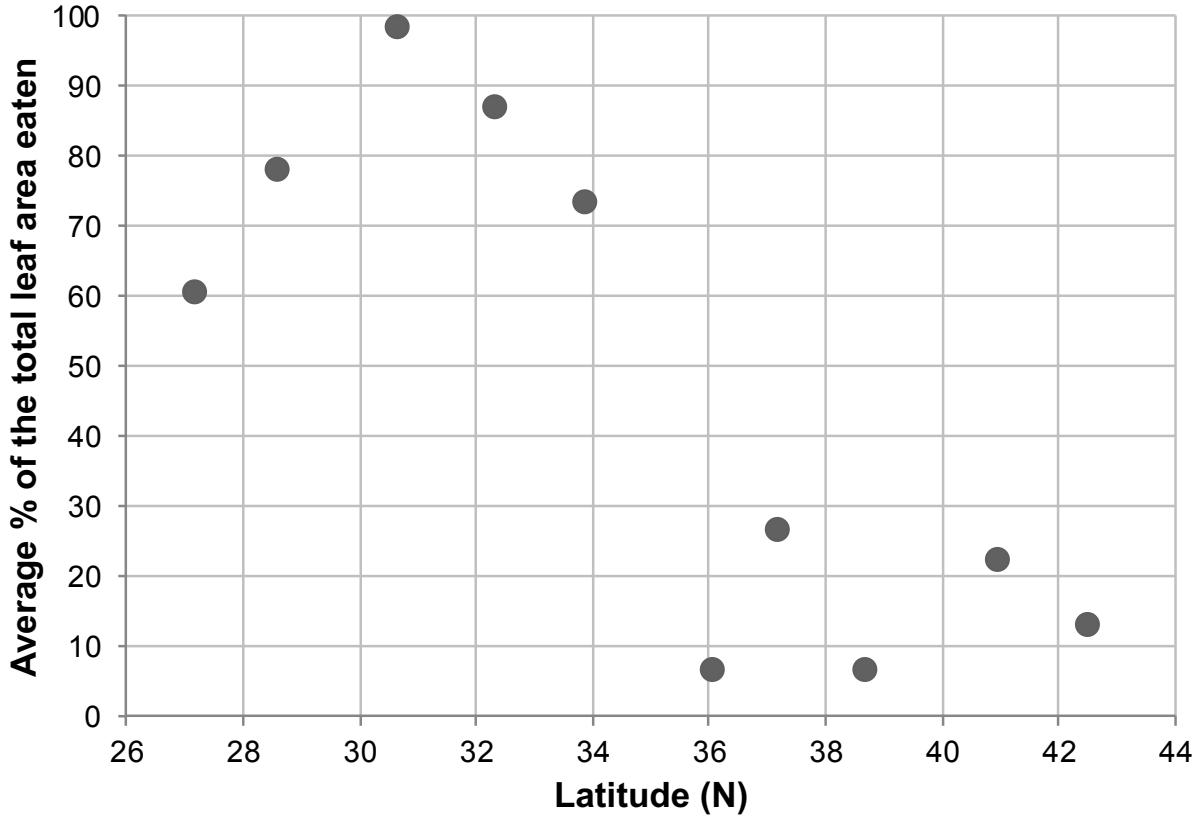
_____

Dependent variable: _____

_____

Name_____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the table or graph.

Name_____

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about how latitude may affect the number of pests on plants.

Did the data support Carina's hypothesis? Use evidence to explain why or why not. If you feel the data was inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question do you think should be investigated? What future data should be collected to answer your question?

Name_____

DATA Nugget

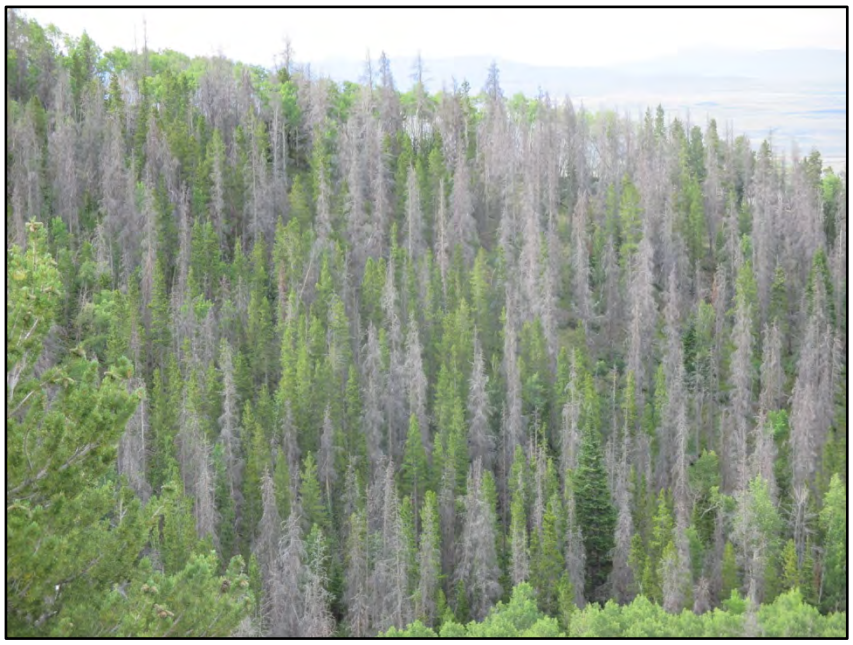
Tree-killing beetles

Featured scientist: Tony Vorster from Colorado State University
Co-written with Yamina Pressler and Paul Evangelista

Research Background:

A beetle the size of a grain of rice seems insignificant compared to a vast forest. However, during outbreaks the number of mountain pine beetles can skyrocket, leading to the death of many trees. The beetles bore their way through tree bark and introduce blue stain fungi. The blue stain fungi kills the tree by blocking water movement. Recent outbreaks of mountain pine beetles killed millions of acres of lodgepole pine trees across western North America. Widespread tree death caused by mountain pine beetles can impact human safety, wildfires, nearby streamflow, and habitat for wildlife.

Mountain pine beetles are native to western North America and outbreak cycles are a natural process in these forests. However, the climate and forest conditions have been more favorable for mountain pine beetles during recent outbreaks than in the past. These conditions caused more severe outbreaks than those seen before.



A Colorado forest impacted by a mountain pine beetle outbreak. Notice the dead trees mixed with live trees. Forests like this with dead trees from mountain pine beetle outbreaks cover millions of acres across western North America.

When Tony moved to Colorado, he drove through the mountains eager to see beautiful forests. The forest he saw was not the green forest he expected. Many of the trees were dead! Upon closer examination he realized that some forests had fewer dead trees than others. This caused him to wonder why certain areas were greatly impacted by the mountain pine beetles while others had fewer dead trees. Tony later got a job as a field technician for Colorado State University.

Name_____

During this job he measured trees in mountain forests. He carefully observed the forest and looked for patterns of where trees seemed to be dead and where they were alive.

Logs from mountain pine beetle killed lodgepole pine trees. The blue stain fungi is visible around the edge of each log. Mountain pine beetles introduce this fungus to the tree.

Tony thought that the size of the trees in the forest might be related to whether they were attacked and killed by beetles. A larger tree might be easier for a beetle to find and might be a better source of food. To test this idea, Tony and a team of scientists visited many forests in northern Colorado. At each site they recorded the diameter of each tree's trunk, which is a measure of the size of the tree. They also recorded the tree species and whether it was alive or dead. They then used these values to calculate the average tree size and the percent of trees killed for each site.

Scientific Question: How does the average tree size in a forest influence its susceptibility to mountain pine beetles?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Name_____

Scientific Data:

Use the data below to answer the scientific question:

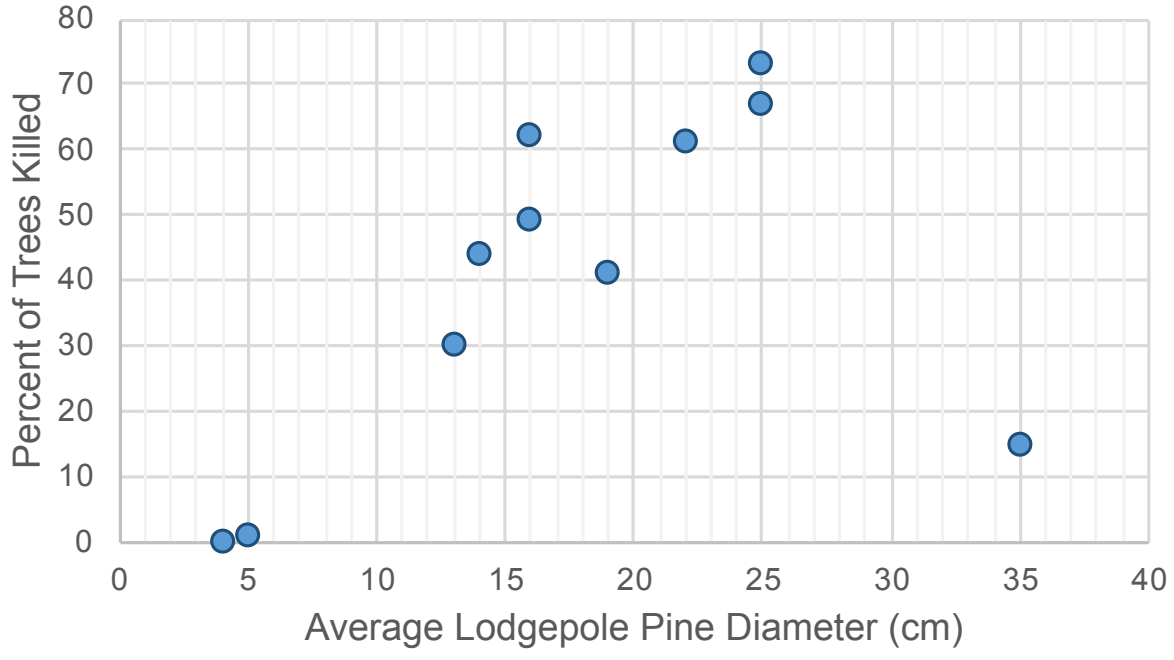
Site number	Average lodgepole pine diameter (cm)	Percent of trees killed	Proportion of forest that is lodgepole pine
1	25	67	0.99
2	19	41	0.65
3	22	61	0.99
4	16	49	0.68
5	16	62	0.99
6	14	44	1
7	13	30	0.94
8	5	1	1
9	35	15	0.15
10	25	73	0.85
11	4	0	1

What data will you graph to answer the question?

Independent variable(s): _____

Dependent variable(s): _____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Name_____

Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the table or graph.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about the impact of mountain pine beetles on lodgepole pine trees.

Name_____

Did the data support Tony's hypothesis? Use evidence to explain why or why not. If you feel the data was inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question do you think should be investigated? What future data should be collected to answer your question?

Name_____

DATA Nugget

A tail of two scorpions

Featured scientists: Ashlee Rowe and Matt Rowe from University of Oklahoma

Animals have evolved many ways to defend themselves against predators. Many species use camouflage to avoid being seen. Others rely on speed to escape. Some species avoid capture by hiding in a safe place. Other animals use painful and venomous bites or stings to try to prevent attacks or to make being captured more difficult. Anyone who has been stung by a bee or wasp understands how stinging could be a great way to keep predators away! However, there is little research that documents if painful stings or bites deter predators.

The grasshopper mouse lives at the base of the Santa Rita Mountains in Arizona. Scientists Ashlee and Matt have been studying populations of this mouse for many years and wanted to know what the mouse ate. In the mountains, there are two scorpions that make a great food source for the mice. One of the scorpion species has a painful sting. The other species is slightly larger, but its sting is not painful. Ashlee and Matt thought that the use of a painful, venomous sting helped the smaller species avoid most predator attacks.

A southern grasshopper mouse (*Onychomys torridus)* capturing and eating the painful species of scorpion (*Centruroides sculpturatus*).

The scientists collected six grasshopper mice from the wild. Back in the lab, they trained the mice to expect a food reward when they tipped over a small cup containing live prey. Once trained, the mice were used in an experiment. The mice were presented with two cups to choose from. One contained the small scorpion species that has a painful sting. The other cup contained the larger scorpion species that has a painless

Name_____

sting. Ashlee and Matt collected data on which cup the mice chose to approach, inspect, or pursue (by tipping over the cup). They also recorded if the mice attacked or consumed the painless or painful species of scorpion. Each trial ended when the mouse finished consuming one of the scorpions. If painful stings prevent a predator from attacking, they predicted the mice would choose to eat the scorpion species with the painless sting more often.

Scientific Question: Do painful scorpion stings affect the behavioral choices of the grasshopper mouse?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Matt and Ashlee Rowe in Arizona

The painful and painless species of scorpion used in the experiment. Note that the painless species tends to be slightly larger.

Name_____

Scientific Data:

Complete the tables and use the data below to answer the scientific question:

Number of times, out of 6 trials, each mouse chose to approach, inspect, pursue (by tipping the cup), attack, and consume the **PAINFUL** species of scorpion first.

Mouse	Approach	Inspect	Tip	Attack	Consume
1	5/6	5/6	2/6	0/6	0/6
2	5/6	5/6	1/6	0/6	0/6
3	2/6	2/6	0/6	0/6	0/6
4	4/6	4/6	1/6	0/6	0/6
5*	4/5	3/5	0/5	0/5	0/5
6	2/6	2/6	0/6	0/6	0/6
Sum					
Proportion					

Number of times, out of 6 trials, each mouse chose to approach, inspect, pursue (by tipping the cup), attack, and consume the **PAINLESS** species of scorpion first.

Mouse	Approach	Inspect	Tip	Attack	Consume
1		1/6	4/6	6/6	6/6
2		1/6	5/6	6/6	6/6
3		4/6	6/6	6/6	6/6
4		2/6	5/6	6/6	6/6
5*		2/5	5/5	5/5	5/5
6		4/6	6/6	6/6	6/6
Sum					
Proportion					

**One of the trials for mouse #5 was terminated early because it inadvertently tipped both cups simultaneously, while jumping, releasing the scorpions and thus preventing any meaningful "choice."*

What data will you graph to answer the question?

Independent variable(s): _____

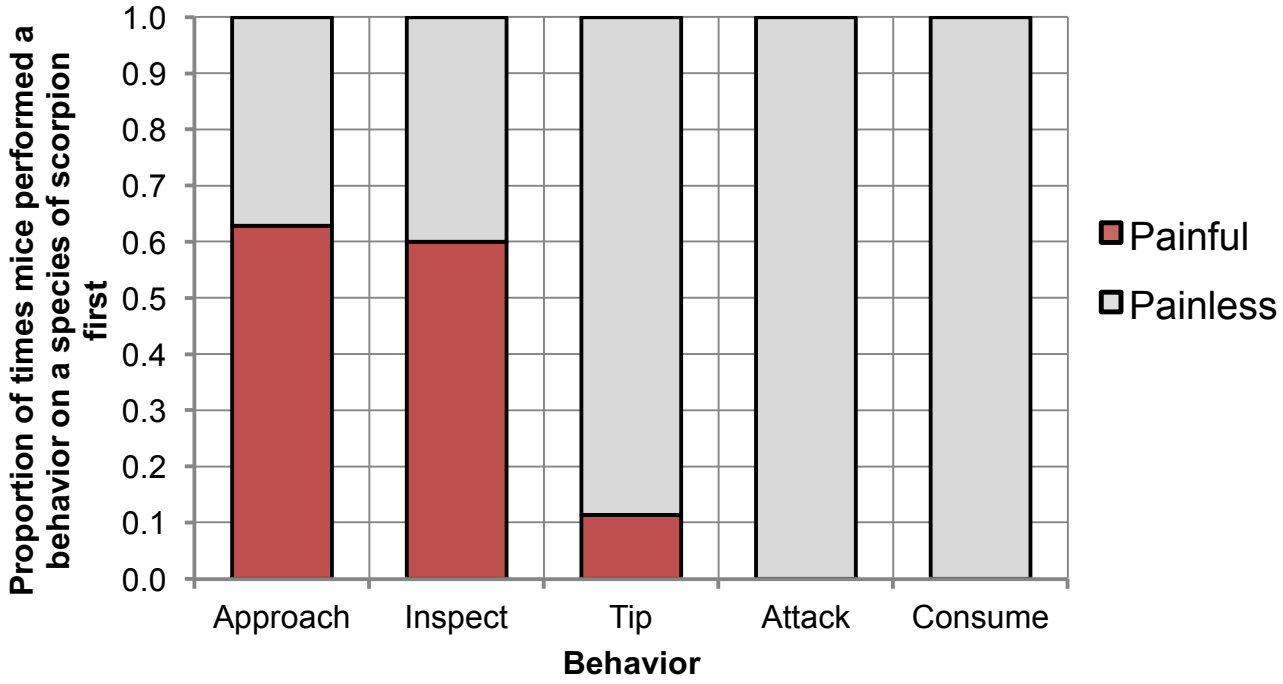
_____

Dependent variable(s): _____

_____

Name_____

Below is a graph of the data: Identify any changes, trends, or differences you see in the graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the tables or graph.

Name_____

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about how prey use defenses to deter predators.

Did the data support Ashlee and Matt's hypothesis? Use evidence to explain why or why not. If you feel the data was inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Ashlee and Matt's research? What future data should be collected to answer your question(s)?

Name_____

DATA Nugget

Deadly windows

Featured scientist: Natasha Hagemeyer from Old Dominion University

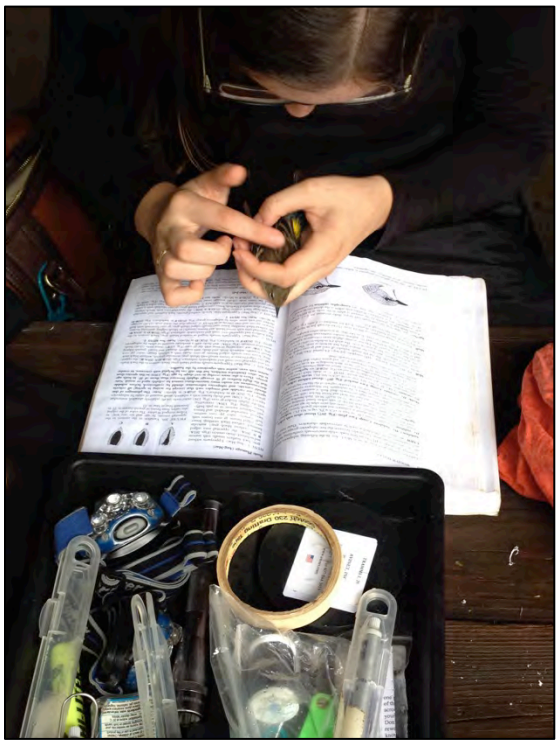
Research Background:

Glass makes for a great windowpane because you can see right through it. However, the fact that windows are see-through makes them very dangerous for birds. Have you ever accidentally run into a glass door or been confused by a tall mirror in a restaurant? Just like people, birds can mistake a see-through window or a mirrored pane for an opening to fly through or a place to get food and will accidentally fly into them. These **window collisions** can hurt the bird or even kill it. Window collisions kill nearly one billion birds every year!

Urban areas, with a lot of houses and stores, have a lot of windows. **Resident birds** that live in the area may get to know these buildings well and may learn to avoid the windows. However, not all the birds in an area live there year-round. There are also **migrant birds** that fly through urban areas during their seasonal migrations. In the fall, for example, migrant birds use gardens and parks in urban areas to rest along their journeys to their winter southern homes. During the fall migration, people have noticed that it seems like more birds fly into windows. This may be because migrant birds, especially the ones born that summer, are not familiar with the local buildings. While looking for food and places to sleep, migrant birds might have more trouble identifying windows and fly into them more often. However, it could also be that there are simply more window collisions in the fall because there are more birds in the area when migrant and resident birds co-occur in urban areas.

Researchers identify the species of each bird caught in one of the nets used in the study. They then place a metal bracelet on one leg so they will know if they catch the same bird again.

Name_____



Researcher identifying a yellow-rumped warbler, one of the birds captured in the net as part of the study.

Natasha was visiting a friend who worked at a zoo when he told her about a problem they were having. For a few weeks in the fall, they would find dead birds under the windows, more than they would during the rest of the year. He wanted to figure out a way to prevent birds from hitting the exhibit windows. Natasha became interested in learning whether migrant birds were more likely to fly into windows than resident birds or if the number of window collisions only increase in the fall because there are a lot of birds around. To do this she would have to count the total number of birds in the area and also the total number of birds that were killed in window collisions, as well as identify the types of birds. To count the total number of birds in the area, Natasha hung nets that were about the same height as windows. When the birds got caught in the nets, Natasha could count and identify them. These data could then be used to calculate the proportion of migrants and residents flying at window-height. She put 10 nets up once a week for four hours, over the course of three months, and checked them every 15 minutes for any birds that got caught.

Then, she also checked under the windows in the same area to see what birds were killed from window collisions. She checked the windows every morning and evening for the three months of the study. Different species of birds are migratory or resident in the area where Natasha did her study. Each bird caught in nets was examined to identify its to species using its feathers, which would tell her whether the bird was a migrant or a resident. The same was done for birds found dead below windows.

If window collisions are really more dangerous for migrants, she predicted that a higher proportion of migrants would fly into windows than were caught in the nets. But, if window collisions were in the same proportion as the birds caught in the nets, she would have evidence that windows were just as dangerous for resident birds as for migrants.

Scientific Question: Do migrant birds collide with windows more frequently than expected by their population?

What is the hypothesis? Find the two hypotheses in the Research Background and underline them. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies. Having two alternative

hypotheses means that more than one mechanism may explain a given observation. Experimentation can determine if one, both, or neither hypotheses are supported.

Scientific Data:

Use the data below to answer the scientific question:

Table 1

Counts	Netted	Window Collision
Resident	50	1
Migrant	129	23
Total		

Table 2

Proportions	Netted	Window Collision
Resident		
Migrant		

What data will you graph to answer the question?

Independent variable: _____

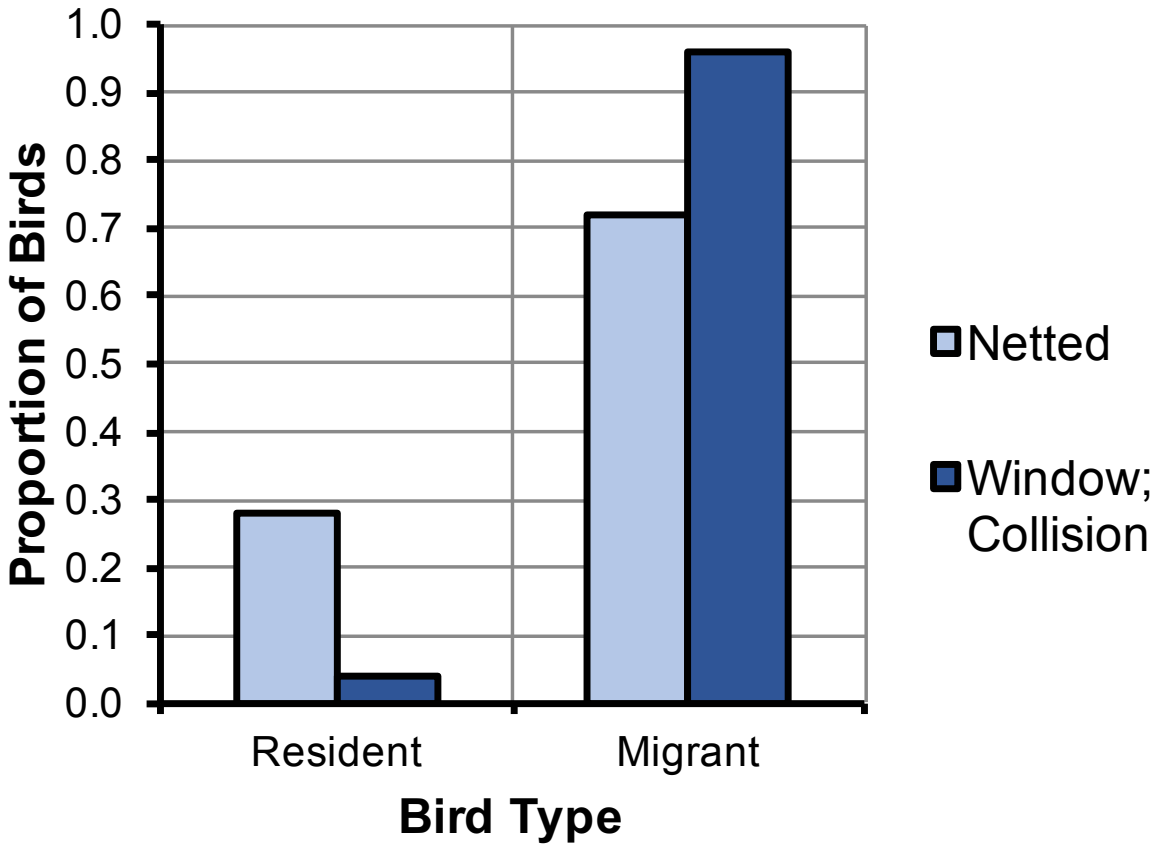
_____

Dependent variables: _____

_____

Name_____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question.

Name_____

What evidence was used to write your claim? Reference specific parts of the tables or graph.

Explain your reasoning and why the evidence supports your claim. Connect the data back to the reasons why windows and mirrored surfaces may be so dangerous for birds.

Did the data support one, both, or either of Natasha's two alternative hypotheses? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

Name_____

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Natasha's research? What future data should be collected to answer your question(s)?

Name_____

DATA Nugget

Dangerously bold

Featured scientist: Melissa Kjelvik from Michigan State University

Research Background:

Just as each person has her or his own personality, animals of the same species can behave very differently from one another! For example, pets, like dogs, have different personalities. Some have a lot of energy, some are cuddly, and some like to be alone. **Boldness** is a behavior that describes whether or not an individual takes risks. Bold individuals take risks while shy individuals do not. The risks animals take have a big impact on their survival and the habitats they choose to search for food.

Bluegill sunfish are a type of fish that lives in freshwater lakes and ponds across the world. Open water and cover are two habitat types where young bluegill are found. The **open water** habitat in the center of the pond is the best place for bluegill to eat a lot of food. However, the open water is risky and has very few plants or other places to hide. Predators, like large birds, can easily find and eat bluegill in the open water. The **cover** habitat at the edge of the pond has many plants and places to hide from predators, but it has less food that is best for bluegill to grow fast. Both habitats have costs and benefits—called a **tradeoff**.

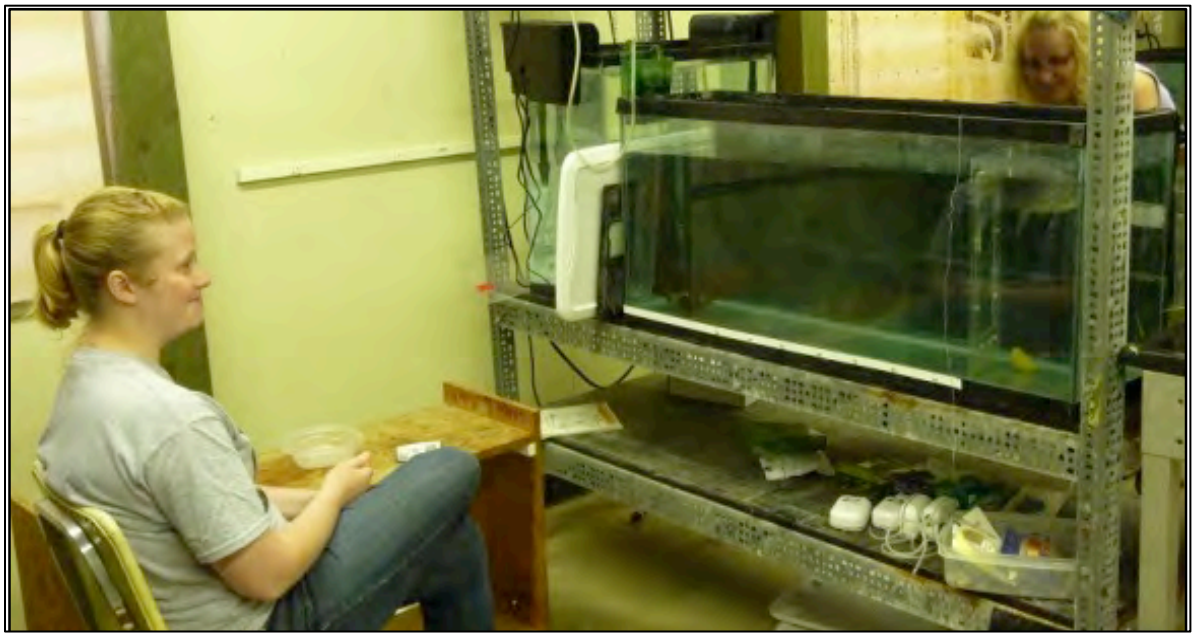
A view of the experimental pond. The center of the pond is the open water habitat with no plants. At the edge of the pond is the cover habitat with plants. At the start of the experiment, 100 bold bluegill, 100 shy bluegill, and 2 largemouth bass predators were placed in the pond. Here, scientists are using a net to collect the surviving bluegill at the end of the experiment.

Name_____

Melissa is a scientist who is interested in whether differences in young bluegill behavior changes the habitats in which they choose to search for food. First, she looked at whether young bluegill have different personalities by bringing them into an aquarium lab and watching their behavior. Melissa observed that, just like in humans and dogs, bluegill sunfish have different personalities. She noticed that some bluegill took more risks and were bolder than others. Melissa wanted to know if these differences in behavior could also be observed in her experimental pond. She reasoned that being in open water is risky, but results in more access to food. Therefore, bold fish should take more risks and use the open water habitat more than shy fish, giving them more food, allowing them to grow faster and larger, but exposing them to more predation. Just the opposite should be true about shy fish: more time for them in the cover habitat of the pond exposing them to less predation, but also giving them less access to food and an overall smaller body size than bold fish. A tradeoff for both types of fish based on personality.

Melissa designed a study to test the growth and survival of bold and shy fish. When she was watching the fish's behavior in the lab, she determined if a fish was bold or shy. If a fish took the risk of leaving the safety of the vegetation in a tank so that it could eat food while there was a predator behind a mesh screen, it was called bold. If it did not eat, it was called shy. She marked each fish by clipping the right fin if it was bold or the left fin if it was shy. She placed 100 bold and 100 shy bluegill into an experimental pond with two largemouth bass (predators). The shy and bold fish started the experiment at similar lengths and weights. After two months, she drained the pond and found every bluegill that survived. She recorded whether each fish that survived was bold or shy and measured their growth (length and weight).

Scientific Questions: How does the boldness of bluegill affect their survival and growth? Is there a tradeoff in bold and shy behaviors?



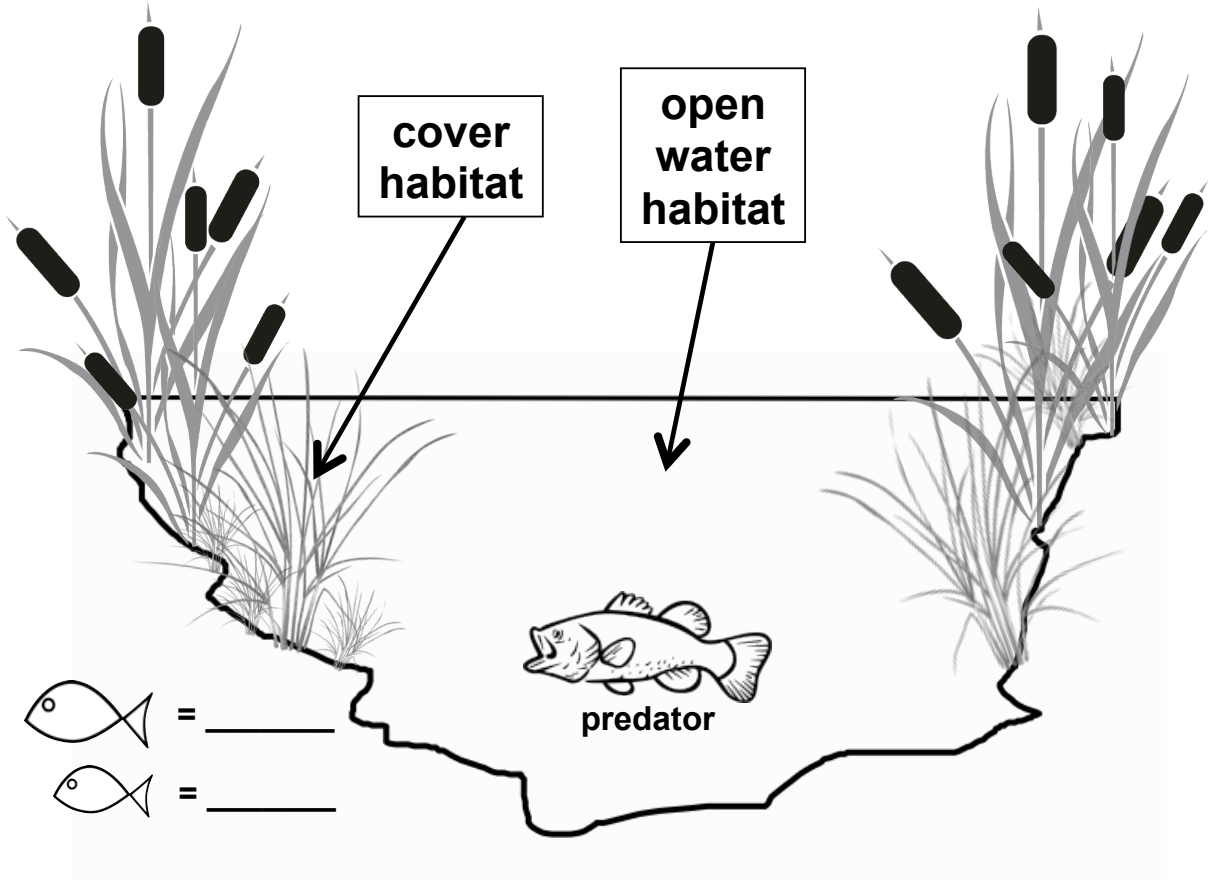
To determine their personality, Melissa observed young bluegill sunfish in the aquarium lab.

Name_____

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Draw your predictions: Below is a diagram of a pond where you can draw your predictions. Think about how bold and shy fish might respond to a predator.

1. Start by looking at the legend. Do you predict bold or shy fish will grow larger? Label which fish is bold and which is shy and choose a color for each.
2. Now move to the pond diagram. Draw bold and shy fish in the habitats where you predict they will spend most of their time.
3. Draw your survival predictions. Do you predict there will be more bold or shy fish left at the end of the experiment? Add more fish to your diagram if necessary.



Name_____

Scientific Data:

Finish filling in the table below. Use the data to answer the scientific questions.

Bluegill Behavior	Proportion Survived	Percent Survival	Average Length (mm)	Length SE**	Average Weight (g)	Weight SE
Bold	66/100		68.6	0.8	5.5	0.2
Shy	74/100		65.6	0.8	4.8	0.2

*** Standard error (SE) tells us how confident we are in our estimate of the mean, and depends on the number of replicates in an experiment and the amount of variation in the data. A large SE means we are not very confident, while a small SE means we are more confident.*

What data will you graph to answer the questions?

Graph 1: Survival

Independent variable: _____

Dependent variable: _____

Graph 2: Length

Independent variable: _____

Dependent variable: _____

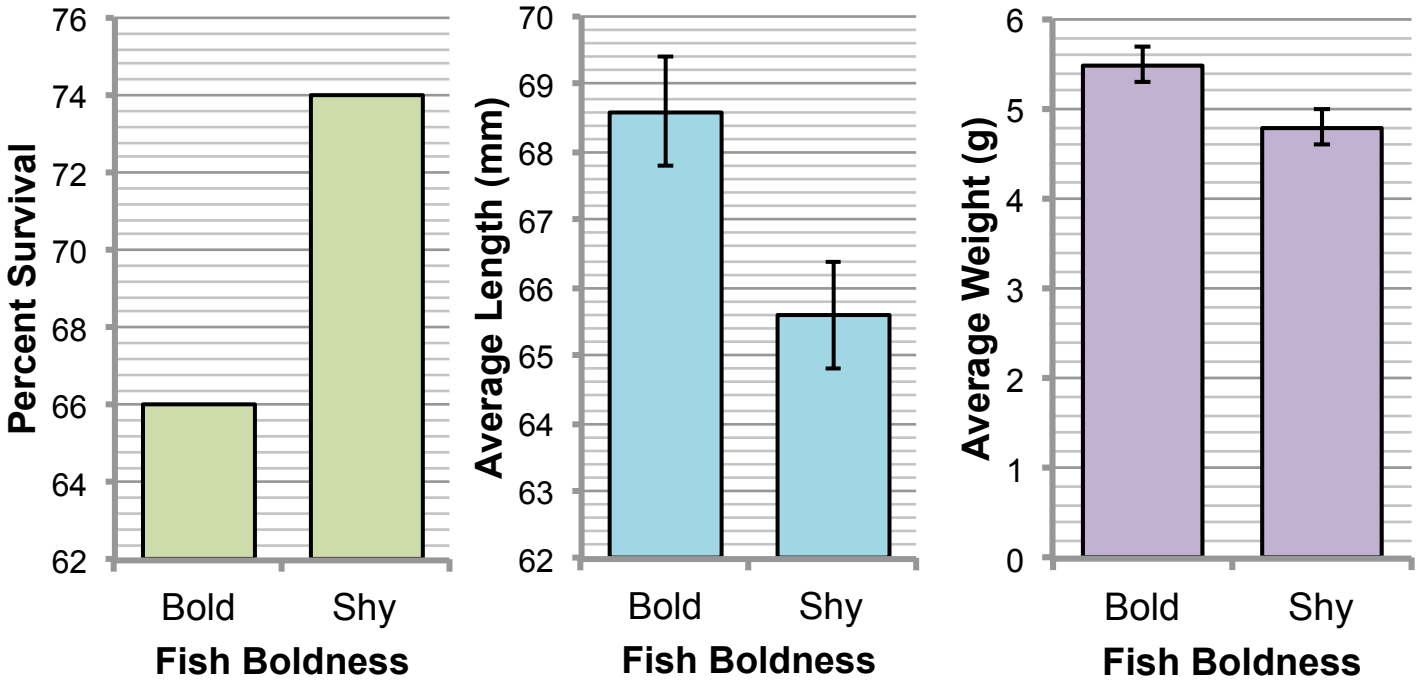
Graph 3: Weight

Independent variable: _____

Dependent variable: _____

Name_____

Below are graphs of the data: Identify any changes, trends, or differences you see in your graphs. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers each of the scientific questions.

What evidence was used to write your claims? Reference specific parts of the table or graphs.

Name_____

Explain your reasoning and why the evidence supports your claims. Connect the data back to what you learned about the tradeoff for using the cover and open water habitats.

Did the data support Melissa's hypothesis? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Melissa's research? What future data should be collected to answer your question(s)?

Name_____

DATA Nugget

Springing forward

Featured scientists: Shaun Davis, Mark Hammond, Elizabeth Schultheis, and Jen Lau from Michigan State University

Research Background:

Scientists collecting data in the climate change experiment. They are recording the date that dame's rocket, a leafy plant, makes its first flower of the year.

Every day people burn fossil fuels like oil, natural gas, and coal. This adds more and more greenhouse gasses to our air. Greenhouse gasses trap more of the sun's heat, causing the Earth to heat up!

Plants are very important for almost all life found on Earth. They make the oxygen that we breathe and are food for people and animals. Because plants are so important, we need to find out how climate change will affect them. How will higher temperatures affect the Earth's plants? One good place to start is by looking at *flowering* plants. Many flowering plants produce their flowers when the weather gets warm in spring, and the date that flowers first come out may depend directly on what the spring temperatures are like. It is possible that warmer and earlier springs generated by climate change cause flowers to bloom earlier and earlier. If flowers start blooming earlier each year, this could cause problems for pollinators (like bees and butterflies). They count on plants flowering around the same date each year.

Scientists Shaun, Mark, Elizabeth, and Jen wanted to know if higher temperatures lead to earlier flowering dates for plants. They chose to look at flowers of dame's rocket, a leafy plant that is related to the plants we use to make mustard! Mark planted dame's rocket in eight plots of land. Half of the plots were left at normal temperature. The other four plots were heated 3°C above normal temperature. Scientists think 3°C is about how much warmer Michigan will be by the year 2100. Mark, Elizabeth, and Jen measured the date that each plant grew its first flower, and the survival of each plant. The scientists predicted that the dame's rocket growing in the heated plots would flower earlier than those in the normal plots.

Name_____

One of the heated plots shown from above. The silver boxes are electric heaters that raised the temperature inside the ring.

Dame's rocket growing in the field. This species of mustard was introduced to the U.S. from Europe and Asia.

Scientific Question: How does temperature affect the flowering time of dame's rocket?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Scientific Data:

Use the data below to answer the scientific question:

Treatment	# of plants surviving to flower	calendar date when first flower appeared	average # of days until first flower (since start of experiment)
Normal	28	May 20, 2013	16.11
Heated	25	May 10, 2013	6.08

What data will you graph to answer the question?

Independent variable: _____

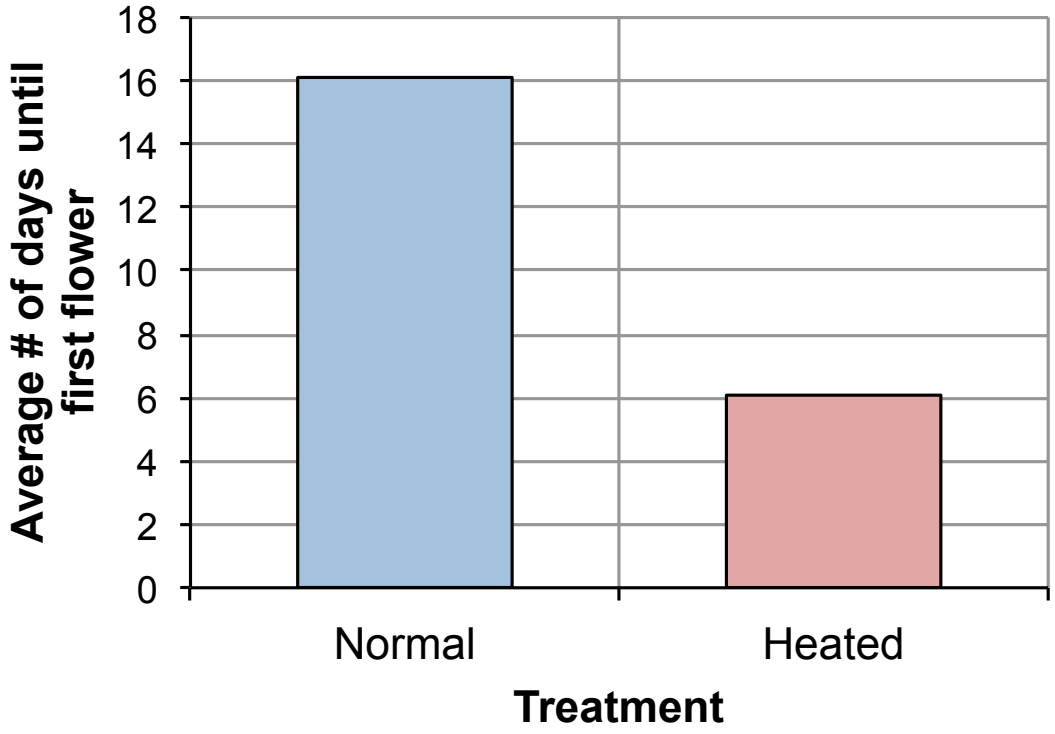
_____

Dependent variable: _____

_____

Name_____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the table or graph.

Name_____

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about climate change and how this could affect flowering time.

Did the data support the scientists' hypothesis? Use evidence to explain why or why not. If you feel the data did not give a clear answer, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Shaun, Mark, Elizabeth, and Jen's research? What future data should be collected to answer your question(s)?

Name_____

DATA Nugget

Coral bleaching and climate change

Featured scientist: Carly Kenkel from The University of Texas at Austin

Research Background:

Corals are animals that build coral reefs. Coral reefs are home to many species of animals – fish, sharks, sea turtles, and anemones all use corals for habitat! Corals are white, but they look brown and green because certain types of algae live inside them. Algae, like plants, use the sun's energy to make food. The algae that live inside the corals' cells are tiny and produce more sugars than they themselves need. The extra sugars become food for the corals. At the same time, the corals provide the algae a safe home. The algae and corals coexist in a relationship where each partner benefits the other, called a **mutualism**: these species do better together than they would alone.

When the water gets too warm, the algae can no longer live inside corals, so they leave. The corals then turn from green to white, called **coral bleaching**. Climate change has been causing the Earth's air and oceans to get warmer. With warmer oceans, coral bleaching is becoming more widespread. If the water stays too warm, bleached corals will die without their algae mutualists.

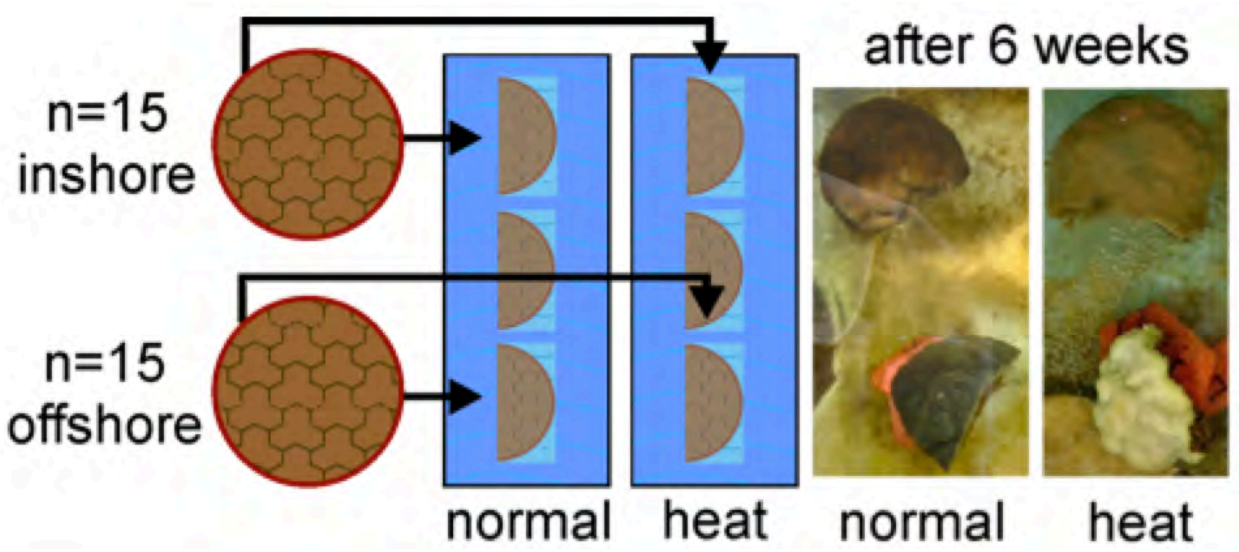
Carly is a scientist who wants to study coral bleaching so she can help protect corals and coral reefs. One day while out on the reef, Carly observed an interesting pattern. Corals on one part of a reef were bleaching while corals on another part of the reef stayed healthy. She wondered, why some corals and their algae can still work together when the water is warm, while others cannot?

A Pacific coral reef with many corals

Carly observing a coral reef

Name_____

Ocean water that is closer to the shore (**inshore**) gets warmer than water that is further away (**offshore**). Perhaps corals and algae from inshore reefs have adapted to warm water. Carly wondered whether inshore corals are better able to work with their algae in warm water because they have adapted to these temperatures. If so, inshore corals and algae should bleach less often than offshore corals and algae. Carly designed an experiment to test this. She collected 15 corals from inshore and 15 from offshore reefs in the Florida Keys. She brought them into an aquarium lab for research. She cut each coral in half and put half of each coral into tanks with normal water and the other half into tanks with heaters. The normal water temperature was 27°C, which is a temperature that both inshore and offshore corals experience during the year. The warm water tanks were at 31°C, which is a temperature that inshore corals experience, but offshore corals have never previously experienced. Because of climate change, offshore corals may experience this warmer temperature in the future. After six weeks, she recorded the number of corals that bleached in each tank.



Scientific Question: What is the effect of water temperature on corals from inshore and offshore reefs?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Name_____

Scientific Data:

Use the data below to answer the scientific question:

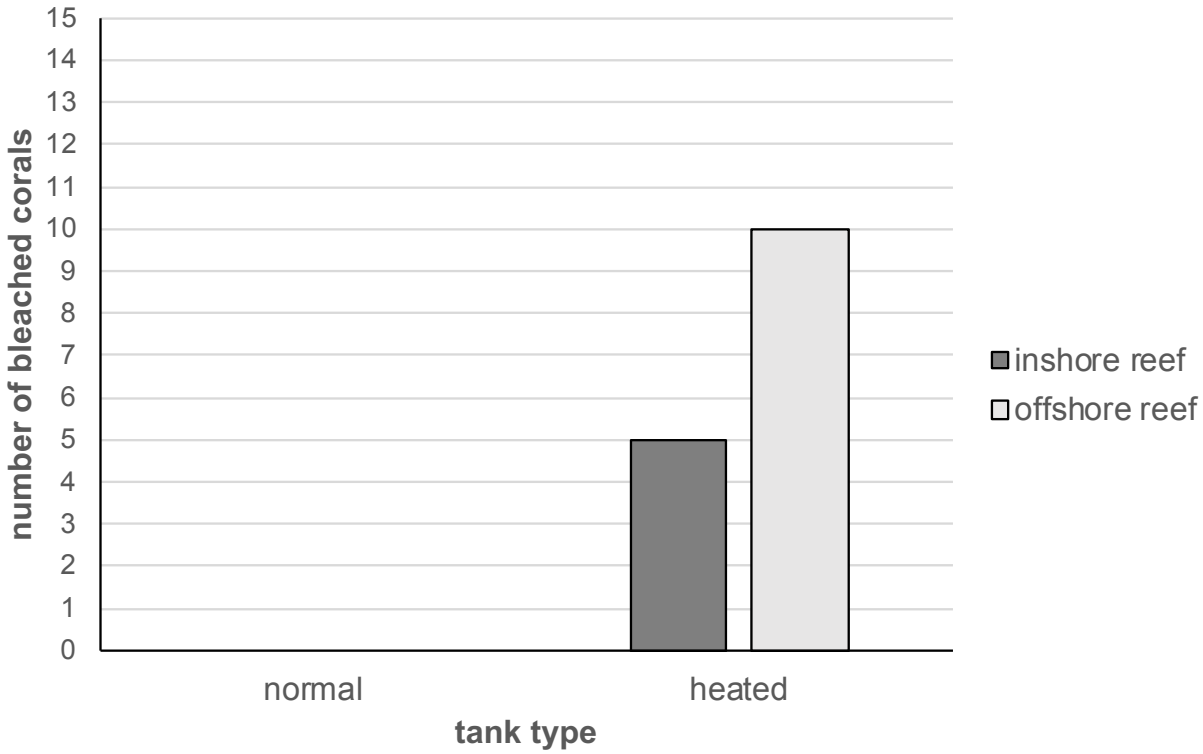
corals from	tank type	number of bleached corals
inshore reef	normal	0/15
offshore reef	normal	0/15
inshore reef	heated	5/15
offshore reef	heated	10/15

What data will you graph to answer the question?

Independent variable: _____

Dependent variable: _____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Name_____

Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the table or graph.

Explain your reasoning and why the evidence supports your claim. Connect the data back to how warm water affects the mutualism between coral and algae.

Name_____

Did the data support Carly's hypothesis? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated next to build on Carly's research? What future data should be collected to answer your question(s)?

Science Enrichment

Section 1

Data Nuggets - CER

Name_____

DATA Nugget

The birds of Hubbard Brook, Part I

Featured scientist: Richard Holmes from the Hubbard Brook Experimental Forest

Research Background:

The Hubbard Brook Experimental Forest is an area where scientists have collected ecological data for many years. It is located in the White Mountains of New Hampshire. Data collected in this forest helps uncover environmental trends over long periods of time, such as changes in air temperature, precipitation, forest growth, and animal populations. It is important to collect data on ecosystems over time because these patterns could be missed with shorter observation periods or short-term experiments.

Each spring, Hubbard Brook comes alive with the arrival of migratory birds. Many come from the tropics to take advantage of abundant insects and the long summer days of northern areas. In the spring, **avian ecologists,** or scientists who study the ecology of birds, also become active in the forest at Hubbard Brook. They have been keeping records on the birds that live in the experimental forest for over 50 years. These data are important because they represent one of the longest bird studies ever conducted!

Richard is an avian ecologist who began this study early in his career as a scientist. He was interested in how bird populations respond to long-term environmental changes at Hubbard Brook. Every summer since 1969, Richard takes his team of trained scientists,

Male Black-throated Blue Warbler feeding nestlings. Nests of this species are built typically less than one meter above ground in a shrub such as hobblebush. Photo by N. Rodenhouse.

students, and technicians into the field to identify which species are present. Richard's team monitors populations of over 30 different bird species. They count the number of birds that are in the forest each year and study their activities during the breeding season. The researchers wake up every morning before the sun rises and travel to the far reaches of the forest. They listen for, look for, identify, and count all the birds they find. The team has been trained to be able to identify the birds by sight, but also by their calls. Team members are even able to identify how far away a bird is by hearing its call!

The study area is located away from any roads or other disturbed areas. To measure the **abundance**, or number of birds found in the 10 hectare study area, the researchers used what is called the spot-mapping method. They use plastic flags on trees 50 meters apart throughout the study area to create a 50x50 meter grid. The grid allows them to map where birds are found in this area, and when possible, where they locate their nests. Using the grid the researchers systematically walk through the plot several days each week from early May until July, recording the presence and activities of every bird they find. They also note the locations of nearby birds singing at the same time. These records are combined on a map to figure out a bird's territory, or activity center. At the end of the breeding season they count up the number of territories to get an estimate of the number of birds on the study area. This information, when paired with observations on the presence and activities of mates, locations of nests, and other evidence of breeding activity provide an accurate estimate for bird abundance. Finally, some species under close study, like American Redstart and Black-throated Blue Warbler, were captured and given unique combinations of colored bands, which makes it easier to track individuals.

By looking at bird abundance data across many years, Richard and his colleagues can identify trends that reveal how avian populations change over time.

Scientific Question: How has the total number of birds at the Hubbard Brook Experimental Forest changed over time?

Name_____

Scientific Data:

Use the data below to answer the scientific question

Year	Total number of birds counted / study area
1969	158
1970	163
1971	212
1972	214
1973	192
1974	161
1975	201
1976	194
1977	187
1978	149
1979	147
1980	131
1981	117
1982	124
1983	118
1984	89
1985	116
1986	91
1987	85
1988	113
1989	101
1990	133
1991	120
1992	130

Year	Total number of birds counted / study area
1993	94
1994	84
1995	72
1996	93
1997	87
1998	72
1999	85
2000	89
2001	91
2002	71
2003	89
2004	76
2005	96
2006	108
2007	100
2008	92
2009	106
2010	108
2011	95
2012	105
2013	120
2014	113
2015	114

**The long-term data on bird abundances above were collected from a 10-ha study area.*

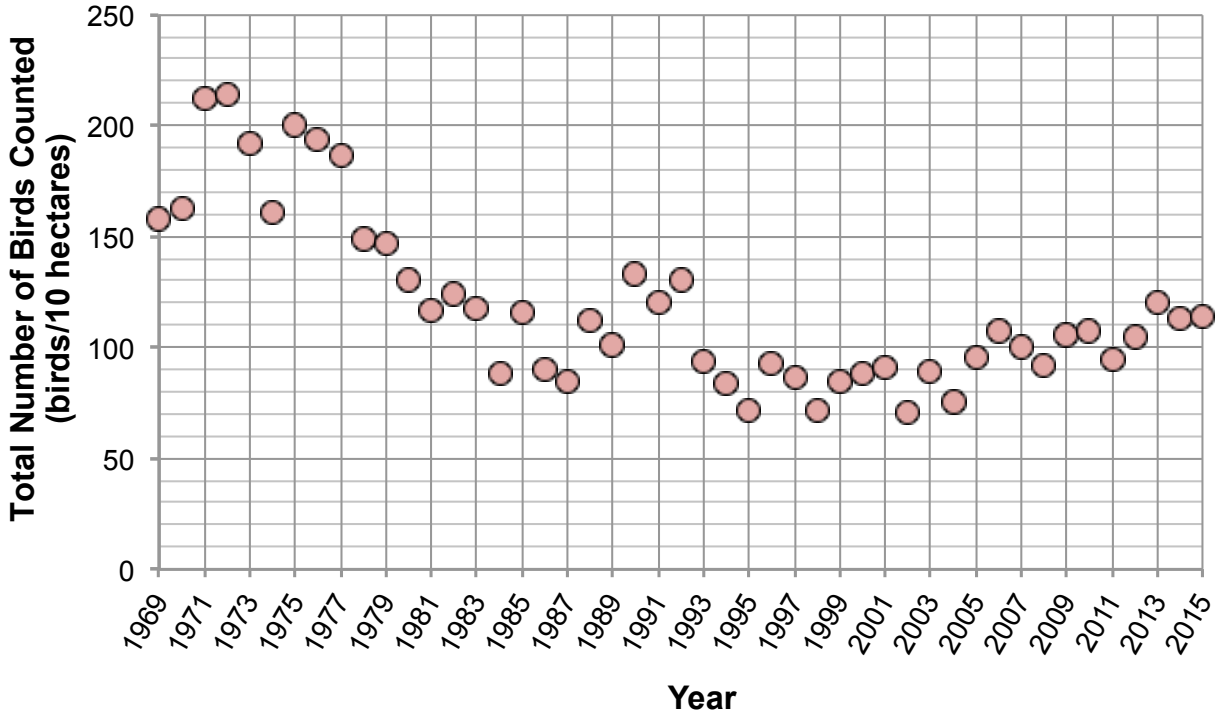
What data will you graph to answer the question?

Independent variable: _____

Dependent variable: _____

Name_____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the table or graph.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about the importance of long-term datasets.

Please continue to Part II

Name_____

DATA Nugget

Which guy should she choose?

Featured scientist: Alycia R. Lackey from Michigan State University

Research Background:

In many animals, males use complex behaviors to attract females. They use **displays** to show off colorful parts of their bodies, like feathers or scales. For example, male peacocks fan out and shake their colorful tails to attract female attention. These displays take up a lot of energy, and yet some males are unable to attract any females while other males attract many females.

Figure 1: A male stickleback tending his nest. Notice the male's bright red throat, blue eye, and blue-green body.

In stickleback fish, males are very colorful to attract females. Their throats turn bright red during the spring when they mate. Stickleback males also court females with zig-zag swimming! The males swim in a z-shaped pattern in front of the female, probably to show off their mating colors. Before male fish can get the attention of female fish, they must gain a territory and build a nest. In sticklebacks, females inspect nests that the males build and then decide if they want to deposit their eggs. Males care for the offspring before and after the eggs hatch. A female fish would benefit from identifying "high quality" males and choosing those males for mates. High quality males would have more energy to protect their offspring and would make better fathers. They could also pass on genes that make offspring more attractive to females in the next generation.

Alycia is a scientist who is interested in the stickleback's mating behaviors. She wanted to figure out why there are differences between males and why certain males can attract a mate while others cannot. What is it about the way a male looks, moves, or smells that attracts females? What male traits are females looking at when deciding on a mate? Alycia thought female sticklebacks may choose males with redder throats and/or more complex behaviors because those traits show the female that those males are high quality. Previous work with these fish showed that male behavior, color, or territory size, or the presence of a nest could all be important. But it was still not clear which characteristic might be most important.

Name_____

Alycia set up an experiment to figure out if male throat color or zig-zag swimming behaviors were attractive to females. She used a total of 24 male fish and six 75-gallon tanks. She divided the males up evenly between the large tanks, placing four males in each one. For 10 days she observed the male fish and recorded competition behaviors, territory defense, and nest building. On the tenth day, she introduced one female to each tank of four males. She recorded how the males behaved in courtship and which males the females chose. She also recorded the redness of each male.

Figure 2: Scientist Alycia collecting fish from a freshwater lake in British Columbia. Canada.

For each of the 24 male fish studied, Alycia collected the following data:

1. Female preference score: The higher the number, the more the female was attracted to that male. The scores were given as follows: (0) the female did not respond to the male, (1) the female approached the male, (2) the female followed the male to his territory, and (3) female examined the male's territory, poking her head into the sand to look for a nest.
2. Male courtship behaviors: number of display zig-zag dances the male did per minute.
3. Redness of male throat: The higher the number, the more red the male's throat was. This score includes both the area covered by and the intensity of red coloration on each male fish's throat.
4. Territory size: Each male's territory size was categorized as small if it was smaller than half the tank and large if it was larger than half the tank.
5. Presence of nest: whether or not the male fish made a nest.

Scientific Questions: Does male throat redness and courtship behavior influence which males females choose, and if so, how?

What is the hypothesis? Find the hypotheses in the Research Background and underline them. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies. Having two alternative hypotheses means that more than one mechanism may explain a given observation. Experimentation can determine if one, both, or neither hypotheses are supported.

Name_____

Scientific Data:

Use the data below to answer the scientific questions:

Female Preference Score	Male Courtship Behavior	Redness of Male Throat	Territory Size	Presence of Nest
(0-3)	*(# per minute)*	*(0-10)*	*(none, small, large)*	*(yes or no)*
0	1.75	5.0	Large	No
0	0.28	5.0	None	No
0	0.00	7.0	None	No
0	0.74	5.0	None	No
0	0.11	3.0	None	No
0	1.20	4.0	Small	No
0	0.28	6.5	Small	No
0	0.49	5.5	Large	Yes
0	1.55	6.5	Small	Yes
1	2.57	7.5	Large	No
1	6.48	7.0	Large	No
1	1.89	7.5	Large	No
1	0.48	5.0	None	No
1	0.14	8.0	Small	No
1	8.04	7.5	Large	Yes
1	0.38	7.5	Small	Yes
1	3.81	8.0	Small	Yes
2	8.23	8.0	Large	No
2	10.00	6.5	Small	No
2	11.07	6.0	Small	No
2	1.87	6.5	Small	Yes
3	3.30	6.0	Large	Yes
3	12.93	7.0	Large	Yes
3	12.72	7.5	Large	Yes

What data will you graph to answer the questions?

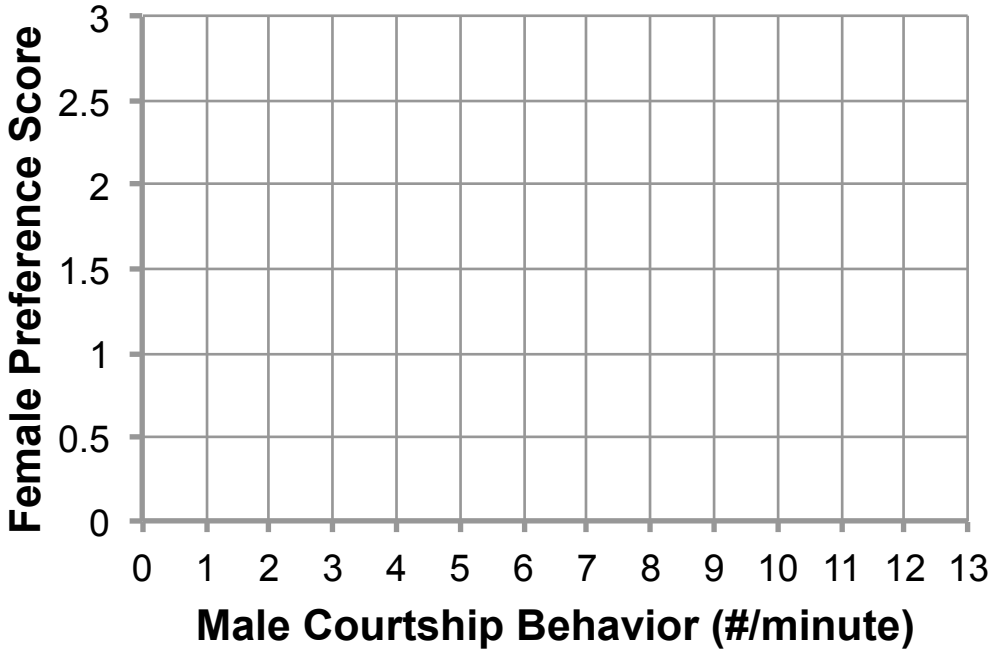
Independent variables: _____

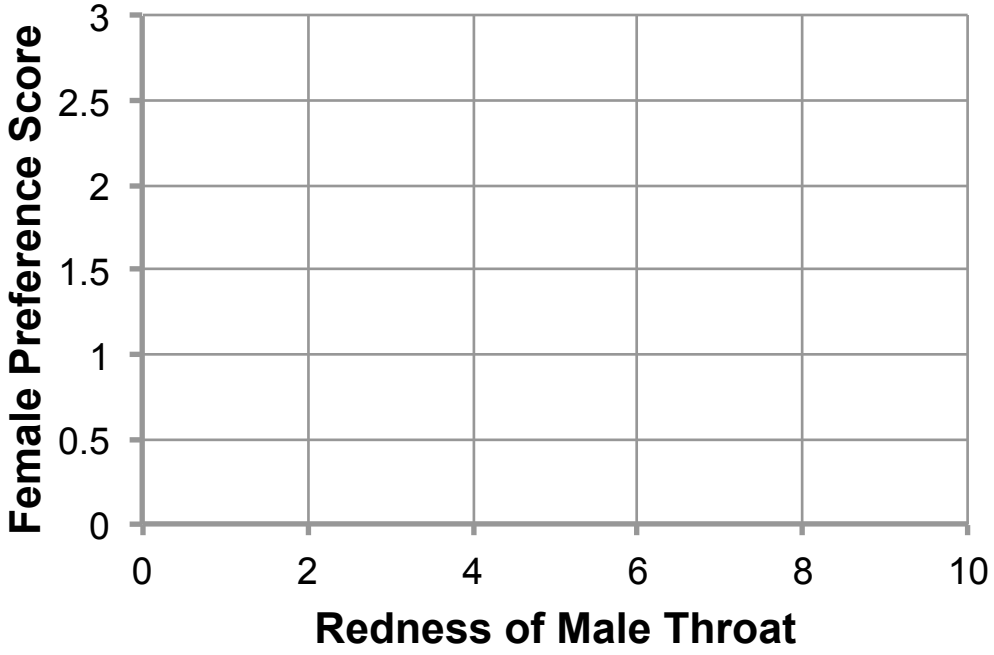
_____

Dependent variable: _____

Name_____

Draw your graphs below: Identify any changes, trends, or differences you see in your graphs. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.





Name_____

Interpret the data:

Make a claim that answers each of the scientific questions.

What evidence was used to write your claim? Reference specific parts of the table or graphs.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about how female stickleback fish choose their mates.

Name_____

Did the data support one, both, or either of Alycia's two alternative hypotheses? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question do you think should be investigated? What future data should be collected to answer your question?

Science Enrichment

Section 2

8 Day Research Investigation

Virology, Epidemiology, and COVID-19

Lesson 1: What is Epidemiology?
Complete the questions and graphic organizers after reading the article about cholera spread and the factors involved in epidemiology.

Lesson 2: Spread of Pathogens
Complete the "Spread of Pathogens" packet using the models to answer the questions.

Lesson 3: Virus Life Cycle
Reading on the viral life cycle and infection mechanisms. The students will answer the questions and label the diagram of the infection and life cycle.

Lesson 4: Covid-19 Information Article
Read and annotate the article about Covid-19, then answer the comprehension questions.

Lesson 5: Patient Zero Activity
Follow the instructions to complete the activity and answer the questions for Patient Zero

Lesson 6: Why Soap Works
Read and annotate the article entitled *Why Soap Works*.
Fill out the Article 6-Pack graphic organizer based on your interpretation of the text.

Lesson 7: Coronavirus Claim, Evidence, Reasoning
Complete the CER graphic organizer after each data set/article. Use supporting evidence from the chart and text.

Lesson 8: Coronavirus and Scientific Graph Reading
Analyze all graphs and use the starter questions at the top of the worksheets to extract as much information as possible from them. Emphasize this data to the current state of the pandemic.

John Snow: The World's First Epidemiologist

Finding the Real Cause of Cholera
Cholera (KOLL-er-uh) is a terrible disease. People who have been infected with cholera have diarrhea so badly that they get dehydrated. Within a short time—two or three days—nearly half the patients will die.

On the night of the 31st of August, 1854, cholera broke out in the Soho section of London. It was, according to a local doctor, "the most terrible outbreak of cholera which ever occurred in the kingdom." In a single night, doctors reported 56 new cases of cholera—all within a few blocks of each other. Before the outbreak was over, nearly 500 people had lost their lives.

In those days, people did not have running water in their homes. They carried in water from pumps located around the neighborhood.

At the time, most people—even the best scientists—thought that cholera was spread through the air. But one local doctor did not agree. His name was John Snow. He believed that cholera was caused by a microbe and was spread by contaminated water.

But at the time, no one knew how this terrible disease was spread. That's what you are going to do. In this activity, you will become "disease detectives," trying to figure out how cholera is spread so you can prevent infection in more people.

Glossary
Contaminated (cun-TAM-in-ay-tud): Polluted, poisoned.

Dehydrated (dee-HY-dray-tud): What happens when there's not enough water in your body. If people lose too much water, then can even die!

Part A: Pretend you are John Snow or a doctor who agrees with him. You want to prove that the cholera in your neighborhood is being caused by contaminated water. How would you prove that?

1. What are some things you would want to know about the people who got sick and died in the neighborhood?
    1.
    2.
    3.

2. What would you want to know about people who lived in the neighborhood who did not die?
    1.
    2.
    3.

What would you want to know about people who died and lived away from the neighborhood?
    1.
    2.

Figure out the information you might need to prove your case. Later, you will present your ideas before the class.

John Snow's Methods

Snow carefully mapped the location of each death. Nearly all lived close to the pump at the corner of Cambridge and Broad Streets. Two women who had died lived many miles away. But Snow learned they had drunk water from the pump.

Some people who lived in the area had not gotten sick. Snow learned that most of them drank water from other wells.

Snow presented the map to local authorities. This time, they paid attention. He asked them to take the handle off the pump, and eventually, they did. The number of new cases of cholera went down (although it had been declining already since so many people had left the area).

Later, people learned that the well below the pump was about 28 feet deep. But close by ran a sewer that was only 22 feet below ground level. A few days before people got sick, some people remembered a bad smell near the pump. The raw sewage had seeped through the ground and into the well. As more people got sick, the sewage contained more of the microbes that caused cholera. That made the water even more contaminated.

Today, John Snow is recognized as one of the first "disease detectives." His methods of gathering information are still used by epidemiologists. One of the first things epidemiologists do when they get to the site of an outbreak of a new disease is to map it. They figure out in detail where all the sick people live, work, and play. They also keep track of anyone with whom a sick person has had contact.

Disease-Causing Microbes

Microbe that Causes Disease	Environment in which the Microbe Thrives	How to Break the Environmental Chain and Control the Spread of the Disease
Salmonella—bacterium that causes salmonellosis	Intestines of people and animals—lives in raw eggs, poultry, and meat.	
Borrelia burgdorferi—bacterium that causes Lyme disease	Lives in deer ticks.	
Group A Streptococcus—bacterium that causes "strep" infections	Lives in the mucus from the nose or throat of an infected person.	
Giardia—protozoan that causes giardiasis	Lives in feces of infected people and animals. Spread by contact with contaminated water.	
Rabies virus	Lives in the saliva of infected animals. Spread when an infected animal bites another animal or person.	

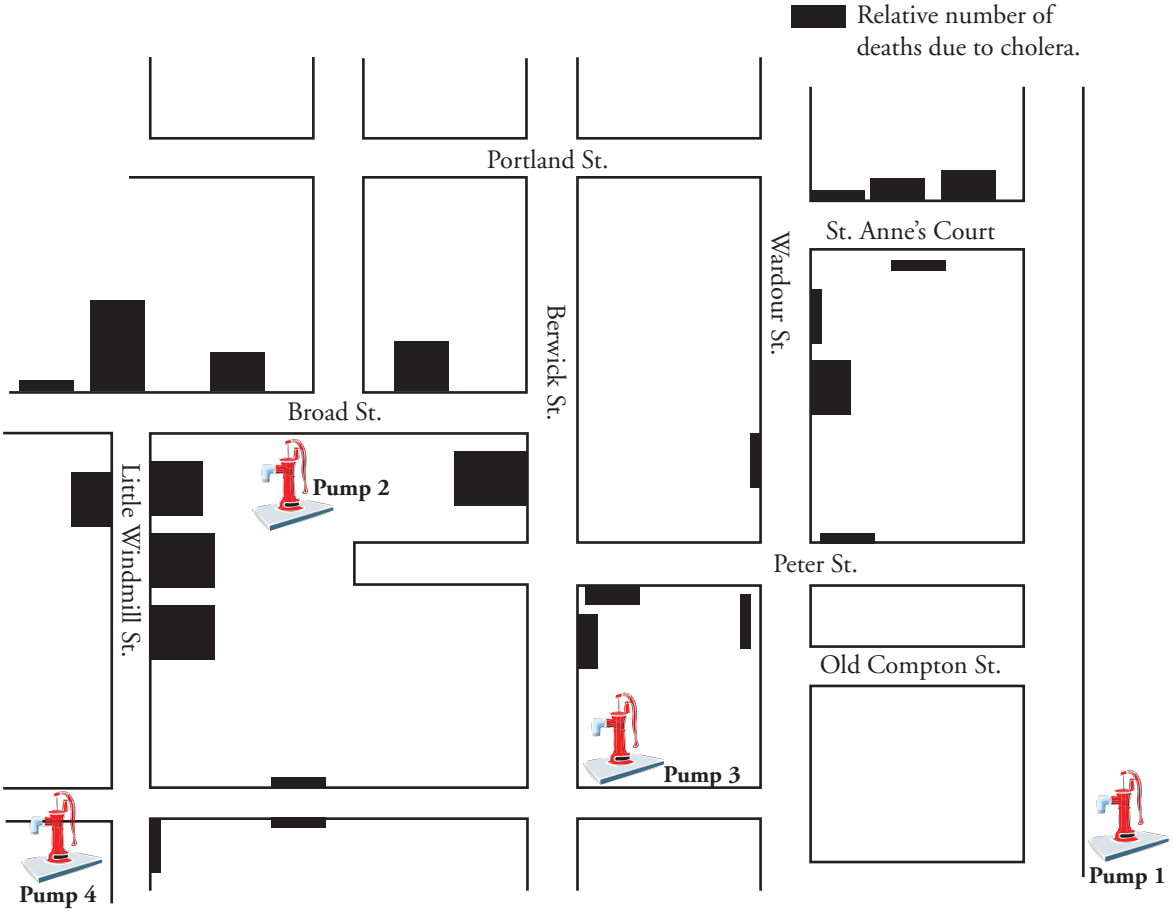
The Spread of Pathogens

How do we get sick?

Why?

Communicable diseases are spread between individuals by different methods, but they are all caused by **pathogens**, which are commonly called "germs." Knowledge of pathogens and the ways in which they can be spread helps humans understand and prevent disease outbreaks.

Model 1 – The 1854 London Cholera Outbreak



1. Model 1 is a map of an area in London where a large number of cases of cholera occurred in 1854.

   a. How many water pumps are shown on the map?

   b. What do the black boxes represent on the map?

   c. What do the relative sizes of the boxes represent?

2. Is the concentration and size of boxes the same at all locations on the map? Explain your answer.

3. Where exactly on the map does the size and concentration of the boxes appear to be the highest?

4. Is there a relationship between the number of black boxes and any of the water pumps? Be specific and detailed in your answer.

5. Based on the information provided in the map, propose a way cholera may be transmitted.

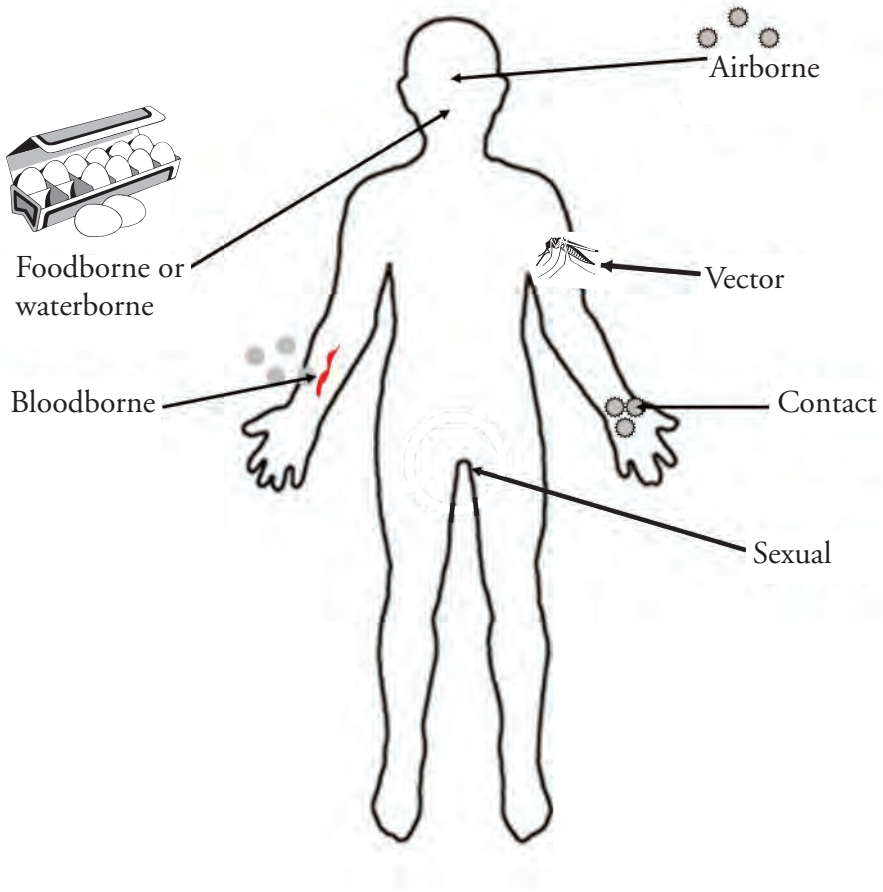
6. Based on this information, what action would you have taken if you had been responsible for public health in London in 1854?

Read This!

Dr. John Snow is often referred to as the "father of epidemiology." **Epidemiology** is the study of the causes and spread of infectious diseases. Dr. Snow's study of the cholera outbreak of 1854 led to the discovery of the cause of this epidemic.

7. Cholera is caused by bacteria found in the fecal material of infected individuals. Brainstorm with your group the possible ways that cholera could have been transmitted from an infected individual into the water. Consider the distribution of deaths shown on the map as you develop your response.

Model 2 – Six Modes of Disease Transmission



8. Model 2 illustrates several methods by which diseases may be transmitted.
   a. List the six modes of disease transmission shown in Model 2.

   b. Which of these modes of transmission require a bodily opening, either natural or artificial?

9. An organism that is used by a pathogen to move from one person to another is called a vector.
   a. What vector is shown in Model 2?

   b. With your group, brainstorm a list of other organisms besides the one shown in the diagram that could be vectors for transmitting pathogens.

10. Considering all of the different ways disease may be transmitted, which modes are more likely to cause large numbers of individuals to get sick in the United States? Explain your reasoning.

11. Consider the information given below concerning several diseases. Identify the mode(s) of transmission from Model 2 that is most appropriate based on the description.

Name of Disease	Class of Pathogen	Scientific Name of Pathogen	Disease Transmission (How it is spread)	Mode of Transmission from Model 2
Cholera	Bacteria	*Vibrio cholerae*	Fecal contamination of water	
Syphilis	Bacteria	*Treponema pallidum*	Sexual contact with body fluids (can include saliva)	
Common cold	Virus	*Rhinovirus*	Touching contaminated objects and surfaces, and then touching eyes/nose; inhaling air contaminated from a cough or sneeze	
AIDS	Virus	Human immunodeficiency virus (HIV)	Body fluids, which include blood, semen, vaginal fluids, and breast milk	
Athlete's foot	Fungus	*Trichophyton sp.*	Moist areas where people walk barefoot	
Tuberculosis (TB)	Bacteria	*Mycobacterium tuberculosis*	Inhalation of respiratory secretions	
Malaria	Protist	*Plasmodium sp.*	Being bitten by certain mosquitoes	
Food poisoning	Primarily bacteria (and some viruses)	*Salmonella* is a common cause	Improperly handled food, fecal contamination of food.	
Lyme Disease	Bacteria	*Borrelia sp.*	Being bitten by deer ticks	

12. Below are several methods used by society to control disease. Under each method of control, list the diseases from Question 11 that could be prevented with that method. (You may list a disease under more than one category.)

a. Preventing the contamination of food and water supplies.

b. Hand washing and good personal hygiene.

c. Avoiding contact with body fluids.

d. Controlling insect populations.

13. Why might diseases transmitted by vectors be harder to control than those transmitted by other means?

14. In the 14th century in Europe, the bubonic plague killed approximately one third of the population. Bubonic plague is caused by the bacteria *Yersinia pestis,* which is spread by an insect vector carried by rats and other rodents. This disease can be spread to other animals besides humans. How is control of a disease such as bubonic plague complicated by the fact that it spreads across multiple animal species?

Extension Question

15. In a recent *Scientific American* article (February 2010), *The Art of Bacterial Warfare,* the authors state that 33% of humans are carrying the *Mycobacterium tuberculosis* bacteria—many without actually getting sick. In addition, 50% of the human population is carrying the bacteria *Helicobacter pylori* (which causes stomach ulcers), and 50% is carrying *Staphylococcus aureus* (which causes skin infections). Knowing that carriers are individuals who often do not show any visible signs of disease, what challenges can you think of for health care officials trying to control these types of communicable diseases?

VIRUSES AND THE CYCLE OF REPLICATION

Directions:

Read the passage below and answer all questions that follow.

Viruses cause damage when the viruses replicate inside the cells. The entry of the virus into the cell is not by itself harmful, but after the virus has replicated itself several hundred times and breaks out, the cell is destroyed. Organ damage in an organism can be severe if enough tissue is damaged by the virus. Any agent that causes disease is called a pathogen.

They cycle of viral infection, replication, and cell destruction is called the lytic cycle. After the viral genes have entered the cell, they use the host cell to replicate viral genes and to make viral proteins, such as capsids. The proteins are then assembled with the replicated viral genes to form complete viruses. The host cell is broken open and releases newly made viruses.

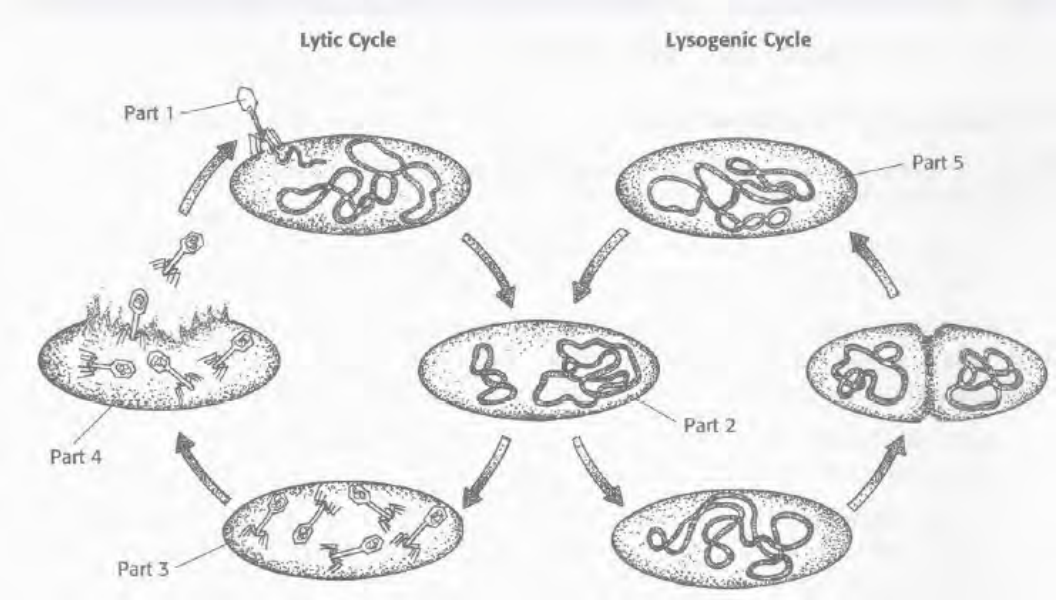
During an infection, some viruses stay inside the cells but do not make new viruses. Instead of producing virus particles, the viral gene is inserted into the host chromosome, and is called a provirus. Whenever the cell divides, the provirus also divides, resulting in two infected host cells. In this cycle, called the lysogenic cycle, the viral genome replicates without destroying the host cell.

1. How do viruses damage the cell?

2. What relationship exists between viruses and pathogens?

3. What sentence expresses main idea of the second paragraph?

4. The figure below shows the lytic and lysogenic cycles. In the spaces provided, describe what is occurring in each numbered part of the figure.



Part 1

Part 2

Part 3

Part 4

Part 5

Circle the letter of the phrase that best completes the statement.

Virus cause damage when they

a. invade cells
b. replicate inside cells.
c. remain inside a host cell.
d. Both (a) and (b).

CDC on COVID-19 Reading
(adapted)

Background

CDC is responding to an outbreak of respiratory disease caused by a novel (new) coronavirus that was first detected in China and which has now been detected in more than 100 locations internationally, including in the United States. The virus has been named “SARS-CoV-2” and the disease it causes has been named “coronavirus disease 2019” (abbreviated “COVID-19”).

On January 30, 2020, the International Health Regulations Emergency Committee of the World Health Organization (WHO) declared the outbreak a “public health emergency of international concern” (PHEIC).

On January 31, Health and Human Services Secretary Alex M. Azar II declared a public health emergency (PHE) for the United States to aid the nation’s healthcare community in responding to COVID-19.

On March 11, the WHO characterized COVID-19 as a pandemic. On March 13, the President of the United States declared the COVID-19 outbreak a national emergency.

Source and Spread of the Virus

Coronaviruses are a large family of viruses that are common in people and many different species of animals, including camels, cattle, cats, and bats. Rarely, animal coronaviruses can infect people and then spread between people.

Early on, many of the patients at the epicenter of the outbreak in Wuhan, Hubei Province, China had some link to a large seafood and live animal market, suggesting animal-to-person spread. Later, a growing number of patients reportedly did not have exposure to animal markets, indicating person-to-person spread. Person-to-person spread was subsequently reported outside Hubei and in countries outside China, including in the United States. Some international destinations now have ongoing community spread with the virus that causes COVID-19, as do some parts of the United States. Community spread means some people have been infected and it is not known how or where they became exposed.

Severity

The complete clinical picture with regard to COVID-19 is not fully known. Reported illnesses have ranged from very mild (including some with no reported symptoms) to severe, including illness resulting in death. While information so far suggests that most COVID-19 illness is mild, a report out of China suggests serious illness occurs in 16% of cases. Older people and people of all ages with severe chronic medical conditions — like heart disease, lung disease and diabetes, for example — seem to be at higher risk of developing serious COVID-19 illness.

COVID-19 Now a Pandemic

A pandemic is a global outbreak of disease. Pandemics happen when a new virus emerges to infect people and can spread between people sustainably. Because there is little to no pre-existing immunity against the new virus, it spreads worldwide. The virus that causes COVID-19 is infecting people and spreading easily from person-to-person. Cases have been detected in most countries worldwide and community spread is being detected in a growing number of countries. On March 11, the COVID-19 outbreak was characterized as a pandemic by the WHO.

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This is the first pandemic known to be caused by the emergence of a new coronavirus. In the past century, there have been four pandemics caused by the emergence of novel influenza viruses. As a result, most research and guidance around pandemics is specific to influenza, but the same premises can be applied to the current COVID-19 pandemic. Pandemics of respiratory disease follow a certain progression outlined in a "Pandemic Intervals Framework." Pandemics begin with an investigation phase, followed by recognition, initiation, and acceleration phases. The peak of illnesses occurs at the end of the acceleration phase, which is followed by a deceleration phase, during which there is a decrease in illnesses.

Risk Assessment

Risk depends on characteristics of the virus, including how well it spreads between people; the severity of resulting illness; and the medical or other measures available to control the impact of the virus (for example, vaccines or medications that can treat the illness) and the relative success of these. In the absence of vaccine or treatment medications, nonpharmaceutical interventions become the most important response strategy. These are community interventions that can reduce the impact of disease.

The risk from COVID-19 to Americans can be broken down into risk of exposure versus risk of serious illness and death.

Risk of exposure:

- The immediate risk of being exposed to this virus is still low for most Americans, but as the outbreak expands, that risk will increase. Cases of COVID-19 and instances of community spread are being reported in a growing number of states.
- People in places where ongoing community spread of the virus that causes COVID-19 has been reported are at elevated risk of exposure, with the level of risk dependent on the location.
- Healthcare workers caring for patients with COVID-19 are at elevated risk of exposure.
- Close contacts of persons with COVID-19 also are at elevated risk of exposure.
- Travelers returning from affected international locations where community spread is occurring also are at elevated risk of exposure, with level of risk dependent on where they traveled.

Risk of Severe Illness:
Early information out of China, where COVID-19 first started, shows that some people are at higher risk of getting very sick from this illness. This includes:

- Older adults, with risk increasing by age.
- People who have serious chronic medical conditions like:
    - Heart disease
    - Diabetes
    - Lung disease

What May Happen

More cases of COVID-19 are likely to be identified in the United States in the coming days, including more instances of community spread. CDC expects that widespread transmission of COVID-19 in the United States will occur. In the coming months, most of the U.S. population will be exposed to this virus.

Widespread transmission of COVID-19 could translate into large numbers of people needing medical care at the same time. Schools, childcare centers, and workplaces, may experience more absenteeism. Mass gatherings may be sparsely attended or postponed. Public health and healthcare systems may become overloaded, with elevated rates of hospitalizations and deaths. Other critical infrastructure, such as law enforcement, emergency medical services, and sectors of the transportation industry may also be affected. Healthcare providers and hospitals may be overwhelmed. At this time, there is no vaccine to protect against COVID-19 and no medications approved to treat it. Nonpharmaceutical interventions will be the most important response strategy to try to delay the spread of the virus and reduce the impact of disease.

CDC Response

Global efforts at this time are focused concurrently on lessening the spread and impact of this virus. The federal government is working closely with state, local, tribal, and territorial partners, as well as public health partners, to respond to this public health threat.

CDC is implementing its pandemic preparedness and response plans, working on multiple fronts, including providing specific guidance on measures to prepare communities to respond to local spread of the virus that causes COVID-19. There is an abundance of pandemic guidance developed in anticipation of an influenza pandemic that is being adapted for a potential COVID-19 pandemic.

Reading Questions

Vocabulary:
Use context clues to determine the definition of each of the following words

1. Chronic

2. Non-Pharmaceutical Interventions

3. Pandemic

4. Infrastructure

Comprehension Questions

1. What is a “coronavirus”?

2. Which happened first:
   A. Health and Human Services Secretary Alex M. Azar II declared a public health emergency (PHE) for the United States to aid the nation’s healthcare community in responding to COVID-19.
   B. The President of the United States declared the COVID-19 outbreak a national emergency.
   C. The WHO characterized COVID-19 as a pandemic

3. Which is the correct order of the Pandemic Phases
   A. Investigation, initiation, recognition, acceleration, deceleration
   B. Acceleration, investigation, recognition, initiation, deceleration
   C. Investigation, recognition, initiation, acceleration, deceleration
   D. Acceleration, recognition, initiation, deceleration, investigation

4. Who are most at risk of severe illness from COVID - 19

Short Answer:
Using the information in this post write a tweet (140 characters or less) explaining what people should do to stop the spread of COVID-19.

Identifying Patient Zero Activity

Introduction

There has been an outbreak at Disney World causing a resort shut down. Millions of children are devastated as they have been looking forward to their trips for months! This new mysterious illness appears to be **communicable** and the **mode of transmission** appears to be through droplets (sneezing/coughing etc).

In this activity you will demonstrate the transmission of an unknown infectious agent from person to person as well as use deductive reasoning to determine "patient zero," the initial patient in the population to develop the infection and ultimately help reopen Disney World!

Procedure

Part 2: Contagion Activity

1. Epidemiologists have noticed that multiple Disney workers have down with a mysterious infection that causes coughing, fever, and difficult breathing. They believe the illness is **communicable** and the **mode of transmission** appears to be through droplets (sneezing/coughing etc). They have collected the last couple week's work schedule to assess which workers came into contact with each other.

Employee	Week 1	Week 2	Week 3
Cinderella	Soarin'	Castle	Space Mountain
Ariel	Astro Orbiter	Soarin'	Splash Mountain
Olaf	Soarin'	Astro Orbiter	Haunted Mansion
Simba	Splash Mountain	Splash Mountain	Soarin'
Mickey	Haunted Mansion	Castle	Splash Mountain
Anna	Splash Mountain	Haunted Mansion	Castle
Sneezy	Castle	Haunted Mansion	Haunted Mansion
Minnie	Castle	Astro Orbiter	Space Mountain
Belle	Astro Orbiter	Space Mountain	Astro Orbiter
Elsa	Space Mountain	Space Mountain	Soarin'
Beast	Haunted Mansion	Soarin'	Castle
Goofy	Space Mountain	Splash Mountain	Astro Orbiter

2. They also have tested each of the workers.

Employee	Test Result
Cinderella	-
Ariel	-
Olaf	+
Simba	+
Mickey	-
Anna	+
Sneezy	+
Minnie	-
Belle	+
Elsa	+
Beast	+
Goofy	+

3. **Devise a way to determine *Patient Zero*. Determine your *Patient Zero options* by showing your work below (include image if you did this by hand):**

4. Now that you have narrowed down your patient zero to 1 or a couple individuals, generate a list of 5 questions that you want to ask when you interview the workers. Your questions should be designed to help you identify who patient zero is, as well as learn more about how this new mysterious disease spreads.

    a.

    b.

    c.

    d.

    e.

5. *Why do you think the CDC (Center of Disease Control) attempts to determine patient zero when there is a disease outbreak?*

Why Soap Works

At the molecular level, soap breaks things apart. At the level of society, it helps hold everything together.

By Ferris Jabr
March 13, 2020

It probably began with an accident thousands of years ago. According to one legend, rain washed the fat and ash from frequent animal sacrifices into a nearby river, where they formed a lather with a remarkable ability to clean skin and clothes. Perhaps the inspiration had a vegetal origin in the frothy solutions produced by boiling or mashing certain plants. However it happened, the ancient discovery of soap altered human history. Although our ancestors could not have foreseen it, soap would ultimately become one of our most effective defenses against invisible pathogens.

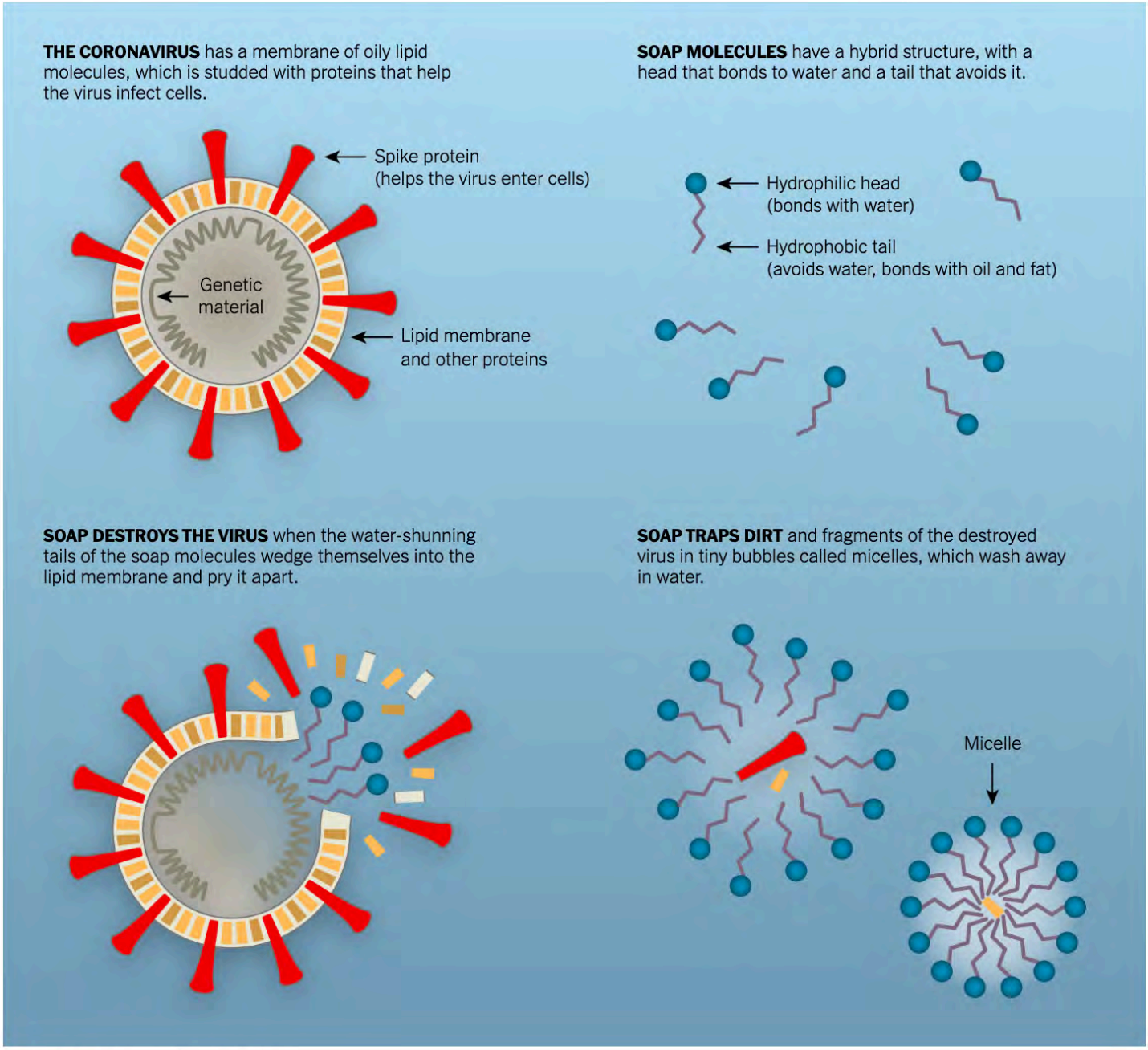
People typically think of soap as gentle and soothing, but from the perspective of microorganisms, it is often extremely destructive. A drop of ordinary soap diluted in water is sufficient to rupture and kill many types of bacteria and viruses, including the new coronavirus that is currently circling the globe. The secret to soap's impressive might is its hybrid structure.

Soap is made of pin-shaped molecules, each of which has a hydrophilic head — it readily bonds with water — and a hydrophobic tail, which shuns water and prefers to link up with oils and fats. These molecules, when suspended in water, alternately float about as solitary units, interact with other molecules in the solution and assemble themselves into little bubbles called micelles, with heads pointing outward and tails tucked inside.

Some bacteria and viruses have lipid membranes that resemble double-layered micelles with two bands of hydrophobic tails sandwiched between two rings of hydrophilic heads. These membranes are studded with important proteins that allow viruses to infect cells and perform vital tasks that keep bacteria alive. Pathogens wrapped in lipid membranes include coronaviruses, H.I.V., the viruses that cause hepatitis B and C, herpes, Ebola, Zika, dengue, and numerous bacteria that attack the intestines and respiratory tract.

When you wash your hands with soap and water, you surround any microorganisms on your skin with soap molecules. The hydrophobic tails of the free-floating soap molecules attempt to evade water; in the process, they wedge themselves into the lipid envelopes of certain microbes and viruses, prying them apart.

"They act like crowbars and destabilize the whole system," said Prof. Pall Thordarson, acting head of chemistry at the University of New South Wales. Essential proteins spill from the ruptured membranes into the surrounding water, killing the bacteria and rendering the viruses useless.



By Jonathan Corum and Ferris Jabr

In tandem, some soap molecules disrupt the chemical bonds that allow bacteria, viruses and grime to stick to surfaces, lifting them off the skin. Micelles can also form around particles of dirt and fragments of viruses and bacteria, suspending them in floating cages. When you rinse your hands, all the microorganisms that have been damaged, trapped and killed by soap molecules are washed away.

On the whole, hand sanitizers are not as reliable as soap. Sanitizers with at least 60 percent ethanol do act similarly, defeating bacteria and viruses by destabilizing their lipid membranes. But they cannot easily remove microorganisms from the skin. There are also viruses that do not depend on lipid membranes to infect cells, as well as bacteria that protect their delicate membranes with sturdy shields of protein and sugar. Examples include bacteria that can

cause meningitis, pneumonia, diarrhea and skin infections, as well as the hepatitis A virus, poliovirus, rhinoviruses and adenoviruses (frequent causes of the common cold).

These more resilient microbes are generally less susceptible to the chemical onslaught of ethanol and soap. But vigorous scrubbing with soap and water can still expunge these microbes from the skin, which is partly why hand-washing is more effective than sanitizer. Alcohol-based sanitizer is a good backup when soap and water are not accessible.

In an age of robotic surgery and gene therapy, it is all the more wondrous that a bit of soap in water, an ancient and fundamentally unaltered recipe, remains one of our most valuable medical interventions. Throughout the course of a day, we pick up all sorts of viruses and microorganisms from the objects and people in the environment. When we absentmindedly touch our eyes, nose and mouth — a habit, one study suggests, that recurs as often as every two and a half minutes — we offer potentially dangerous microbes a portal to our internal organs.

As a foundation of everyday hygiene, hand-washing was broadly adopted relatively recently. In the 1840s Dr. Ignaz Semmelweis, a Hungarian physician, discovered that if doctors washed their hands, far fewer women died after childbirth. At the time, microbes were not widely recognized as vectors of disease, and many doctors ridiculed the notion that a lack of personal cleanliness could be responsible for their patients' deaths. Ostracized by his colleagues, Dr. Semmelweis was eventually committed to an asylum, where he was severely beaten by guards and died from infected wounds.

Florence Nightingale, the English nurse and statistician, also promoted hand-washing in the mid-1800s, but it was not until the 1980s that the Centers for Disease Control and Prevention issued the world's first nationally endorsed hand hygiene guidelines.

Washing with soap and water is one of the key public health practices that can significantly slow the rate of a pandemic and limit the number of infections, preventing a disastrous overburdening of hospitals and clinics. But the technique works only if everyone washes their hands frequently and thoroughly: Work up a good lather, scrub your palms and the back of your hands, interlace your fingers, rub your fingertips against your palms, and twist a soapy fist around your thumbs.

Or as the Canadian health officer Bonnie Henry said recently, "Wash your hands like you've been chopping jalapeños and you need to change your contacts." Even people who are relatively young and healthy should regularly wash their hands, especially during a pandemic, because they can spread the disease to those who are more vulnerable.

Soap is more than a personal protectant; when used properly, it becomes part of a communal safety net. At the molecular level, soap works by breaking things apart, but at the level of society, it helps hold everything together. Remember this the next time you have the impulse to bypass the sink: Other people's lives are in your hands.

Name: _____ Date: _____

Article 6-Pack

Find at least two important pieces of information from the article and explain why they are so central to what the author is trying to say. **Determining Importance**	Write at least two connections between the article and your own experience. **Making Connections**
Select a sentence or passage from the article that made you think. Explain why it caught your attention and how it connected to the rest of the text. **Drawing Inferences**	Create an open-ended question about the article. **Questioning**
Identify some new or unfamiliar words or phrases you encountered. Explain the meaning of the words from the context. **Build Vocabulary**	Create a drawing or graphic that helps you understand or organize the ideas presented in the article. **Visualize**

Claims, Evidence, & Reasoning about the Coronavirus

Part 1: Coronavirus & the Flu

Comparison of the Flu and Coronavirus

	Flu	Coronavirus
Illnesses	34 million in US	100,000 worldwide
Deaths	20,000 in US	3,000 Worldwide
Death rate	0.1% in the U.S	2.3% in mainland China
Virus transmission R0	1.3	2.5

basic reproduction number," or R0 (pronounced R-nought). This is an estimate of the average number of people who catch the virus from a single infected person

BIG QUESTION: Is the Coronavirus *just* the flu?

Claim: *Answer the Big Question in a complete sentence.*

Evidence: *What data or text supports your claim?*

Reasoning: *Why does the evidence you chose support your claim? Explain Why!!*

Part 2: The *New* Coronavirus? *Read the article below and then fill out the CER.*

In recent weeks, a new coronavirus disease called COVID-19 has spread from where it was first detected in China to dozens of other countries. Now, several U.S. states have confirmed cases.

"Like any novel infection that's reported, it's certainly a public health concern," says Steven Gordon, MD, Chairman of the Department of Infectious Disease. And there is still much to learn about this new coronavirus disease.

As the situation continues to evolve, infectious disease specialist Frank Esper, MD, encourages people to stay informed and follow common-sense practices like proper hand-washing to reduce the spread of viruses.

Coronavirus is a family of viruses that are common in people and animals. They can cause a variety of illnesses, ranging from the common cold to severe pneumonia.

Coronaviruses spread from person to person through droplets released when people who are infected cough or sneeze. These infected droplets can land on people nearby, who can then become infected if the virus gets into their body through their eyes, nose or mouth.

So you could get COVID-19 from coming in close contact with an infected person who is coughing and sneezing, Dr. Gordon says. Experts also suspect that you can get it from touching a surface that has been contaminated with virus-containing droplets.

Because of this, the Centers for Disease Control and Prevention recommends that people who have or might have COVID-19, or anyone caring for someone who has it, wear face masks to prevent the spread. However, you do not need to wear a face mask if you are not sick.

Symptoms are what one would expect from a typical upper respiratory infection, including cough and fever. Some people also have other symptoms that mimic the flu, such as muscle aches and sore throat, Dr. Esper notes.

"Unfortunately there is no truly identifying feature of this coronavirus that separates it from other viruses out there," he says.

Most people who contract the virus will have mild symptoms and can recover on their own at home. But people over age 50 and people who have heart disease, lung disease or weakened immune systems seem to be more at risk for serious infections that could lead to pneumonia and difficulty breathing, Dr. Esper says.

The only way to confirm that someone has COVID-19 is through a swab test. Efforts are underway to make testing more widely available in U.S. hospitals and healthcare facilities. Because of this, Dr. Esper expects to see an uptick in the number of cases of COVID-19 being diagnosed and reported.

However, the CDC currently considers the immediate health risk to the American public to be low.

The priority: Prevention

While there is no specific treatment for COVID-19, the best way to protect against it and any other upper respiratory infection is to practice good cold and flu season hygiene, Dr. Gordon says.

Actions to prevent the spread of viruses include:

- **Washing your hands thoroughly with soap and water**, or using an alcohol-based hand sanitizer.
- **Properly covering your nose and mouth** with a tissue or your sleeve when you cough and sneeze.
- **Staying home from school or work** if you're not feeling well, whether you think you have something extremely contagious or not. Wear a mask if you are sick.
- **Disinfect surfaces** that are frequently touched, like doorknobs and handles.
- **Avoiding close contact** with people who are sick.
- **Avoid touching your face** to prevent the spread of viruses from your hands.
- **Follow travel guidelines** from the CDC.

If you think you may have been infected with the coronavirus, call your healthcare provider. They will ask about your symptoms and recent travel, and recommend what next steps you should take.

BIG QUESTION: Is the Coronavirus *new*? (Consider ways that it is and is not new, then state your claim!)

Claim: *Answer the Big Question in a complete sentence.*

Evidence: *What data or text supports your claim?*

Reasoning: *Why does the evidence you chose support your claim? Explain Why!!*

Graph of the Week **Name**_____

February _____, 2020

Analyze the graphs below and write a reflection on what you think the graphs are communicating to you. To guide you with your response, start with some observations.

- What is the topic of the graph?
- What quantities are being compared? (If there are x- and y- axes, what do they represent?)
- What are some observations that you can make based on the graphs?
- What do you foresee happening in this data 10 years from now?

Questions to ask when reading graphs:

- Is there an upward or downward trend?
- Are there any sudden spikes in the graph?
- What is being compared in the graph?
- What prediction can I make for the future?
- What inferences can I make about the graph?

Wuhan coronavirus compared to other major viruses

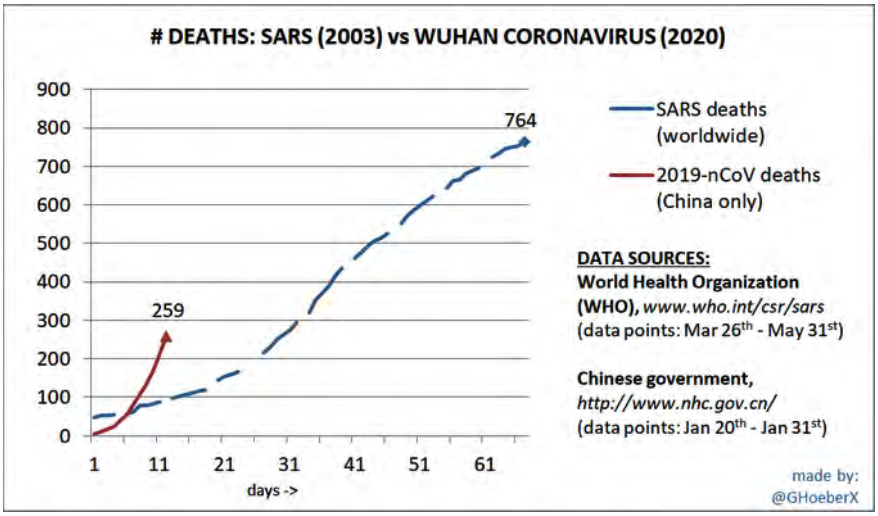
VIRUS	YEAR IDENTIFIED	CASES	DEATHS	FATALITY RATE	NUMBER OF COUNTRIES
Marberg	1967	466	373	80%	11
Ebola*	1976	33,577	13,562	40.40%	9
Hendra	1994	7	4	57%	1
H5N1 Bird Flu	1997	861	455	52.80%	18
Nipah	1998	513	398	77.60%	2
SARS	2002	8,096	774	9.60%	29
H1N1**	2009	>762,630,000	284,500	0.02%	214#
MERS***	2012	2,494	858	34.40%	28
H7N9 Bird Flu	2013	1,568	616	39.30%	3
2019-nCoV*	2020	11,871	259	2.2%	24

*As of January 31, 2020 **Between 2009 and 2010 ***As of November 2019

#Countries and overseas territories or communities

Sources: CDC; UN; WHO; New England Journal of Medicine; Malaysian Journal of Pathology; CGTN; Johns Hopkins University; The Lancet; Reuters, CIDRAP

BUSINESS INSIDER



Graph of the Week 3PA **Name**_____

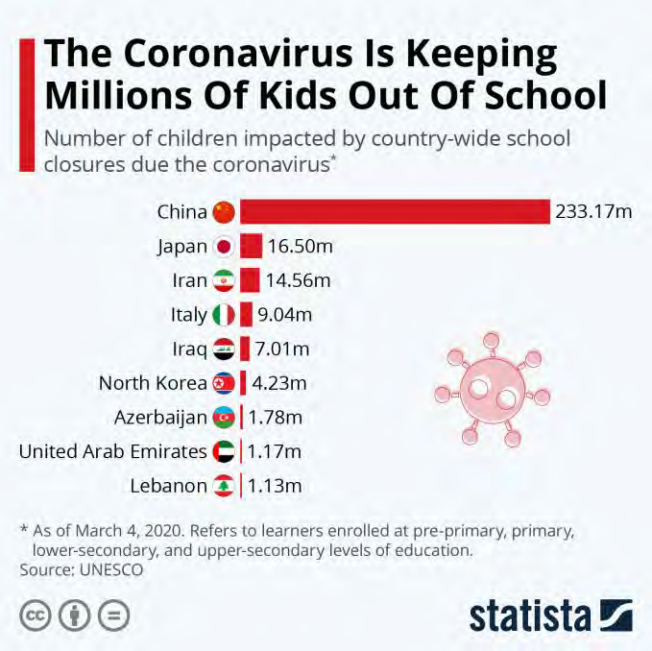
Date_____

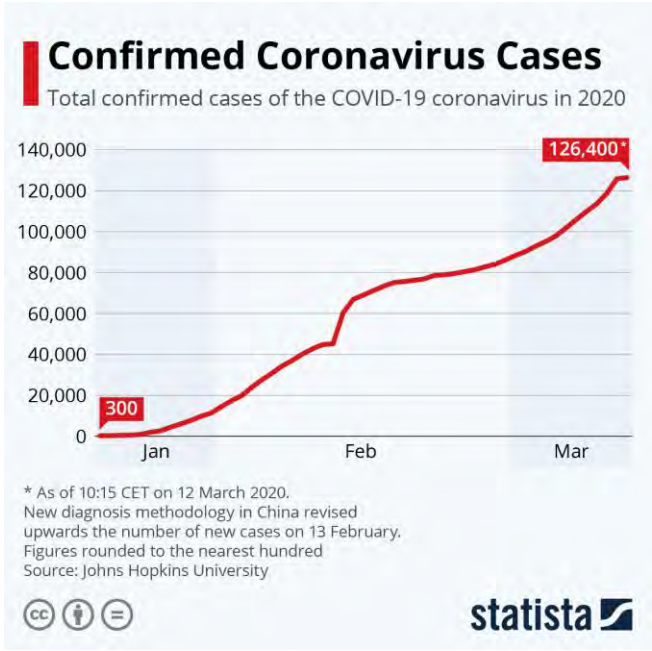
Analyze the graphs below and write a reflection on what you think the graphs are communicating to you. To guide you with your response, start with some observations.

- What is the topic of the graph?
- What quantities are being compared? If there are x- and y- axes, what do they represent?
- What are some observations you can make based on the graph?

Questions to ask when reading graphs:

- Is there an upward or downward trend?
- Are there any sudden spikes in the graph?
- What is being compared in the graph?
- What prediction can I make for the future?
- What inferences can I make about the graph?





A. Analysis

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B. What can you foresee happening in the near future?

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C. Based on your response in part B, what solution(s) can you investigate or what other information/resources can you gather to strengthen your argument?

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Make an illustration or represent the data in your own way in the space below:

Science Enrichment

Section 3

Articles and Questions

ADDICTED TO SUGAR

(1) When people think of addictions they think of substances like alcohol, cigarettes and illegal drugs like cocaine and heroin. However, what if there's a more addictive substance that is more common, found in all of our homes and aggressively marketed and even legally sold to children? This substance exists and it is sugar.

(2) Over the last few years, more and more research points to sugar as a major contributor to health problems like cardiovascular disease, obesity, diabetes, liver disease, some cancers and even lowered mental functioning. We all know we shouldn't eat too much sugar, but most of us don't realize how much sugar we're actually consuming and how it's affecting our health. Many of us might say that we have a "sweet tooth" but very few of us would think that we have a sugar addiction.

(3) Research is beginning to show that many of us exhibit signs of sugar addiction. Signs like cravings for sugar, loss of self control around sweets and feelings of withdrawal (feeling bad or unhappy) when not eating it. Studies have been done on rats to investigate the addictive properties of sugar versus other addictive drugs. In these studies, rats were given cocaine or heroin until they become addicted. After drug addiction was established, the rats were introduced to sugar along with the drug. Over a short period of time, over 90% of the rats began to choose sugar over the drug they were already addicted to and developed a stronger sugar addiction than drug addiction. Research like this shows the powerful addictive capacity of sugar.

(4) Highly sweet and refined sugars have not existed in our diets until recently. Our ancestors lived in a world where dietary sweetness was less consistent because sweet fruits were not as common, especially in more Northern climates where fruit was smaller, and more sour and bitter than sweet. It wasn't until humans developed agriculture and began selecting only the sweetest fruits to farm that fruits became very sweet and widely available. For many of our hunter-gatherer ancestors, super sweet foods were very scarce and some likely consumed no more than 20 teaspoons of sugar a year while we can consume the equivalent of that in one soda! Our brains are

not adapted to the overload of pleasure that occurs when we consume sweets. Sugar triggers the same pleasure, reward, and habit formation pathways in the brain as cocaine and heroin. This pleasure ensures continued sugar consumption that can lead to addiction.

(5) Not only are fruits sweeter and more available than ever before, we are also consuming a greater amount of added sugars in other foods. High fructose corn syrup (HFCS) was developed in the 1970s and since then it has become a very common sweetener in sodas, sugary drinks, and many processed foods. Unlike sucrose (cane sugar) which is already very sweet, HFCS is even sweeter and more rapidly absorbed by the body to provide a very quick reward for the brain. Many children in Westernized countries will consume 2 beverages a day containing HFCS and this is a major contributor to childhood obesity, diabetes and sugar addiction.

(6) The majority of us consume too much sugar and even if we avoid the obvious added sugars there is still a whole world of hidden added sugars in our diet that most of us are unaware of. These sneaky hidden sugars make it very difficult to avoid added sugars. Foods like ketchup, barbeque sauce, pasta sauce, salad dressings, cereals, power bars and baked beans contain a lot of hidden added sugar.

(7) Imagine that you've decided to kick your sugar addiction and start eating healthier. For breakfast you have bowl of cereal, for lunch you have a sandwich with a side of coleslaw and a cup of strawberry yogurt, and for dinner you have a chicken salad. You've said no to all

ADDICTED TO SUGAR

the desserts and sodas today. If a woman should have no more than 24g of added sugar and a man no more than 36g, did your diet stay within these limits? A cup of cereal has between 10g-20g of sugar, a side of coleslaw has 15g of sugar, a serving of salad dressing can have 5g-7g of sugar and a serving of fruit flavored yogurt has 17 g of sugar. This totals 47g to 59g of added sugars! The hidden sugars in food often fool people into thinking they don't eat as much sugar as they do.

(8) With so much hidden sugar everywhere, it might seem impossible to cut out added sugar. However, reading food labels will really begin to help you identify hidden added sugars. When reading labels, you should do the following things: 1) identify how much sugar is in each serving of food, 2) identify where sugar is located in the ingredients list. Ingredients are listed in the order of their greatest quantities first, so if sugar is one of the first 3 ingredients, you know there's a high sugar content and 3) learn to identify sugar by its different names: sucrose, fructose, high-fructose corn syrup, glucose, lactose, evaporated cane juice, dextrose, brown rice syrup, molasses, and honey. With a little awareness and determination, you can cut down your sugar consumption greatly.

Article Questions

1) List the signs of sugar addiction.

2) Explain two ways that the rat study showed that sugar may be more addictive than cocaine or heroin?

3) Describe two reasons why our hunter-gatherer ancestors consumed less sugar than we do now.

4) How does sugar affect the brain?

5) Where do you find high-fructose corn syrup and how is it different from traditional sugar (cane sugar)?

6) Next time you pick up a box of cereal and you want to know about its sugar content, what three things should you do?

ANTIBIOTICS: PENICILLIN AND BEYOND

(1) Most of us have taken antibiotics at some point in our lives and the majority of us will need to take them multiple times before we die. Antibiotics are prescription drugs used to treat infections caused by bacteria like strep throat, ear infections, pneumonia, cholera, syphilis and tuberculosis. Some antibiotics also work against certain infections caused by fungi and protozoans. Antibiotics don't work on colds and flus because these are infections caused by viruses, though some doctors still wrongly prescribe antibiotics for these illnesses.

(2) Antibiotics either work by being bactericidal, meaning they kill bacteria, or by being bacteriostatic, meaning that they prevent bacteria from replicating. Bactericidal antibiotics destroy bacterial cell walls and cell membranes and can interfere with bacterial enzymes vital to the bacteria's survival; these include penicillin, sulfonamides and polymyxins. Bacteriostatic antibiotics work by disrupting the ability of bacteria to make proteins; these include tetracyclines and lincosamides.

(3) Antibiotics can also be classified as either narrow spectrum, meaning they kill only specific types of bacteria, or broad spectrum, meaning they can kill a wide range of bacteria. You might think that broad spectrum antibiotics are superior because they can kill many types of bacteria, but this means that they are also capable of killing good bacteria that do not cause infection. Broad spectrum antibiotics can kill the beneficial bacteria in your intestines. The absence of beneficial gut bacteria can lead to digestive complications as well as cause *C. difficile* infections. *C. difficile* is a disease-causing bacteria which easily takes over the intestines when beneficial bacteria are absent.

(4) Penicillin was accidentally discovered in 1928 by a Scottish scientist named Alexander Fleming. On the 28th of September 1928, Fleming noticed that one of his Petri dishes looked strange. The dish was meant to grow only staphylococcus bacteria but Fleming noticed that mold had contaminated his sample because it was growing in the dish with the bacteria. However, surrounding the mold

was an empty area where none of the bacteria seemed to grow. Fleming concluded that the mould must be secreting a chemical capable of killing or preventing the bacteria's growth. On further analysis, he discovered that the mould produced a bactericidal compound and Fleming named it penicillin after the mold growing in the dish, which was called *Penicillium*. Though penicillin was discovered in 1928, the technology to mass produce it wasn't developed until the 1940s. This is when antibiotics became the number one treatment for bacterial infections. Antibiotics were a huge advancement for medicine and Fleming, along with Howard Florey and Ernst Boris Chain, the two scientists who helped create the mass production method, were awarded the Nobel Prize in Medicine in 1945 for their work. Before the use of antibiotics, life expectancy was lower and childhood death rates were much higher. Infections easily cured by today's antibiotics killed many children during that era.

(5) We have now figured out that all antibiotics originate from nature and are produced by fungi and bacteria. Fungi synthesize antibiotics to protect themselves from bacterial infection. Bacteria manufacture antibiotics to kill competing bacteria. Once an antibiotic is discovered it can be developed into different variations. To date, there are over 100 antibiotics that have been developed, though health organizations are concerned that the rate of discovery of new antibiotics has slowed down greatly in the last 20 years.

(6) Though antibiotics are important for treating human bacterial infections, the majority of antibiotics are actually used in the

ANTIBIOTICS: PENICILLIN AND BEYOND

commercial livestock farming of cattle, pigs, sheep and poultry. 80%-90% of the antibiotics used in the U.S. are used on livestock. Most of the antibiotics used for livestock are not used to treat infections. For reasons that aren't exactly clear, when antibiotics are put in the feed of livestock, it causes them to develop more muscle and milk very quickly. Large commercial farmers save a lot of money using antibiotics because it decreases the time it takes to raise livestock to a size appropriate for slaughter. Antibiotics used for non-medical reasons like this are called subtherapeutic antibiotics, but they are controversial because their widespread use contributes to antibiotic resistance.

(7) Antibiotic resistance occurs when antibiotics kill the weakest bacteria in a population but are unable to kill the strongest. As more antibiotics are used, more antibiotic resistant survivors are left. When these survivors pass on their antibiotic resistance to their offspring, the entire population eventually becomes resistant. There is great concern that an increasing number of bacteria are exhibiting antibiotic resistance and that this the beginnings of a public health crisis for which we are very unprepared. Health organizations blame the misuse and over-prescription of antibiotics as well as the heavy use of subtherapeutic antibiotics for causing the troubling rise in antibiotic resistance.

Article Questions

1) What is the difference between a bactericidal antibiotic and a bacteriostatic antibiotic?

2) What is the difference between a narrow spectrum antibiotic and a broad spectrum antibiotic?

3) How can the use of broad spectrum antibiotics lead to negative health consequences. Describe two of these negative health consequences.

4) What was the first antibiotic discovered, when was it discovered and who discovered it?

5) What did Fleming observe that caused him to suspect that the mold was producing a substance that prevented the bacteria from growing?

6) What are subtherapeutic antibiotics and what effect do they have?

7) What is antibiotic resistance and how does it develop?

Name: _____ Date: _____

ANTIBIOTICS

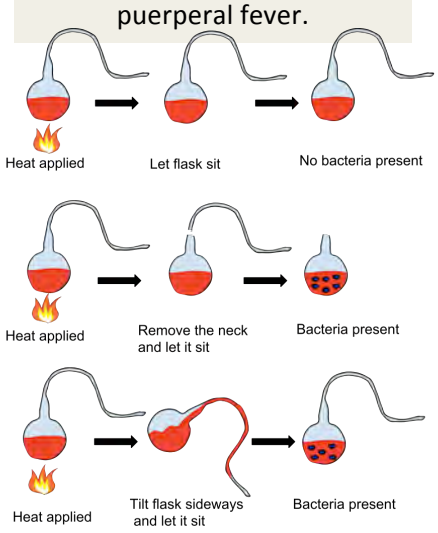
Did you know, there are 10x more bacterial cells in your body right now than there are human cells? Bacteria thrive in your gut, but can also be found on your skin. In fact, bacteria are virtually everywhere: plants, air, soil, water, and your kitchen sink, even volcanoes!

Luckily, most of these bacteria are commensal bacteria. What this means is that they cannot infect you and make you sick. Many of them are simply hanging out in your intestines, eating whatever you eat, and everyone is happy; they help you with digestion, you provide the nutrients. Another key reason why these non-harmful bacteria are helpful is because they help to keep the bad bacteria out of your cells by providing a protective barrier.

Harmful bacteria are bacteria that invade your cells and are capable of causing disease. We call these bacteria pathogenic bacteria. Pathogenic bacteria are equipped to invade our cells: they have the ability to stick to our cells and can create toxins. Though our immune system is pretty on top of this, sometimes we need additional help in order to survive.

Ignaz Semmelweis was a doctor known as the "savior of mothers". He worked as an obstetrician delivering babies in Austria and noticed that far fewer mothers contracted puerperal fever (known as "childbed" fever) if he washed his hands before assisting them in delivery. Childbed fever was common; in the mid-19th century it resulted in death in about one out of every four deliveries at the particular hospital Semmelweis was employed at. However, after he had convinced his colleagues to partake in hand washing before doctoring, the mortality rate was decreased to less than 1% of all births. Unfortunately, during Semmelweis' time of the 1850s, some doctors were offended by his suggestions that they wash their hands, and others flat out did not believe it made a difference. Most people, including doctors, did not realize there could have been tiny microscopic beings that were making us sick.

Streptococcus pyogenes is a strain of bacteria that causes puerperal fever.



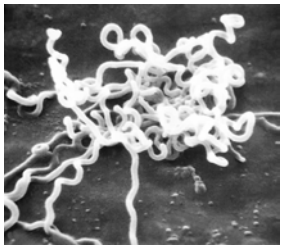
Louis Pasteur was a leading scientist in developing the germ theory, and also in disproving organisms appeared from nowhere, an idea called "spontaneous generation."
To disprove spontaneous generation, Pasteur used fermentation techniques used in wine making to prove that microbes must come from somewhere and not simply show up as an act of God. In wine making, many batches of wine would turn out to be sour, and, therefore, would need to be disposed of. Pasteur proved that the sour taste was from bacteria in the wine that use the sugars in wine to produce lactic acid. The same effect was had on beer and milk, causing them to spoil. Pasteur was able to defeat the microbes found in wine by using the scientific method to perform an experiment in which he used broth. When Pasteur covered the broth and then boiled it, it did not spoil. However, as soon as he

removed the cover and exposed the broth to the air, it would become contaminated (his broth had to be exposed to the outside environment in order to grow microbes). We now make sure that wine, beer, and milk need to be heated and covered in order to prevent spoilage.

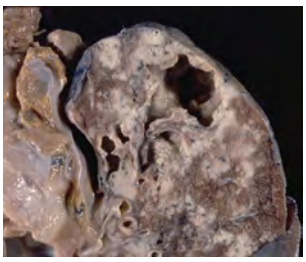
Pasteur also helped to make the connection between bacteria and disease. Around 1865, a mystery disease wiped out silkworms around the world. Pasteur showed that microorganisms, which were only found in the tissues of diseased silkworms, moths, and eggs, caused the disease. They could be seen using a microscope. He found a way of avoiding the disease by identifying the infected eggs, saving the silk industry. This was the first clear evidence of microorganisms causing disease.

About 10 years after Pasteur in 1876, a German microbiologist named Robert Koch was working on an experiment to prove that anthrax (a common disease among farm animals) was caused by bacteria. Though the anthrax bacteria had already been discovered, no one was certain that the bacteria were actually causing the illness among animals. Koch's experiment to prove that the bacteria were indeed making the animals sick was simple: he collected blood from the farm animals that had died of anthrax and introduced it to one group of mice. In another group of mice, he introduced the blood of healthy animals. The mice that were in the cage mixed with the blood of animals that had died from anthrax grew sick and died. The mice that were in the cage mixed with the blood of healthy animals continued to remain healthy.
Koch went on to continue to study bacteria and disease and successfully experimented with bacteria in controlled environments to prove to the world that bacteria indeed could make us ill.

Koch also developed a sugar-based gelatin to grow bacteria in. He won a Nobel Prize in 1905 for his contributions into the medical world, and he also helped to develop one of the first antibiotics, which he called "magic bullets." He and a colleague named Paul Ehrlich worked together to try to find a drug that would both attach to the bacteria and kill it. A formula known as "drug no. 606" finally worked, and was sold under the name "Salvarsan". Salvarsan was used to treat syphilis, specifically.



For the most part, your body is well equipped with a magnificent and diligent immune system that can help fight off an infection. However, there are some infections that are more serious than others. Before the development of antibiotics, many people thought that diseases were caused by acts of God. For example, syphilis is a sexually transmitted disease that can lead to dementia. Many people thought syphilis was a disease for the immoral. Syphilis is caused by the bacteria *Treponema pallidum*. The first sign of syphilis is a sore where the bacteria have entered your body, which eventually leads to a rash. However, syphilis occurs in stages, and it remains dormant between each stage. The stages that syphilis affects your body occurs over many years, and it could be ten years after contraction that you became deathly ill when the bacteria attack your internal organs, causing dementia and heart failure.



Tuberculosis is caused by *Mycobacterium tuberculosis* and is one of the oldest bacterial diseases to devastate mankind. Tuberculosis is particularly known for wiping out generations of Egyptian pharaohs. Tuberculosis can spread through the air and usually attacks the lungs (though it can attack other parts of the body, as well). Coughing, sneezing, even simply breathing, were means of contracting the disease, though it was typically spread within households where people were near each other. **Necrosis** is a term used to describe cell

injury or death. The picture at right depicts a lung from a victim of tuberculosis. The large hole in the lung is due to the necrosis caused by *Mycobacterium tuberculosis.*

Many diseases, such as tuberculosis, pneumonia (and of course childbed fever) would cause fever, which is an immune response to ward off the bacteria. However, if the fever were too high, many people would die of the fever itself because their body (specifically their enzymes) could not function with such high temperatures, thus resulting in death. More often than not, people died of fevers than they did of necrosis caused by bacteria.

Though Koch and Ehrlich made a successful "magic bullet" to help treat syphilis, the first widespread antibiotic was a Sulfur-based drug known as "Sulfa Drugs." Developed in 1935 by Gerhard Domagk, it was used to treat a variety of diseases. Sulfa drugs would inhibit the ability for bacteria to create folic acid. Folic acid is required for bacteria to make DNA. So essentially, sulfa drugs prevented bacteria from creating DNA, or in other words, from reproducing and multiplying. However, many bacteria have grown resistant to sulfa drugs, though they are commonly used to treat urinary tract infections, which are normally caused by Staphylococcus infections.

In 1928, Alexander Fleming accidentally discovered the antibacterial effects of penicillin. When he was working in the laboratory, some mold fell into a bacteria colony he was studying and killed it off. The mold was a fungus called *Penicillium notatum*. Most bacteria contain an outer cell wall made up of sugars and proteins known as peptidoglycan. One function of the cell wall is protection and support. Penicillin inhibits enzymes that are required for bacteria to build their cell wall so that they essentially burst. Penicillin was a popular treatment of pneumonia, ear, skin, throat and chest infections. By 1943, penicillin was being mass-produced as a general antibiotic. Today, a popular man-made penicillin-based antibiotic is Amoxicillin.

No matter what type of antibiotic, they all work the same way: they inhibit the growth of bacterial cells, be it the DNA or the cell wall of the bacteria. Antibiotics do not provide an immediate kill, which is why you often need to take them for at least ten days. Antibiotics help fight bacterial infections, as they are designed to specifically target the structure of bacteria. Antibiotics will not help fight viral infections, as viruses are basically encapsulated DNA, with no cell wall (and they can take on the DNA of their host, which can make them especially tricky). For example, there are two types of bronchitis: viral and bacterial. Antibiotics could not be used to treat the viral form of the disease. Antibiotics do not discriminate against certain types of bacteria: they will also destroy the good bacteria in our bodies, as well, which makes it important to be even more cautious when prescribing antibiotics.

However, we are now facing a problem: bacteria are becoming resistant to antibiotics; some so greatly that they are known as "Super Bugs" and are typically found in hospitals. Not only can strains of bacteria acquire resistance through natural selection or mutation, but we now know that some strains can acquire "transfer resistance", a term used to describe when bacteria can actually transfer their antibiotic resistant genes to other bacteria. In fact, approximately 23,000 people in the U.S. have died from infections caused by resistant bacteria.

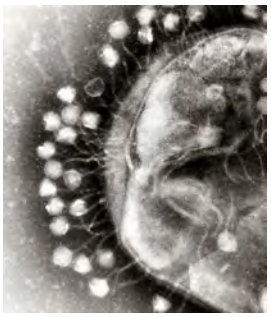
Antibiotic-resistant bacteria are mostly developed by genes that some bacteria have. Within a species of bacteria, there is genetic variation. This means that some bacteria have slightly different DNA sequences than others. This difference in DNA can be rather meaningless, and usually does nothing to help or harm the species. However, sometimes as environmental conditions change, these DNA variations can provide benefit to the species. Recall that antibiotics target enzymes that the bacteria need to build their cell walls. In other words, the antibiotics prohibit the bacteria from producing these enzymes, which without they cannot build the proper molecules to create the cell wall. However, some bacteria can still develop these enzymes even when exposed to the drug through means of mutation. This means they survive and replicate while all the other members of the bacteria population that do not have that particular gene for antibiotic resistance die off. As the resistant bacteria multiply, eventually the entire population is composed of resistant bacteria.

So, what exactly are resistant bacteria? They are bacteria that make slightly different enzymes than other non-resistant bacteria, due to a slightly different DNA sequence. These enzymes that they can create are able to degrade the antibiotic so that it can no longer do its job. Some bacteria are even able to pump the antibiotic out of itself.

A particularly notable superbug is MRSA: Methicillin-resistant *Staphylococcus aureus.* MRSA (pronounced not as the acronym, but as "mersa"), was first recognized in 1961. *Staphylococcus aureus (S. aureus* for short) is resistant to virtually any antibiotic available. S. *aureus* became resistant to penicillin by 1950. Scientists worked hard to provide another penicillin-based antibiotic known as methicillin, which worked for another ten years or so against S. *aureus.* But by 1961 it was clear that S. *aureus* was now resistant to methicillin, and so MRSA began. Though it is called *Methicillin* Resistant S. *aureus*, it is actually resistant to any penicillin-based antibiotic. The most common MRSA infection is MRSA pneumonia or sepsis, in which case 1 out of every 4 survive with specialized treatment, but in many cases, the patients may develop a reoccurring infection.

MRSA isn't the only resistant strand of bacteria; there are other resistant types out there, such as a resistant strand of salmonella. These bacteria can especially thrive as the weaker, non-resistant bacteria are killed off, giving the resistant bacteria more room and resources to grow within your body. In addition, when some resistant bacteria die, they can release their DNA, which can be picked up by other bacteria. The bacteria can incorporate the antibiotic-resistant genes into their DNA, thus becoming resistant themselves. This is known as transfer resistance.

The good news is we are learning from this, and we acknowledge the problem and are working to solve it. Antibiotics at one point were being "overprescribed", but now that we know this has detrimental effects, they are being prescribed unless absolutely necessary. We also now know that less harmful bacteria can actually protect your body from superbugs, by acting as direct competition to the superbugs. Another option that scientists all over the world are researching is phage therapy. Phage therapy uses bacteriophage viruses to destroy the bacteria by entering them causing them to burst, which scientists could alter to work in our favor.



Viruses called bacteriophages attacking a bacterium.

ANALYSIS

1. What are commensal bacteria? _____

_____.

2. What are pathogenic bacteria? _____

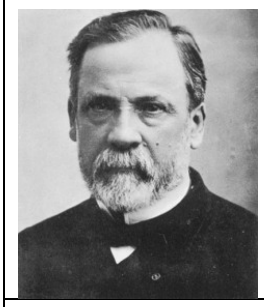
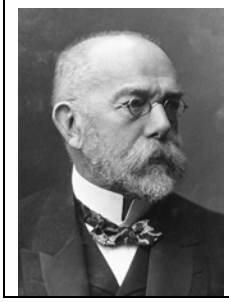
_____.

3. How did Ignaz Semmelweis contribute to modern medicine and the germ theory?

_____

_____.

4. Fill in the following table to accurately describe how Pasteur and Koch both contributed to the germ theory (the idea that bacteria cause disease): You can use bullets to create a list.

SCIENTIST	CONTRIBUTION
LOUIS PASTEUR 	
ROBERT KOCH 	

5. More often than not, people would die of _____ than they would of necrosis caused by bacteria. Why? _____

_____.

6. Who discovered the effects of penicillin on bacteria, and how? _____

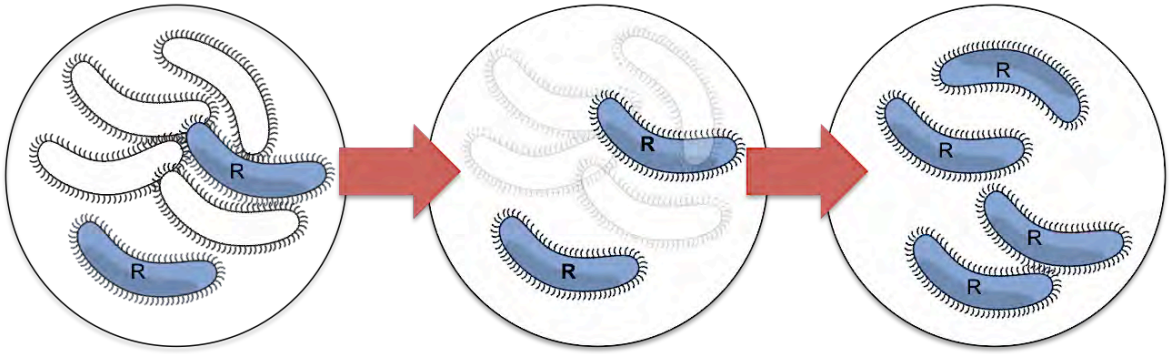
_____

_____.

7. Can antibiotics be used to treat viruses? Why or why not? _____

_____.

The diagram below depicts the evolution of bacteria to form antibiotic-resistant strains of bacteria. The darkened bacteria labeled "R" contain genes that make them resistant to antibiotics. In the line below, write "A", "B", or "C" to match each statement with the correct numbered picture. Use the information in the text to help you.



8. ___ 9. ___ 10. ___

A. The resistant bacteria have preferred conditions to grow and multiply.

B. A high number of bacteria are causing an infection. A few of them are resistant to antibiotics.

C. Antibiotics kill the bacteria causing the infection, as well as the good bacteria in our bodies.

11. How do resistant-bacteria actually resist antibiotics?

_____

_____

_____

12. What is MRSA and why is it significant? _____

_____

_____.

13. How do antibiotics fight off bacterial infections (include both sulfa drugs and penicillin)?

_____

_____

_____

_____.

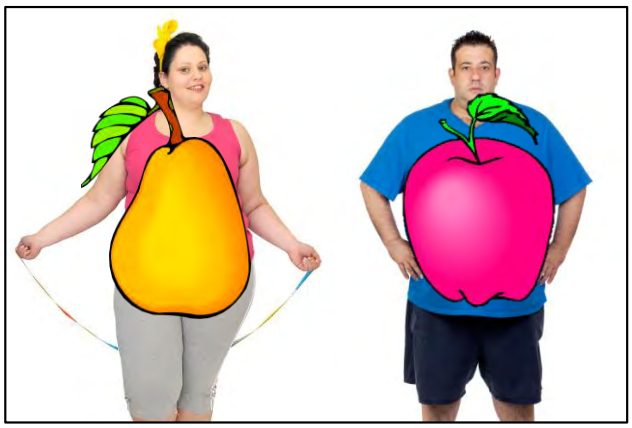
14. Defend the following statement: antibiotics do not directly kill bacteria. _____

_____

_____.

BODY FAT: THE GOOD, THE BAD AND THE UGLY TRUTH

(1) Do you ever wonder why different people have different body shapes? Skeletal structure determines height and overall frame, but beyond this, different body shapes have mainly to do with the distribution of muscle and fat on the body. Except for professional athletes and body builders, most people can thank their fat more than their muscles for their general shape. This becomes more apparent the more weight someone gains. In general, men and women develop two different patterns of fat distribution that create two different body shapes when they gain weight. Men tend to gain fat around their abdomen faster than in other areas. This gives them a characteristic "apple" shape that is seen when someone has a beer belly. Most women gain fat faster on their buttocks and hips causing them to have a characteristic "pear" shape when they gain weight.



(2) What difference does body shape make? It turns out it can make a big difference to your health. Most of the fat that causes the pear shape is called subcutaneous fat. This is fat that is found directly under the skin and over the muscles. This fat is used for energy storage, fuel, insulation and cushioning. For healthy people, around 80% of their body fat is this subcutaneous type. Unfortunately, the belly fat that causes the apple shape isn't only subcutaneous, it is also formed by visceral fat. Visceral fat is the fat that surrounds the internal organs (heart, lungs, stomach, intestines, liver, kidneys, etc.) within your peritoneal cavity. This fat is important in cushioning and insulating your organs, however, too much visceral fat is worrisome because it is linked to developing diabetes, heart disease, breast cancer and colorectal cancer.

(3) Besides subcutaneous fat (which is mostly white fat cells) and visceral fat, there is also a third type of fat cell that is called brown fat. We have very little of this in our body but it is powerful stuff. For example, the average healthy adult has only 50 grams of brown fat in their body, but this measly amount of brown fat can burn roughly 10 pounds of white fat a year! Some researchers are currently looking into brown fat as a potential hope for treating some metabolic conditions and obesity related diseases. Babies have a lot of brown fat and it helps them generate heat. We lose brown fat as we get older and as we gain more weight.

(4) Did you know that your fat cells need sleep to function properly? In a 2012 study, scientists recruited seven lean and healthy people to participate in a study to see the effect of sleep on body fat. For four consecutive days these people were made to sleep for 8.5 hours and then a month later they were made to sleep for 4.5 hours for another four consecutive days. In both cases, their diets were kept identical. After each four day sleep session, the participants' fat cells were retrieved for analysis. The effect of the lack of sleep was dramatic. The sleep deprived fat cells were 30% less sensitive to a hormone called insulin. Insulin enables your muscle, fat and liver cells to utilize glucose for energy. When your cells can't respond to insulin, you become at risk of developing diabetes.

(5) Fat cells are called adipocytes. People who become fat as adults experience a growth in the size of their adipocytes as these cells accumulate with fat. This cell growth is called hypertrophy. When a person becomes obese,

BODY FAT: THE GOOD, THE BAD AND THE UGLY TRUTH

they exceed the limit at which their adipocytes can hypertrophy, so the body creates more fat cells to hold more fat. If a person loses weight after becoming obese, their extra adipocytes remain. You can never lose fat cells; you can only gain them. It is harder for people to lose weight when they have more adipocytes versus when they just have larger ones. This has important implications for childhood obesity. Compared to an adult, a child more easily responds to weight gain with the creation of more adipocytes. When obese children reach adulthood, they will have more adipocytes than someone who never was obese as a child. This makes it harder for them to lose weight as an adult.

(6) There is another type of fat that is found in your bloodstream; it's called cholesterol. Often cholesterol is given a bad name because it is often associated with cardiovascular disease, but the truth is that it is also vital for life. It is so vital that your cells will produce cholesterol on their own. When your diet contains cholesterol, your cells will make less, and when your diet lacks cholesterol, your cells will make more. Cholesterol is needed to make cell membranes and to synthesize hormones like testosterone and estrogen. Cholesterol only becomes a problem when there is too much floating in the bloodstream which can cause cardiovascular disease. Excess cholesterol in the blood occurs due to a combination of genetics, diet and inactivity.

Article Questions

1) The scientific term for a fat cell is _____. Of the types of fat in your body, you have the least amount of _____ fat, but this fat is capable of helping you burn a lot of white fat. The fat floating in your blood is called _____.

2) In terms of their location, what is the difference between subcutaneous fat and visceral fat?

3) If you were overweight, what body shape would be worse for your health and why?

4) How is adequate sleep important for weight maintenance?

5) In terms of fat storage, what are the two ways that your body responds to increased fat in the body?

6) Why does getting fat when you're a child make it harder for you to lose weight as an adult when compared to someone who only started gaining weight in adulthood?

CONCUSSIONS IN SPORTS

(1) These days sports concussions are getting more attention as there are up to 4 million cases of concussions reported due to recreational, amateur and professional sports in North America each year. A concussion isn't just a simple bump to the head. It can be a very serious injury, especially when experienced repeatedly as in the case of professional sports like football and boxing.

(2) A concussion is an injury to the brain which can result in bruising of the brain tissue, damage to the brain's blood vessels and injury to its nerves. The term concussion comes from the Latin term *concussus*, meaning the "action of striking together". Concussions occur when a player takes a blow to the head by contacting another player, by being hit by equipment or when hitting the ground. A concussion can also occur due to a blow to the body that causes the head to rapidly snap forward. When a concussion happens, it means that the force to the head was great enough to bypass the two main protective features of the brain.

(3) The brain is a 3 lb organ made up of soft and vulnerable tissues. The brain has two forms of protection against physical damage. One is the cranium, which is the curved top part of the skull (not including the jaw bone), which encases the brain. The other protection involves the thin layer of fluid, called cerebral spinal fluid (CSF), that surrounds the brain and is found between the surface of the brain and the cranium. Essentially, the brain is gently "floating" in a liquid within your skull. When you turn, nod or shake your head, your brain would hit the inside of your cranium if you didn't have CSF to absorb the impact. The combination of your cranium and your CSF protects your brain from minor injuries. During a concussion, the blow to the head causes the brain to contact the inside of the cranium forcefully which bruises the brain tissue. The thin layer of CSF is not sufficient enough to cushion such a strong impact.

(4) Concussions can be caused by coup or contrecoup injuries. Coup injuries often occur when a moving object hits the head, like when a fastball hits a batter on the head during a baseball game. In this situation the brain is injured at the site of impact because the skull

accelerates very rapidly and slams into the brain. The thin layer of CSF can't provide enough shock absorption in this case. Contrecoup injuries occur at the side opposite the point of impact. These typically occur when a moving head slams into a stationary object, like the ground. In this scenario, the brain slams into the inside of the skull when the skull decelerates upon impact. A combination of both a coup and contrecoup injury can also occur simultaneously if the brain is first injured at the site of impact, causing a coup injury, and then whiplashes to the opposite side of the skull, causing a contrecoup injury. A concussion with a contrecoup injury component is often more dangerous because they are difficult to diagnose since it isn't obvious that the head has been hurt opposite to the site of impact.

(5) The immediate and short-term symptoms of a concussion can include any combination of the following: headache, nausea, vomiting, confusion, slurred speech and trouble walking. About a quarter of people with concussions also report delayed and chronic symptoms that can include fatigue, memory problems, sleep disturbance and mood changes. Short-term symptoms are typically noticed right away, but some people can suffer a concussion and not exhibit symptoms until later. This can be dangerous because players can sustain a concussion in a game but show few immediate signs of injury so they want to continue playing. In the past, many coaches pushed their players to continue even after a concussion had been suspected, but these days, growing awareness has made this practice more questionable. Once a player has suffered a concussion, they are 3 times more likely to suffer another one.

CONCUSSIONS IN SPORTS

This can be extremely dangerous if the brain has not yet healed from the first concussion.

(6) The long-term consequences of multiple concussions are most widely seen in boxing and football. A progressive degenerative brain disorder (meaning it will get worse with time) called chronic traumatic encephalopathy (CTE) can result from a career filled with blows to the head. It can lead to unpredictable behavior, drug and alcohol abuse, depression and in some cases, suicide or an early death. The only way to know with certainty if someone suffers from CTE is to open up their brain, so CTE is difficult to diagnose while a person is alive. On December 1st of 2012, 25 year old Jovan Belcher, an NFL linebacker with the Kansas City Chiefs, shot his girlfriend and then himself. A year after the funeral, Belcher's family requested that his body be exhumed and his brain be examined. The examination revealed that Belcher suffered from CTE which may have contributed to his deadly behavior. Multiple head traumas in athletes is also suspected in the later development of Alzheimer's, ALS (amyotrophic lateral sclerosis) and Parkinson's disease. Mohammed Ali's boxing career was a great one, but may have contributed to the development of his Parkinson's.

Article Questions

1) What are the two main things that protect the brain from physical damage?

2) When a boxer is hit in the head by a moving fist, what type of concussion injury does this cause? Explain how the brain is injured in this situation.

3) When an athlete has a hard hit to the head in a game, but shows no signs of a concussion, why might this be a dangerous situation?

4) What are some of the long-term symptoms of a concussion?

5) What is CTE and how do athletes get this type of injury?

6) Why do you think Jovan Belcher's family want his brain examined after his death?

7) If a football player has a career that results in CTE, who do you think is responsible and why?

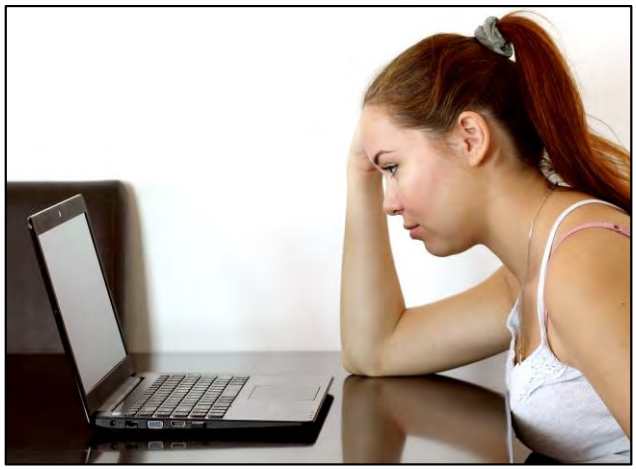
FACEBOOK BLUES: IS FACEBOOK MAKING YOU UNHAPPY?

(1) Do you have Facebook? You most likely do, and if you don't, you have friends who do, and they probably think you're strange if you don't have it. Globally, there are almost 1.5 billion users of Facebook. For many of these people, Facebook isn't just something they check once a week, or even once a day. Many people compulsively check their Facebook multiple times a day. You might think of Facebook as harmless fun, but is it?

(2) Recent studies have shown that using Facebook can make many people feel worse. One 2013 study was conducted by Ethan Kross, a psychologist from the University of Michigan. He gathered 82 people and studied them over a period of two weeks. During that time, the subjects had to report in 5 times a day about their level of Facebook use and answer questions about their subjective well-being. Subjective well-being refers to how people rate and evaluate the quality of their own lives. This includes *affective* well-being, which involves their emotions and *cognitive* well-being, which involves mental judgements and includes how satisfied they feel about their lives.

(3) The results showed that, in general, the more often people use Facebook, the more they reported feeling worried, lonely and dissatisfied with their lives. Overall, frequent Facebook users reported being less happy. This data is supported by other studies that show similar results. Some studies also reveal that Facebook and other forms of social media can inspire feelings of envy, low self-worth and even anger.

(4) How is it possible that Facebook, whose initial intention was to increase social connectivity between people, ends up making people feel unhappy about themselves? One answer lies in the social comparison theory. This theory proposes that humans have a constant instinctive desire to evaluate their own opinions, abilities and status against those of their peers. We also tend to compare ourselves with those who are the most similar to us. For example, if you are a 14 year old girl living in a city, you are more likely to compare yourself to someone similar to you than to an 80 year old man living on a farm.



(4) Is there a purpose to all of this comparison? The process of evaluation allows us to gain a more accurate idea of our standing in a social group and helps us to define ourselves. On paper, this drive towards self-evaluation through comparison seems reasonable, however, a problem arises through the constant use and exposure to social media.

(5) Platforms like Facebook, Twitter, Instagram and other social media, allow us to curate, meaning selectively represent, our online persona. On social media, it is easy for people to choose how their ideas, experiences, and abilities appear to others. Most people curate their online images so that others don't see moments of failure, loneliness, sadness and mediocrity, all of which are aspects of everyone's life. Instead, people overemphasize moments of success, social triumph and happiness. Before social media, we had a greater tendency to compare ourselves to our peers face-to-face. We saw their pimples, saw the times they ate lunch by themselves and knew when they failed a test. Now this reality is overshadowed by social media images of friends having fun at a party to which you weren't invited. Very few people show images of themselves popping that zit before the party. On social media, everyone seems happier, more popular, more attractive and more successful than they really are. If we consume a lot of social media, this is bound to make us feel like we don't measure up. This is why studies on social media and well-being show a decline in happiness and self-worth the more you use it. If you suspect Facebook has this effect on you, why don't you stop using it or cut down?

FACEBOOK BLUES: IS FACEBOOK MAKING YOU UNHAPPY?

(6) One simple answer is that Facebook and other social media is addictive. Dr. Cecilie Andraessen of the University of Bergen in Norway developed the Bergen Facebook Addiction Scale which can measure your level of Facebook dependency. Through studies, Andraessen shows that symptoms of Facebook addiction closely resemble alcohol, drug and other forms of chemical addiction. For Facebook addicts, using Facebook triggers the same reward pathways in the brain as would be triggered by drug use. As well, social media addicts also exhibit a greater activation of their amygdala and striatum, which are regions of the brain associated with impulsive behaviors. This makes it more likely that they will log into Facebook more often than they want. Like with many other addictions, the use of Facebook for addicts comes with feelings of anxiety, conflict as well as withdrawal when they are unable to use Facebook. Nir Eyal is the author of a book titled *Hooked: How to Build Habit-Forming Products.* He says Facebook has been intentionally designed to have addictive qualities. These are the keys to how Facebook hooks users, "…a trigger, such as loneliness, boredom, or stress; an action, such as logging into Facebook; an unpredictable or variable reward, such as scrolling through a mix of juicy and boring tidbits in the newsfeed; and investment, which includes posting pictures or liking someone's status update." Does this sound familiar?

Article Questions

1) What is subjective well-being?

2) Summarize what Ethan Kross's study found about the amount of Facebook use and the level of subjective well-being people experience.

3) What does social comparison theory propose?

4) To whom are you most likely to compare yourself?

5) Why does social media distort your ability to compare yourself to others accurately?

6) What is Facebook addiction similar to?

7) Use the Bergen Facebook Addiction Scale to measure your level of Facebook addiction. For each statement answer: very rarely, rarely, sometimes, often or very often.

    1) You spend a lot of time thinking about Facebook or planning the use of Facebook.
    2) You feel the urge to use Facebook more and more.
    3) You use Facebook to forget about personal problems.
    4) You have tried to cut down on the use of Facebook without success.
    5) You become restless or troubled when you can't use Facebook.
    6) You use Facebook so much that it has a negative impact on your work or studies.

If you answer "often" or "very often" to at least four of the above statements, then you might have a Facebook Addiction.