Student Edition

IQWST

Life Science

Why Do Organisms Look the Way They Do?

Second Edition

IQWST LEADERSHIP AND DEVELOPMENT TEAM

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Investigating and Questioning Our World through Science and Technology (IQWST)

WHY DO ORGANISMS LOOK THE WAY THEY DO?

Heredity and Natural Selection

LIFE SCIENCE

Student's Edition
Life Science 3 (LS3)
LS3 Organisms SE 2.0.3
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Why Do Organisms Look the Way They Do?
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About the Publisher

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LS3 CONTENTS

SCIENTIFIC PRINCIPLES

A scientific principle states a scientific idea that is believed to be true based on evidence. As your class decides on new principles in this unit, add them to the list.

SCIENTIFIC PRINCIPLES

PATTERNS AND EVIDENCE NOTES

PATTERNS AND EVIDENCE NOTES

DRIVING QUESTION NOTES

Use these sheets to organize and record ideas that will help you answer the Driving Question or your own original questions.

DRIVING QUESTION NOTES

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ART

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Lesson 11

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Lesson 1

The Same and Different You and Me

ACTIVITY 1.1 – WHAT TRAITS DO HUMANS HAVE?

What Will We Do?

We will generate a list of human traits and distinguish between acquired traits and inherited traits.

Procedure

Part 1

1. Meet with your group and brainstorm a list of human traits. Remember that in a brainstorm session, you record everyone's ideas with no comment or discussion. You may use the blank pages at the end of your book to record your ideas.

2. After the brainstorm list is complete, discuss your group's list. Decide if each item is a human trait. Cross off any that your group decides is not a trait.

3. Record the traits that you have agreed are human traits in the chart. With your group, list possible variations in the individual variation column.

4. In class, you will share and compare your list with other groups.

5. If there are traits that were not on your group's list, add them.

Trait	Variations

Part 2

You learned that inherited traits are those that come from parents. Acquired traits are those that can be learned or changed depending on an organism's interaction with its environment.

6. Look at your list of human traits.

7. Decide whether each trait is inherited, acquired, or both.

8. Place that trait in the appropriate column on the Human Traits Chart. You may have to add additional rows.

Human Traits Chart

Inherited	Acquired	Both

Making Sense

Choose one of the traits that you listed in the *Both* column. Explain how that trait could be both acquired and inherited.

ACTIVITY 1.2 – TRAITS OF YOU AND ME

What Will We Do?

We will collect and analyze class data on selected human traits in order to determine if there are any patterns.

Procedure

1. Observe the following pictures of some inherited traits.


Earlobe A – Detached


Earlobe B – Attached


Overlapping Thumb – Right or Left on top?


Widow's Peak

Hitchhikers Thumb


No


Yes

2. Your class will select two inherited traits from the list you generated in Activity 1.1 and two from the inherited traits previously listed. List the traits your class selects in the data table.

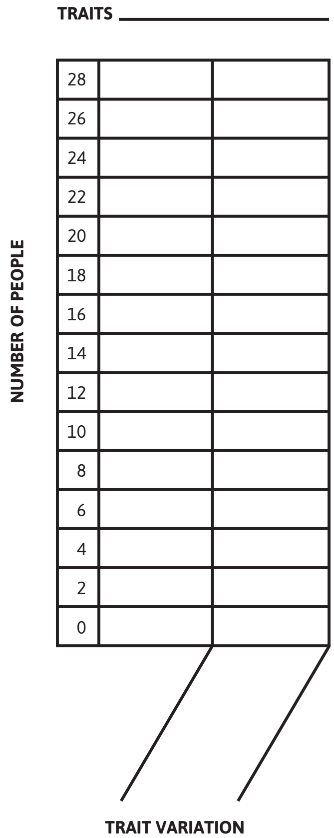
3. Tally how many people in your group have each variation of the trait and record it in the data table.

4. Meet again with your whole class and combine your group data to get a number that shows how many people in your class have that trait. Then record the total number from the class in the class data column.

5. From the class data, generate graphs on each of the four traits.

Trait	Variation	Group Data		Class Data
		Tally	Group Total	Total Number from All Groups

GRAPHS


TRAITS
NUMBER OF PEOPLE
28
26
24
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4
2
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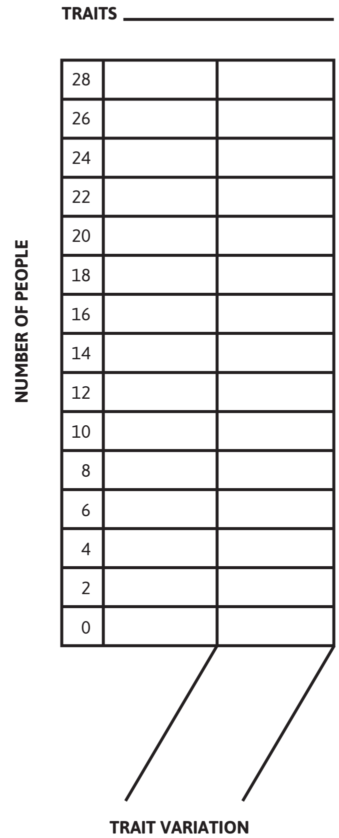
TRAIT VARIATION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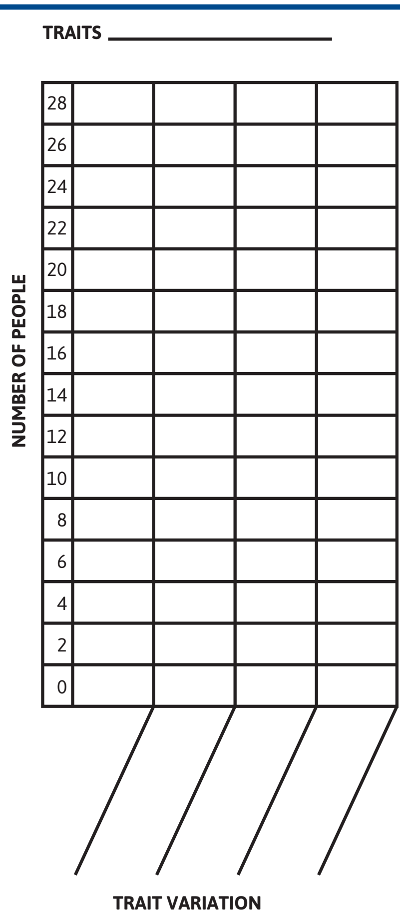
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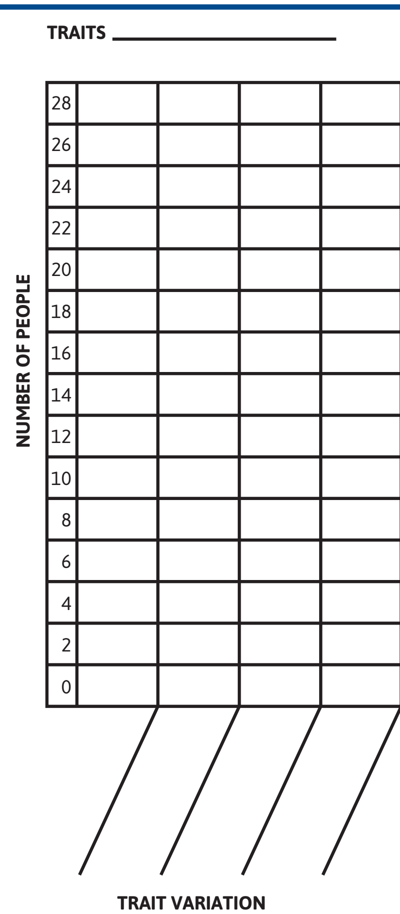
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TRAIT VARIATION

Making Sense

1. For each trait, were all the variations about equal, or were some more common? Were there any traits where one of the variations was very rare?

2. Can you think of another human trait that is more equally distributed? What about one where there is a very rare variation?

ACTIVITY 1.3 – BABY, WHERE DID YOU GET THOSE EYES

Reading 1.3 – Where Did You Get Those Eyes?

Getting Ready

As a woman walked by a little girl who was playing with her dog, the woman asked, "Where did you get those big brown eyes?" The little girl wrinkled up her face as she thought about the question. After a little while, she responded in a happy tone of voice, "I got them from my dog!"

Why is the little girl's answer funny?

That answer is cute from a young child, who does not understand how she gets her traits from the people and the environment around her. As a middle school student, however, you know that traits originate from different sources, and that your pet is not a source of any of your traits. As you read, think about your own traits and where you think they originated.

In class, you and your classmates collected data on traits. Traits are characteristics that distinguish one organism from another. Inherited traits are traits that you are born with. Traits that are acquired or learned traits can be changed depending on how you interact with your environment. Some traits are both. You are born with a muscular structure. If you exercise with weights, you can develop larger muscles. If you have light skin, but you are outdoors in the sun a lot, your skin color darkens. Traits can have many variations. Hair, for example, can be brown, blonde, black, or red, but even within each of those colors are many shades of difference. The same thing is true for eye color. Other traits you either have, or you do not have. Dimples are an example; either you have dimples or you do not.

Why Do Scientists Care about Traits?

The little girl had big, brown eyes. Her dog had eyes that also were big and brown. It seemed natural to the little girl that since her eye size and color traits were the same as her dog, she must have gotten her eyes from the dog. You know that was a humorous but incorrect response. Heredity, the passing down of traits from one generation to another, gave her eyes the variations of brown and big. DNA, a molecule in the nucleus of a cell, carried instructions for the size and color of her eyes from her parents. Scientists want to find out how these traits are passed down. They investigate genetics, the mechanisms of how traits are passed down.

Why do you think scientists are interested in studying genetics? Have You Ever Wondered . . .

- Why do my brother and I have the same nose, but our sister's nose looks very different?
- Why do people say I look like my grandfather?
- Why do my cousin and I look more alike than my sister and I do?
- Why do my dog's puppies look so different from one another?
- Why do hamsters in the same litter look alike, but kittens in a cat's litter do not look alike?

If you wonder about questions like these, you have already started your study of genetics. Genetics is an interesting field of study, but it is also an important one. As you read the following section, consider reasons why studying genetics is important.

The principles of heredity explain how one generation of a plant or an animal shares similar characteristics with the generations that came before it. Corn plants come from the seeds of corn plants. Puppies are born from dogs that were once puppies born from another generation of dogs. Dogs and corn have very different traits. Principles of heredity always apply, but one of those principles is that some traits vary. Tall parents tend to have tall children, but everyone probably knows an example where that is not true. A short child born to tall parents may be exhibiting a characteristic that had not been seen in parents, or grandparents, or in their parents or grandparents.

Characteristics like height, eye color, and hair color are obvious through observation. But not all inherited traits are obvious. Some people may inherit the tendency to develop a certain disease, for example. You cannot see that in another person or even in yourself. Whether someone actually develops the disease, however, might depend on factors in their environment.

Although the field of genetics is interesting to many people, scientists study genetics to learn important information. One area of study is the role of genetics in how diseases or disease resistance may be passed from one generation to another through particular traits. You might imagine how this information would be helpful in preventing or treating diseases in humans, in animals, or in plants. Farmers are especially interested in plants that are resistant to diseases that could threaten to ruin an entire crop, for example. Scientists who study genetics are interested in many aspects of genetic material, including how traits get passed from one generation to another.

Your Driving Question Board contains an area for species traits and an area for individual traits. Based on the reading, list one trait that can vary between individuals within the species, and one trait that is a species trait.

Individuals can vary in height. Dogs have four legs and humans have two.

In the reading, an example is given of a trait that is both inherited and is influenced by the environment. Describe that example.

Recently, scientists have determined that a particular gene affects whether you would be better as a marathon runner, who has endurance for running long distances, or as a sprint runner, who has speed for short distances. People who are really good at those two sports engage in rigorous training, too. So, if you want to become a super athlete, do you count on your genes or on a really good workout program? Before you read the next section, list some of your ideas.

Genes or Environment: What Influences Athletic Performance?

Genetics influence many things about you. Your athletic ability is one of them. Athletic ability is a characteristic in which you can see the influence of both genetic material you inherited and of environmental factors. For example, someone may come from a family of people with exceptional speed, or endurance, or other abilities. Genetics play a role in strength, flexibility, lung capacity, and other factors, as well. But factors that affect performance include eating habits, mental skills, and things like balance and reaction time. Genetics have less influence or no influence over factors like these. Environment and genetics, together, play a role in athletic performance. If a person overeats and never exercises, his or her genetic potential to be an exceptional athlete will not be realized. Genetics may also limit your potential to be a strong athlete. But still, some people with limited genetic potential might be able to train and become a strong competitor. Some shorter basketball players, for example, can become great because of their extreme quickness, or by training to develop their skills in ball handling, or other aspects of the game.

Think about your own athletic abilities. Do you think they are more influenced by genes or by environment? Explain your ideas.

Genetics can also affect how your body responds to various influences. Research has shown that some people's bodies respond to training better than other people's bodies. For example, some kinds of training can improve how your heart works as you exercise, but genetics may limit the extent to which training can improve how your heart works. People who inherit genetic ability may also have bodies that respond better to training. Both genetics and environmental factors, together, affect athletic performance. Athletic performance is not just about what people think of as natural ability, or raw talent, or being born a gifted athlete.

Think about your previous response. Do you have any new ideas about what factors shape your own athletic performance? Explain your ideas.

Lesson 2

What Traits Get Passed On?

ACTIVITY 2.1 – ARE TRAITS CONNECTED?

What Will We Do?

We will determine whether there is a connection between an inherited trait and the preference for certain foods.

Prediction

1. Do you think the preference for certain foods is inherited or acquired?

_______ Inherited
_______ Acquired
_______ Both

2. Explain your choice.

Procedure

1. Your teacher will give you a sample of Brussels sprouts to taste. After you taste it, answer the questions below.

   a. Have you ever tasted Brussels sprouts before? YES NO

   b. Do you like the taste of Brussels sprouts? YES NO

   c. Describe the taste? (salty, sweet, sour, bitter, umami)

2. In this step you will taste two pieces of paper. The first one is a plain piece of paper with nothing on it. The second piece has been treated with a chemical called PTC. Follow your teacher's instructions for tasting the papers and then answer the questions below.

    a. Did the plain piece of paper have any taste? YES NO

    b. Were you able to taste the PTC? YES NO

    c. If you were able to taste the PTC, describe the taste. (salty, sweet, sour, bitter, umami)

Data

3. Record the tasting data for your group in the data table.

Raw Data		
Name	Likes Brussel Sprouts yes/no	Tastes PTC yes/no

Group Tally		
	Taste PTC	Non-Taste PTC
Likes brussel sprouts		
Dislikes brussel sprouts		

Making Sense

1. Based on the data from your group, do you think there is a connection between disliking Brussels sprouts and being able to taste PTC? Explain your answer.

2. Answer this question after the class discussion about this activity. Now that you have seen the data from the whole class, would you change your answer to question #1 above? Why?

Reading 2.1 – Do the Traits I Inherited Affect My Sense of Taste or Smell?

Getting Ready

Have you ever been told, "Eat your vegetables!"? You know that vegetables are good for your health, but you still might have some that you just do not like. Fill in the two charts below.

Vegetables I like	Vegetables I do not like

Think about the ones that you do not like. Why do you dislike them? You may have different reasons for different vegetables. List the reasons you do not like certain vegetables.

In class, you tasted PTC paper. Some of your classmates thought it tasted bitter, but some people could not taste anything at all. You also tasted Brussels sprouts, which some people thought tasted bitter, too. As you read, you will learn more about the connection between whether people can taste PTC and whether or not they like the taste of some vegetables. As you read, look for the link between these two tastes.

Who Discovered PTC and Its Link to Inherited Traits?

In 1931, Arthur Fox was doing research on artificial sweeteners in the laboratory at the DuPont chemical company. He was using a powdered chemical that accidentally blew into the air around him. He and another scientist got some in their mouths, and the other man said how bitter the chemical tasted. Dr. Fox was surprised because he did not taste anything. Since the chemical he was working on was not dangerous, he decided to taste it again. Both he and his partner tasted it a second time and got the same results. Dr. Fox did not taste anything, but his partner insisted that it tasted very bitter.

Dr. Fox wanted to learn more about this chemical, so he had friends, family members, and other scientists taste it. Some people tasted nothing, but others found it extremely bitter. The chemical Fox was using is phenylthiocarbamide (PTC). This is the same chemical you tasted in class. Other scientists began to study people's ability to taste PTC. They discovered that the ability to taste it seemed to be the same within families. Children who could taste PTC also had at least one parent who could taste PTC. Children who could not taste the chemical usually had parents who could not taste it either. It was what scientists call an inherited trait. An inherited trait is passed from parents to their children. The evidence was so strong that this trait was inherited and ran in families, that long before scientists knew how to do DNA testing, PTC tasting was used as evidence to prove that people were related to each other.

Why might it be important for people to be sensitive to bitter-tasting things?

What Does PTC Have to Do with Vegetables?

Many plants produce a chemical similar to the bitter tasting PTC in order to protect themselves. If a plant tastes bad, animals are not likely to eat it. In some plants, such chemicals are poisonous. When your ancient human ancestors were living in caves and eating whatever grew nearby, it was important for them to be able to detect plants that might be harmful. Having taste receptors that were sensitive to the bitter chemicals in the plants was important, as it may have saved some people from eating poisonous plants.

In the IQWST LS2 unit, you learn that you have receptors in your fingers that detect pressure and allow you to touch some things and not others. You also have receptors on your tongue that are sensitive to certain tastes. In class, you learned that there are five kinds of tastes: bitter, sweet, sour, salty and umami. You have receptors on your tongue to taste bitter, just like your ancient ancestors did. Just as people are different in many traits, the ability to taste is also different. The ability to taste PTC or the chemicals in Brussels sprouts is not the same for everyone. You do not have to worry about picking and eating poisonous plants, but because some vegetables like Brussels sprouts and broccoli have these bitter chemicals in them, many people do not like them.

About that Broccoli

If you do not like broccoli, you are not the only one. Back in 1990, the 41^{st} President of the United States, George H. W. Bush, made the following statement: I do not like broccoli, and

I have not liked it since I was a little kid and my mother made me eat it. And I am President of the United States and I am not going to eat any more broccoli!

Not only did the President not eat any more broccoli, he banned broccoli from the menu at the White House where he lived in Washington, D.C. The entire time he was in the White House, no broccoli was served.

If you gave President Bush a strip of PTC paper, do you think he would be able to taste it? Explain.

Do Inherited Traits Only Affect Taste?

You have learned that different substances have different odors because of the molecules of which they are made. The receptors in your nose detect the molecules of chemicals in the air, and you experience that as being able to smell something. Do you think everyone has the same ability to detect odors? Why?

Almost 200 years ago, doctors began to make a connection between eating certain foods and the odor of human urine. Farmers had grown asparagus for 2000 years, but in the early 1700s, they began using a fertilizer that contained a lot of sulfur. This fertilizer gives asparagus its distinctive flavor. Scientists also believe that it is the source of a strong-smelling urine odor.

It only takes about 20–30 minutes after eating asparagus for the effects to show up in someone's urine. However, everyone cannot smell it. Scientists have studied this for years. They discovered that when a person eats asparagus, and their body digests it, a chemical compound containing sulfur is released from the body. Some people's bodies release the compound and some do not. Scientists have discovered that this ability to release the compound is an inherited trait. Based on their studies, scientists believe that about 80% of Americans produce this compound in their urine when they eat asparagus. Those people inherited the trait from their parents.

If so many people produce the chemical, why does not everyone smell it? Explain your ideas.

Some scientists believe that only some people produce the smelly urine when they eat asparagus, and only some people have the ability to smell the odor. Studies show that between 75% and 90% of people cannot detect the bad odor. So, even though most people produce the chemical in their bodies, most people cannot smell it in their urine.

You have read about three inherited traits:

1. The tongue's ability to detect PTC (or not).
2. The body's ability to produce smelly urine after eating asparagus (or not).
3. The nose's ability to detect the strong urine smell (or not).

Everyone who has these traits got them from their parents.

Based on what you have done in class and read, do you think that if someone has the trait for tasting PTC, they could still like broccoli or Brussels sprouts? Explain.

ACTIVITY 2.2 – HOW DO PLANTS REPRODUCE?

What Will We Do?

We will investigate sexual reproduction in plants.

⚠ Safety

In this lab, you will be using sharp instruments (forceps and probes). Be careful when handling these instruments. Follow your teacher's safety instructions.

Procedure

1. Your teacher will give your group a flower. Be careful when handling the flower. You do not want to disturb any of the flower parts before you dissect it.

2. Be sure to cover your workspace with newspaper. As you dissect the flower, place the flower parts on the paper plate. You will need them for the last step of the activity.

3. Begin by carefully removing each of the petals from the flower.

4. After you remove the petals, draw a diagram of what is left on your flower. Use the image your teacher projects to help label what you see.

5. Using the scalpel, carefully remove the stamen by cutting it at the bottom.

   - Place the stamen on a piece of paper.
   - Hold the anther at the bottom and shake the top over a piece of paper. Use a magnifying lens to look more closely at what is on the paper. Describe what you see.

6. Next, take out the pistil by cutting it at the bottom.

   - Touch the stigma at the top of the pistil. Describe what it feels like.

- Place the pistil on the paper and carefully cut open the ovary at the bottom. Do you see anything inside of the ovary? Even if you cannot see anything, what is inside of the ovary? Why wouldn't you be able to see them?

7. Use the large piece of white paper that your teacher gave your group, and take the flower parts and put them together to form a flower. Label each of the flower parts. Use the image to help you with the names.

Making Sense

1. What are the male parts of the flower?

2. What are the female parts of the flower?

3. Why do you think the stigma felt sticky when you touched it?

4. Now that you have dissected a flower and have seen how it reproduces, compare plant reproduction to human reproduction.

Reading 2.2 – What Is the Buzz About?

Getting Ready

Have you ever had a pesky bee fly around your food or your body when you are eating outdoors? Has a bee ever taken a dive into your soda can? Bees can be annoying, but they are necessary. Without bees, you would not have much of the food you like to eat. Why do you think bees are necessary for you to have food?

In class, you learned about the parts a flower needs in order to reproduce. Flowers reproduce sexually, which means they have male and female parts. The male part is the anther, which produces pollen. The female part is the stigma, and an ovary is at the bottom of the stigma. If the egg in the ovary is going to be fertilized and produce seeds, the pollen has to be moved from the anther to the stigma. This movement of pollen is called pollination. But how does the pollen get moved to the ovary?

Pollen on the Move

Pollen can be moved in several ways, but most flowering plants are able to reproduce because insects, bats, birds, or other animals move pollen from one place to another. For some plants, the wind transfers pollen from one flower to the next. But most pollination that happens on Earth is done by bees. This insect, which can be annoying, plays an important role in producing the food you eat.

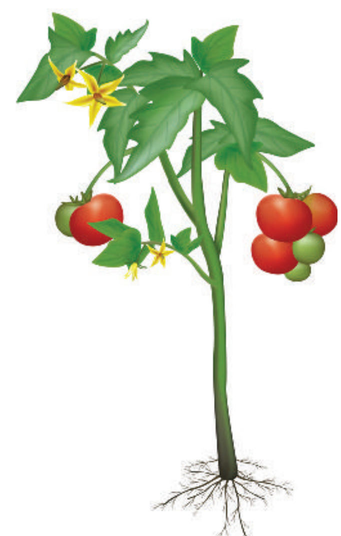
Without bees, much less food would be produced on Earth. If the eggs in the ovary of a plant do not get fertilized, the flower cannot turn into a fruit. A fruit is the ripened ovary of a flower. About 15 percent of the food Americans eat comes directly from plants that are pollinated by honeybees. Another 15 percent comes from animals that eat the food that bees pollinate. That adds up to 30 percent of the food Americans eat. That is a lot of busy bees!

But, why do bees visit those flowers in the first place? What do they get out of this process? If you said, "They also get food," you would be right. Bees visit flowers to get pollen and nectar as food for their own bodies. Both the plant and the honeybee benefit from the visit. In the IQWST LS2 and IC3 units you learn that sugar provides energy, and protein can be used as building material. Nectar from a flower has a lot of sugar in it, and the bees use that sugar for energy.

Bees use pollen for protein. The honeybees gather these two substances as they land on flowers, and they take the nectar and the pollen back to the beehive where they are used for food.

Bees do not pollinate flowers on purpose. When a honeybee is collecting pollen from the anthers, it puts the pollen in special pollen baskets on its hind legs. These are like pouches that hold the pollen when the bee flies back to its hive. The honeybee is a messy pollen gatherer. Some of the pollen gets stuck on the hairs of its body, as you can see in this photo. The yellow dust on the bee's body and legs is pollen from the flower on which it landed. When the bee visits the next flower, some of that pollen brushes off, and if it sticks to the stigma, pollination takes place. The bee does not make any effort to put the pollen in the right place. It gets to the right place while the bee is gathering its own food.

Do you know anyone who has tried to grow his or her own tomatoes? Tomato plants get yellow flowers on them, just like in the photo. The red tomato is now growing where a flower used to be. The two yellow flowers in the photo could become tomatoes (fruits), but they might not. Sometimes, even though a tomato plant has lots of flowers, only some of them will produce tomatoes. Why do you think that happens?



The Case of the Disappearing Bees

Since bees are so important for pollinating many types of flowering plants, if bees ever disappeared, many people, including scientists, would be concerned. That is exactly what began to happen in 1990. Honeybees began to disappear from their hives. They would fly away and never be seen again. There were no dead bee bodies to be found, no sign that someone had killed the hive. The hive would eventually die because there were no bees bringing back pollen and nectar. Between September 2008 and April 2009, 29 percent of the honeybee colonies in the United States vanished. Scientists are not sure why this is happening, but they are trying to figure out the cause. However, it still remains a mystery.

The good news is that even though many colonies disappeared in the winter of 2008–2009, fewer disappeared than in the year before that. Scientists believe that the problem is becoming less serious, but they are still trying to figure out the cause, so that they can try to prevent it from happening again. Therefore, the next time you are being pestered by a bee, think twice before you swat it away. It may be on its way to pollinate the flowers in your yard, an apple tree, or one of the many other plants for which bees move pollen.

Did You Know?

- Bees are found on every continent except Antarctica and in every habitat on the planet that contains insect-pollinated flowering plants.
- Bees fly 10–15 miles per hour and visit 50–100 flowers in each pollination trip.
- To produce one pound of honey, honey bees must visit two million flowers and fly about 55,000 miles.
- When a honeybee returns to the hive after finding a good pollen source, it gives out samples of the flower's nectar to its hive mates. It also performs a dance that details the distance, direction, quality, and quantity of the food supply. The richer the food source, the longer and faster the dance.

ACTIVITY 2.3 – IS THERE A PATTERN TO HOW TRAITS GET PASSED ON?

What Will We Do?

We will determine if there is a pattern in the way plant traits are passed from one generation to the next.

Prediction

1. Predict what color you think the stems of the next generation of plants will be if they come from a cross of each of the following parent plants. Then, circle the combination your group is testing.

P: Purple stem	P: Non-purple stem	P: Purple stem
P: Purple stem	P: Non-purple stem	P: Non-purple stem
F_1	F_1	F_1

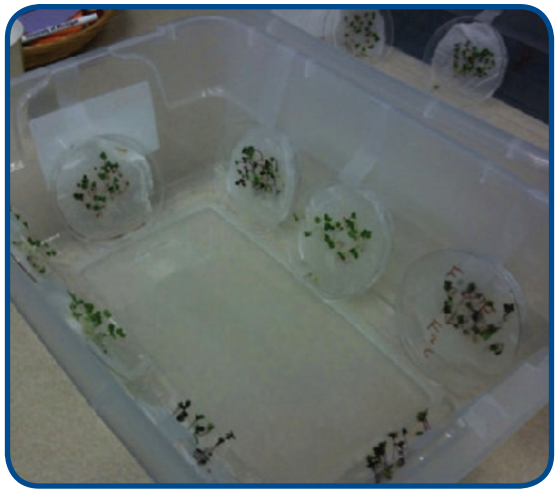
2. Explain your prediction.

Procedure

For this investigation, the plants you are using are Wisconsin Fast Plants™. They have a very fast life cycle. However, you would still need a month to obtain seeds from the parent plants and germinate them. Because you do not have that much time, your teacher will give you seeds to germinate for the F_1 generation.

1. Gather the materials you will need for this activity.
2. Write your group's name or number on the Petri dish. Also, write F_1 on the dish.
3. Place the filter paper or paper towel on the bottom of the lower part of the Petri dish.
4. Pour water over the paper in the Petri dish. Wait a few seconds until the paper is soaked and pour out any excess water.
5. Place the seeds in four rows on the upper two-thirds of the paper in the Petri dish.
6. Tilt the Petri dish slightly so that any extra water runs to the bottom of the dish.

7. Place the Petri dish into the class container. There should be about 2cm of water in the bottom of the container. The Petri dish should be put into the container on its side so that all of the seeds are above the water line. Your teacher will cover the container with plastic wrap so that it does not dry out. When you finish, your setup should look like the following picture.



8. The seeds should sprout in two to three days. Record your data about the plant traits that appear on Activity Sheet 3.2.

Can We Determine Patterns in Traits?

ACTIVITY 3.1 – WHAT ARE THE PATTERNS IN HOW TRAITS ARE INHERITED?

What Will We Do?

We will analyze the data in a pedigree to find patterns in how traits are inherited.

Predictions

The following two tables show four possible parent combinations of the PTC-tasting and tongue-rolling traits for the parents. Predict what variation that the offspring of each parent combination could have by putting a check mark in the cell for that variation. If you think there could be offspring with one variation, and another with the other variation, check both boxes.

	Mom and Dad both are PTC tasters	Mom and Dad both are Non–PTC tasters	Dad tastes PTC; Mom is a Non–PTC taster	Dad is a Non–PTC taster; Mom is a PTC taster
Child Tastes PTC				
Child is PTC Non–taster				

	Mom and Dad Both are Tongue Rollers	Mom and Dad both are Non–Tongue Rollers	Dad is a Tongue Roller; Mom is a Non–Tongue Roller	Dad is a Non–Tongue Roller; Mom is a Tongue Roller
Child is a Tongue Roller				
Child is a Non–Tongue Roller				

Part 1

1. Your teacher will give your group a set of pedigrees. A1 and A2 are pedigrees for the PTC-tasting trait. B1 and B2 are pedigrees for the tongue-rolling trait. When you get your pedigree, follow the directions at the top of the Group Data table to complete the blanks on the table.

2. Study your group's pedigrees. For each of the parent combinations, count the number of offspring for each variation. Record the number in the correct cell on the Group Data table.

Group Data

Fill in the pedigree set with the trait pedigree and set indicator with which you are working. (For example, Tongue roller B2.) Fill in each blank line in the column types with the trait (For example, PTC taster; tongue roller).

Pedigree Set ________ ________	**Mom and Dad both are** ________	**Mom and Dad both are Non-** ________	**Dad is a** ________ **Mom is a Non-** ________	**Dad is a Non-** ________ **Mom is a** ________
Child is				
Child is Non-				

Part 2

1. Your teacher will assign you to a new group, so that you will be working with classmates that had different sets of data than you did. Your new group will have representatives for all of the pedigrees.

2. If your trait pedigree was PTC tasting A1, combine your data with the group that had PTC tasting A2 for a total number of each type of offspring with that trait. If you had the trait pedigree for Tongue rolling B1, add the numbers you had in your group data with the group that had Tongue rolling B2. Record your total number in the appropriate summary data table for that trait.

3. Copy the total number of each type of offspring from the groups who had the pedigree for the trait you did not have. When you finish, you should have both charts completed.

Combined Data for PTC Tasting

Number of Children Who Taste or Do Not Taste PTC				
	Mom and Dad Both Are PTC Tasters.	Mom and Dad Both are Non-PTC Tasters.	Dad Is a PTC Taster. Mom is a Non-PTC Taster.	Dad Is a Non-PTC Taster. Mom is a PTC Taster.
Child Tastes PTC				
Child is a PTC Non-Taster				

Combined Data for Tongue Rolling

Number of Children Who Can or Cannot Roll Their Tongue				
	Mom and Dad Both Are Tongue Rollers.	Mom and Dad Both Are Non-Tongue Rollers.	Dad Is a Tongue-Roller. Mom is a Non-Tongue Roller	Dad Is a Non-Tongue Roller. Mom is a Tongue Roller.
Child is a Tongue Roller				
Child is a PTC Non-Taster				

Making Sense

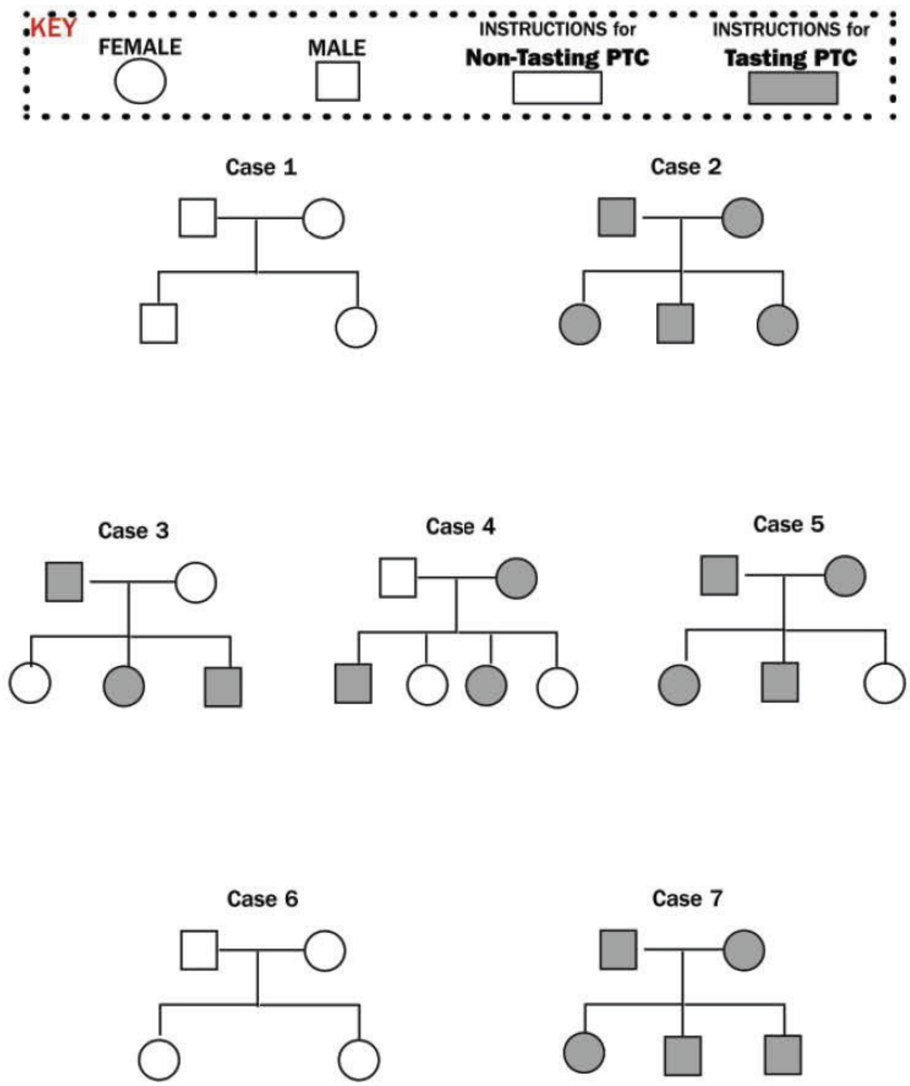
1. When two parents that taste PTC have children, are all of the children tasters, non-tasters, or was there a mixture? Does this result match your prediction?

2. Did you see the same pattern or a different pattern for two tongue-rolling parents? Does this match your prediction?

3. Based on your data, if parents do not have the same variation of a trait, are children more likely to have the same trait as their mother, their father, or is it about the same for both?

4. Which result in your data table did you find most surprising? Why?

What Are the Patterns in How Traits Are Inherited?
Pedigree Set A1

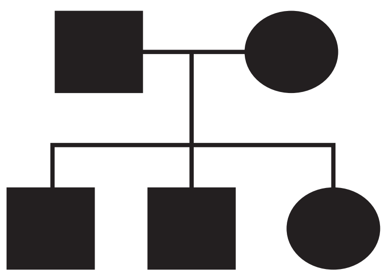


What Are the Patterns in How Traits Are Inherited?
Pedigree Set A2

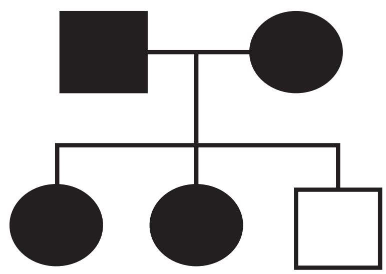
KEY

FEMALE	MALE	INSTRUCTIONS FOR **Non-Tasting PTC**	INSTRUCTIONS FOR **Tasting PTC**

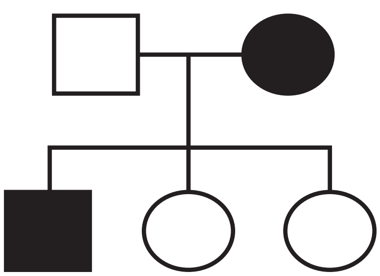
Case 8



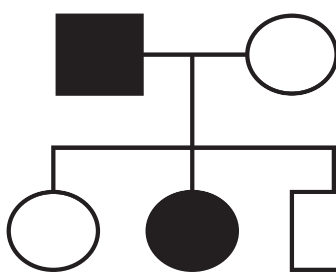
Case 9



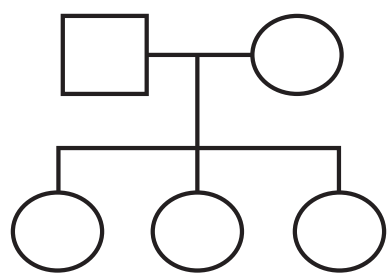
Case 10



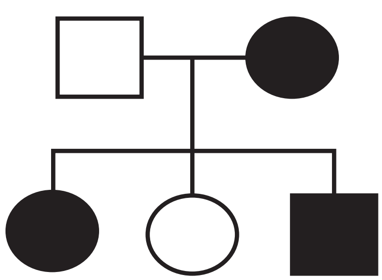
Case 11



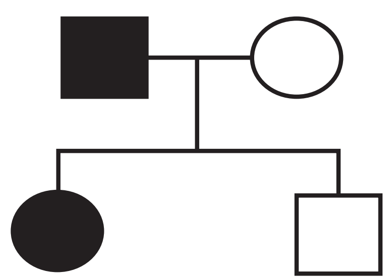
Case 12



Case 13



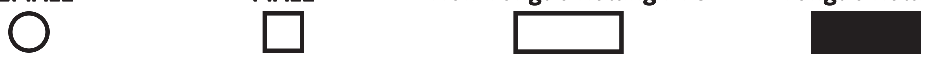
Case 14



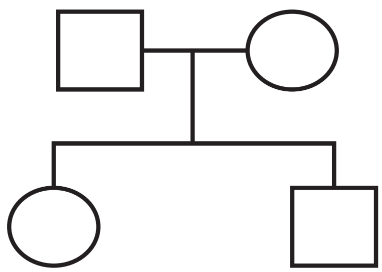
What Are the Patterns in How Traits Are Inherited?
Pedigree Set B1

KEY

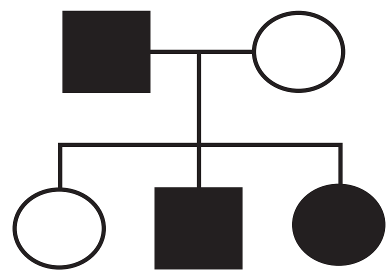
FEMALE | MALE | INSTRUCTIONS FOR **Non-Tongue Rolling PTC** | INSTRUCTIONS FOR **Tongue Rolling**



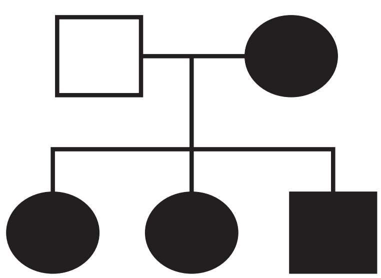
Case 1



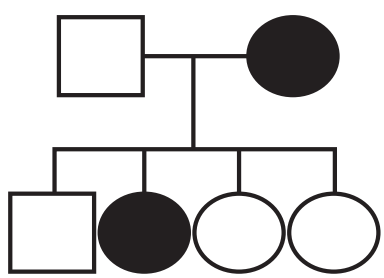
Case 2



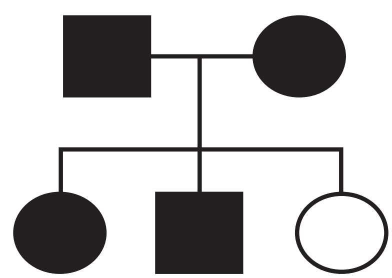
Case 3



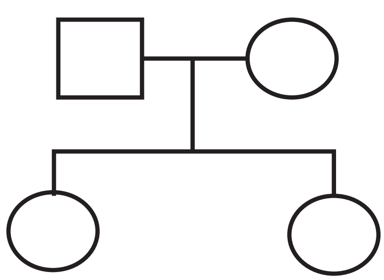
Case 4



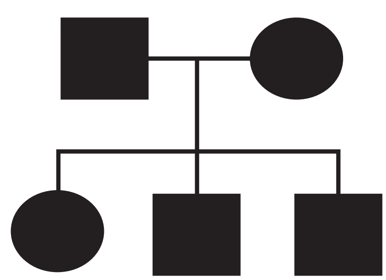
Case 5



Case 6



Case 7

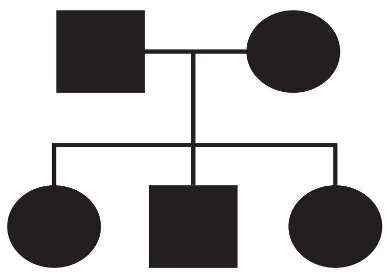


What Are the Patterns in How Traits Are Inherited?
Pedigree Set B2

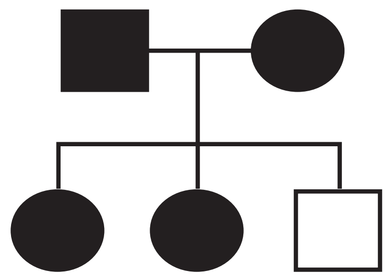
KEY

FEMALE	MALE	INSTRUCTIONS FOR **Non-Tongue Rolling PTC**	INSTRUCTIONS FOR **Tongue Rolling**
○	□	(open rectangle)	(filled rectangle)

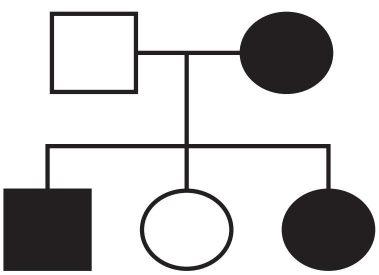
Case 8



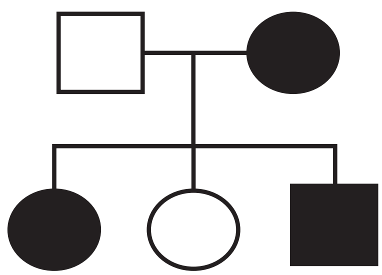
Case 9



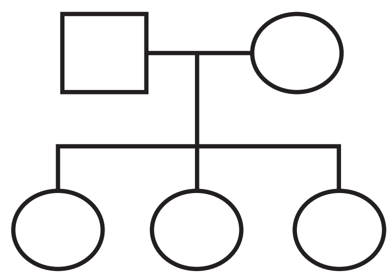
Case 10



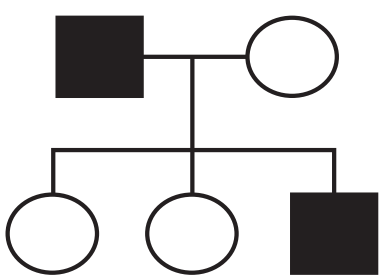
Case 11



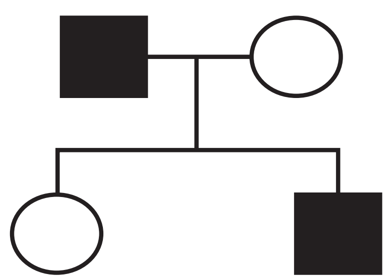
Case 12



Case 13



Case 14



ACTIVITY 3.2 – ARE THERE PATTERNS IN PLANT TRAITS?

What Will We Do?

We will analyze the patterns in the way plant traits are passed from one generation to the next.

Procedure

1. Review your prediction from Activity Sheet 2.3.

2. On the group data table on the next page, record the trait (color) of the two parent plants that were crossed to obtain your group's seedlings. Record it in the first row under *P*. Plant Generation.

3. Count the number of seedlings with a purple stem. Record that number on the purple line in the second column *Number of seedlings* for the first generation (F_1). Count the number of seedlings with a non-purple stem. Record that number on the non-purple line in the second column *Number of seedlings* for the first generation (F_1).

   Fill in the F_2 row in Lesson 4. It should be left blank now. The class data table for the F_2 generation also will be completed in Lesson 4.

4. After your group collects the data, each group shares the results. These are recorded on the class data table. Copy the additional data, and add it to your class data tables.

Group Data

Plant Generation	Number of Seedlings of Each Color
P (parents) ______________ × ______________	
F_1 First generation offspring	Purple Stem:
	Non-Purple Stem:
(To be completed in Lesson 4) F_2 Second generation offspring	Purple Stem:
	Non-Purple Stem:

F_1	PARENTS of F_1		
NUMBER OF OFFSPRING	A) Two Purple Stem	B) Two Non-Purple Stem	C) One Purple Stem One Non-Purple Stem
Purple Stem			
Non-Purple Stem			

Same Group

Same Group

Same Group

F_2 (To be completed in Lesson 4)	PARENTS of F_2		
NUMBER OF OFFSPRING	D) Cross F_1 from Group A	E) Cross F_1 from Group B	F) Cross F_1 from Group C
Purple Stem			
Non-Purple Stem			

Making Sense

You will need to refer to the pedigrees from Activity 3.1 and your earlier work on this activity sheet to respond to the follow up questions. Compare the class data to your predictions for F_1.

1. In your first-generation seedlings (F_1), were your predictions correct? (Answer yes or no.)

   a. Offspring of both purple stem parents? YES NO

   b. Offspring of both non-purple stem parents? YES NO

   c. Offspring of one purple stem parent and one non-purple stem parent? YES NO

2. Pick one result that did not match your predictions. Why do you think the plants produced offspring with these traits?

3. Compare the results for the purple stem trait to the results for the tongue-rolling trait and complete the following statements.

   a. How is the purple stem trait variation similar to the tongue-rolling trait variation?

   b. How is the purple stem trait variation different from the tongue-rolling trait variation?

4. Why do you think they are different?

5. Now that you have seen what happened in the first generation (F_1), predict what you think will happen if you take two of the plants from each group of the F_1 generation and cross them. Will the pattern be the same for the three combinations, or do you expect something different will occur? Indicate your predictions below.

F_2 Generation Predictions

Parent of F_1	Color of F_1	Color of F_2

Complete the Following Section after Lesson 4.

Making Sense (F_2)

1. In your first generation seedlings (F_1), were your predictions correct? (Answer yes or no.)

   a. Offspring of both purple stem parents? YES NO

   b. Offspring of both non-purple stem parents? YES NO

   c. Offspring of one purple stem parent and one non-purple stem parent? YES NO

2. Explain why you think your predictions were/were not correct.

3. How did the F_1 results compare to the F_2 results?

4. List any questions you have about how traits get passed on.

ACTIVITY 3.3 – WHAT SEED PATTERNS ARE THERE IN A FUTURE GENERATION?

Reading 3.3 – Heredity Patterns—A Key to Diagnosis

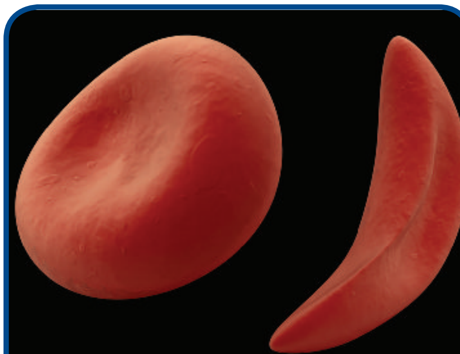
Getting Ready

Often times Sam gets very sick. Sometimes his body experiences a lot of pain and other times he is too tired to even go out and play his favorite sport, baseball, with his friends. Right after he was born, a simple blood test was performed and he was diagnosed with sickle-cell anemia, a disease that is inherited. But Sam does not quite understand why he has it when his mother, father, sister, and brother do not have it.

Think about the human pedigree patterns that you observed in class. Did you see any pattern that showed an offspring with a trait variation that neither parent had?

Sickle-Cell Anemia

Sickle cell disease is an inherited blood disorder. Students may recall in the IQWST LS2 unit, observing healthy red blood cells. These blood cells have a component called hemoglobin. The hemoglobin molecules carry oxygen from the lungs to all the cells of the body and bring carbon dioxide back to the lungs. The pain Sam has is caused by weird-shaped red blood cells. Instead of the smooth, doughnut-shaped blood cells of a person without sickle cell, many of Sam's blood cells are long, rod-like shapes. Sickle cells are stiff and not flexible enough to fit through the small blood vessels. Instead, they pile up and cause a blockage that will not let the cells of the body get the oxygen they need to function well. This causes the episodes of pain Sam experiences and can cause severe damage to the organs of the body. That is why the disease is called sickle-cell anemia.

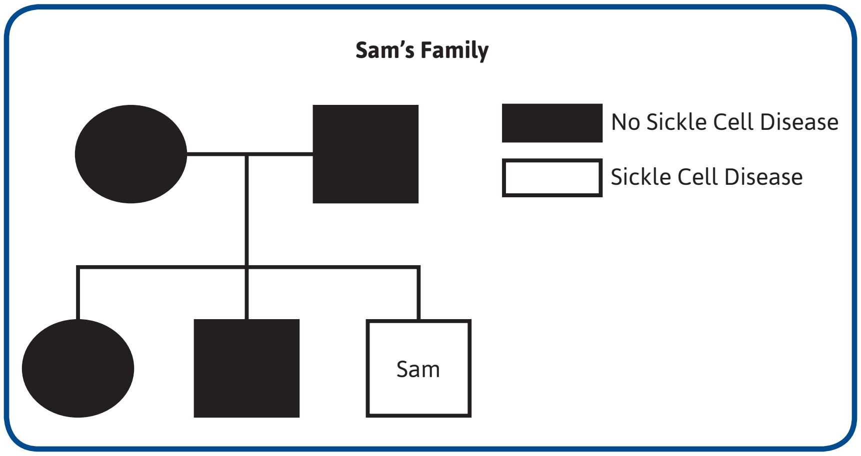


Normal red blood cell (left) and red blood cell of person with sickle-cell anemia (right)

Normal blood cells last about 120 days. The sickle cells die after only 10 to 20 days. Since they are not replaced fast enough, blood is often lacking enough red blood cells and this causes a condition called anemia. The decreased amount of red blood cells means the cells all over the body cannot get all of the oxygen they need. This is the cause of Sam being too tired to do the things he would like to do.

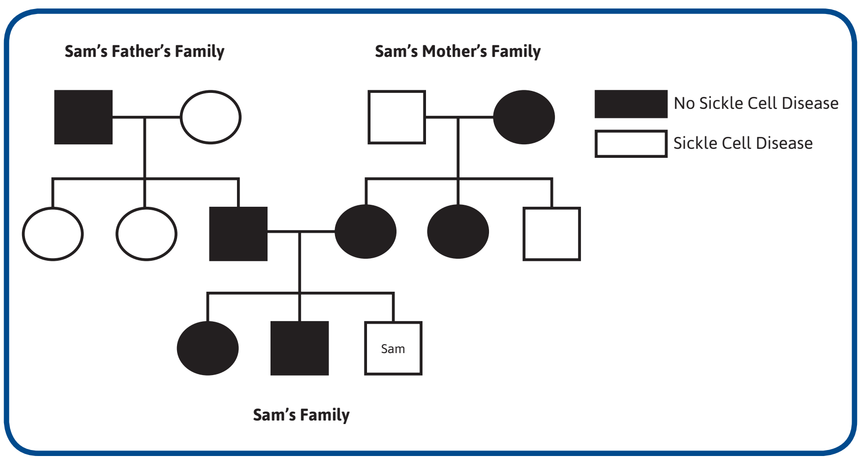
Where Did the Sickle Cell Disease Come From?

When you observed plants in class, you saw that a purple plant and a purple plant always produced a purple plant. And, when you looked at the human pedigrees, two non-tasting PTC parents always had non-tasting offspring. However, parents who were both tasters sometimes produced a non-tasting offspring. If we were to make a pedigree of Sam's immediate family, you would see a similar pattern.



Neither of Sam's parents has sickle cell disease. Nor do his siblings, but he does. If sickle cell is an inherited disease and no one else in his immediate family has it, where do you think it could have come from?

You knew that the P generation of your purple plants only came from purple plant seeds, and the non-purple P generation plants only came from non-purple plant seeds, but you did not know about the previous generations of the humans who were shown on the pedigrees. Maybe if you were to look at the offspring from your F_1 generation of plants, you might see a pattern more similar to the human pattern, so let us take a look at a pedigree that includes Sam's grandparents, parents of both his mother and father, to see if we can find out from where his sickle cell disease might have been inherited.



Looking at this pedigree, we can see that Sam's grandmother on his father's side and his grandfather on his mother's side both had sickle cell disease. Two of his father's sisters and his mother's brother had sickle cell. It looks like the trait for sickle cell was inherited from both sides of his parents.

Genetic Counseling

Before Sam was born, his parents decided to go for genetic counseling. They knew that sickle cell disease was hereditary. Even though neither of them had the disease, they wanted to know if they had a chance of having a child with the disease.

Genetic counseling is a process that helps individuals and families who are at risk for an inherited disease to determine the probability of the disease occurring as well as helping them to understand the disease and how to deal with it. The process involves studying family history, medical records, and genetics to evaluate and determine the risk factors. The counselor, using information that Sam's parents provided about their families, created a pedigree of the types of hemoglobin their families had. The counselor was able to determine that it was possible for Sam's parents to have a child with sickle cell disease. That was why Sam and his brother and sister were tested as soon as they were born to see if they had the disease. Genetic counseling helped his parents to provide Sam with the earliest possible diagnosis. They understood the disease and were prepared to provide Sam with the best treatments available. They became involved with the Children's Sickle Cell Foundation and took part in the support groups. Genetic counseling prepared Sam's parents to help Sam deal with the sickle cell disease.

Pedigrees used by genetic counselors often include other information about the families. Ages, dates of birth, and dates of death are often included. Converting family history into a pedigree, the genetic counselor can easily see the relationships between family members and track the occurrence of the disease. A pedigree can help identify possible causes for a sudden death from a disease that may not have been identified. For example, a young, seemingly healthy boy dies suddenly during football practice for no obvious reason. A pedigree may show a pattern of familial hypertrophic cardiomyopathy (HCM), an inherited disease of the heart muscle. This information could help other members of the family get an early diagnosis and obtain effective treatments.

Before genetics became a science, people knew that some diseases ran in families. That is, a certain disease would show up in some members of the same family and in different generations of that family. How the disease was passed down from healthy parents to some of their children was unclear. The world had to wait until the science of genetics allowed us to begin to understand the patterns of heredity.

Does Sam's story give you any ideas for how two taster parents might have a child who is a non-taster? Explain.

Do Traits Show Patterns over Multiple Generations?

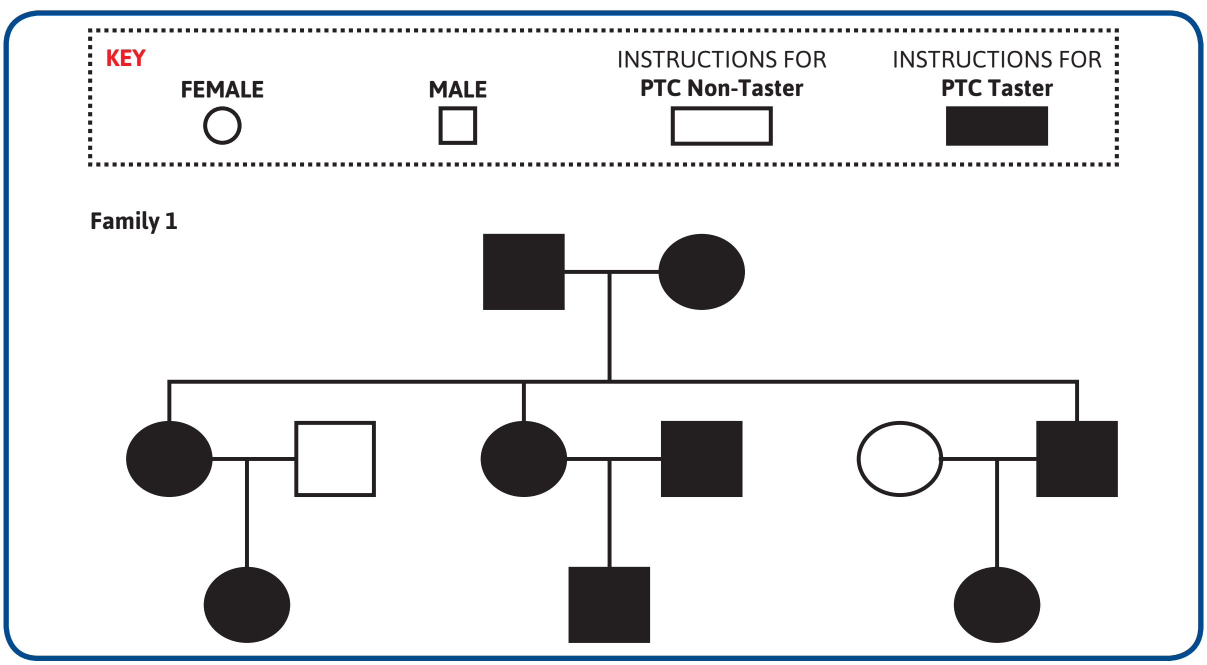
ACTIVITY 4.1 – HOW DO TRAITS GET PASSED ON?

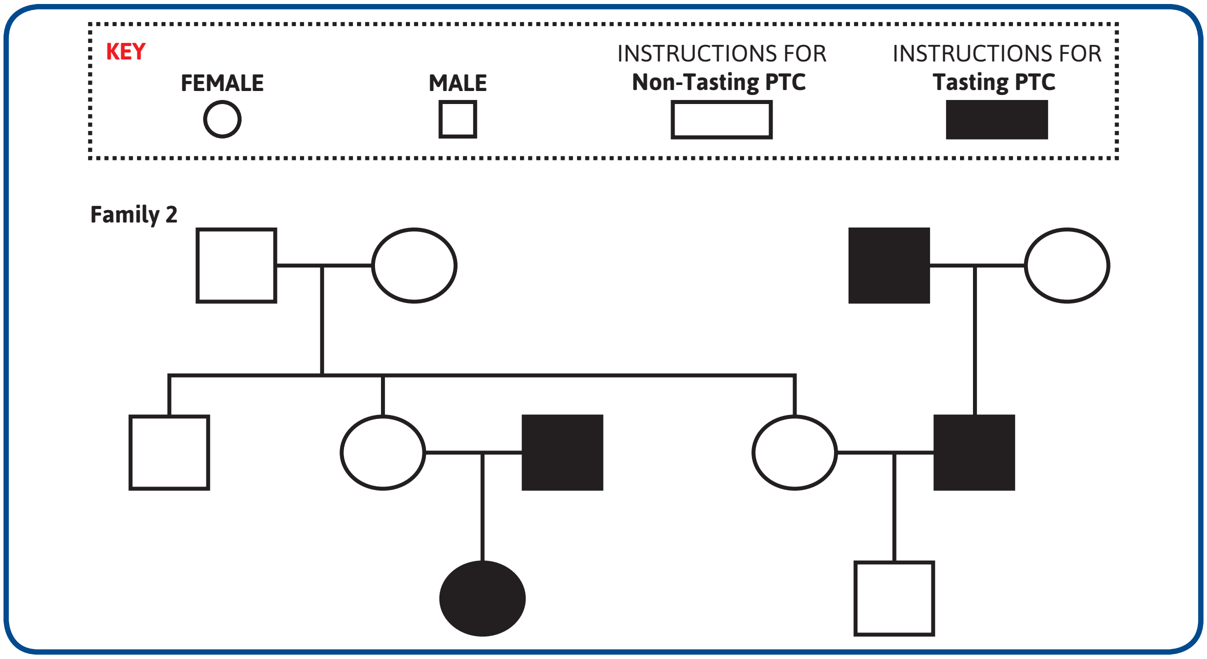
What Will We Do?

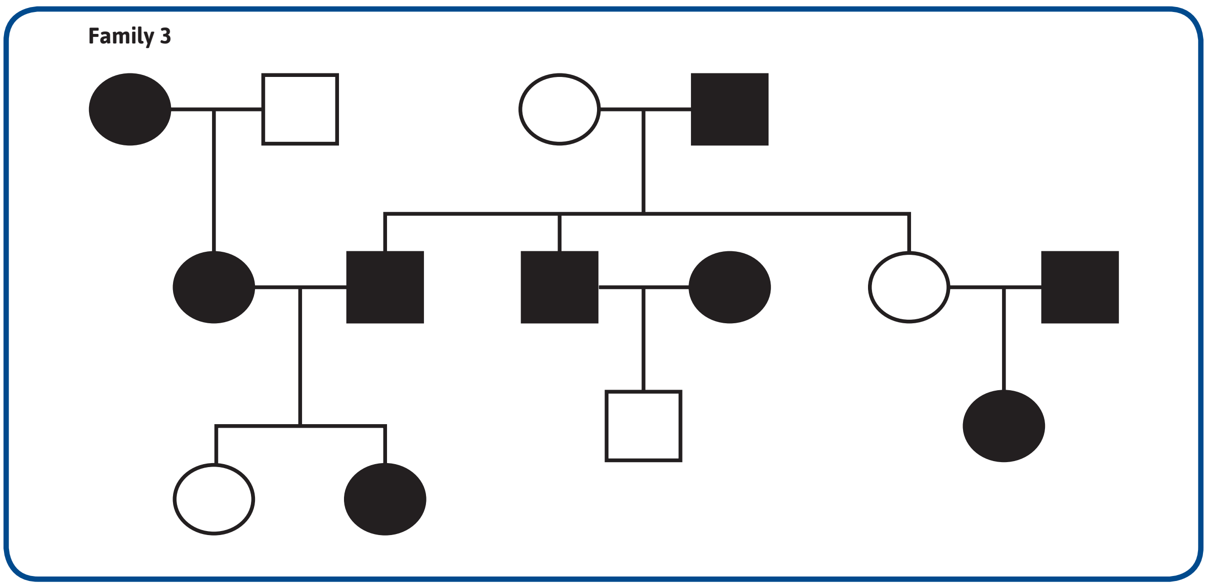
We will analyze the data in a pedigree to see which traits get passed on from one generation to the next.

Procedure

1. You will work in groups to complete the Case Family Observation Data table.
2. Look carefully at each of the following pedigrees and see if you can find the patterns that answer the questions on the data table.
3. Put a check in either the yes or no column for each pattern. Repeat this for each of the family pedigrees.
4. After you have filled in the table for each of the pedigrees, total the number of yes and no responses for each pattern.




KEY
FEMALE
MALE
INSTRUCTIONS FOR
Non-Tasting PTC
INSTRUCTIONS FOR
Tasting PTC
Family 2


Family 3

Data

Pattern	Observations
1) Can offspring get instructions for the variation of a trait from either parent?	Families Where This Happens
2) Do all offspring from the same parents inherit identical variations of a trait?	Families Where This Happens
3) Can offspring sometimes show a variation of a trait that neither parent shows?	Families Where This Happens
4) If parents have different variations of a trait, does it seem that one is more likely to be passed on?	Combinations Where This Is True

Making Sense

1. In Lesson 2, you saw that two parents who did not taste PTC always had offspring who did not taste PTC. Did you see a similar pattern when looking at the human pedigrees of multiple generations? If so, describe what you saw.

2. In Lesson 2, you saw that two parents who tasted PTC could have offspring that taste PTC or offspring that do not taste PTC.

   a. Did you see the same thing when looking at the pedigrees of multiple generations of a family? If so, describe what you saw.

   b. Do the data from the previous generations help you figure out how two parents who taste PTC could have offspring who do not taste PTC? Explain how.

3. Is there anything in the data from this lesson that helps figure out which tasters might be able to have offspring that do not taste? Record any questions that you have about how traits get passed on.

ACTIVITY 4.2 – WHAT ABOUT THE NEXT GENERATION OF SEEDS?

What Will We Do?

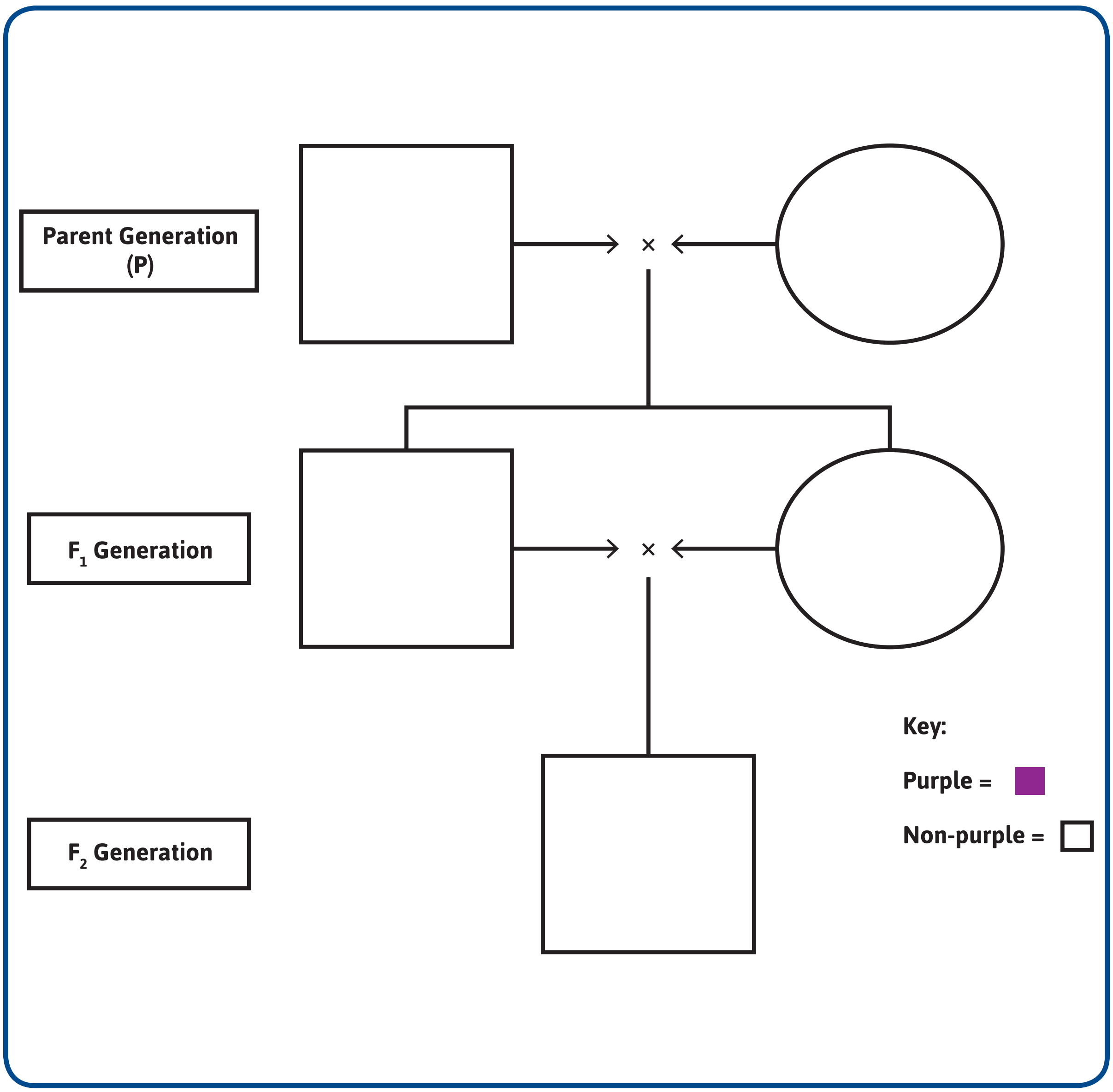
We will summarize the data collected from the plant experiments in Lessons 3 and 4.

Procedure

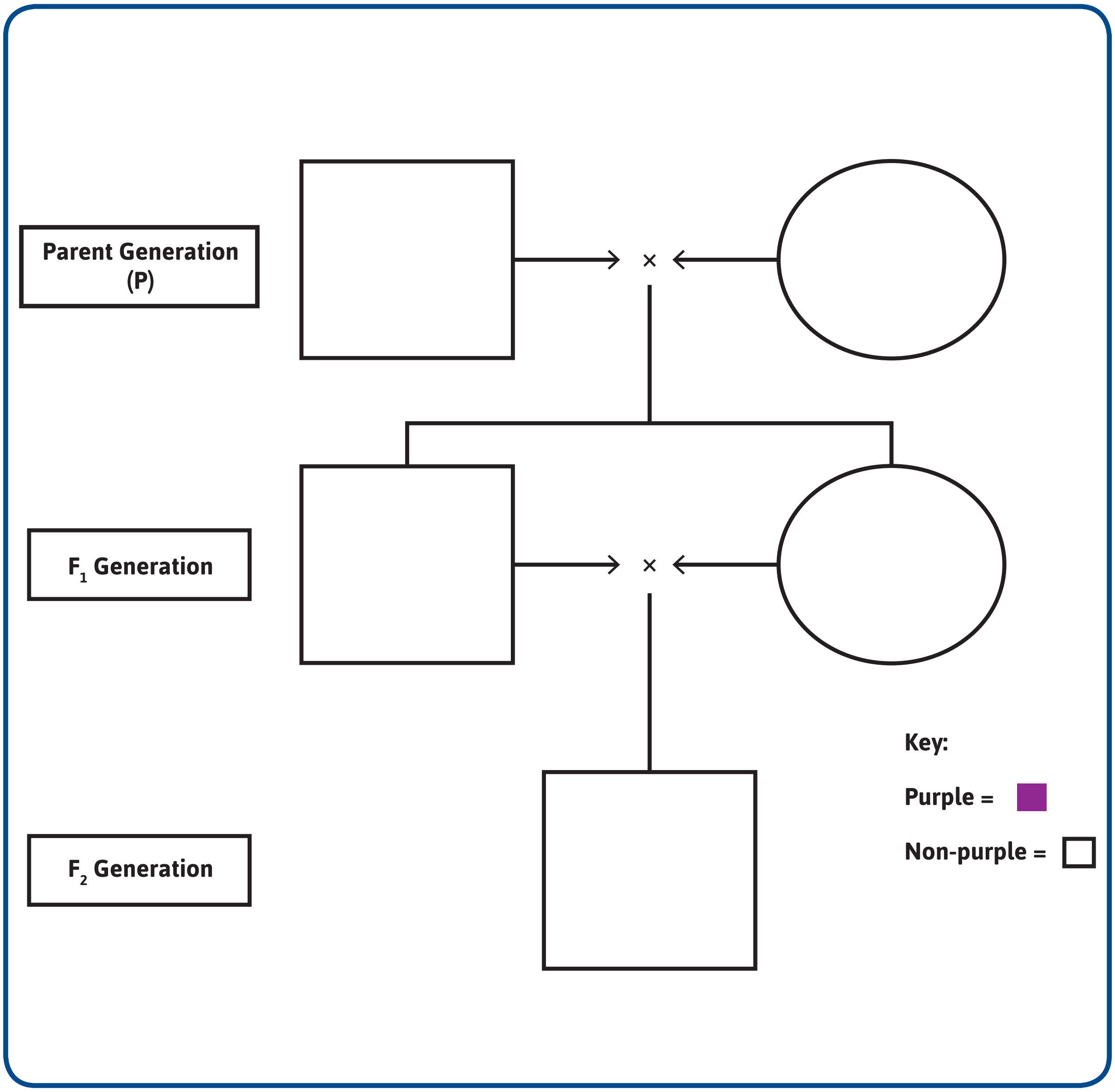
1. Begin by filling in the key. Using the data table on Activity Sheet 3.2, complete the pedigree below for your seeds. If there was more than one group using the same seeds, you should combine your data.

2. You will complete one sheet for the data collected by each of the groups.

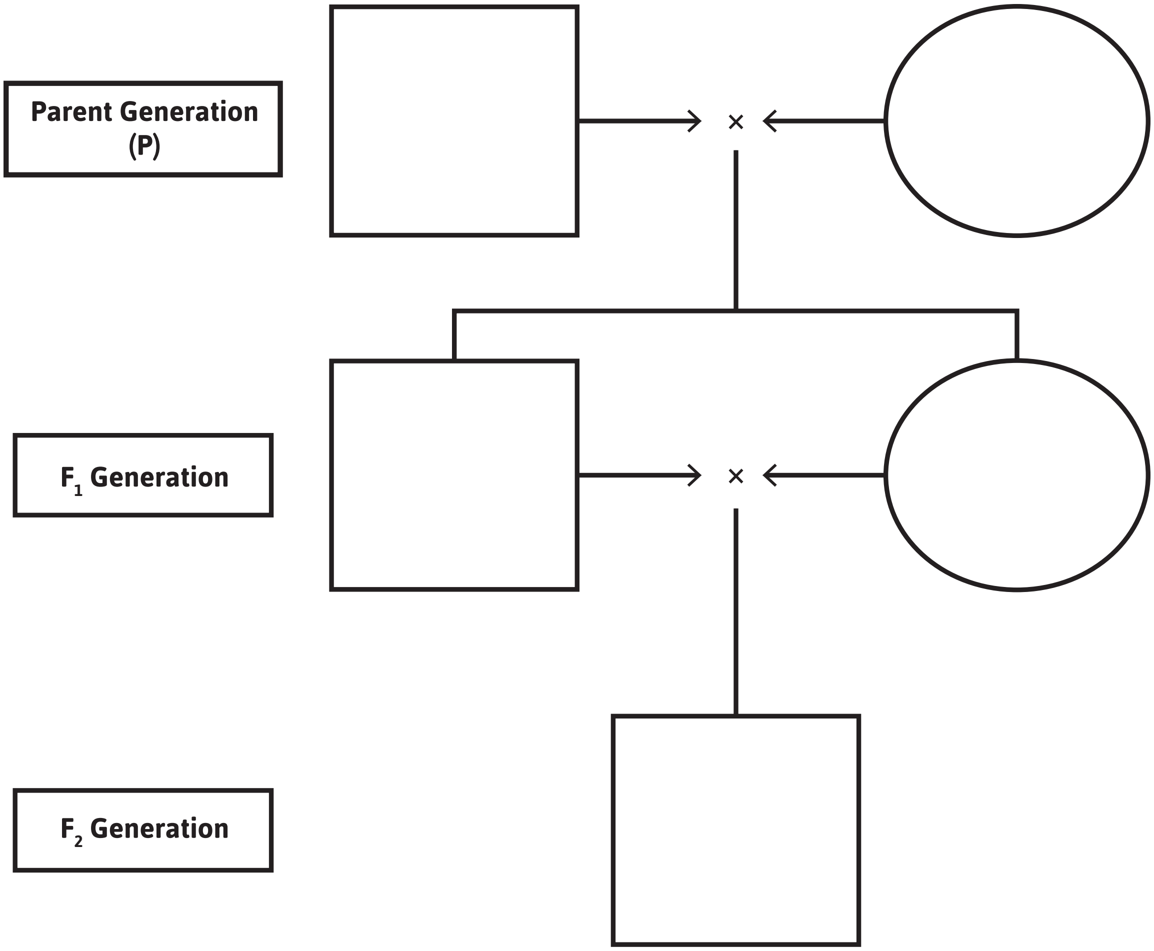
Seed Packets A and D



Group: Seed Packets B and E



Group: Seed Packets C and F



Key:

Purple = ■

Non-purple = □

ACTIVITY 4.3 – SYNTHESIZING THE DATA

Reading 4.3 – Why Are Patterns Important?

Getting Ready

Jen is trying to figure out what the next number would be in the sequence:

0.99, 9.9, 99, 990, ______.

Can you help?

The next numeral in the sequence is ______________________

The pattern is ____

The pattern shows that the decimal point is moved one place to the right in each succeeding number.

Did you figure out what number would be next? _______________________________

Scientists often look for patterns when they are trying to figure things out. You may have looked for patterns in trout and sea lamprey data to determine what happened to the trout population in the Great Lakes if you studied invasive species in the IQWST Life Sciences Unit.

In the IQWST ES3 unit you may have investigated patterns in earthquake and volcano data to help you learn about Earth's plates. In this unit, you identified traits that you and your classmates share, such as having hair and eyes. Then you talked about differences in those traits like the color of your eyes or hair, and you learned that those differences are called variations. You also saw that traits can run in families. You may have the same color hair as your mother, or everyone in your family may have the same eye color. The Driving Question for this unit is Why Do Organisms Look the Way They Do? You have been looking for patterns for how traits get passed on in different organisms, such as plants and humans. This reading will introduce you to a scientist who first used patterns to learn about traits in organisms.

Who First Studied Patterns in Inheritance?

Humans who lived thousands of years ago noticed that traits seemed to run in families. That means tall parents often had children who grew up to be tall. Hair color and eye color also seemed to be passed from parent to child. But some traits were harder to explain. Sometimes traits seemed to skip generations. Some children resembled their grandparents more than their parents.

In this lesson, you noticed that the variation of non-tasting of PTC seemed to be able to skip generations. Even though they could not explain how it happened, people noticed the pattern.

Until the mid-1800s, most ideas about heredity came from people's observations about themselves and the organisms around them. That is when Gregor Mendel, a monk living in Austria, decided to do experiments to figure out how traits were passed on. Mendel was interested in nature and science, but he was not part of the scientific community. He was the son of farmers in Eastern Europe. He did well in school, but his family could not afford to send him to college, so he entered a monastery to continue his education. A monastery is a place where monks or priests live and study.

Mendel loved animals, but having grown up on a farm he was also interested in plants. The gardens around the monastery provided many types of plants. As Mendel observed the gardens, he noticed that new plants almost always looked like the parent plant. However, sometimes a plant would not look like the parent plants. He wondered how this could happen, so he decided to conduct experiments to determine how traits were passed from parents to offspring.

From Pea Plants to Heredity

Mendel decided to use the monastery gardens to conduct his experiments. He knew that he had to have a plant that had traits that he could easily observe. He also needed a plant that could be grown in large numbers. He decided to use the common pea plant. Mendel spent an entire year breeding plants before he began his experiments.

Why do you think Mendel spent so much time observing plants and their offspring before he began experimenting with them?

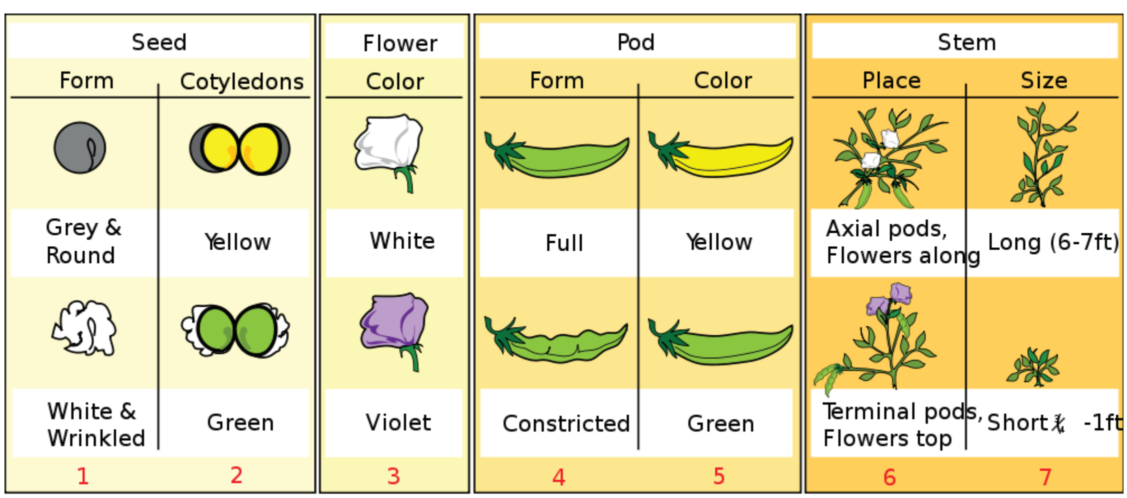
In class, you observed human traits like tasting PTC and tongue rolling. For each of these traits you found that people either had them or not. There are only two variations of the trait. These were the kind of traits that Mendel was looking for in the pea plants. Mendel spent the year before he began his experiments, determining which traits he would study.

Mendel discovered four traits that were easily observable that he could follow:

1. Flower color – purple or white
2. Seed color – yellow or green
3. Seeds shape – round or dented
4. Plant height – tall or short

In class, you learned that flowering plants reproduce sexually. Sexual reproduction requires both male and female parts, and many plants have both. But for the plant to reproduce, pollen has to move from the anther (male part) to the stigma (female part). Usually, pollen moves because insects, other organisms, or the wind move it from one part of the plant to another or to another plant. This also means that a person could move the pollen from one plant to another. Mendel could choose which traits to experiment with, and he could manipulate those traits by putting pollen from the stigma of one plant on the anther of another plant.

This process is called cross-pollination because pollination happens across different plants. Mendel experimented with particular traits and observed the outcome over many generations of the plants. This helped him develop ideas about heredity and passing traits from one generation to the next. Just like you observed different stem colors being passed from one generation to another, Mendel observed flower color, plant height, and seed color passing from one generation to the next.



What Did Mendel Learn?

Mendel worked on his experiment with pea plants for seven years with about 28,000 pea plants. He developed a model to explain the results of his experiments. This model has four important parts:

- The inheritance of traits is determined by units or factors that are passed on to offspring unchanged.
- An individual inherits one factor from each parent for a trait.
- A trait may not show up in an individual, but can still be passed on to the next generation.
- Some traits are dominant over others. By this, he meant that if a plant had a purple and a white factor, it would appear purple because purple is dominant.

Think back to the list of patterns of inheritance that you identified on your Pattern and Evidence Chart. Compare the patterns you identified to the ones Mendel discovered.

Similar Ideas	Different Ideas

Today, scientists who study patterns of inheritance, which is called the study of genetics, would not use Mendel's methods. Mendel's methods would take too long to get results. Mendel's pea plants only produced two or three generations of plants each year, so it took him seven years to collect data. Modern laboratories and scientific equipment are much more expensive to operate than growing plants in a garden, but scientists use organisms that reproduce much faster. Two organisms that are often used are fruit flies and bacteria. Fruit flies reproduce in about two weeks and bacteria reproduce in three to five hours, so scientists can see many more generations of those organisms in a much shorter period of time.

Modern scientists now know much more about genetics, but Mendel's work started them thinking. You have seen the patterns, and you know that instructions for traits do get passed on from generation to generation. Now that you have started thinking about how instructions for traits get passed on from generation to generation, do you think that you have enough information to explain how that happens? Is there anything else you need to know to complete your answer?

LESSON 5

How Do Instructions from Our Parents Get inside Us?

ACTIVITY 5.1 – HOW DO I GET NEW CELLS?

ACTIVITY 5.2 – HOW CAN PARENTS PRODUCE OFFSPRING WITH DIFFERENT TRAITS?

What Will We Do?

We will demonstrate how alleles can separate to produce multiple combinations in gametes.

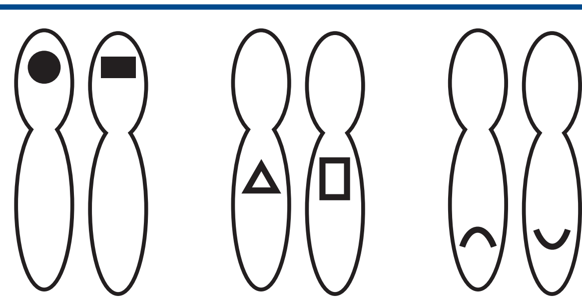
Procedure

1. You are going to work with the chromosomes of an imaginary organism called an yllis. The yllis has only six chromosomes (three pairs). Each chromosome carries a gene for one of the traits below. Each trait has two possible alleles (variations). The following chart shows you the traits and their variations.

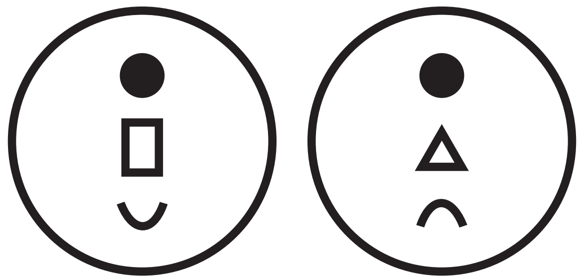
TRAIT	ALLELE 1	ALLELE 2
eyes	round	narrow
nose	flat	pointy
mouth	curve up	curve down

2. Look at the images that show the three chromosomes pairs for an adult yllis. The pairs represent the chromosomes that came from its parents.

3. Each one of the chromosomes carries the gene (instruction) for the traits above. Your job is to figure out how many possible combinations of the alleles can appear in the gametes of this adult yllis. Your teacher will go through the first two examples with you.



Three Chromosome Pairs of a Yllis



Examples of Gamete Combinations
#1 #2

Additional Combinations

Making Sense

1. Compare the number of combinations you determined with other students. If you disagreed on the total number, go back and see if you can figure out whether someone missed a combination.

2. The yllis only has three pairs of chromosomes but can produce many different possible gamete combinations. Think about humans that have 23 pairs of chromosomes. How do you think the number of possible gamete combinations of a human compares to that of the yllis?

Reading 5.2 – Discovering the Source

Getting Ready

Look at the picture of these children. You have been focusing on traits and have learned that traits can have variations, so it should not surprise you that you can observe variations between the two children in the photo. Traits like mouths, eye shape, and skin color have variations, but this might surprise you—these children are twins! How could their hair color be so different?

Often you can observe hair color variations in your own family. From the work you have done in class, you know that when gametes are formed, the alleles of one gene separate independently from the alleles of another gene, so if the mother had dark brown hair and brown eyes, and the father had blond hair and blue eyes, it would be possible for one of their offspring to have brown hair and blue eyes.

Amazing Twins

When two people act alike, or dress alike, or have many of the same preferences, people often joke that they must be twins. When you think about genetics, however, you probably think of twins as two people born of the same parents, on the same day, that look alike. Appearance is your primary source of information that they are twins, so when twins are born with different hair color or eye color, they might not be seen as twins.

The same genetic event that you see in the photo at the beginning of this reading has happened in other families, too. A set of twins born who are born from the same parents at the same time and yet have different hair color and eye color. Fraternal twins come from two eggs, with each egg fertilized by a different sperm. Because the children come from different combinations of eggs and sperm, fraternal twins have different genetic material from each of their parents. Scientists think that several genes work together to produce eye color; therefore, many combinations are possible. That is true even in one family, and it is true even when two people are twins.

Using what you have learned in class about F_1 and F_2 generation plants, how do you think twins with different hair color were born to these parents?

How Did Scientists Learn about the Genes?

The case of twins with different hair color and eye color is an interesting genetic event. It can help people understand how parents' genes influence trait variations in their children. How do scientists know that genes are on chromosomes? How do they know that traits are passed from one generation to another? The answer is that people's understanding today comes after a long history of scientific investigation. Scientists have built on the discoveries of those scientists who came before them.

In the last reading, you were introduced to Gregor Mendel, whose work with pea plants led to four basic conclusions about heredity. From these conclusions, Mendel's Laws were developed.

Two of his laws relate to the lesson you just did in class:

1. Law of Segregation basically states that for any pair of factors, only one factor ends up in a gamete. You observed this when you compared the somatic cell division to the sex cell division.

2. Law of Independent Assortment states that for two or more traits, the factors will separate and be independent from the others. You saw how this could happen when you worked with the yllis genes to see what various combinations could be made.

For several years, no one paid much attention to Mendel's work. In 1903, Wilhelm Johannsen started to use the word *gene* to replace Mendel's using the language of factors that pass on traits. The word *gene* comes from a Greek word that means, "to be born." Mendel's factors of heredity had a name, but at that time in the history of science, no one knew what they actually were or how they worked.

Learning More about Genes

During the 1880s, scientists observed structures like threads inside of a cell's nucleus. While they were not sure of the function the structures served, they named those parts of the cell *chromosomes*. In 1903, Walter Sutton, a graduate student at Columbia University, thought that the chromosomes might be the structures that contained genes. Thomas Hunt Morgan, a professor working in zoology at Columbia, and his students studied genes in fruit flies. In 1911, they discovered that genes seemed to be fixed in a certain place along chromosomes. Their work proved that Sutton's idea was correct.

Scientists then understood that genes were on chromosomes, and chromosomes were made of protein and DNA. You know that DNA is what carries the instructions for the traits an organism will have, but during the 1920s and 1930s, scientists thought that DNA was a simple molecule that could not be a major part of heredity. So, the question, what are genes? was not completely answered. Scientists still wanted to know where genes are located and how they function.

In 1943, Oswald Avery discovered that when he injected DNA from certain disease-causing bacteria into harmless bacteria, it transformed these bacteria into disease-producing bacteria. This led Avery to believe that DNA gave new traits to the bacteria when it was injected.

Now scientists knew that DNA was the only substance capable of storing the information needed to create a living being. Now that you know that there are actual molecules in cells that carry instructions that are called DNA, how does that help or change the explanation you have so far about how heredity works?

Lesson 6

Constructing a Model of Inheritance

ACTIVITY 6.1 – CONSTRUCTING A MODEL OF INHERITANCE

What Will We Do?

We will develop a model to explain how alleles are passed from parents to offspring in order to determine the offspring's traits.

Procedure

1. Fill in the chart using the information from the chart filled out during the class discussion.

Genotype (Instructions)	Phenotype (What You See)
p/p	
np/p	
np/np	

Making Sense

1. Which rules for deciding on phenotype based on genotype are you most sure about? Why do you think those rules are accurate?

2. For the genotype np/p, what do you think the phenotype of the offspring will be and why do you think that?

ACTIVITY 6.2 – TESTING THE MODEL

What Will We Do?

Test the models of inheritance developed in Activity 6.1 in order to see which one fits the plant data that has been collected.

Procedure

1. Fill in the following pedigrees together with your class. You will test Model 1 with both purple and non-purple offspring.
2. Using the Data Summary from Lesson 4, fill in all of the phenotypes on the first few pages.
3. Next, fill in the genotype for each generation based on Model 1. Be sure to begin at the bottom of the pedigree and work to the top.
4. Answer the questions that follow.
5. In groups, use the pedigree to test Model 2. Remember that for the model to work, all of the rules of the model must work in all generations of the pedigree that are shown on the Data Summary.
6. After you test the model, be sure to answer the Making Sense questions at the end of this activity.

Model 1

(Non-purple is stronger.)

Genotype (Instruction)	Phenotype (What You See)
p/p	purple
np/p	non-purple
np/np	non-purple

Model 2

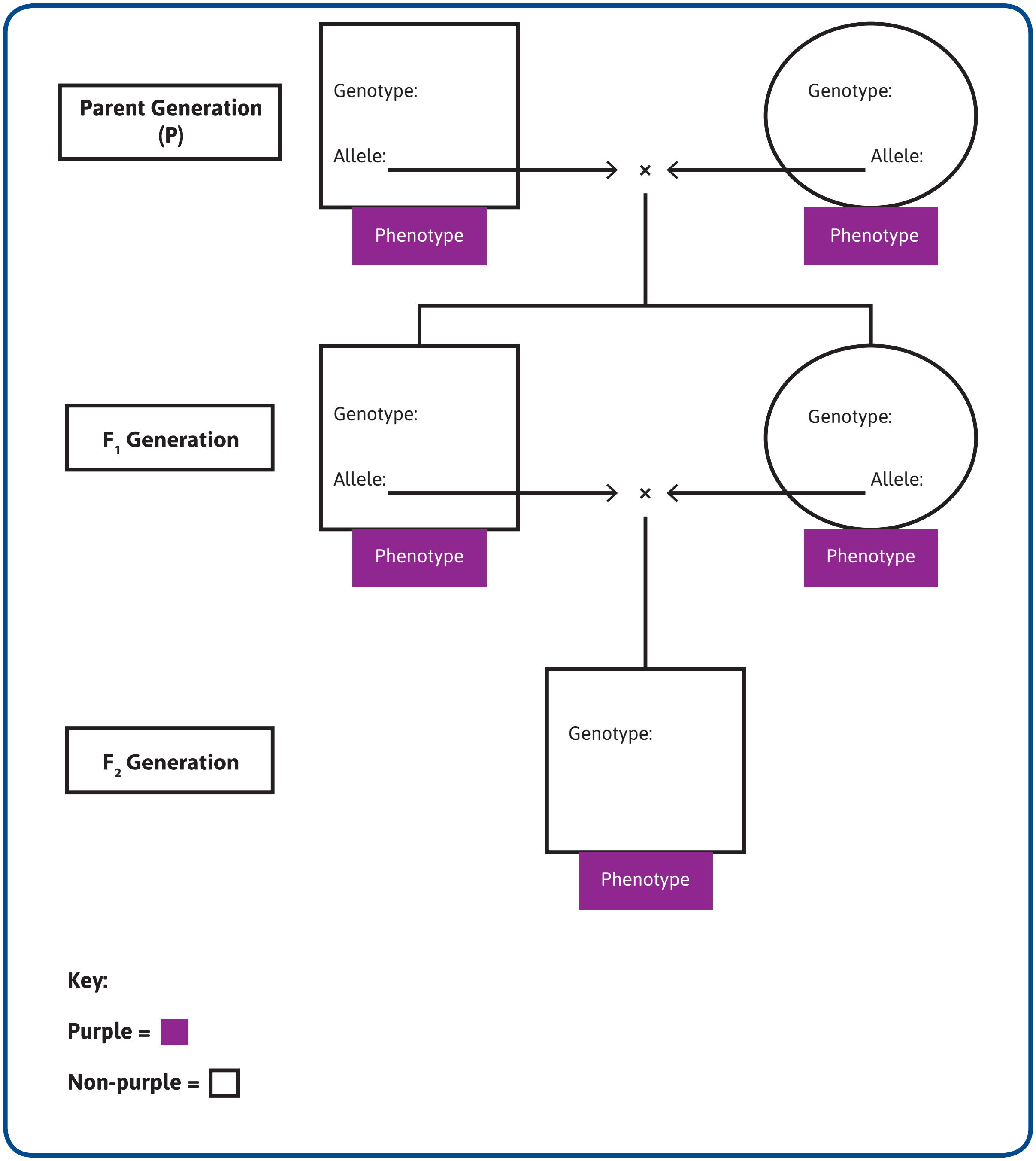
(Purple is stronger.)

Genotype (Instruction)	Phenotype (What You See)
p/p	purple
np/p	purple
np/np	non-purple

Testing the Model

Group A and D

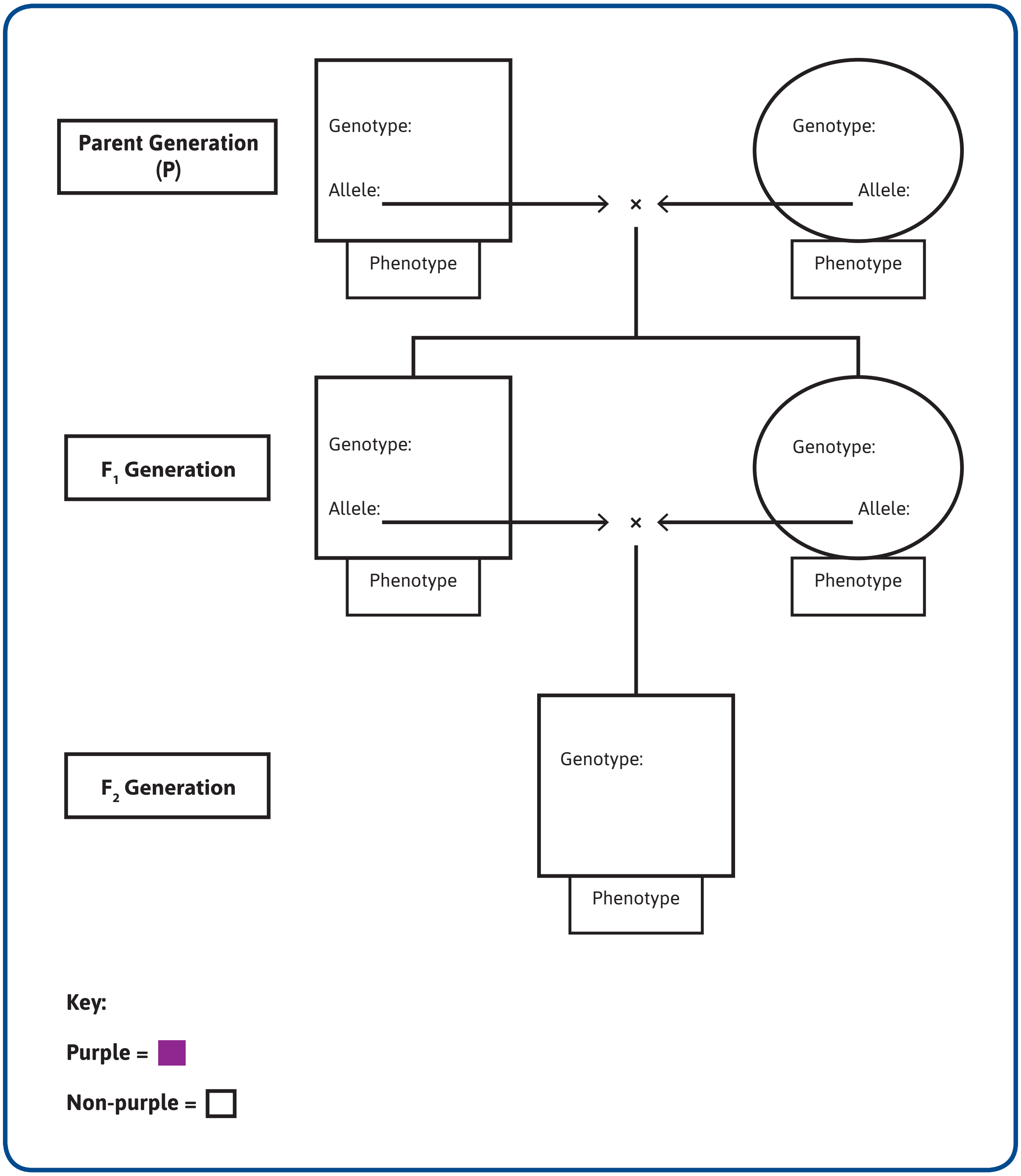
Model 1



1. Does the model account for the data? Yes No
2. If not, where does it fail and why?

Model B and E

Model 1

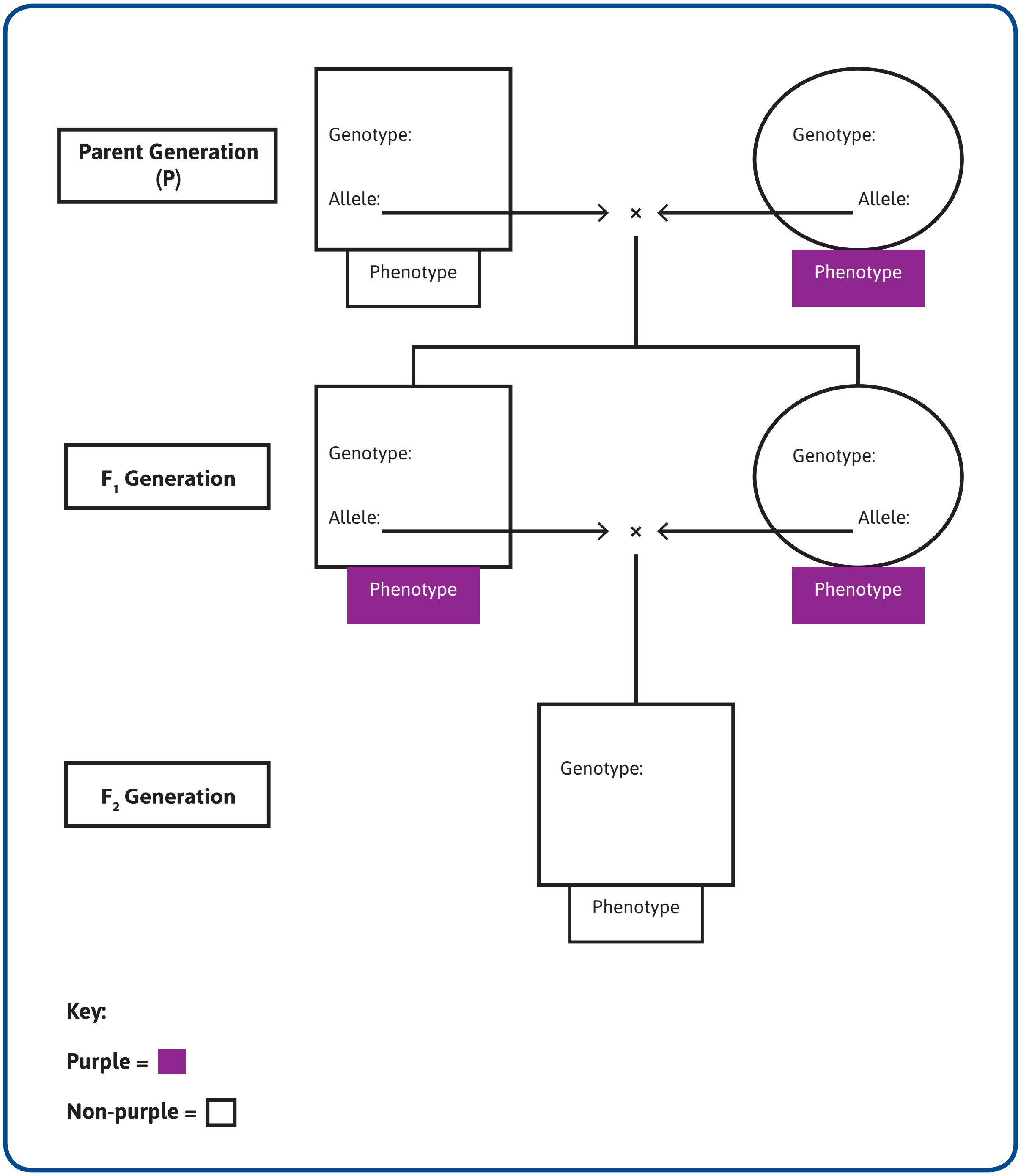


1. Does the model account for the data? Yes No

2. If not, where does it fail and why?

Group C and F

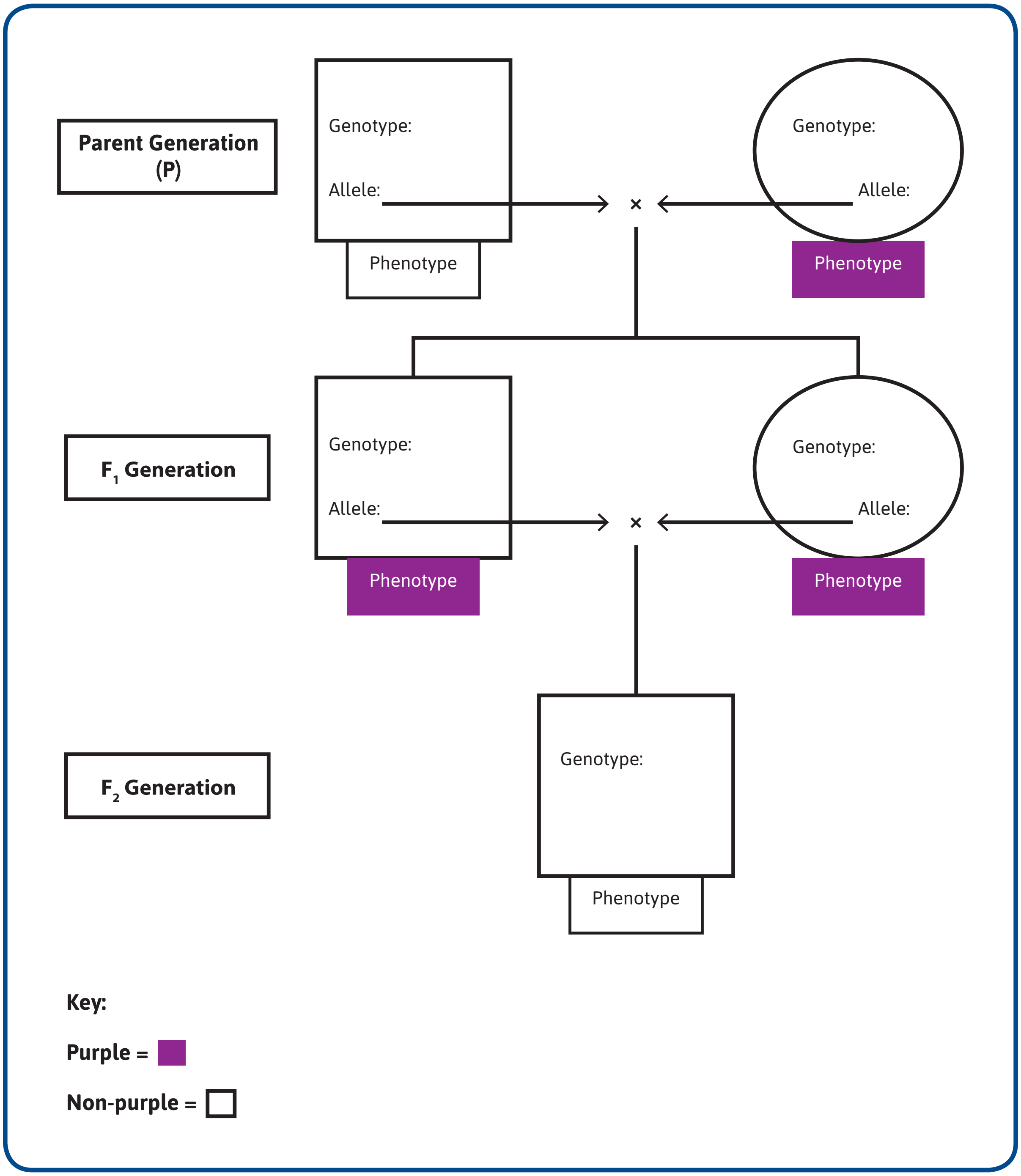
Model 1



1. Does the model account for the data? Yes No
2. If not, where does it fail and why?

Group C and F

Model 1

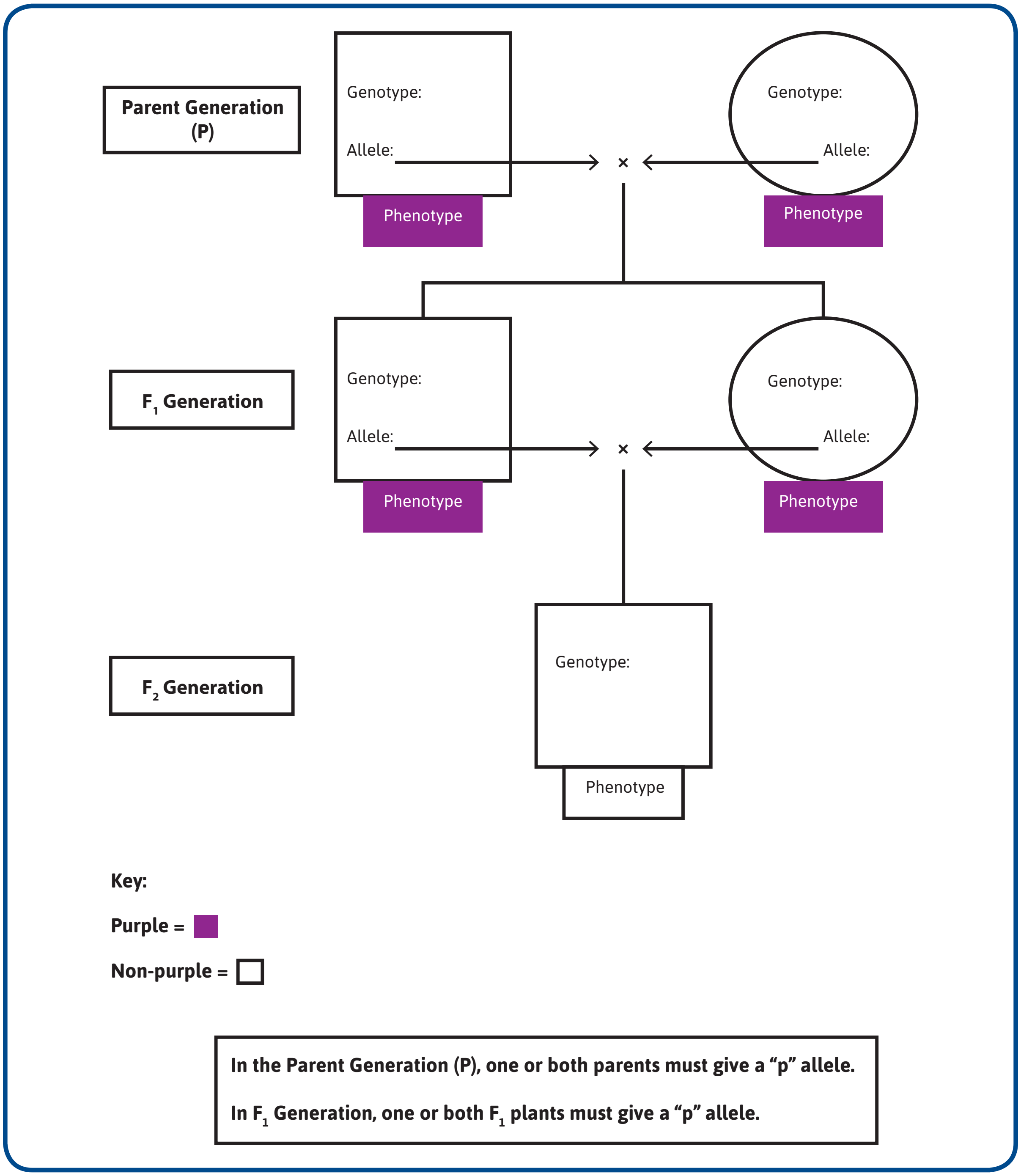


1. Does the model account for the data? Yes No

2. If not, where does it fail and why?

Group A and D

Model 2

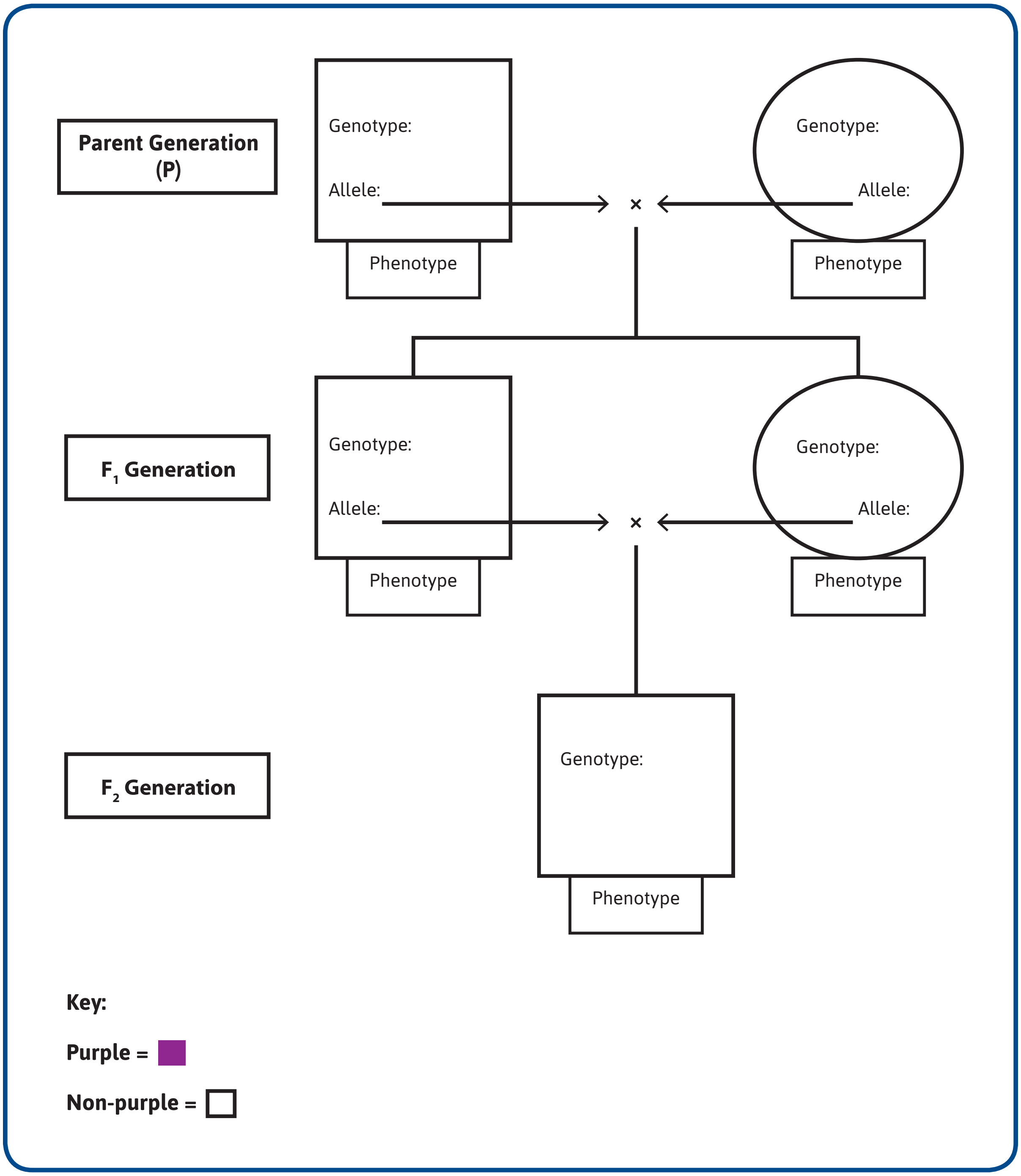


1. Does the model account for the data? Yes No

2. If not, where does it fail and why?

Group B & E

Model 2

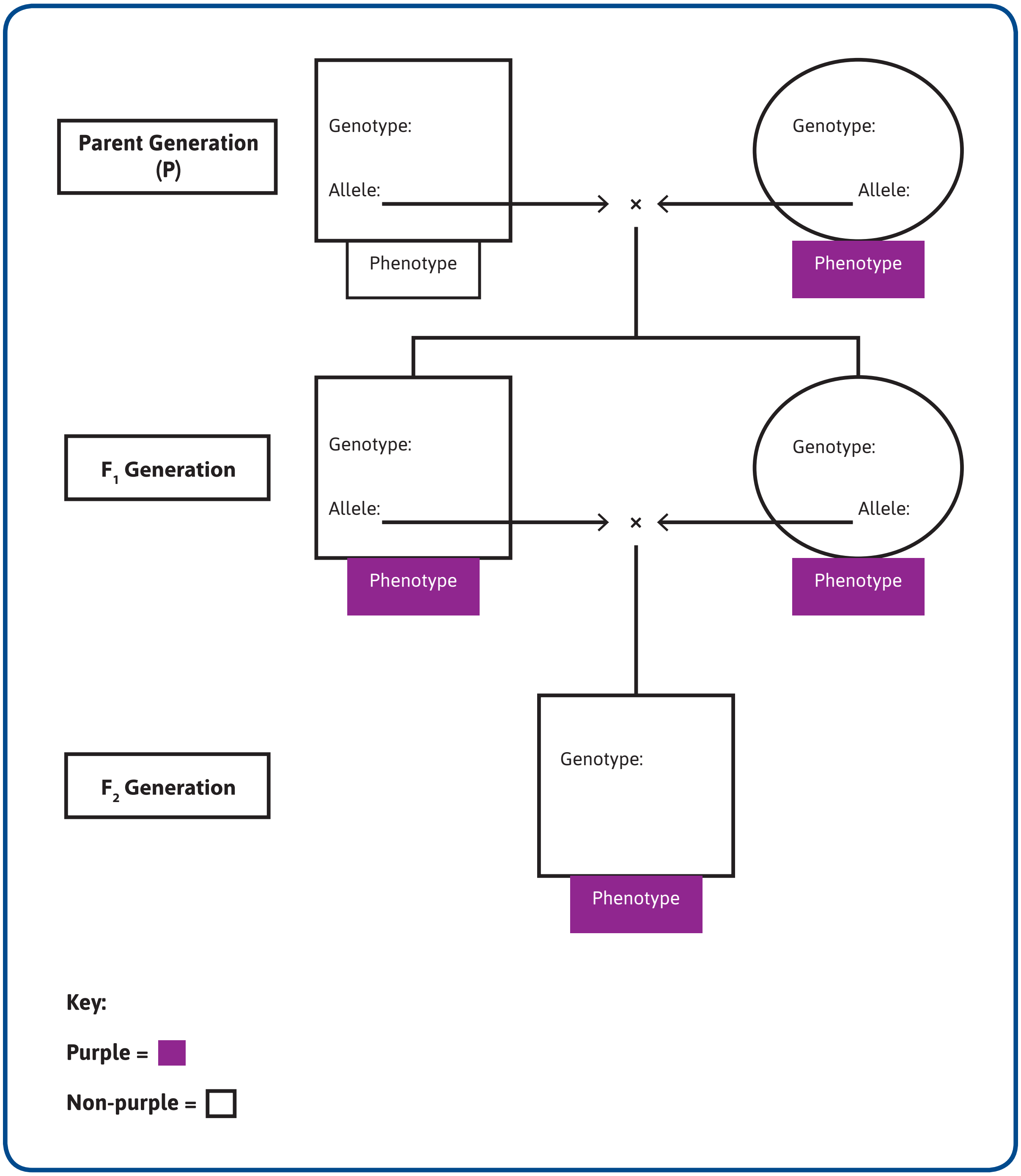


1. Does the model account for the data? Yes No

2. If not, where does it fail and why?

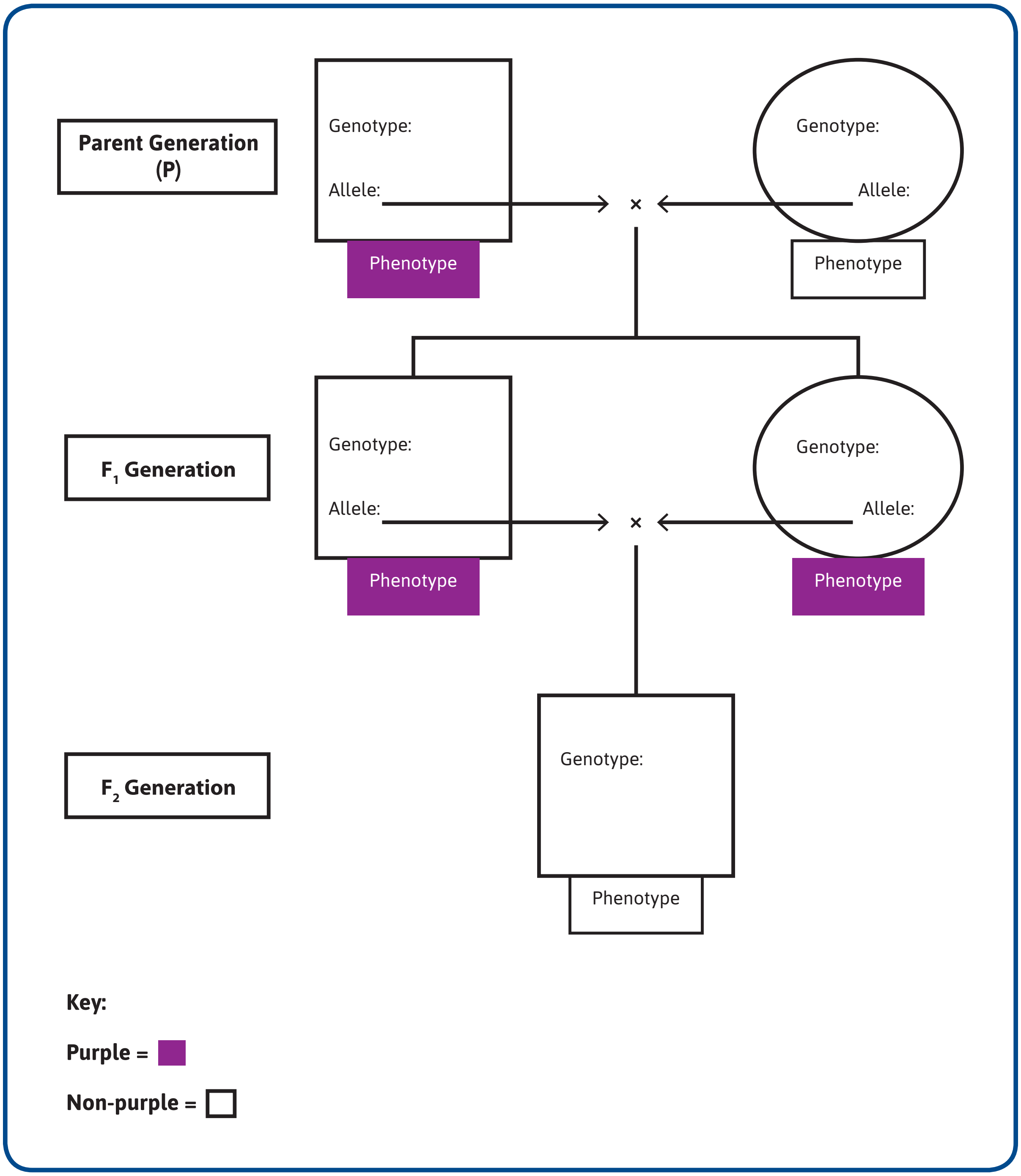
Group C & F

Model 2



1. Does the model account for the data? Yes No
2. If not, where does it fail and why?

Group C & F
Model 2



1. Does the model account for the data? Yes No
2. If not, where does it fail and why?

Making Sense

1. Using the information you have collected about your models, construct an evidence-based explanation to answer the following questions:

    a. How can two plants that look the same on the outside produce offspring that look different from them?

    b. Why can two non-purple plants not produce offspring that do not look like them?

Reading 6.2 – Models: Using Models to Decide between Possible Explanations

Getting Ready

In class, you have been working on a model to test out your ideas about how heredity works. You may have wondered, how can I make a model if I am not sure yet how this should work? Constructing models is one way scientists have for working out their ideas, sharing them with each other, and seeing whether they can find the evidence. How do scientists do this?

What Is a Model?

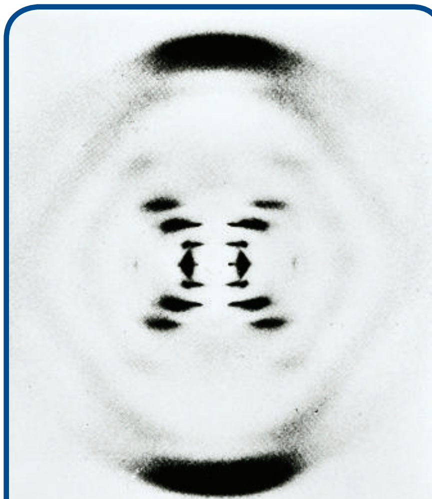
If you have studied other IQWST units, you may have had a chance to work with many models, such as constructing a model to understand how light interacts with objects, making a model to show how odors can travel across a room, using a computer model of an ecosystem to explore predator-prey interactions, and perhaps making a model to explain how storms work.

Now you are using a model to test your ideas about how heredity works. This way of using models is a little different from what you have done in earlier units. In the earlier units, you developed models to fit your data, and revised them when you learned more from your experiments. With the heredity model, you are using the process of developing a model to help think through and compare possible explanations. This is an important use of models by scientists—not only to capture what they already figured out to show others, but also to help them decide between possible explanations.

In the reading in Lesson 5, you read how scientists figured out that DNA was the only substance capable of storing the information needed to create a living being. Somehow DNA carried the instructions for traits. But, what did it look like? How did it carry out the incredible function of heredity? In this reading, you will learn more about the discovery of the secret of heredity.

How Was the Secret Discovered?

The search for answers continued. In the early 1950s, Rosalind Franklin's photographic skills laid the groundwork for revealing the secret. Using an x-ray device, she was able to actually take a picture of a DNA molecule. Her photograph was instrumental in the discovery of what DNA is.

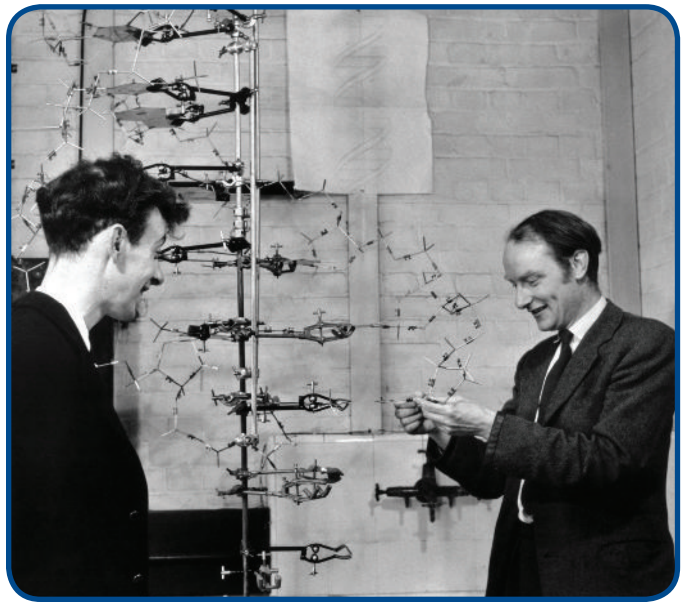


Rosalind Franklin's
X-ray diffraction photograph of DNA

Maurice Wilkins, a co-worker of Franklin's, gave Franklin's x-ray data to James Watson and Francis Crick. Watson and Crick were two scientists who were trying to unravel the heredity secret. Using the data, as well as having an understanding of all of the research on genes that had developed in the past 150 years, Watson and Crick constructed a Tinkertoy™ model of DNA. Tinkertoy™ was a popular construction set with children during this time. They constructed the two-strand shape, with each strand a template for reproducing itself. Once they understood the shape, they were able to discover how it worked. Finally, in 1953, Francis Crick was able to exclaim, "We found the secret of life!"

Why Models Change

Like Watson and Crick, scientists use reasoning with models to compare possible explanations, test their hypothesis, and to predict future events. Professor Warren Porter from the University of Wisconsin at Madison is studying how climate change may affect populations of animals. In the IQWST LS1 unit you may have gathered data on individuals in order to understand what was happening to the trout population. Professor Porter is doing that as well. He is gathering data on individual animals like their behavior, genetics, and body shape. Using a computer model, Professor Porter puts the information into a computer to build a model that will describe how well the population can survive, grow, and reproduce when its environment changes.



Professor Porter is testing his model in different locations with different animal populations. When talking about his models, he stated, "We are constantly testing them." The tests have already led to a deeper understanding of how climate change will affect some populations' chances for survival.

How is what Professor Porter is doing with his model, similar to what you are doing with your model of inheritance?

Lesson 7

Extending and Applying the Model of Inheritance

ACTIVITY 7.1 – EXTENDING AND APPLYING THE MODEL OF INHERITANCE

What Will We Do?

We will determine if the model of inheritance can be applied to human data.

Procedure

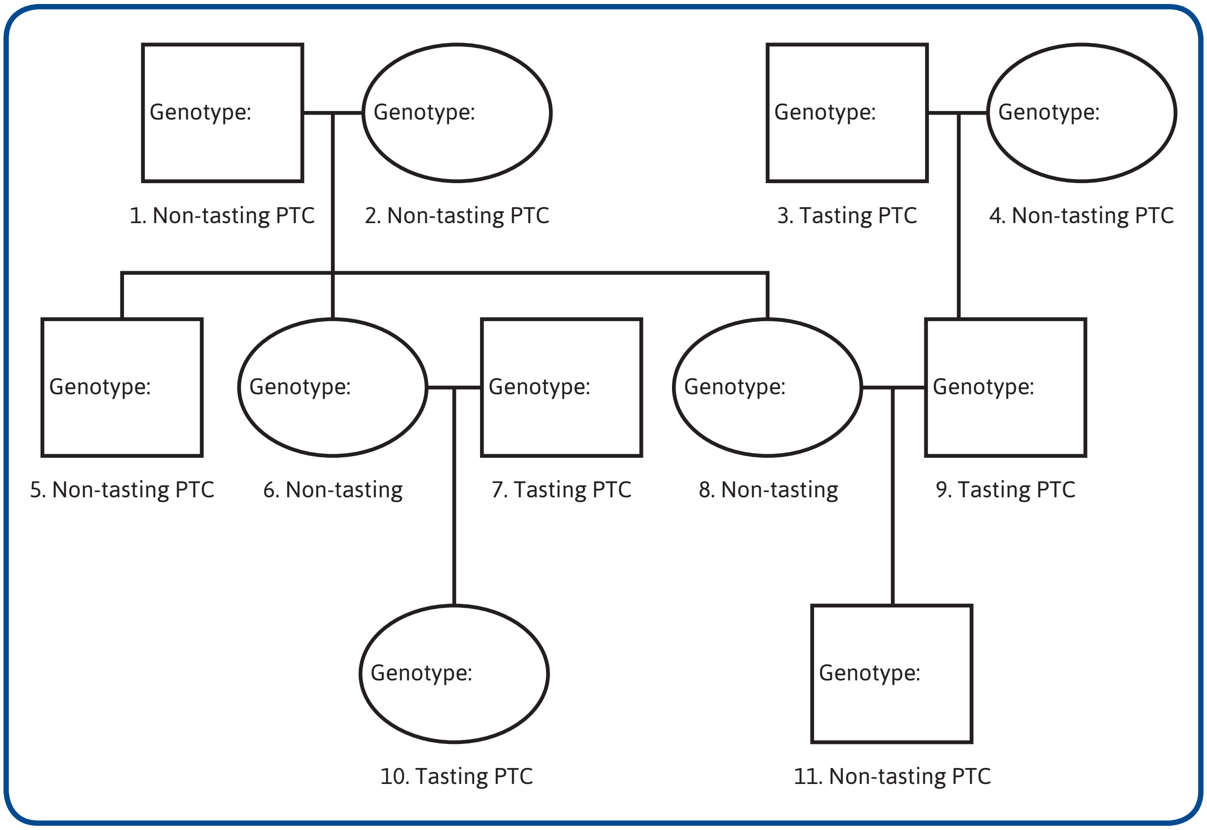
1. Fill in the following chart with the information for PTC tasting, so that it follows the rules for Model 2 from Activity 6.2. Use the information for tasting PTC and non-tasting PTC that your teacher put on the board.

Genotype (Instruction)	Phenotype (What You See)

Key: t = allele for tasting PTC, nt = allele for non-tasting PTC

2. Your teacher will assign you group either Pedigree 1 or Pedigree 2.
3. Using the Pattern and Evidence Chart, find the patterns on your pedigree that you need to explain. Write the genotypes for each individual on the pedigree.
4. Answer the Making Sense questions.

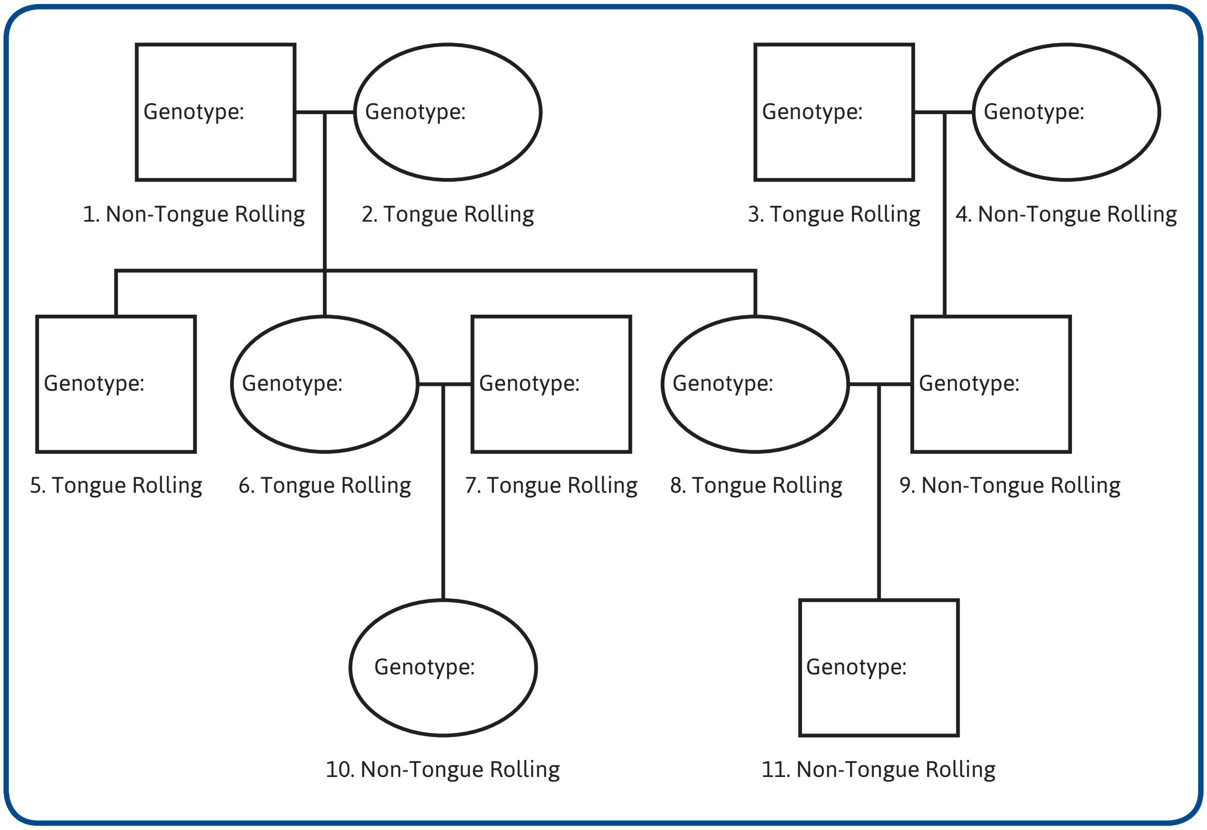
Pedigree Family 1



Making Sense

1. Did the model work? Were there any parts of the pedigree that the model could not help you explain? Circle these and describe what the model could not explain.

Pedigree Family 2



Making Sense

1. Did the model work? Were there any parts of the pedigree that the model could not help you explain? Circle these and describe what the model could not explain.

ACTIVITY 7.2 – INTRODUCING ALBINISM

What Will We Do?

We will explain how some variations are dominant over others.

Procedure

1. Fill in the following chart with the information about albinism so that it follows the rules for the model on which the class has agreed. Use the information for having albinism that you discussed in class to help fill in the model.

Genotype (Instruction)	**Phenotype (What You See)**

Key: A = Allele for not having albinism, a = Allele for having albinism

2. Based on the discussion in class and what you know about how traits are passed from parents to offspring, answer the following questions:

   a. How can two non-albino parents have an albino child?

   b. Why is only one allele enough to make a person non-albino? What is happening inside the organism?

Reading 7.2 – Which Instructions Get Followed?

Getting Ready

Have you heard someone in your family talking about needing to lower their cholesterol? Maybe their doctor has told them to get more exercise and eat foods with less fat. Commercials on television encourage people to eat foods that will help lower cholesterol like the oatmeal in the picture. Maybe you have an aunt or uncle who is very careful about what they eat and also takes medicine, so that their cholesterol level does not go up. Below is the pedigree of Sam's family that you saw in Lesson 3. Use what you have learned about dominant and recessive genes to explain how Sam has sickle cell disease when neither of his parents does.

List three things you know or have heard about cholesterol.

Cholesterol is a fatty substance found in the blood. There are two kinds of cholesterol in the body. You may have heard them called good cholesterol and bad cholesterol. Your body needs cholesterol to make cell membranes. It also needs the good cholesterol to help get rid of the bad cholesterol from the body. But, some cholesterol gets stuck to the walls of veins and arteries as it is being moved through the body. That is the bad kind. This can cause arteries to block and not let the blood through.

What Does This Have to Do with Genetics?

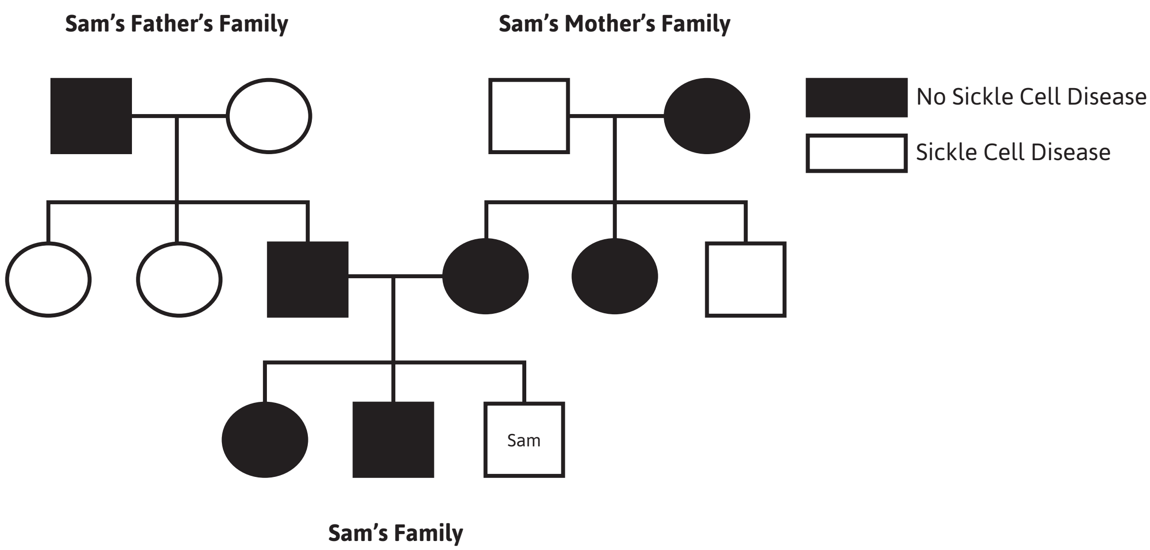
If cholesterol comes from the food you eat, what does that have to do with genetics? There is a second place from where it can come—the body. The body produces cholesterol in the liver. The body can also get rid of the bad cholesterol that it does not need. The instructions for the body to do this are carried on a chromosome.

You have learned that the instructions for everything in the body are located in the nucleus of the cells on the chromosomes. There are two alleles for every trait. In the cholesterol example, each allele carries instructions for getting rid of the bad cholesterol. In this lesson, you learned about dominant and recessive alleles. When the two alleles do not agree, sometimes the instructions of one allele are the ones that are followed. That is the dominant allele. In the case of cholesterol, the allele with the instructions not to get rid of the bad cholesterol is the dominant one. You only need one allele to produce that phenotype of the trait. Almost one in every 500 people has the dominant allele that causes the body to have high levels of the bad cholesterol. Therefore, while high levels of cholesterol can come from the foods you eat, the body's ability to get rid of the bad cholesterol is inherited from your family.

Another Example of Dominant and Recessive

In Lesson 3, you read about Sam, the boy with sickle-cell anemia. You learned that sickle-cell anemia is a disease that is inherited. But, neither of Sam's parents had the disease.

Sometimes the dominant gene, in this case the gene that produces non-sickle blood cells, is not completely dominant over the recessive gene. Both alleles give instructions for how cells are formed. If a person inherits both recessive alleles, then they inherit the disease, and their body makes only sickle cells. An individual must get the instructions to make sickle cells from both parents. An individual that has one of each kind of allele has blood cells of both types: sickle cell and normal. This kind of dominance is called co-dominance. The prefix co- means together, like in the word *cooperate* (work together). In the case of alleles that are co-dominant, they both produce phenotypes in the individual, but neither one are completely dominant.



Look at the pedigree of Sam's family that you saw in Lesson 3. Use what you have learned about dominant and recessive genes to explain how Sam has sickle cell disease when neither of his parents do.

Lesson 8

Variations, Variations, and More Variations

ACTIVITY 8.1 – WHAT DO I DO WITH ALL THIS DATA?

What Will We Do?

We will collect, represent, and analyze data on a trait that has more than two variations.

Procedure

1. In your group, measure each member's height in centimeters (cm). Your teacher will give you instructions on how to do this.

2. Record each member's height in the *Our Group* column of the data table.

3. Share your data with another group so that you have a larger amount of data. Your teacher will tell you which group.

4. When you have gathered the data, try to represent your data as a graph to show how your group varies in height. Remember, you cannot just make a table of the number of yes/no as you did with tongue rolling and PTC tasting.

Data

Our Group

Subject	Height

Other Group

Subject	Height

Graph

Representation Type	Evaluation

Making Sense

1. Look at your graph. Do you think that this type of representation would be useful when you have a larger amount of data to include? Why?

2. Describe one strength of this type of graph in representing large amounts of data. See Chart for suggested answers.

ACTIVITY 8.2 – HOW CAN WE SHOW RANGES OF VARIATION?

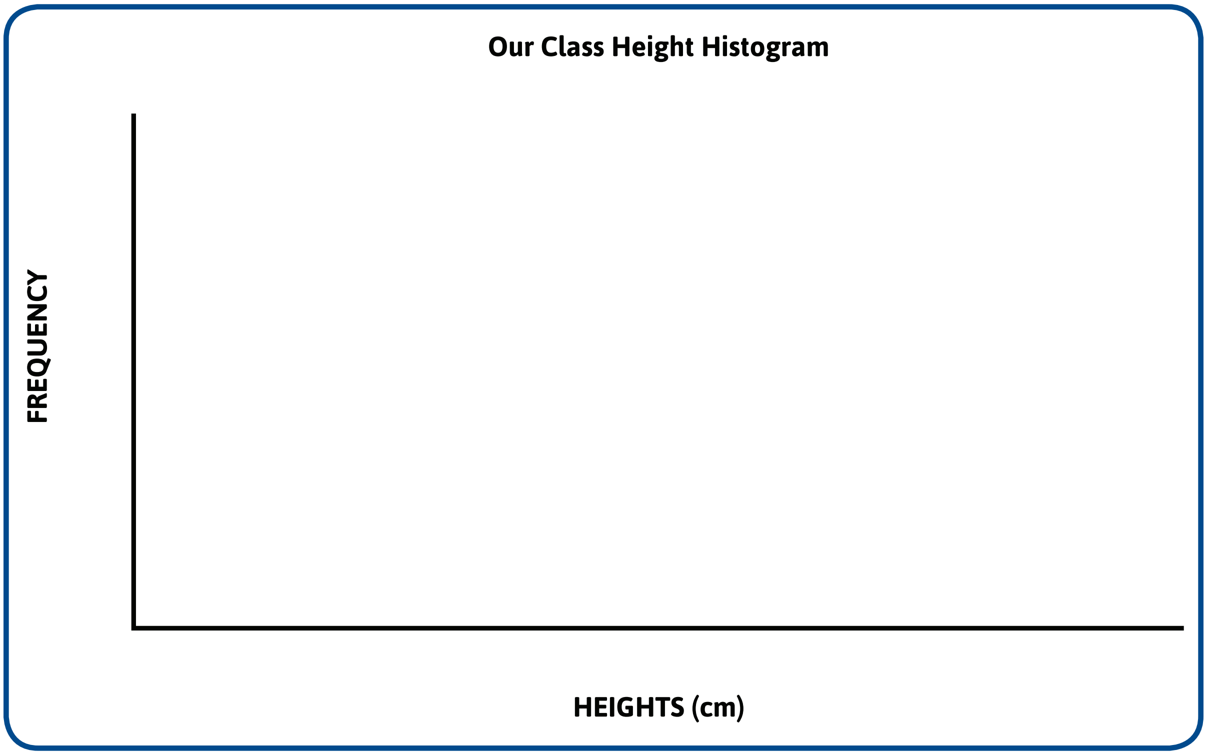
What Will We Do?

We will create histograms of the height trait and compare data across histograms.

Procedure

1. Work with your teacher to create a class histogram of height in your class. Copy the class histogram in the following chart.

Our Class Height Histogram



2. After creating your class histogram, you focused on comparisons that you could make about a population of 8th-grade students. The following data is from an 8th-grade class. Create two histograms so that you can compare the graphs to analyze the question, is there a difference in the height of 8th-grade boys compared to 8th-grade girls?

Remember

- Calculate the range of the data and divide it evenly into bins.
- The ranges of data (the bins) must be the same on both histograms in order to be able to compare the data.

Prediction

I think the trend on the Lincoln Middle School histograms will show that the concentration of boys are ____________ the concentration of girls. (Circle the phrase to fill in the blank with your prediction.)

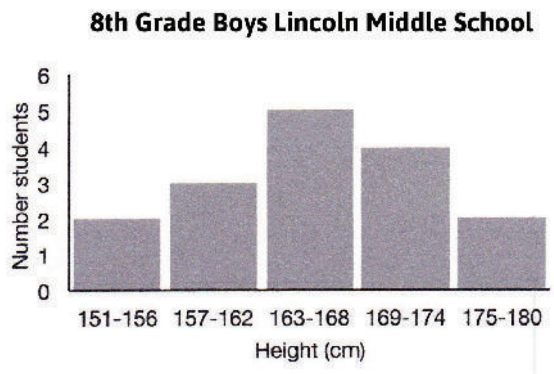
to the left of	to the right of	the same as

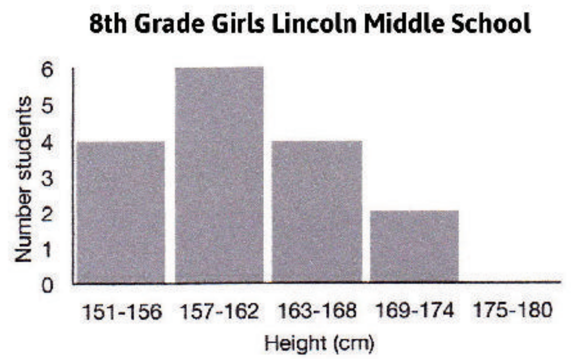
Data

Lincoln Middle School 8th Grade Student Height

Girls		Boys	
Subject	Height (cm)	Subject	Height (cm)
1	151.0	1	155.0
2	153.0	2	155.5
3	153.5	3	157.0
4	155.0	4	158.0
5	158.0	5	160.0
6	159.0	6	163.0
7	160.0	7	164.0
8	160.5	8	165.0
9	161.0	9	165.0
10	162.0	10	166.0
11	163.0	11	169.0
12	163.5	12	169.5
13	165.0	13	170.0
14	166.5	14	172.0
15	170.0	15	176.0
16	171.0	16	176.5

Histograms





Making Sense

1. Was your prediction correct? What evidence do you have to support your prediction?

2. Where was the concentration of boys compared to the girls on the histogram for your class and Lincoln Middle School? (Circle the position of concentration of boys to the concentration of girls.)

Class histogram	to the right of	to the left of	the same as
Lincoln histogram	to the right of	to the left of	the same as

3. What does this position mean?

4. From the evidence you collected about the comparison of girl height to boy height, what can you conclude?

5. Besides differences in the heights, what else was different between the boy and girl data in Lincoln Middle School? Does that change the results?

Homework 8.2 – Who Uses Social Networks More?

What Will We Do?

We will create histograms of Facebook© usage over a thirty-day period and compare data across histograms.

Procedure

1. Imagine that you want to do a science project to answer the question, who used Facebook© more often in a month—males or females?

2. You have done your research. The following chart shows what you have found out about Facebook users by age and gender.

Estimated Number of Facebook© Users (Dec., 2010)

Age	Male	Female
13-17	6,646,820	7,719,380
18-25	23,004,960	27,048,020
26-34	13,588,320	15,577,380
35-44	10,216,440	12,775,140
45-54	6,915,900	10,176,980
55-64	3,982,340	6,301,480

Source: http://www.kenburbary.com/2011/03/

3. Use the chart to make two histograms (one for males and one for females) displaying this information so that you can compare the data.

4. Answer the Making Sense questions to analyze your data.

Histograms

Making Sense

1. a. Overall, who uses Facebook© more—men or women?

   b. What is your evidence in the histogram?

2. Which age group has the greatest difference between men and women Facebook© users?

3. Write a short conclusion statement about what your two histograms have revealed about your question.

ACTIVITY 8.3 – VARIATION EVERYWHERE, SO WHAT?

What Will We Do?

We will identify traits in organisms that have more than one variation and then analyze data about the frequency of occurrence of those traits.

Your teacher will project these images in color so that it is easier to see how the traits vary between individuals.

Part 1: Identifying Traits

Procedure

In groups, use the following tables to note the traits and variations that can be observed in each picture.

Organism	Trait	Variations
		

Organism	Trait	Variations
		

Organism	Trait	Variations
		

Making Sense

1. What are some traits that you think could be used to tell these individuals apart?

2. Which of these traits do you think are probably inherited?

3. Are there any other factors that might be influencing these traits?

Part 2: Analyzing Trait Data from Histograms

Procedure

1. Examine three different populations and analyze data about those populations.

2. As you read and examine the data, consider why that graphic representation was used to display the data.

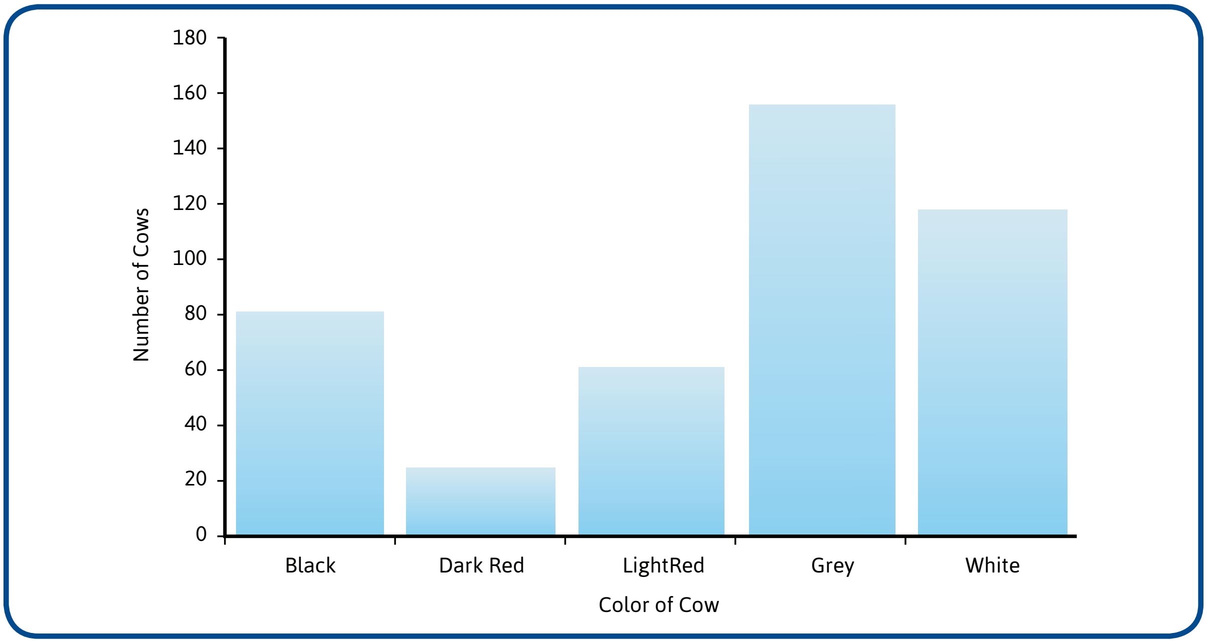
Charlolais cows are on the left. On the right is a Holstein cow.

Case 1 – That's a Cow of a Different Color

It may not be surprising to you that cows, just like dogs, can be found in different breeds. People tend to use different breeds of cows to produce different food products. For example, Holstein cows are raised for their milk, and beef cows in England are known as Charolais cows. Each of these cows looks fairly similar but demonstrates variations in their traits. Holstein cows tend to be white with black spots and Charolais cows can vary in color from white to cream. Some scientists were interested in understanding the relationship between a cow's genes and the color of its coat. In order to understand this relationship, the scientists examined cows that resulted from breeding Charolais and Holstein cows together. They tracked the colors of a population of 436 cows. They classified the cows into five different colors. They then determined how many cows was each color. The information they gathered is shown in the following table.

Data Table

Color	Number of Cows (population of 436)	Percent of Cows (population of 436)
black	80	18.4
dark red	24	5.5
light red	60	13.8
grey	155	35.6
white	117	26.9



Making Sense

Answer the following questions based on the data gathered on cows.

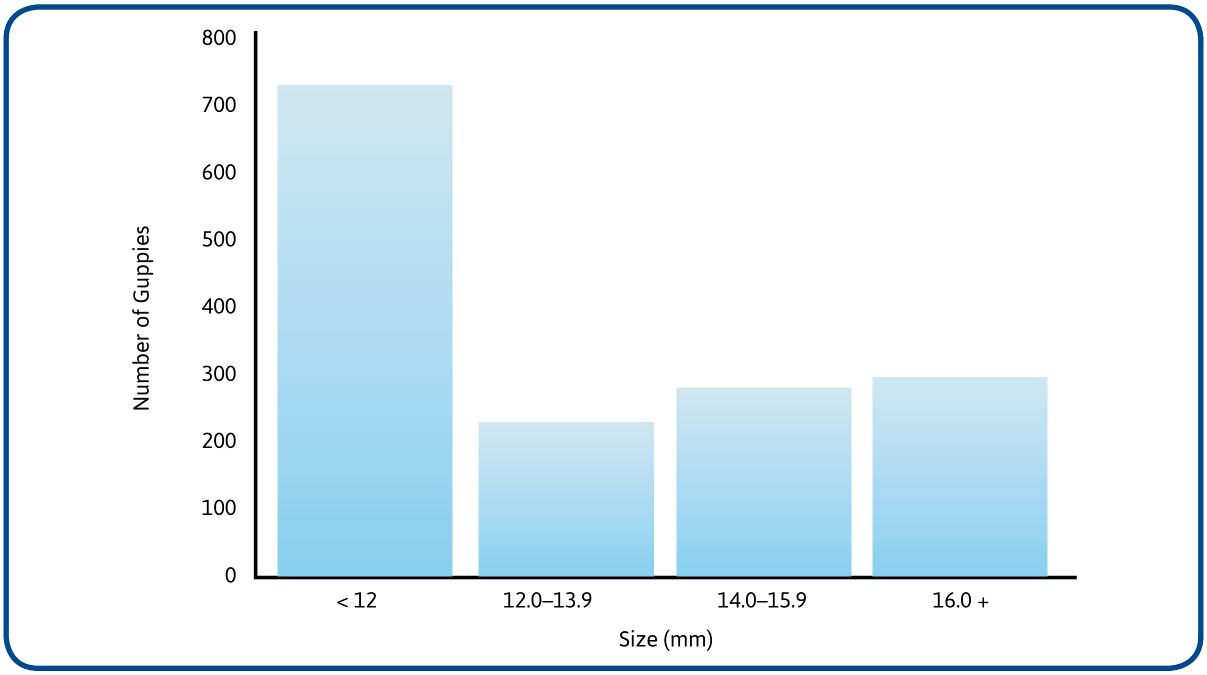
1. a. What type of graph is this?

   b. Why is this a good graph to represent these data?

2. What do these data show?

Case 2 – Guppy Size

A group of scientists were interested in environmental factors (such as number of predators, water quality, and water temperature) that affected the size of guppies in local ponds. In order to understand these factors, the scientists first looked at the sizes of the guppies found in 14 different ponds. The data for the total number of guppies of each size is found in the following graph.



Making Sense

Answer the following questions using the graph about guppy size.

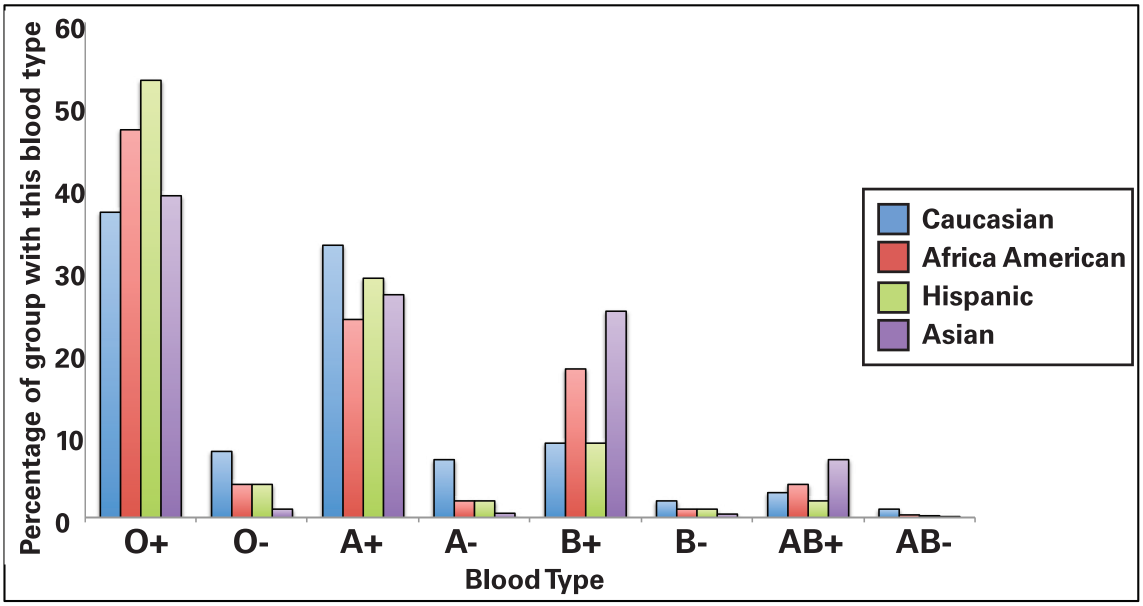
1. a. What type of graph is this?

   b. Why is this a good graph to represent these data?

2. What do these data show?

Case 3 – Blood Donations

Nearly 5 million people every year receive blood transfusions that save their lives (Source: Medline Plus, NIH). Getting blood that will save your life is not as easy as asking someone to make a donation. People actually have variations in the kind of blood that they have. Doctors identify this variation by blood type. During a blood transfusion, receiving blood that is a different type than your own could have very bad results. Organizations like the American Red Cross collect all different kinds of blood so that it is available when people need it. The following graph shows the percentage of people in the United States who have each blood type.



Making Sense

1. What can you learn about the variation of blood in people from this graph?

2. Why do you think the graph uses percentages of each ethnic group rather than actual numbers?

3. Why is it useful to show the ethnicity of people who have each blood type on this graph?

4. What other information or categories could they have used?

Making Sense

Think about all of the data with which you have worked in this entire lesson to answer the following questions:

1. What are some things you have to consider when you are deciding how to represent data on traits?

2. You have now analyzed variations for people, guppies, flowers, snails, and cows. Pick one example of a trait that you discussed in class. Explain why an organism with one variation of a trait would have an advantage for survival over an organism that had a different variation of the trait.

ACTIVITY 8.4 – HOW DO GENES WORK FOR CONTINUOUS TRAITS?

Reading 8.4 – Height—Unraveling a Genetic Puzzle

Getting Ready

Jaylee stomped into the house and expressed her frustration to her family, "I hate being tall!"

"Why would you complain about being tall?" asked her older brother Matt, who is shorter than Jaylee. "I am always in the back row for everything!" she exclaimed.

"Yeah?" he said, in an equally frustrated tone, "I have to be in the front row for everything!"

What might be the reason that a brother and sister are such different heights, or that an older brother might be shorter than his younger sister?

In class, you collected and analyzed data on height. Height is one trait that scientists have studied for a very long time. However, height is a trait that they know very little about. Height, you have learned, has many variations due to the fact that more than one gene influences the trait. Scientists do not know how many genes affect height, but it may be several, maybe even as many as 20. They know that more than one region of DNA may affect height, but they do not know yet things like why, in general, men are taller than women. Scientists have also identified environmental factors that can affect height, such as nutrition.

Even in one family, people can be very different heights, as in the Getting Ready of this reading. Perhaps the mom had very different medical care or eating habits from one pregnancy to the next. Doctors know that medical care and nutrition affect the health of a baby. To what extent do those things also affect how genetic material is expressed? In order to learn more about the effects of the environment on traits, scientists often study twins.

More about Twins

Identical twins are offspring that come from a single egg, fertilized by a single sperm, so they have exactly the same DNA. Fraternal twins result from two different eggs being fertilized by two different sperm. Fraternal twins' genetic material is like that of any other brother and sister, but the offspring are born at the same time.

Scientists often look at identical twins when they want to study the effects of environment. Because both have the same genetic material, if one develops a disease that the other does not develop, the role of environment can be studied more carefully. Scientists look at fraternal twins for other reasons. Because twins' environment in the womb was similar, and their environment after they are born is similar, studying twins lets scientists focus on their genes more closely. The environmental factors are never exactly the same, but they are close, given that the twins were conceived, born, and raised at the same time. Certainly the environmental factors are closer than the factors between siblings born at different times.

Scientists have looked at many pairs of twins to look for patterns in their genes. They learned that an important DNA region for height is on one chromosome, and other significant regions for height are on other chromosomes. They have narrowed their search down to a small number of regions. Now that those key regions have been identified, scientists can focus on finding the primary gene (or genes) associated with height. With all of the traits that could be studied, you can imagine that scientists who study genetics will be asking (and answering) important research questions for many years to come.

Think about what you have learned about meiosis, the gametes produced, and its offspring. Why would fraternal twins have different DNA?

Think about Jaylee and Matt and how you explained their height difference. After reading, what can you add to make your explanation more complete?

Do Variations between Individuals Matter?

ACTIVITY 9.1 – THE CASE OF THE PEPPERED MOTH

What Will We Do?

We will learn about the peppered moth's characteristics and about the problem.

Procedure

1. Read the following information to learn about the peppered moth.

2. Answer the Making Sense questions.

Peppered Moth Background Information

Species name: Biston betularia

Variations

This photograph shows the two variations of the peppered moth—the Typica variation on the left and the Carbonaria variation on the right.

Food Sources

During the time that the moths are caterpillars, they eat plants. The adults rarely eat. They only drink nectar to keep a balance of water in their systems. That is all they need, since they do not live long as adults.

Behavior

During the day, moths usually rest on trees. They can sometimes be found on the underside of branches or on the tree trunk right below a branch, where they are in the shadow of the branch. At night, the males fly around looking for mates. The females fly on their first night after hatching. After that night, they do not fly around much and usually rest on trees. They try to attract mates by releasing pheromones. Pheromones are special chemicals that the males can detect. A female lays about 2,000 eggs in cracks in the bark of trees.

Predators

When the moths are resting, woodland birds such as jays, woodpeckers, sparrows, and others prey on them. At night, when they are flying around, their main predators are bats.

Life Cycle

The peppered moths have one generation of offspring per year. Females lay the eggs and they hatch into caterpillars. The caterpillars become pupae and spend the winter in the soil. They emerge as adults in May and usually live until the end of August.

History

- 1800s – During the first half of the nineteenth century, peppered moths and other species of moths were studied by naturalists in Britain. The typica peppered moth was the only form that was observed for many years.

- 1848 – The first black form of the peppered moth was found in Manchester, England. They gave it the name carbonaria. They did not know it was the same species as the typica peppered moth they had seen earlier.

- 1850s—The carbonaria, or black type, of the peppered moth was rare but beginning to be noticed by the naturalists. Scientists discovered that the carbonaria and the typica moth are variations of the same species, the peppered moth.

- 1895 – By this time, 98% of all peppered moths caught were the carbonaria form. The typica, or light form, of the moth had become very rare.

Making Sense

1. Scientists had identified a pattern in the moths that they thought was important. What was that pattern?

2. The class identified several factors that could affect populations. One of those factors was abiotic. What are some abiotic factors that you think could be affecting the moth population. Brainstorm and list as many as you can.

3. Other organisms were another factor. What kinds of changes in other populations of organisms could be affecting the moths?

ACTIVITY 9.2 – HOW DOES VARIATION MATTER?

What Will We Do?

We will analyze data about the peppered moth in order to figure out what caused the change in the population.

Procedure

1. Your teacher will assign your group one of the studies in this activity. Circle or highlight the number and title of the study that your group is assigned.
2. Carefully read the study your group is assigned.
3. There is a chart on the last page of the activity sheet. Find the row for your study and summarize the patterns you found in the data. Record your interpretations of the data in the last column.
4. When your group has finished, jigsaw with people from each of the other studies. Record their information in the chart at the end of the activity. When you finish, you should have information about each of the studies.
5. Take detailed notes about what the other groups discover. You will need all of the information in order to write an evidence-based explanation in Activity 9.3.

Studies of the Peppered Moth

Beginning in the 1950s, scientists began to study the peppered moths. Their goal was to figure out why the carbonaria form of the moth had become more frequent than the typica peppered moth during the late 1800s. Before that time the carbonaria form had been very rare.

Biologists had some hypotheses about what might have been going on. The next sections contain four collections of studies. The studies look at different types of interactions between the moths and the abiotic and biotic factors in their ecosystem. These studies provide clues that can help figure out why the populations of peppered moths have changed over time.

The four studies and the questions they are trying to answer are:

1. Pollution – Does pollution have anything to do with the proportions of the carbonaria and typica peppered moths? There are two studies for this question. Each one will be assigned to a different group.

2. Predation – Do birds prey on one variation of the peppered moth more easily than the other?

3. Pollution reduction – How did the proportions of carbonaria and typica moths change in the last 50 years?

4. Inheritance – Is the color of the moth inherited, or is it something that happens to the moth due to its environment?

1. Pollution Experiments

Research Question: Does pollution have anything to do with the proportions of carbonaria and typica peppered moths?

A major change in the environment in England was underway in the 1800s caused by the Industrial Revolution. Population sizes in urban centers were increasing dramatically. Coal was now being used in homes and in factories. Smoke, sulfur, and other pollutants from the coal were common in the industrial areas. Pollution was also high in urban areas where many people used coal in their homes for heating and cooking.

The woods near these urban and industrial areas also suffered. Tree bark became blackened with soot, and many of the lichens that grew on trees in the woods died. Scientists wondered if somehow the increased numbers of carbonaria had something to do with the observation that the woods were becoming polluted.

Pollution Study #1

To investigate this idea, scientists compared the proportion of carbonaria and typica peppered moths in different parts of England.

Method

Data were gathered from woods in England during the spring and summer when the adult form of peppered moths is active. To count insects that are active at night, like the peppered moth, scientists set up traps called light traps. The moths fly toward a bright light above a box with a small opening and get caught in the box. The next morning, the scientists collected the moths, classified and counted them, and then released them. The scientists set up the traps for several nights. They collected at least 25 moths and sometimes as many as 300.

Scientists collected the data from three different areas of England.

- Industrial – These areas had the greatest concentration of industry. The nearby woods also showed the most pollution, including darkened bark of trees and loss of lichens on trees.
- Intermediate – These were urban areas with less industry. However, they showed evidence of pollution from the use of coal in homes.
- Rural – These were areas away from the industry and cities and were relatively pollution free.

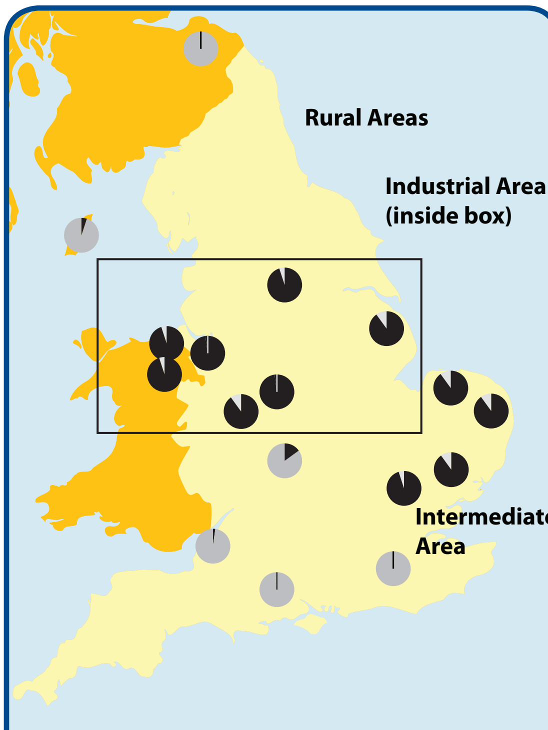


Fig. 1: Proportion of carbonaria and typica peppered moths in different areas of England 1952–1956

Results
The data for each site are shown as two-color pie charts on the map.

- Dark Grey = the proportion of carbonaria (dark colored) moths
- Light Grey = the proportion of typica (light colored) moths

Making Sense
What can you conclude from this pollution experiment? On the chart at the end of this activity sheet, summarize the evidence and record your interpretation. How can this evidence help explain the population change in the peppered moth?

Pollution Study #2

The scientists studying the peppered moths wanted to investigate whether the pollution affected the plants and other organisms where the moths lived. If other organisms and plants were affected by the pollution, they wanted to see if that was connected to the increase in the carbonaria moths. Because sulfur dioxide is given off into the air when coal is burned, scientists tested the amount of it in the air in many different areas. They also examined the organisms in the area and the frequency of carbonaria versus typica moths in these same locations. They looked for a pattern between these three variables: amount of pollution, growth of organisms, and relative proportions of carbonaria versus typica.

They collected data to answer two questions:

- Does the amount of pollution affect the lichens and trees?
- Is the type of lichen on trees related to the types of moths found there?

The results of the experiments to answer these two questions are reported in the following graphs.

Results
Does the amount of pollution affect the lichens and the trees?

Scientists found a high correlation between the amount of air pollution (sulfur dioxide) and the growth of lichen on the trees.

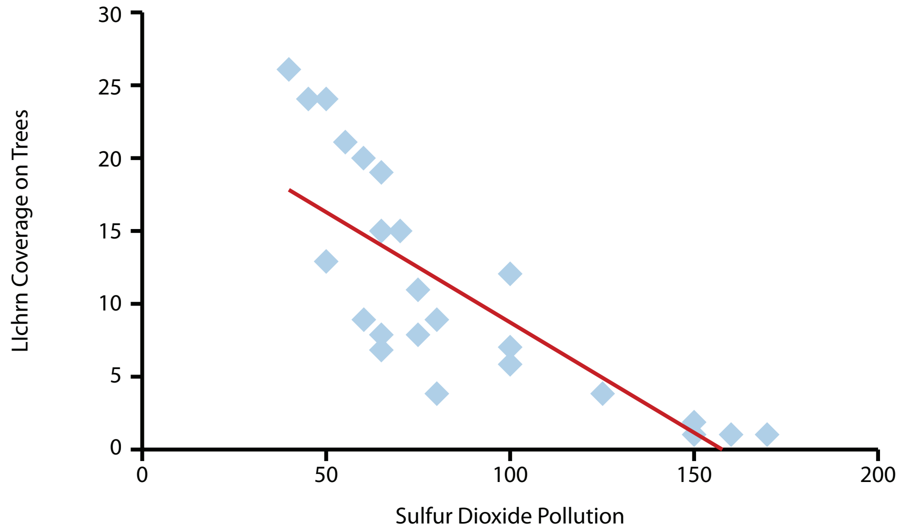


Fig. 2: The effect of sulfur dioxide pollution on the lichen coverage on trees. Each blue point shows a different site in England with varying degrees of pollution. The red line is the best-fit line through the center of the data points.

Is the type of lichen coverage on trees related to what types of moths are found there?

Scientists again found a high negative correlation between the amount of lichen coverage on trees and the proportion of peppered moths that were the carbonaria rather than the typica variation.

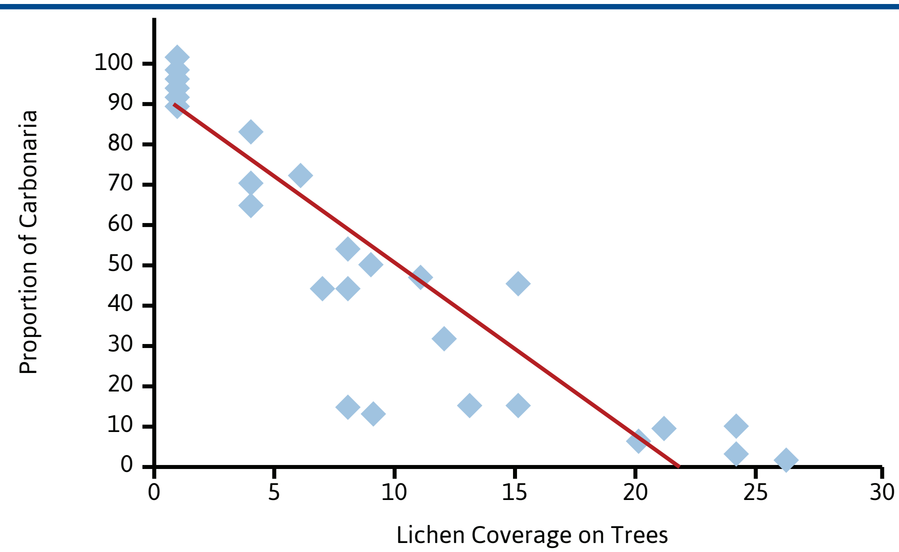


Fig. 3: The relationship between the lichen coverage on trees and the frequency of carbonaria peppered moths. Each blue point shows a different site in England with varying degrees of lichen coverage. The red line is the best-fit line through the center of the data points.

Making Sense

What can you conclude from these two pollution experiments? How can this data help explain the population change in the peppered moth? On the chart at the end of this activity sheet, summarize the evidence and record your interpretation.

2. Predation Experiments

Research Question: Do birds prey on one variation of moth more easily than the other?

Scientists were excited by the findings that pollution influenced the plants that grow on trees where peppered moths rest during the day. They wondered whether the carbonaria and typica moths might differ in how easily predators could find them in polluted woods. It was difficult to test this idea through observations, so scientists tried a number of different kinds of experiments.

Predation Experiment #1: (1953–1955) Methods

One method was to compare what happened to moths in two different woodlands. One was heavily polluted (Birmingham) where the trees were almost totally free of lichens. The other was a non-polluted woodland (Dorset). In each location, they tried two methods. One method involved observing the predation on the moths. In the second, live moths were marked so that they could be identified. They were then released, and later, the survivors were counted.

Results

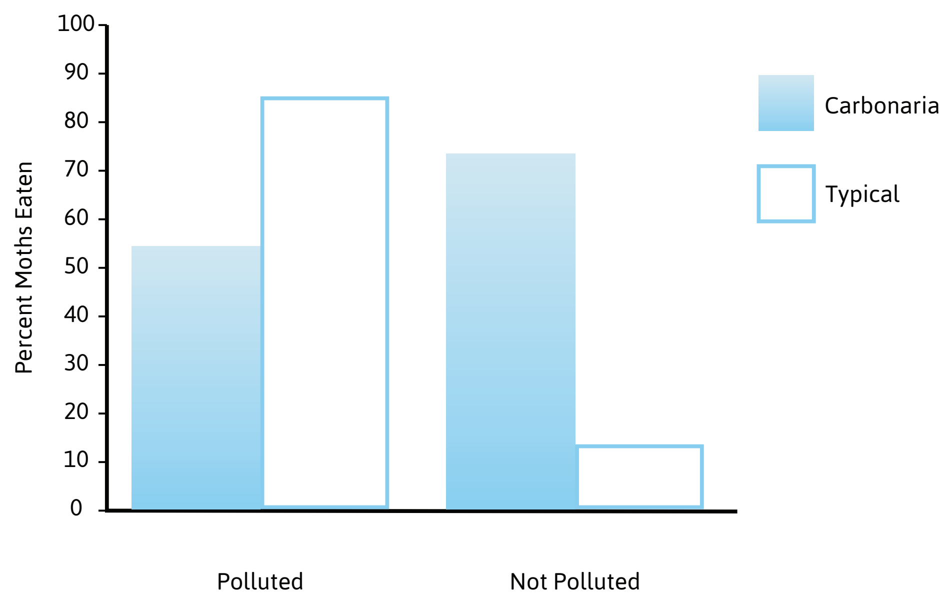


Fig. 4a: Did the birds eat carbonaria or typica moths?

Observed Predation Method

- Released live moths of each form in early morning in trees.

- Observe birds eating moths during the day

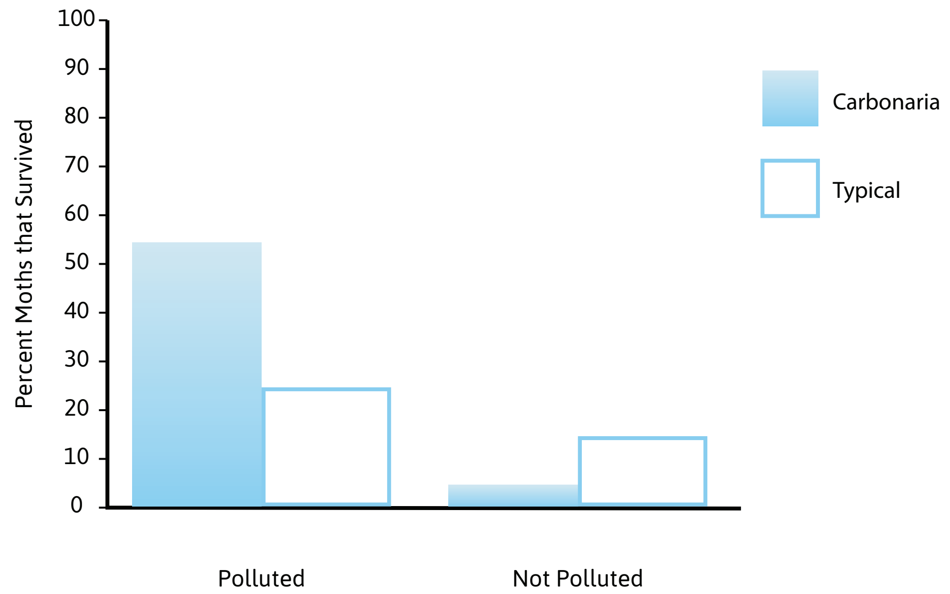


Fig. 4b: What proportion of moths survived?

Recapture Method

- Mark and then release live moths of each form early in the morning.

- Collect moths over the next few evenings in traps.

Predation Experiment #2: (1975)

Another method scientists tried to determine if predators could find one type of moth more easily than another, was to place moths on trees and collect them later. They could see which ones were missing, and therefore, may have been eaten.

Method

Scientists placed dead moths on trees in the places moths would normally rest. They put moths on various trees using approximately the total numbers that would normally occur. The scientists thought that since moths do not move from their resting positions on trees during the day, the number taken by predators would be similar to what would happen naturally. Scientists used wooded sites in more polluted and less polluted locations and compared them.

Results

Did the predators prey on the two variations of moths equally?

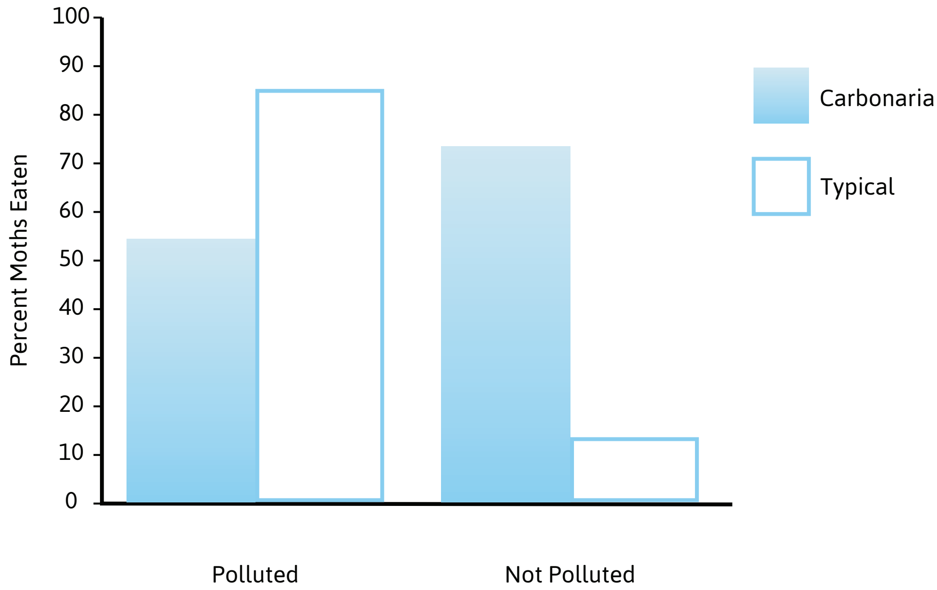


Fig. 5: The graph shows the proportion of peppered moths of each type that were eaten by predators. Two different groups of sites are shown: a group of more polluted sites and a group with less polluted sites.

Making Sense

What can you conclude from these experiments on predators? How can this data help explain the population change in the peppered moth? On the chart at the end of this activity sheet, summarize the evidence and record your interpretation.

3. Decline of the Carbonaria Peppered Moth

Research Question: How did the proportions of carbonaria and typica forms of the peppered moth change in the last 50 years?

England began to try to reduce air pollution in the 1950s. Clean air laws were put into effect. In addition, using coal as fuel for machines and homes was being replaced by electricity and oil. These were less polluting sources of fuel. Over the years from the 1970s to the present, the air has steadily improved. Scientists decided to track whether these changes had any effect on the peppered moths. They collected and analyzed data for almost 50 years.

Method

Data were gathered from woods in England during the spring and summer when the adult form of peppered moths is active. As in prior studies, scientists set up traps to catch the moths flying around at night. They classified them and then released them at the end of the study.

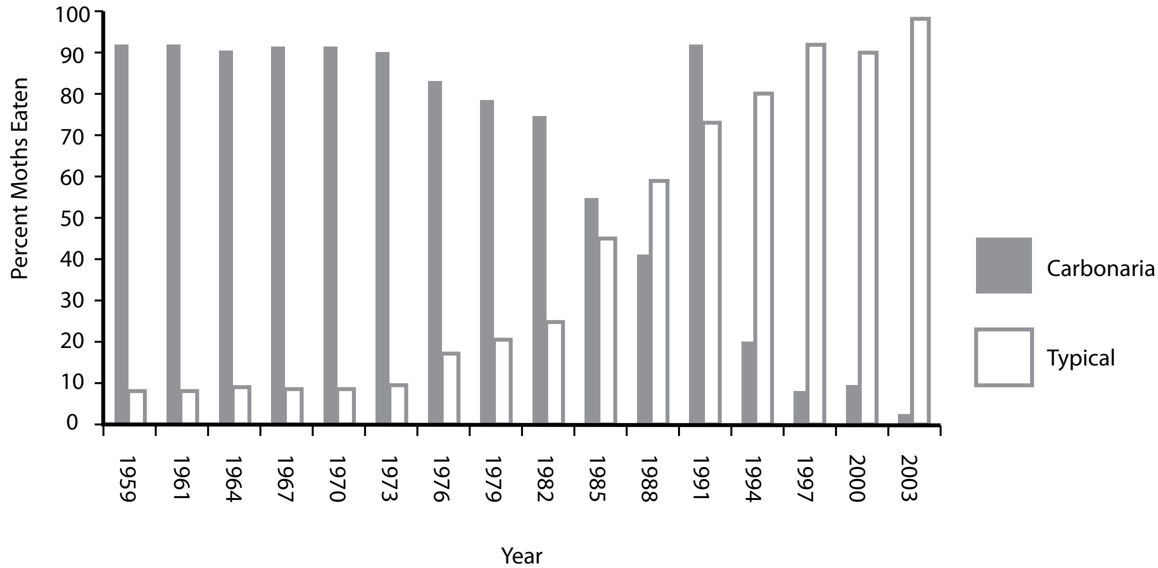


Fig. 6: Changes in the proportion of two varieties of the peppered moth between 1959 and 2003 in a highly polluted wooded area in England.

The scientists also looked at sites across the country. They separated them into groups: industrial, intermediate (urban), and rural. They wanted to see if these changes were happening in all environments across the country.

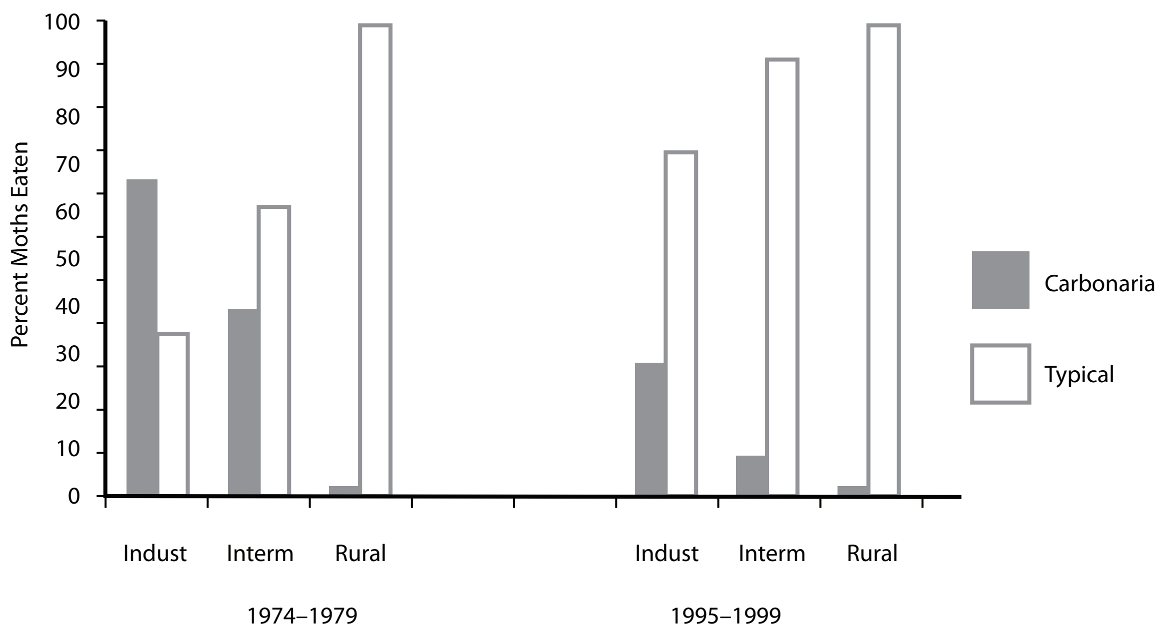


Fig. 7: Proportion of carbonaria peppered moths in three areas of England (industrial, intermediate, and rural) in two time periods, twenty years apart.

What can you conclude from these studies of the decline of the carbonaria? On the chart at the end of this activity sheet, summarize the evidence and record your interpretation. How can this evidence help explain the population change in the peppered moth?

Is the Color of the Peppered Moth Inherited?

An important part in figuring out why the population of peppered moths was changing was understanding the moth's color. Since the carbonaria and typica moths have different variations of the color, scientists wanted to know if it was inherited. Is it like the purple versus non-purple plant stems or tasting or not tasting PTC? Or could living in a more polluted environment somehow affect a moth's color, turning it darker during its lifetime?

Method

Scientists thought that the trait was not environmental, because color in insects is usually an inherited trait. They tested their ideas to be sure. They tried breeding carbonaria and typica moths to see what offspring would be produced.

Results

	Parents		
Number of Offspring	carbonaria X carbonaria	carbonaria X typica	typica X typica
carbonaria	405	350	0
typica	110	152	509

This table shows a summary of the offspring produced by the three possible combinations of parent moths.

The results of these breeding experiments reassured the scientists that the color of the moth was inherited. All of the moths were raised in the same environment in these breeding studies. However, they produced both types of offspring. This helped convince the scientists that the color variation was not caused by the environment.

They were also excited to see that two typica peppered moths had only typica offspring and no carbonaria. They took this as evidence that the color of the peppered moths was due to inherited traits and not influenced by the environment.

Making Sense

How can the finding that the peppered moth's color is inherited help explain why the population has changed over time? On the chart at the end of this activity sheet, summarize the evidence and record your interpretation.

Evidence Organizer

Type of Study	Evidence (Describe the Pattern In the Data)	Interpretation (Evidence?)
Pollution Studies		
Predation Studies		
Pollution Reduction		

Type of Study	Evidence (Describe the Pattern In the Data)	Interpretation (Evidence?)
Inheritance of Moth Color		

Making Sense

Using evidence from all of the studies, write out a chain of cause and effect that explains why the population of peppered moths has changed over time. Your chain of reasoning should include the following:

- Variation in the population
- Pollution
- Lichens and trees
- Predators
- Offspring and inherited traits

Reading 9.2 – How Does Variation Matter?

Getting Reading

If you live in the country, you may have noticed clover's sweet smell in the summertime. If you live in the city, you may never have seen or smelled clover. However, this little plant has an interesting story about variation, and why that variation helps it to survive in one part of the United States but not in another.

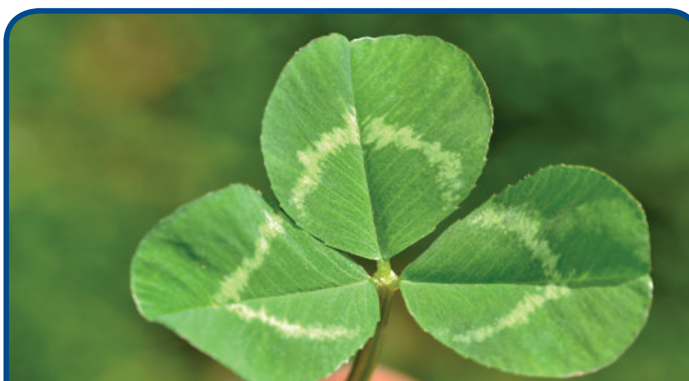
This field shows flowering white clover with plain leaves.

In class, you investigated the story of the peppered moth and the two variations that it had. You learned that when a species has different variations, they are called morphs. The morphs of the moth were different colors, light and dark. In the peppered moth case, that variation caused a change in the population based on which moths survived.

What variation, beside color, can you think of that might make a difference in a plant's survival?

What Is the Variation?

There are two types of clover in the white clover species: plain clover and striped clover. The plain clover looks like the plant in the picture. Striped clover gets its name because of the stripe on its leaves, but it is not their variation in color that matters. This plant has a much more interesting story.



Here is a white clover with striped leaves.

White clover is native to Europe and Asia and was introduced about 300 years ago in North America. Both types of clover were introduced in places, but something happened. Scientists who study plants began to notice a difference in where each type of clover was found.

These charts show two states where each type of clover is found today. They show the frequency distribution of the clover. Just like the histograms you created in Lesson 8 showed how height was distributed in your class, these pie charts show where the striped and plain clover is distributed in two states. What variation could cause this difference in the frequency distribution of the clover?

In your list of variations, did you include poison? Probably not, but that is exactly the variation between these two morphs. It is why they are found in two different areas of the country. Before you can figure out how the variation matters, you need to learn more about these two plants and what makes them different from each other.

Cyanide is a chemical that is poisonous to humans, animals, and plants. The morph of white clover that produces cyanide is the striped clover. There are two chemicals that are stored in different parts of the leaves of this clover. One is stored in the cytoplasm of the cell. The second chemical is an enzyme that is stored in the cell wall. You learned in the IQWST LS2 unit, that an enzyme speeds up a reaction. As long as they are separate, cyanide is not formed. However, when these two chemicals come together, the enzyme causes a reaction to take place that releases the poison, cyanide. Scientists have learned that the ability to create these chemicals is determined by the DNA of the clover. That means that it is an inherited trait.

How Does the Variation Matter?

Clover is found in many parts of the United States. When it was first introduced, both kinds of clover were found in both the northern and southern parts of the country. However, now almost all of the clover that produces the poison, cyanide, is found in the southern part of the country where the weather stays warm most of the year. The variation that does not produce the chemical is found in parts of the country where the winters are very cold.

In order to figure out the connection between the variation and the weather, you need to think about some ideas you learned in other IQWST units. In the LS2 unit, you learned that cells and cell walls in plants are made mostly of water. In the ES1 unit you may have learned that water expands when it freezes and can even break apart rock in a process called weathering.

Think about the clover that is found in the southern part of the United States. Some animals eat clover. However, the clover that produces the cyanide tastes bitter when eaten. Animals that eat the clover do not like the taste, so they eat the clover that does not contain the poison. Very little of the non-poisonous clover survives. That means there is not much of it left to reproduce. If the trait to produce the poison is inherited, then, those alleles are not getting passed on to the offspring. The frequency of the clover that produces the poison is increased. That changes the population of clover. Almost all of the clover in the southern part of the country is the poisonous kind.

What about the Other Variation?

Can you put together the other half of the variation story? With what you know about cells and water and the poison in the plants, why do you think there is not very much clover that produces the poison in the northern part of the country?

In the northern part of the country where the winters are very cold, the plant cells can burst because they are mostly water. When water freezes, it expands and the cells break. The chemicals in the cells come in contact with one another and create the poison and kill the plant. The plants cannot reproduce so there is more non-poisonous clover in the north.

If the water in the cells and cell walls expands when it freezes, then the enzyme and the chemical that produces the cyanide come in contact. The cyanide is poisonous to the plant and the plant dies. In contrast, the plants that do not contain the chemicals survive and reproduce the following season. Those plants pass their alleles on to their offspring. In northern states like Minnesota, there is more plain or non-poisonous clover. The difference in temperature in the two parts of the country caused a different variation to be an advantage in each place. Because of that, the frequency of each type of clover is different in each place.

ACTIVITY 9.3 – EXPLAINING THE CHANGE IN THE PEPPERED MOTH POPULATION

What Will We Do?

We will construct an evidence-based explanation to explain why the population of peppered moths has changed over time.

Procedure

1. Using your chain of reasoning from the Making Sense question at the end of Activity Sheet 9.2, construct an evidence-based explanation for why the population of peppered moths has changed over time.

2. Meet with your group and compare your explanations.

    - Does the explanation include evidence for each of the following points?
        - o variation in the population
        - o pollution
        - o lichens and trees
        - o predators
        - o offspring and inherited traits

    - Does the evidence support the claims in the explanation? Be sure to go back to Activity Sheet 9.2 and check any evidence that does not make sense. Add any new evidence at this point.

3. As a class, construct a consensus evidence-based explanation for why the population of peppered moths changed over time.

My Evidence-Based Explanation

New Evidence:

LESSON 10

The Finch Investigation

ACTIVITY 10.1 – BACKGROUND TO THE MYSTERY

What Will We Do?

We will discover information about the island of Daphne Major and the organisms that live there.

Procedure

1. Fill in the first column of the chart with the factors that affect an organism's survival.
2. During the class discussion, complete the chart with what you learned about Daphne Major and the finch population.

Things that Affect an Organism's Survival	Information about Daphne Major and the Finches

ACTIVITY 10.2 – INTRODUCING DATA COMPARISONS AND INDIVIDUAL FINCH DATA

ACTIVITY 10.3 – INVESTIGATING THE FINCHES

What Will We Do?

We will explore the interactive website to become familiar with the kinds of data we can access and the comparisons that we can make in order to answer these questions:

- Why did some finches die?
- Why were some finches able to survive?

Procedure

1. Your group will use the Galapagos Finches interactive website to investigate the two questions about the finches and collect data to support your answers.
2. Record your group's Data Log identifier here. ______________________________
3. Remember to save data that you think is important in your Data Log in the interactive website. Record your ideas about why the data is important in the Data Log as well.
4. When you think you have identified data that can be used as evidence for your explanation, record what you find in the charts.

Data

Environment Changes

Changes in the Environment	Evidence

Description of the Population Change

Difference Between Survivors and Non-Survivors	Evidence

Description of How the Population Differs After the Change

Difference Between Survivors and Non-Survivors	Evidence

Summary of Possible Claims about Variation

Trait that Varies	Some Individuals Reasoning	Evidence

Reading 10.3 – Where Did the Data Come From?

Getting Ready

When you think of a scientist collecting data, what kind of picture do you have of where that person does their work? Describe what you think.

If your description included a laboratory, test tubes, and other equipment, you would be right. Many scientists collect their data in that kind of setting. Do you think that scientists who want to collect data about organisms, do all of their work in a laboratory? In the IQWST LS1 unit, you may have studied data about trout and other fish that live in the Great Lakes. Scientists collected that data by going out and studying the fish in the lakes. In class, you have been using an interactive website that contains large amounts of data about the finches on the Galápagos island of Daphne Major. In this reading, you will learn about two scientists who collected the data that you have been using. As you read, think about whether you would like to do the kind of work they did.

Using a Natural Laboratory

Rosemary and Peter Grant are a husband and wife team of biologists who studied the finches in the Galápagos. The Grants and their assistants used the island of Daphne Major in the Galápagos as their laboratory for almost forty years.

Beginning in 1973, the Grants have spent about six months of the year, every year, on the island. They return to collect data in both the wet and dry seasons. They have caught, measured, and identified thousands of birds as well as studied their diet of seeds. However, working in a natural laboratory is very different from working in a regular laboratory and going home to your own house in the evening.

Daphne Major is one of the most deserted islands in the Galapágos. It is actually the top of an extinct volcano that is about one-third of a mile in diameter. It is so small that at the top there is only one small space that is flat enough to set up a couple of tents and a tarp for shade. There are no trees on the island and no sandy beaches where you can swim and enjoy the warm water of the Pacific Ocean. During the hot weather, the temperature can reach 120°F. A container of water left outside at noon can get so hot that it nearly boils and is too hot to drink.

Since there is nothing on the island, the Grants have to bring everything they will need for their stay with them. They arrive by boat, but there is no shore or beach for them to land on. There is only one way to get onto the island. They must jump from their boat onto a small ledge near the water. Then, they have to unload all of their equipment from the boat and take it to the top of the island.

Make a list of all the things you would need to have on the island if you were going to stay there for three or four months.

Look at the photograph that shows the tiny island of Daphne Major. The landing spot is the lower left, and the top of the volcano rim is where the Grants set up their camp. Everything they brought had to be carried by them to the top of the cliff. They brought tents, bamboo poles, clothes, and all of their food and water. Every drop of water they need must be carried up the cliff. Each container of water weighs about 100 pounds. Setting up their natural laboratory is hard work. After they set up their camp, they may take the time to enjoy the view and watch the sun set over the nearby islands. The next day, their work begins.

Collecting the Data

The interactive website you are using in class has data on several traits of the finches from the Galápagos. There is data on wing length, leg length, weight, and beak length. There are also field notes about individual birds and what they do and eat. How did the Grants get that data? How do you tell one finch from another?

The Grants' day begins at 5:30 a.m. before dawn so that they can set up their mist nets to capture the birds. Mist nets look like volleyball nets strung between two poles. However, the net is made of very fine mesh so that it is almost invisible to the birds.

As the birds fly, they get caught in the net and the scientists can capture and measure them. The nets have to be checked frequently, since the longer a bird is in the net, the more tangled up it becomes. The bird in the photograph is caught in a mist net. If the bird is left too long, it can get hurt or die.

The next step for the Grants is to band and measure the birds. They place metal bands around the leg of the birds they capture. They use different colors to distinguish between things like male and female, age, and location of where the bird was found. They also band each bird with a number. In their years on the island, they have banded and measured almost 20,000 birds.

Why do you think it is important for the Grants to band and be able to identify each bird?

Look at the finches in the bottom two photos. They appear almost identical. Without banding and identifying each bird, when the birds are recaptured in the following years, the Grants could not tell them apart. There are birds on Daphne Major that they recaptured for many years and kept detailed notes on. This process helped them to learn a lot about how the birds on the island changed over a long period of time.

Other data that you saw in the interactive website were about wing length, beak length, and weight. For each bird they capture, each of those traits is carefully measured, and a sample of the bird's blood is also taken. The Grants record all of this information in their field notebooks and when they return to their offices at Princeton University, it is all entered into their computers. When they first began working on Daphne Major forty years ago, they had to bring back all of their handwritten notes and try to make sense of their data without help from a computer. Now, that part of their work is much easier.

What other kind of data do you think the Grants needed to collect if they were going to understand how the finches were able to survive on this island?

In the IQWST LS1 unit, you studied ecosystems and the relationships between organisms in ecosystems. You learned about what happened to an ecosystem when an invader entered, and how populations changed when their food supply changed. It was not just the trout that were affected by the sea lamprey. The fish that ate the trout changed, too. In order to learn more about how some finches were able to survive, the Grants had to learn about the whole ecosystem and the relationships that existed on Daphne Major.

The Grants spent their mornings capturing and measuring finches, but the afternoons were spent learning about the things that grew on the island and what the finches ate for food. They counted plants and examined seeds. They watched to see what kinds of things the finches ate and they recorded that in their field notes, too. (Remember, you can learn a lot about the finches by reading the *Field Notes* in the interactive website.)

Peter Grant once said how lucky he was to have been able to do his work outdoors and on the islands of the Galápagos. It also was family work, since his wife was also a biologist who joined in the work. It involved the entire Grant family, since they began taking their two daughters with them when they were six and eight years old.

Do you think you would like to be a scientist who does their work in a "natural laboratory"? Explain why.

ACTIVITY 10.4 – MIDPOINT SHARING

What Will We Do?

We will share your group's explanations and evidence with another group to get feedback on your ideas.

Procedure

Part 1: Constructing our Explanations

Fill in the tables with your claim, reasoning, and evidence to support your reasoning. You need to fill in a table for each of the questions you are trying to answer.

A) Why did the finches die? Our claim:

Data

Chain of Reasoning	Supporting Evidence (Write evidence next to the reasoning step it supports.)

B) Why did some of the finches survive? Our claim:

Data

Chain of Reasoning	Supporting Evidence (Write evidence next to the reasoning step it supports.)

Part 2: Comparing Explanations

1. Read the explanations the other group wrote.

2. Use the following charts to compare the explanations from both groups.

3. After you have completed the charts, talk with the other group to compare explanations.

A) Why did the finches die?

What We Agreed On	What We Disagreed About
Claim	Claim
Reasoning	Reasoning
Evidence	Evidence

B) Why were some finches able to survive?

What We Agreed On	What We Disagreed About
Claim	Claim
Reasoning	Reasoning
Evidence	Evidence

Making Sense

1. What does your group see as the major strengths of the other group's explanation?

2. Are there any gaps in their reasoning or steps that need to be supported by evidence? If so, what?

3. What is the main suggestion that you would give to the other group?

Follow Up

Based on the suggestions from the other group and the class discussion, what are your next steps for improving your explanations? List the questions you want to answer, or the evidence you want to look for when you go back to the interactive website.

ACTIVITY 10.5 – EXPLAINING THE MYSTERY

What Will We Do?

We will construct final explanations to answer the two questions about the finch mystery.

Procedure

Write an evidence-based explanation for each of the questions.

A) Why did the finches die?

B) Why were some finches able to survive?

This is a very good explanation supported by evidence and reasoning. However, the following details are missing:

1. There is no evidence to support why the variation of a longer beak is an advantage based on structure/function.

2. All of the evidence is graphical. There is no evidence from field notes or other text in the interactive website.

3. There is no mention of the inheritance of the variation of the trait.

Homework 10.5 – What Happens Next?

What Will We Do?

We will explain what will happen to the finches if conditions on Daphne Major change again.

In class, you explained why some birds on the island of Daphne Major were able to survive and why others died. You used data collected by scientists about the birds as well as conditions on the island. In the IQWST LS1 unit, you may have learned that there are four factors that affect the survival of an organism: environment, food, other organisms, and reproduction. Because of the drought on the island, food became scarce and only large seeds were available. The birds with the larger beaks were able to survive. Those birds reproduced and their offspring had larger beaks as well.

New Changes

Because the Grants continued to return to the island for many years after the drought in 1977 ended, they learned even more about how populations can change. In 1982, the large ground finch settled on Daphne Major. In the IQWST LS1 unit, you learned that competition for resources can have an effect on the population. In studying the medium ground finch, you learned that competition between birds with large beaks and small beaks could result in a change in the population.

The large ground finch was almost twice the size of the medium ground finch and it was easily able to eat the large Tribulus seeds, which were the main food for the medium finch. This was not a problem at first, because there were plenty of seeds. In 2003, there were about 350 of these large finches on the island. That year there was another drought. As the two groups of birds competed for food, the supply of large seeds was soon exhausted. About half of each population died. Of the medium ground finches, the ones with the larger beaks were the worst off. Only 13% of them survived.

In 2003, there were changes in the environment and food, in addition to another organism added to the ecosystem on Daphne Major. What about reproduction? In their study of the medium ground finch, the Grants found that female finches usually mate with males that have the same beak size. So if there were fewer large beaked males, the larger beaked females would not mate.

Using what you have learned in this lesson, do you think the population of finches on the island changed after the drought in 2003? Explain.

Example:

Lesson 11

Constructing a General Model of Population Change

ACTIVITY 11.1 – CONSTRUCTING A GENERAL MODEL OF HOW POPULATIONS CAN CHANGE

What Will We Do?

We will develop a model that describes how change in the environment can lead to changes in a population of organisms.

Part 1 – Procedure

1. In the two-column chart that follows, your group will identify what is common between the moth and finches explanations by writing out the main parts of the explanations in the column for that population.

2. Some steps have been started, and you will have to complete them based on what your class generated. Other steps are blank for you to fill in.

3. Review the class explanations for each population change (moths and finches).

4. Identify all of the main steps of cause and effect that led to the population change.

5. Record the steps in the chart. For example, if pollution in the air was important for the moths, include a sentence similar to the following: the air pollution in the environment increased from 1850 to 1950.

6. Corresponding parts of each explanation will be placed opposite one another in each appropriate column. For example, put variation that mattered for peppered moths opposite the variation that mattered for the finches.

7. Include your claims and reasoning, but you do not have to include the evidence.

PEPPERED MOTHS

Peppered moths vary on the inherited trait of color. There are *carbonaria* (dark) and *typica* (light spotted).

+

The air pollution in the environment increased from 1850 to 1950.

↓

The air pollution affected...

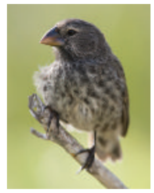
↓

The *carbonaria* moths had an advantage because...

↓

↓

The proportion of *carbonaria* moths increased from 1850 to 1950.



GALAPAGOS FINCHES

Finches vary...

+

The environment changed...

↓

↓

↓

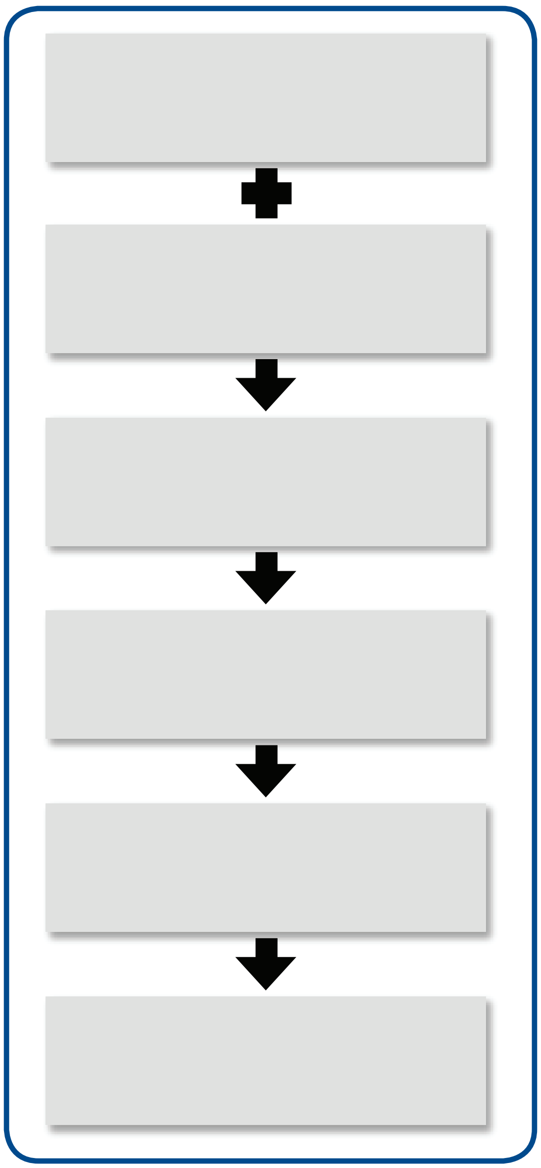
↓

Part 2 – Procedure

1. Your class will now construct a general model for how populations can change. Refer to the finch and moth cases in your group table on the previous page during the class discussion.

2. As your class agrees on each step in the model, write it in your copy of the model.

Consensus Model of Population Change



Reading 11.1 – Does Selection Always Occur Naturally?

Getting Ready

In the picture, there are some ears of sweet corn just waiting to be cooked and eaten. However, did you know that corn did not always look or taste like the corn we eat? Thousands of years ago, ancient people were eating a form of corn that became the corn we know today. It was called maize (mays) and that name is still used by people around the world. In the United States and Canada, we call it corn. As you read, you will learn about how that ancient corn changed through a process of selection to become corn on the cob.

In class, you developed a model for natural selection that could be used to explain how populations can change over time. You were able to explain how the population of finches on the Galapagos and the peppered moths in England changed because of this process. The model that you developed said that the following chain of events had to take place in order for natural selection to change the population:

a. There had to be a trait with variations that already existed in the population.

b. A change had to occur in the environment.

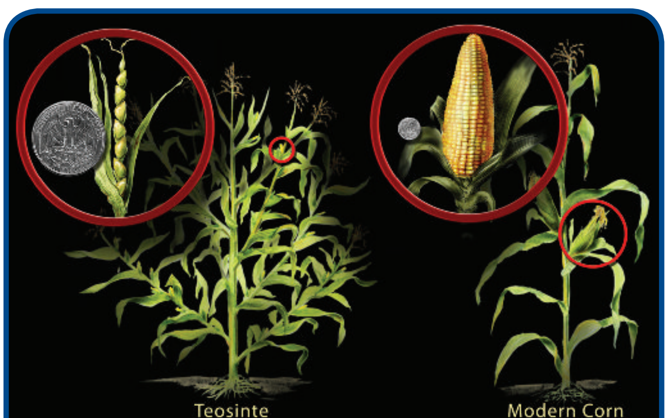
c. The change in the environment led to one of the variations being an advantage.

d. This led to a change in the population so that the proportion of those with the variation that was the advantage increased.

Both the finch and peppered moths fit this model of population change. In the following reading, you will learn about another kind of selection.

What Is Selective Breeding?

What do you think it means to selectively breed organisms? The word *select* means to pick or to choose. The term *selective breeding* means that someone picks or chooses which organisms will breed and produce offspring. These organisms are bred to produce specific variations of traits or combinations of traits. What does this have to do with corn? In order to answer that question, you need to learn something about corn's history.



The teosinte plant is the ancestor of modern corn.

Over 4,000 years ago, a plant called teosinte (tA-O-sin-tE), grew in what is now Mexico, Guatemala, and Nicaragua. This picture shows a kind of teosinte that still grows in

Mexico today. This wild grass produced an ear of corn that was only two to three inches long and had five to seven kernels on it. If you compare that to the ears of corn on the first page of this reading, they do not look very similar. Today's ear of corn is about twelve inches long and has 500 or more kernels.

What do you think are some of the variations that you would have found on the ancient ears of corn?

Why Are Variations Important?

People liked the taste of teosinte, but the kernels of corn had a hard coating that was difficult to chew. One way they used it was to grind it into flour. They could get the taste they liked, but not have to chew the hard kernels; however, the small ears meant they had to gather a lot of them to make the flour.

Variations like taste, size of the ear of corn, and hardness of the kernels were all important. Also, some plants grew better in the weather conditions of the area. You have learned that traits are part of the instructions carried in the DNA of organisms. The variations of each trait are carried by alleles. This DNA is passed from parent to offspring. The ancient farmers that wanted to have better corn did not know anything about DNA or the science behind inheritance. They were still able to figure out how to change the teosinte plant into a plant that produced corn that was better to eat.

Modern Corn Plant

One of the traits that they wanted to improve was the hardness of the kernels. They figured out that if they only took seeds from the plants that had softer kernels and crossed those, the offspring from those plants would have softer kernels. If they kept selecting only the plants with the softest kernels, the hard coating was reduced. This process of selective breeding over many generations of plants reduced the hard coating. Today, all that is left of the hard coating is the annoying bit of thin tissue that sometimes sticks between your teeth when you eat corn on the cob.

Today's corn plant looks very different form the teosinte. This photograph shows modern corn on the right that has a single stalk and does not branch out. It produces fewer ears of corn per stalk, but the ears are larger. Scientists, who have gone to the area in southwest Mexico where these ancient people lived, have discovered ancient ears of maize that were left in the caves where the people lived. They took some of these ears of maize in order to study their DNA. They found that these 4,400 year old ears of corn had many of the same genes that modern corn has. All of the genes necessary to form modern corn were already present in the teosinte population. All the early farmers did was to select teosinte plants that had the variations of the plant that they wanted. This process of selective breeding then created what we now call maize or corn.

How Is Selective Breeding Different from Natural Selection?

Both of these processes depend on variation in organisms. These variations are present in the organisms before the processes begin. In natural selection, there is a change in the environment that makes one variation an advantage over the other. Those organisms with the advantage survive and reproduce. That causes a change in the population, because the proportion of those organisms with the advantaged trait becomes larger. In selective breeding, the environment does not change. Humans select, or choose, which organisms will reproduce based on what traits are wanted in the offspring. This also causes a change in the population. The proportion of organisms with the selected trait will increase in the population.

ACTIVITY 11.2 – DOES THE CONSENSUS MODEL WORK?

What Will We Do?

We will apply the consensus model to other population change cases.

Procedure

1. Your teacher will assign you to a group. Each group will have one of two cases on which to apply the model, either antibiotic-resistant bacteria or DDT-resistant insects.

2. Read the fact sheet with the basic information about the case that was given to your group.

3. In the first column of the chart, copy the class consensus model from Activity 11.1.

4. Use facts you discovered in the fact sheet and place them next to the corresponding step in the consensus model.

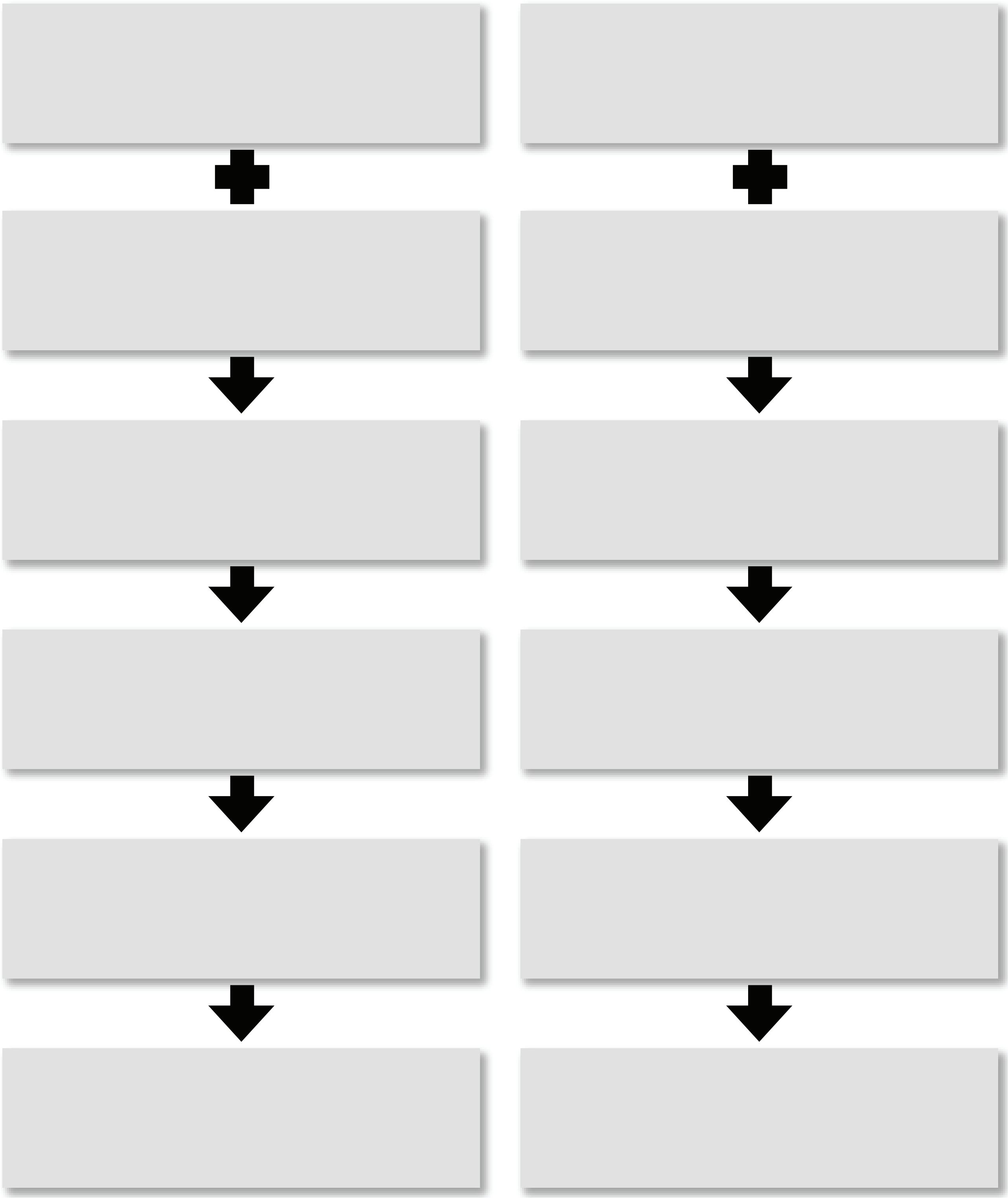
5. Sometimes information will not be directly indicated in the fact sheet. You may have to hypothesize a step in order to apply the model. Fill in only what you can infer from the fact sheet; do not make up details that are not necessary.

6. When your model is complete, your class will share models and discuss the results.

7. Complete the Making Sense questions.

MODEL OF POPULATION CHANGE

POPULATION CHANGE IN
Bacterica / Insects



Making Sense

1. It currently is a common practice to put antibiotics into the food for farm animals. What might be the effect of this practice?

2. People who take antibiotics when they are sick are told by their doctors to take the full treatment for the prescribed number of days even if they feel better. Why is that important?

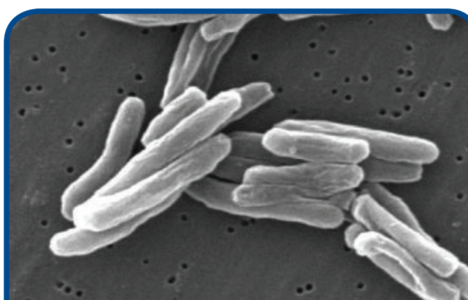
3. When DDT was first introduced, it was used often year after year. How would that lead to a different result than if it was only rarely used?

Fact Sheet Population Change in Bacteria

Problem

Tuberculosis is caused by a type of bacteria that can be spread from one infected person to another through the air. In the 1900s, more than 100 million people died from this disease. In 1946, the first antibiotics were developed that killed these bacteria. Antibiotics became very widespread in the years that followed. Treating patients with antibiotics almost wiped out this disease completely in the 1970s. But in the last 20 years, the incidence of tuberculosis has been on the rise. Doctors have found that drugs that previously killed this kind of bacteria were no longer working for some infections.

How could this happen? How can bacteria become resistant to antibiotics that previously killed that kind of bacteria? Can you piece this story together using your model to explain the population change? Here are some important facts that are known about the situation:



Tuberculosis

1. Bacteria are single-celled organisms that can infect people and cause many kinds of serious diseases.

2. Bacteria reproduce very quickly. Growing bacteria can produce a new generation in several hours.

3. An antibiotic is a chemical that is poisonous to a particular kind of bacteria.

4. Antibiotics may kill populations of bacteria by inhibiting growth of the cell wall, interfering with basic metabolism, or preventing them from reproducing.

5. When doctors first started using antibiotics beginning in the 1940s, they found the drugs to be very effective, curing almost all bacterial infections they treated.

6. When you take a dose of antibiotic, it does not instantly kill all of the bacteria causing the disease. Bacteria vary just like other organisms. Some die more quickly. Some require a larger concentration of the drug to kill them. So doctors usually tell patients to take the antibiotic once or twice per day for seven days.

7. Antibiotics are now often given in low doses in animal feed to try to keep the animals healthy.

8. Until recently, antibiotics were sometimes given by doctors to patients even when bacteria did not cause the disease.

9. People have bacteria living in their bodies all the time; most of them are not harmful.

10. In the last 20 years, doctors have found many kinds of infections caused by bacteria that are resistant to the antibiotics that killed earlier generations of the same bacteria.

Fact Sheet Population Change in Mosquitoes
Problem

When DDT was discovered in 1940 it generated a lot of excitement. The pesticide was used across large areas to try to kill insects that can carry disease. Early trials in the 1940s found DDT was a very powerful killer of insects, and was able to stop epidemics of disease. DDT began to be used widely to kill harmful insects that carried disease or destroyed crops, but eventually insects started appearing that resisted normal doses of DDT. The DDT eventually killed them, but it took much larger doses to kill them.

How could this happen? How can insects become resistant to a pesticide that previously killed those kinds of insects? Can you piece this story together using your model to explain the population change? Here are some important facts that are known about the situation.

1. Some insects can bite humans and infect them with diseases that they carry. Malaria can be transmitted by mosquitoes, typhus can be transmitted by lice, and typhoid can be carried by flies. Medical scientists have been searching for ways to stop the spread of these diseases.

2. DDT is an insecticide, discovered in 1940, that is poisonous to many kinds of insects, including mosquitoes.

3. The U.S. Army tested DDT in 1943. They found DDT to be very effective. Use of DDT in Mexico, Algeria, and Egypt quickly killed most of the flies and stopped the typhus

epidemic in progress. Later that year in Italy, it was used with the same results. Within a month of spraying with DDT, there were no new cases of typhus and the epidemic was stopped.

4. By the end of World War II, DDT was declared safe for general use and began to be used around the world. In the 1950s, use of DDT around the world led to a massive decrease in malaria. Use on farms against insect pests led to a large increase in farm crops.

5. Scientists discovered that DDT stayed around in the environment for a long time. When sprayed in houses, it would kill insects for months afterward. It was detectable in the environment long after it had been sprayed on plants.

6. Mosquitoes and other insects vary just like other organisms. Some die more quickly in the presence of DDT than others. Some require a larger concentration to kill them.

7. After years of use, some DDT-resistant mosquitoes, houseflies, and other insects are now appearing in the environment. Very large doses of DDT were required to kill these more resistant insects.

8. The occurrence of DDT-resistant insects increased over time. More and more resistant insects were found as the use of DDT continued.

ACTIVITY 11.3 – PUTTING IT ALL TOGETHER—
WHY DO ORGANISMS LOOK THE WAY THEY DO?