Task 1: Introduction to spider silk

LT: I can explore various resources in order to describe different types of silk and why traits for silk flexibility can vary within a family of Darwin's bark spiders.

Watch and summarize the following videos which will allow you to meet a scientist who is researching traits in spiders. She is especially interested in the different kinds of spider silk. We will focus on these traits throughout the extended task.

https://sites.google.com/a/ps207tigers.org/207sci/spiders

https://sites.google.com/a/ps207tigers.org/207sci/spiders-in-the-lab

To: Student Researchers
From: Dr. Ada Sattari, Lead Scientist at Bay Medical Company
Subject: Spider Silk Research

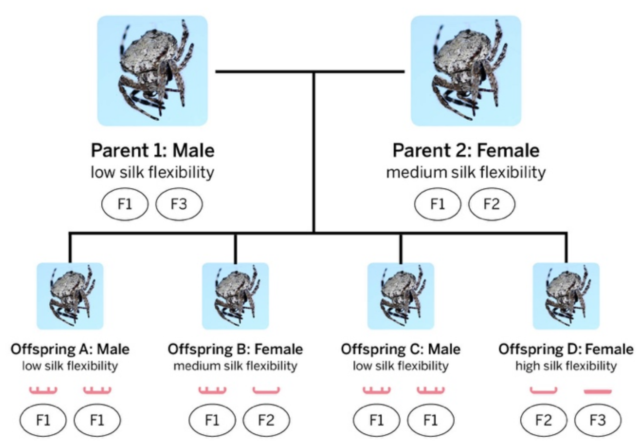
BAY MEDICAL COMPANY

I lead the Spider Silk Research Team, a group of genetic researchers. We are working on medical treatments that use silk from the Darwin's bark spider, a newly discovered spider species. These spiders produce very strong silk. We want to see if their silk can be used to make tendons and stitches for humans. For this to work, the silk must be both strong and flexible. A medium level of flexibility is optimum.

Unfortunately, we have discovered that not all Darwin's bark spiders are the same. Some spiders, even those in the same family, make more flexible silk than others. As student researchers, you will work to explain why traits such as silk flexibility can vary within a family of Darwin's bark spiders.

Eye color is a feature. People have different traits for eye color. For example, they could have blue, brown, or green eyes.
Silk flexibility is also feature. All of the Darwin's bark spiders have this feature (They all have spider silk that has some flexibility), but some spiders make silk that is more flexible than other spiders' silk. High, medium, and low silk flexibility are different traits for the silk flexibility feature.
This image shows the spider family, which students will be researching throughout the unit.

Traits for Silk Flexibility in the Spider Family



Read and take notes that describe different types of silk and why traits for silk can vary.

Different Silks for Different Functions

Deep inside the body of a spider, specialized cells produce protein molecules that are much longer than ordinary protein molecules. These long protein molecules connect to form an amazing material: spider silk.

Spiders use their silk to build strong webs, to trap bugs, to save themselves from falling, to wrap their eggs safely, and even to glide through the air. How can one material—spider silk—be used for so many different functions? Different uses for spider silk are possible because not all spider silk is the same: there are many variations, or differences, in spider silk. This is because there are different features of spider silk, such as strength, stickiness, stretchiness, and color. For each of these features, there are several possible traits. For example, for the feature of silk color, a spider might have the trait of making gray, white, or even golden-colored silk.

Spiders have different traits for each feature because of differences in the protein molecules that make up the silk. The cells of different spiders make different kinds of protein molecules, and these molecules combine to make different kinds of silk. This means that the kind of protein molecules a spider makes for a feature determine its trait for that feature.

Spider Silk for Gliding Through the Air

A tiny spider climbs to the tip of a leaf. It stands up high on its legs, tilts its body upward, and shoots out several threads of fine, wispy silk. The wind catches the silk and it becomes a kind of sail, lifting the spider into the air. The spider glides away under its silk sail, traveling much faster than it could by crawling along the ground.

The weight of the spider silk is a feature. Some spiders have the trait for a kind of lightweight silk called gossamer silk. Gossamer silk is extremely light and fine because of the protein molecules it is made of. These proteins make gossamer silk perfect for gliding: the light silk catches the air, but doesn't weigh the spider down.

Spider Silk for Spitting at Prey

A spitting spider prowls through the night, finding its way in the dark by feel. A small moth wanders into its path. The spider spits out a stream of sticky silk, waving it back and forth to cover its prey. The moth never had a chance!

Silk stickiness is a feature. The spitting spider has the trait for extremely sticky spider silk. This silk is so sticky because of the protein molecules that make it up. The silk also contains another kind of protein: venom. The venom paralyzes insects, making them unable to move. Once its prey is paralyzed, the spitting spider moves in to feast.

Spider Silk for Living Underwater

Imagine an animal that needs air to breathe but spends its whole life underwater. How could it possibly survive? Diving bell spiders manage to do it...with the help of spider silk. Diving bell spiders use their silk to build themselves tiny underwater homes.

To make its home, a diving bell spider weaves a waterproof net of silk and attaches it to an underwater plant. Then the spider gathers bubbles of air from the surface. It carries the bubbles down to the silk net, filling the net with air. When it is finished, the diving bell spider has a small air-filled chamber surrounded by a net of silk. Because of the protein molecules it is made of, the silk net holds air in and keeps water out.

Scientists have studied the air inside diving bell spiders' homes. They've discovered something surprising: oxygen gas dissolved in the surrounding water comes in through the silk walls, giving the spiders extra oxygen to breathe. The silk net keeps water out, but lets oxygen in. That's very special silk—and it's all thanks to the proteins that make it up.

Spider Silk for Super-Sized Webs

You are boating down a river in Madagascar. You look up and see a spider web stretching from one side of the riverbank, all the way across the river, to the bank on the other side. This huge web is the work of a Darwin's bark spider.

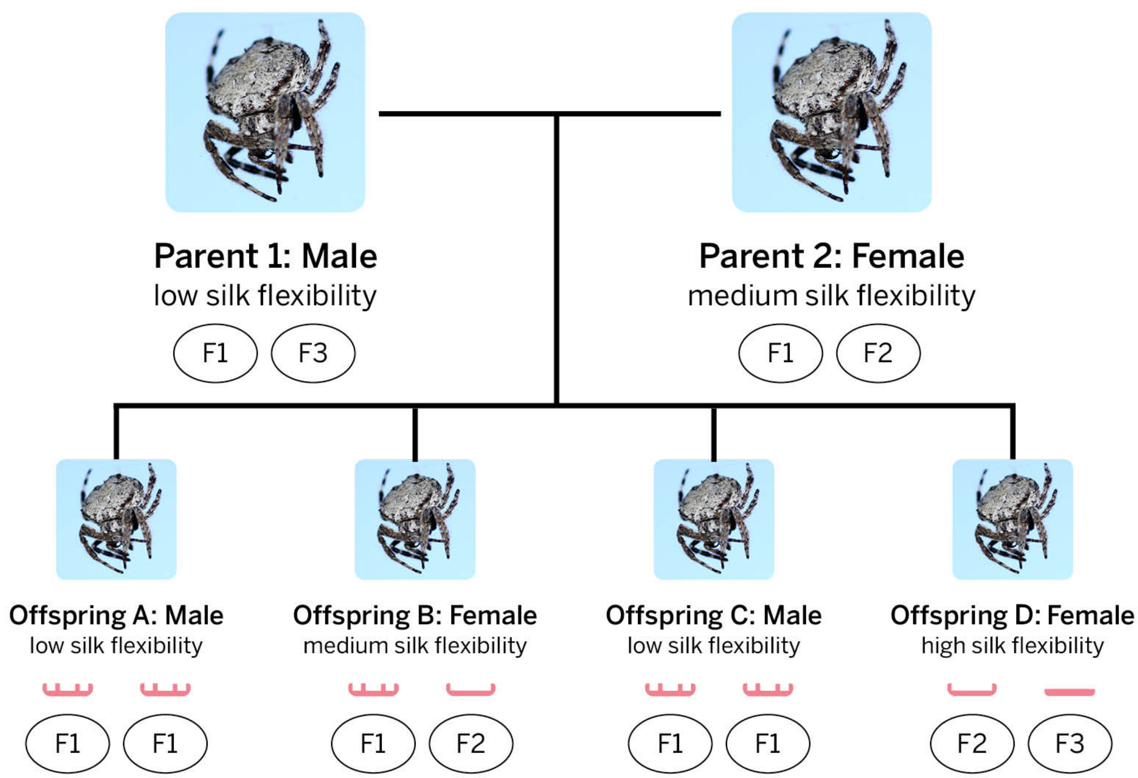
Darwin's bark spiders build some of the world's largest webs—as big as 82 feet across. To build such huge webs, Darwin's bark spiders need to produce very strong silk. The strength of spider silk is a feature. Darwin's bark spiders have the trait for extremely strong spider silk. Scientists only discovered these spiders recently, and they are studying the spiders' silk to find out what makes it so strong. Because spider silk is almost entirely made of protein molecules, it may be something about the protein molecules that makes Darwin's bark spider silk so strong.

These are claims about why the trait for silk flexibility varies within the spider family.
Copy the question and select one claim that you feel best answers the question. Support your claim with reasoning.

Question: Why do traits for silk flexibility vary within this family of Darwin's bark spiders? Claim 1: The offspring have mutations that affect their traits. Claim 2: The offsprings' traits depend on which parent the offspring received more traits from. Claim 3: The offspring received different combinations of traits from their parents.

As we learn more about traits in this unit, we will return to these claims, determining how convincing they are based on the information gathered.

Traits for Silk Flexibility in the Spider Family



Task 2: Spider Trait Variations

LT: I can use a simulation to describe how protein molecule structure determines traits.

The three models represent three different protein molecules for spider silk.

protein 1 | **protein 2** | **protein 3**

The following model represents a strand of spider silk.

protein 1: silk strand | **protein 2:** silk strand | **protein 3:** no silk strand

a. Which protein molecule do you think formed the most flexible silk strand?

b. How did the structure of the proteins make this strand more flexible?

c. Did any protein molecule not connect? How did the structure of this protein molecule affect its function?

Throughout this unit, we will be using a Simulation called the *Traits and Reproduction* Simulation. We will use this Simulation to help us learn more about variation in the traits of spiders.

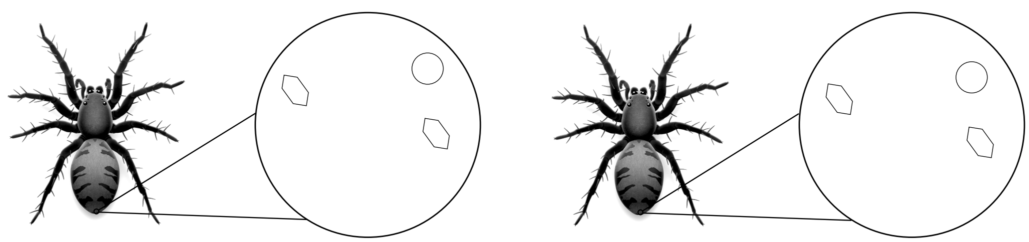
Launch the *Traits and Reproduction* Sim https://apps.learning.amplify.com/traitsandreproduction/
Compare spiders with high, medium, and low silk flexibility.

1. With your partner, find three spiders, each with a different trait for silk flexibility (high, medium, or low). Note: You and your partner should first each observe two different spiders, one on each device. Then, observe the third spider together.
2. Work with your partner to compare the protein molecules in each of the spider's cells.
3. Record your observations in a data table and complete the "Silk Flexibility Model."

Spider's Name	Silk Flexibility Trait	Protein Molecule Structure

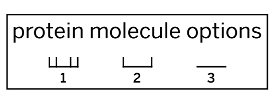
Silk Flexibility Model

Show how different protein molecules determine each spider's traits for the silk flexibility feature.



Spider A
high silk flexibility

Spider B
low silk flexibility



Enrichment: Collect more evidence about what determines traits at the molecular level. Use the Sim to add different proteins to a spider's cell and observe how the proteins affect that spider's trait.
*You can add more protein molecules by dragging them into the cell from the "Possible Proteins" key at the bottom of the screen. Note: Proteins can only be added to the circular drop zone that appears in the cell when a protein is selected. Additional proteins cannot be added until the cell resets.

Task 3: Different Proteins for Different Traits

LT: I can collect text evidence that explains how organisms can make different proteins for a trait.

In previous lessons, we learned that the traits an organism has depend on the proteins in its cells. For example, differences in the structure of protein molecules in spiders' cells result in different traits for silk flexibility. We also saw that different organisms have different protein molecules, resulting in trait variation. Our next question relates to why organisms make different protein molecules for a particular feature. Once you have a better understanding of this, it will bring you closer to assisting Bay Medical Company in determining how they can breed spiders with the trait for medium silk flexibility.

Dr. Sattari from Bay Medical Company sent us an article. It's not about spider research. Instead, it is about a blood disorder called hemophilia, which is caused by differences in proteins. This article will help you understand how organisms can make different proteins for a trait in their cells.

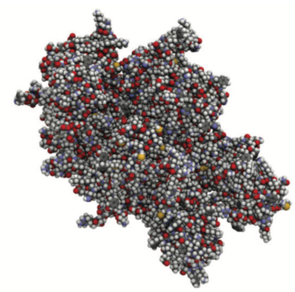
Read and take notes on the following article:

Hemophilia, Proteins, and Genes

You fall off your bike and scrape your knee. Blood drips out, but soon a scab starts to form and the bleeding stops. Sounds simple, doesn't it? However, if you could zoom in to see what's happening on a molecular scale, it's not simple at all. Your blood includes thirteen different protein molecules called clotting factors.

Clotting factor proteins work together to bind blood cells into a clot that stops the bleeding.

When you injure yourself, these clotting factor proteins all connect and work together to form a solid clot (also known as a scab). If you were missing even ONE of those thirteen proteins, the clot wouldn't form, and the dangerous bleeding would continue. This is exactly what happens in a disease called hemophilia (HEE-mo-FEEL-ya). People with hemophilia are missing one of the proteins needed for blood clotting.

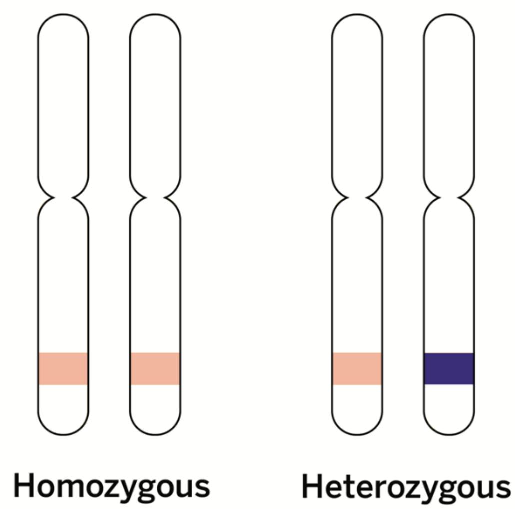


There are thirteen different clotting factor proteins. This model represents a molecule of one of these proteins—the one most hemophilia patients are missing.

Causes of Hemophilia

People with hemophilia are missing clotting factor proteins because of a problem with their genes. Different genes carry instructions for making different proteins. For every gene, there may be several possible versions. (Different versions of a gene can also be called alleles.) An organism has two copies of each gene. Those gene copies can either be the same version (homozygous) or different versions (heterozygous). If the gene copies are homozygous, just one type of protein is produced, since both gene copies give the same instructions. If the gene copies are heterozygous, two types of protein are produced, since each gene copy gives a somewhat different instruction.

People with hemophilia have a version of the gene that doesn't have the right instructions for making clotting factor protein. Without the right instructions, their cells can't make that protein—or they make a protein that doesn't work. Without functional clotting factor protein, the proteins in their blood can't make the connections needed to form clots and build scabs. Healthy people have at least one copy of the gene version that provides the right instructions for making all of the clotting factor proteins.



An organism with two gene copies that are the same is homozygous, while an organism with two gene copies that are different is heterozygous.

Being able to form scabs may seem so basic that it's strange to think of it as a genetic trait like having brown eyes or having freckles. However, just like those other traits, the ability to form scabs is a trait that is determined by proteins. To have that trait, you need to have those proteins—and to make those proteins, you need to have the genes that give your cells the instructions for making them.

Treating Hemophilia with Proteins

Even though hemophilia is a serious disease, most hemophilia patients can live relatively normal lives if they get proper treatment. Hemophilia is caused by a missing protein, so doctors treat it by replacing that protein. Doctors inject clotting factor protein into a patient with hemophilia so the patient's blood clots the way it is supposed to. Injecting the protein into the body does not change the proteins the body produces; instead, it supplies the protein the blood needs to clot properly. People with hemophilia need to have the missing protein injected into their bodies throughout their lifetimes because the injected protein will be used up. The patients then need to be injected again for their blood to continue to form clots properly.

For many years, the only way to get clotting factor protein was to separate the protein from donated blood. However, it takes a lot of blood to get just a little bit of clotting factor protein! Today, scientists can make lots of clotting factor protein by inserting human genes into hamster chromosomes. If you put the human gene for making clotting factor protein into the chromosomes in the nucleus of a hamster cell, the cell makes the protein. Even though it's a hamster cell, the cell makes clotting factor protein that's identical to clotting factor protein made in human cells. As long as the cell has the gene with instructions for making clotting factor protein, the cell will make the protein.

Gene Therapy for Hemophilia

Hemophilia can be treated using clotting factor protein, but it can't be cured...for now, at least. Scientists are researching possible cures for hemophilia: cures that would get the patient's own cells to produce clotting factor protein.
For this kind of a cure, scientists would have to figure out how to fix a patient's faulty gene for making clotting factor protein. If the faulty gene were fixed, the patient's cells could start making clotting factor protein naturally. Working to fix or replace genes is called gene therapy. Hemophilia can't be cured with gene therapy yet, but scientists are working on it.

Task 4: Modeling How Proteins Are Made in the Cells

LT: I can model the role genes play in building proteins.

Do genes build proteins, or are genes only the instructions for building proteins?

1. The envelope represents the nucleus. Each instruction inside the envelope represents one copy of a gene.
2. Two students will serve as readers. The other pair will serve as ribosomes.
3. The pair of readers should each take one of the instructions from the envelope and read it aloud to one of the student ribosomes.
4. The ribosome that receives the instruction should build the protein molecules accordingly.
5. After completing this activity, complete the following prompts:

1. In this modeling activity, what do each of the items below represent? Explain why.
   a. envelope:
   b. instructions:
   c. students building the protein molecules:

2. Draw and compare your two protein molecules. Are they the same or different? Why?

3. Select and copy the claim about genes' role in building proteins that best fits considering the modeling activity you have just completed.

☐ Claim 1: Genes provide instructions and build proteins.

☐ Claim 2: Genes provide instructions for making proteins, but they do not build the proteins themselves.

Genes are instructions for making proteins, which determine the traits of an organism. There are different versions of each gene. Each gene version is a unique instruction for making a specific protein molecule.
In the activity you just completed, there were two different sets of instructions. The instructions were for gene version A1 or gene version A2. Some groups had two copies of the same gene version while other groups had two different gene versions. Different versions of a gene can also be called *alleles*.

Task 5: Modeling Mutations

LT: I can use protein molecules to model how mutations happen.

What happens when there is a change to a gene? Using the protein molecules from the last activity, you will now model what happens when there is a mutation.

1. Take apart the protein molecules from the last activity.
2. Now, switch roles so that the readers are now ribosomes, and ribosomes are now readers.
3. The teacher will give each reader a new step. This represents a mutation in the gene. Place the new step over the indicated step number from your previous instructions.
4. Try to follow the new instructions to build a new protein. You can only add pieces to your protein if you are able to follow the instructions exactly.
5. **Record your observations.**

Copy and complete the following prompt:

The change in the instruction caused the protein to:

- ☐ be incomplete. (We couldn't finish building the protein.)
- ☐ no longer exist.
- ☐ have a different structure.
- ☐ have the same structure.

A mutation is a random change to a gene version. This means that the instructions to build the proteins change, which can cause the protein to be shaped differently.

Mutations that affect the trait of an organism are very rare. Most mutations result in a new protein that does not affect a trait because it does not interact with other proteins. Very rarely does a mutation occur with instructions for a protein that will interact and affect a trait.

Watch the video to learn more: https://sites.google.com/a/ps207tigers.org/207sci/mutations

Task 6: Comparing Spiders

LT: I can use a simulation to gather evidence about why some organisms make one type of protein for a feature while other organisms make two.

1. Launch the *Traits and Reproduction* Sim https://apps.learning.amplify.com/traitsandreproduction/

2. Choose a feature to focus on. You can select any feature except body size.
   a. By observing the cells for each spider, find a spider that makes only one type of protein for your selected feature.
   b. By observing the cells for each spider, find a spider that makes two types of proteins for your selected feature.

3. Record your results.
   a. feature observed:
   b. name of spider that makes one type of protein for this feature:
   c. name of spider that makes two types of protein for this feature:

4. List ideas for why you think one spider makes one type of protein while another spider makes two types of proteins for this feature.

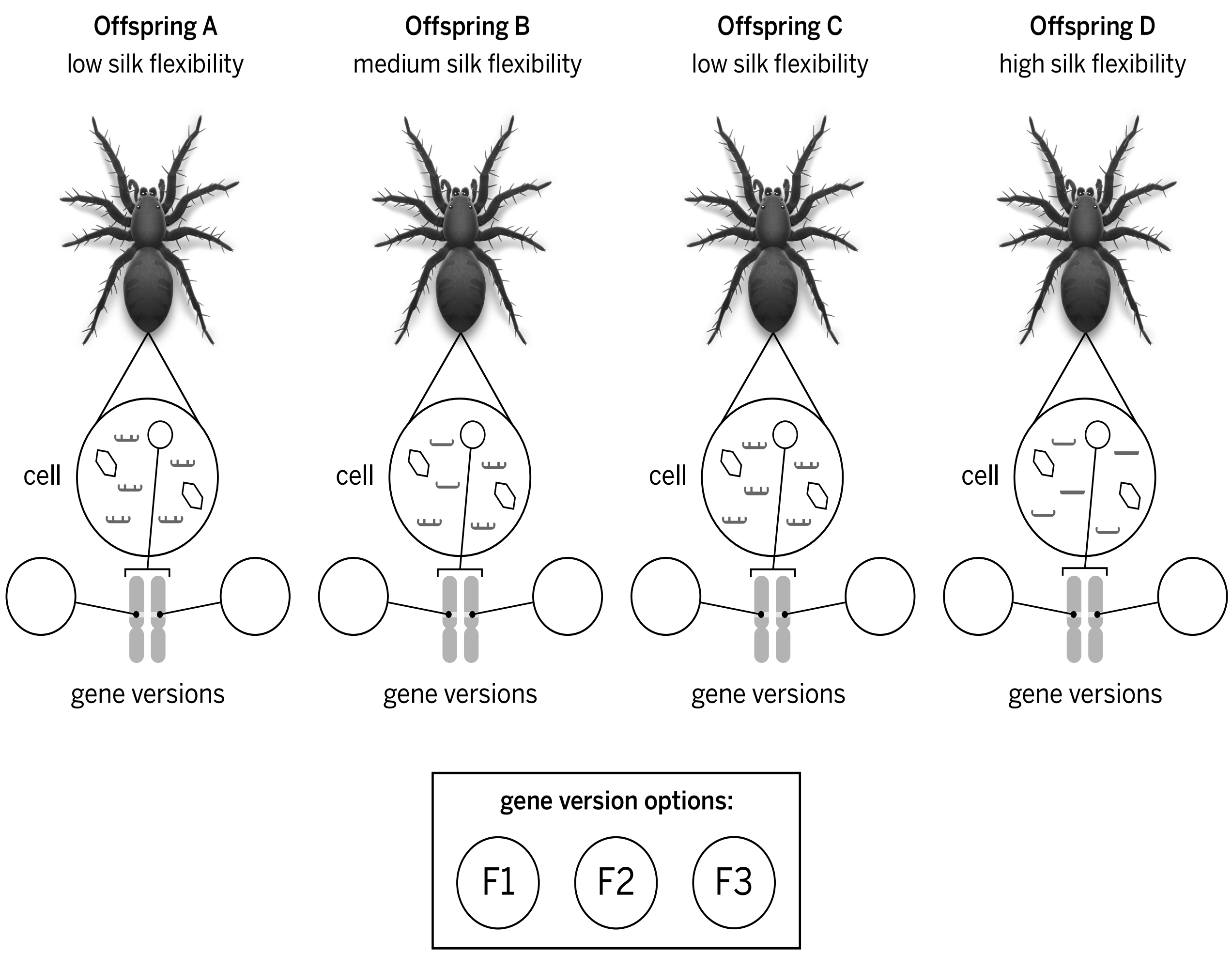
5. Work to change your spiders' genes so that both spiders produce the same proteins for the feature you selected.

6. Describe what changed and what you noticed.
   a. What did you do to make the spiders produce the same proteins?
   b. How did this change affect the spiders' traits?
   c. Describe what you did and observed in the Sim.
   d. What differences did you notice in the Sim when you added proteins compared to when you changed gene versions?

Name: ______________ Date: ____________

Variation in Spider Offspring Model

Show why the spider offspring have different traits for silk flexibility.



Task 7: Gene Inheritance Article

LT: I can use text evidence to describe if organisms can inherit a greater number of genes from one parent. People often think that an offspring looks more like one parent because that offspring received more genes from one parent over the other. Is this true? Can organisms inherit a greater number of genes from one parent? Take notes on the article to support or refute this claim.

Why Are Identical Twins Rare?

Everyone is different. We can recognize one another's faces because every face is unique, with different combinations of traits like eye color, skin color, nose shape, and so on. All these differences are called variation. Where does variation come from? Genes instruct for proteins, which determine our traits. People have different traits because our protein molecules are different, and our proteins are different because our genes are different. Every human has a unique set of genes, different from anyone else's...at least, almost all of us do.

Identical twins are identical because their genes are the same.

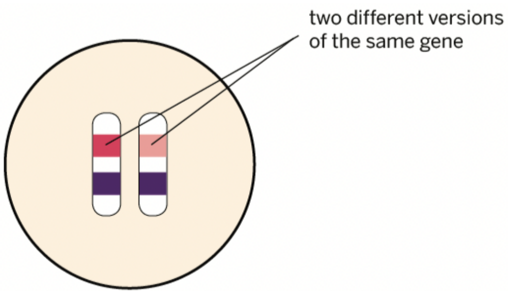
Imagine knowing someone who looks almost exactly like you—so much like you that people often mistake you for each other. You are the same height, your hair and eyes are the same colors...even the shape of your smile is the same. If you are an identical twin, you already know what that's like.

Identical means "exactly the same." Identical twins look so much alike because they have the same proteins, and they have the same proteins because their genes are the same. How can two different people end up with identical genes?

How We Get Our Genes

We inherit our genes from our biological parents through the process of sexual reproduction. Each parent has a complete set of genes. These genes are organized on matching pairs of chromosomes. Each chromosome pair has two copies of each gene. However, the two copies of any particular gene can be the same version or different versions.

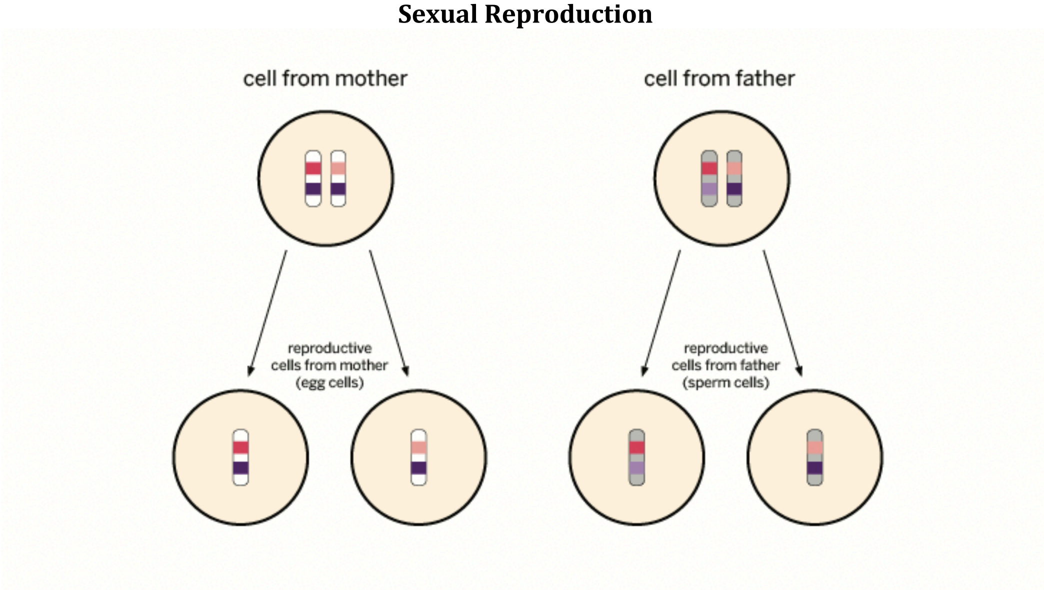
Chromosome Pair



This is a simplified diagram. It shows a cell with just one pair of chromosomes. People don't really have one pair: we have 23 pairs! That's too many to show in this diagram.

Sexual reproduction involves special reproductive cells from both parents. The mother's reproductive cells are called eggs, and the father's reproductive cells are called sperm. Unlike other cells that have two copies of every gene, egg cells and sperm cells only have one copy of each gene, which means the cell only contains one version of each gene. If a parent has two different versions of the gene, some reproductive cells will end up with one version, while other reproductive cells will end up with the other version. Each time these special cells are produced, the division of genes is different and random. Every sperm or egg cell is unique!

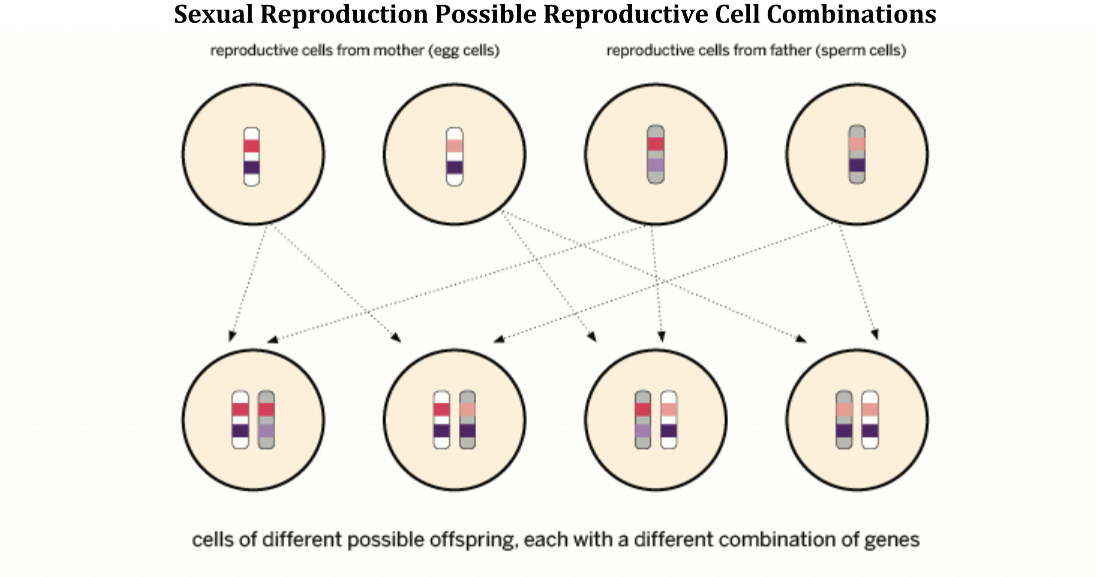
Sexual Reproduction



While all other cells contain two gene copies, reproductive cells are different. They contain just one gene copy.

When the egg and sperm cells from two parents come together, fertilization occurs. Fertilization is when these cells combine to form the first cell of a new offspring. This new cell has two copies of each gene, one from each parent. Each parent randomly passes on only one copy of each gene, so there can be lots of possible combinations of genes passed on from two parents. The many possible combinations of genes are what give us variation.

Sexual Reproduction Possible Reproductive Cell Combinations



Reproductive cells can combine in lots of different ways. This diagram shows four possible combinations for just one chromosome. Remember, humans have 23 chromosomes! The possibilities are practically endless.

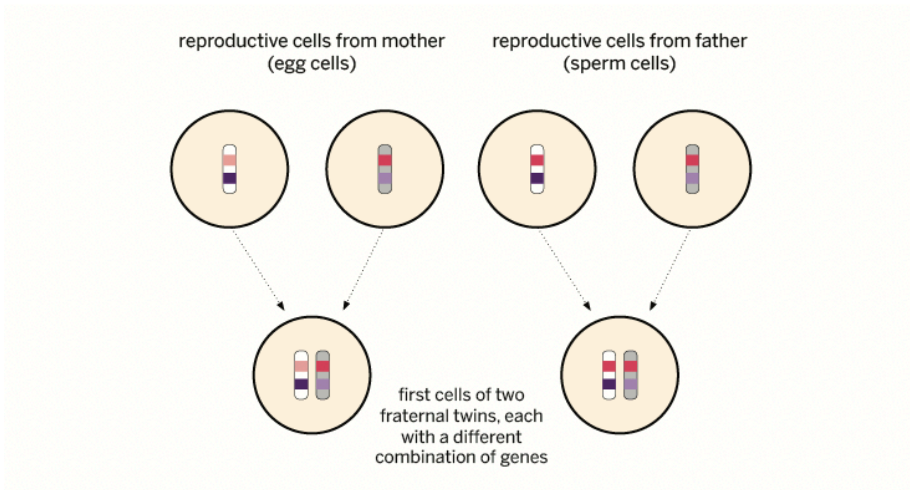
All variation in humans comes from sexual reproduction. Identical twins DO vary from their parents; however, identical twins have the same gene versions as each other. How is this possible? To understand why, let's think about the difference between identical twins and fraternal twins.

Not All Twins Are Identical

Many sets of twins are fraternal twins. Unlike identical twins, fraternal twins have different traits. They may have different eye colors and different heights, and can even be different sexes. There can be lots of variation between fraternal twins.

The difference between fraternal twins and identical twins has to do with fertilization. In fraternal twins, fertilization happens twice. A sperm cell from the father combines with an egg cell from the mother to form the first cell of one twin. At around the same time, a different sperm cell from the father fertilizes another egg cell from the mother to form the first cell of the other twin. The cells of these two twins inherit completely different combinations of genes from the parents. Because they inherited different genes, the fraternal twins will have different proteins—which will interact to determine different traits. Because sexual reproduction happens twice, and each time one copy of each gene is randomly passed on to each of the offspring, fraternal twins have lots of opportunities for genetic variation.

Fraternal Twins



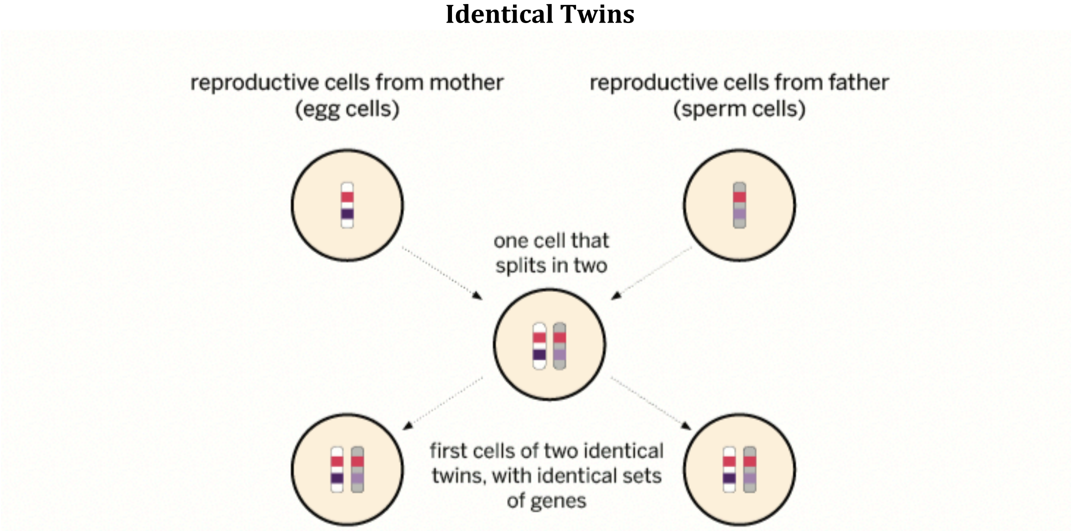
Because fraternal twins inherit totally different combinations of genes from their parents, they can vary genetically.

How Identical Twins Get Identical Genes

On the other hand, in identical twins, fertilization happens only once. A sperm cell from the father combines with an egg cell from the mother to form a cell. Then this single cell copies itself and splits, forming two identical cells—the first cells of two identical twins. The cells of these twins inherit the same combinations of gene versions, because they were produced from the same egg and sperm cells. Because they have the same genes, the identical twins will have identical genetic traits.

Of course, even identical twins will develop in different ways over their lives, becoming individual people with different talents and experiences. One twin may train to become a muscular body builder, while the other may sit at a computer writing all day. Just because they inherited the same genes, that doesn't mean they are the same person. Even identical twins aren't identical in every way.

Identical Twins



Identical twins happen when one fertilized egg splits into two cells. The two cells have exactly the same genes.

Task 8: Gene Inheritance SIM

LT: I can use a model to describe if organisms can inherit a greater number of genes from one parent.

People often think that an offspring looks more like one parent because that offspring received more genes from one parent over the other. Is this true? Can organisms inherit a greater number of genes from one parent? You will the Sim to see if you can either support or refute this claim.

Traits and Reproduction Sim https://apps.learning.amplify.com/traitsandreproduction/

As we are trying to determine if offspring can inherit more genes from one of their parents over the other, we need to carefully observe both Otis's and Anne's genes.

- Select the bristle feature.
- Copy and complete the table below that compares Otis's and Anne's traits and gene versions for the bristle feature.

Parents	Gene Versions	Trait
Otis	R1R2	
Anne		Dense

Model creating reproductive cells in the Sim.

- Select the spider named Anne. Drag the spider on top of Otis and hold until a dotted circle appears. Let go, allowing the two spiders to mate.
- Press CREATE REPRODUCTIVE CELLS. Notice that the genes are color coded to indicate which is the sperm cell and which is the egg. (The male reproductive cell is green, and the female cell is purple.)
- Focusing on Otis, notice that each sperm cell has only one copy of Otis's genes. Some cells received a copy of the R2 gene version, and some received a copy of the R1 gene version.
- Press RANDOMLY FERTILIZE. Observe the offspring and note which gene versions and traits the offspring inherited in the table below.

	Gene version from Otis	Gene version from Anne	Gene Versions
Offspring 1	R2	R1	Sparse
Offspring 2			
Offspring 3			
Offspring 4			

The offspring produced will not always have the same set of gene combinations. Each spider offspring can inherit any of the possible combinations.

Now that you understand how organisms inherit their genes from their parents, focus on investigating why the spider offspring have different traits for silk flexibility even though they have the same parents. Examine the traits and combinations of gene versions for each offspring. Then, record your observations.

Parents	Gene Versions	Trait

	Gene version from ___	Gene version from ___	Gene Versions
Offspring 1			
Offspring 2			
Offspring 3			
Offspring 4			

Task 9: Breeding Spiders
LT: I can use a simulation to test for the probability of a desired trait.

Mission: Help Bay Medical Company Decide Which Spiders to Breed
Launch the Sim, and then determine which parents researchers should breed in order to produce offspring with the trait for medium silk flexibility. Record your results. Then, share your recommendation with Bay Medical Company.

Note: You may need to run multiple tests with the same or different parents.

Test 1

	Gene Versions for silk flexibility	Trait for silk flexibility
Parent 1		
Parent 2		

What percentage of the offspring had the trait for medium silk flexibility? 0%; 25%; 50%; 75%; 100%

Test 2

	Gene Versions for silk flexibility	Trait for silk flexibility
Parent 1		
Parent 2		

What percentage of the offspring had the trait for medium silk flexibility? 0%; 25%; 50%; 75%; 100%

Test 3

	Gene Versions for silk flexibility	Trait for silk flexibility
Parent 1		
Parent 2		

What percentage of the offspring had the trait for medium silk flexibility? 0%; 25%; 50%; 75%; 100%

Bay Medical Company should breed spiders with the following gene versions in order to produce the greatest number of offspring with the trait for medium silk flexibility.
Parent 1: ____ Parent 2: ____

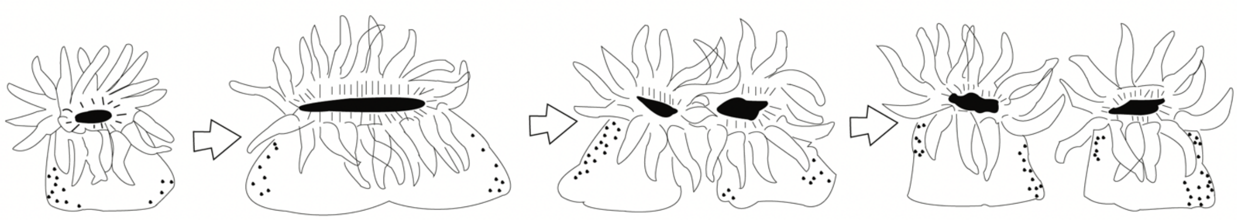
Task 10: Comparing Reproduction

LT: I can use text evidence to describe how types of reproduction determine variation among offspring.
Read and take notes on the topic. Be sure to focus your notes on describing how types of reproduction determine variation among offspring.

Sea anemones are animals that attach themselves to the sea floor.

Sea Anemones: Two Ways to Reproduce

Can you split yourself in half to create a new you? You could if you were an aggregating sea anemone (ah-NEH-muh-nee). Sea anemones are animals that attach themselves to the sea floor. Most sea anemones have a thick stalk with finger-like parts at the top. They look a bit like plants growing out of the bottom of the ocean, but they are actually animals that eat tiny organisms they find floating in the water.



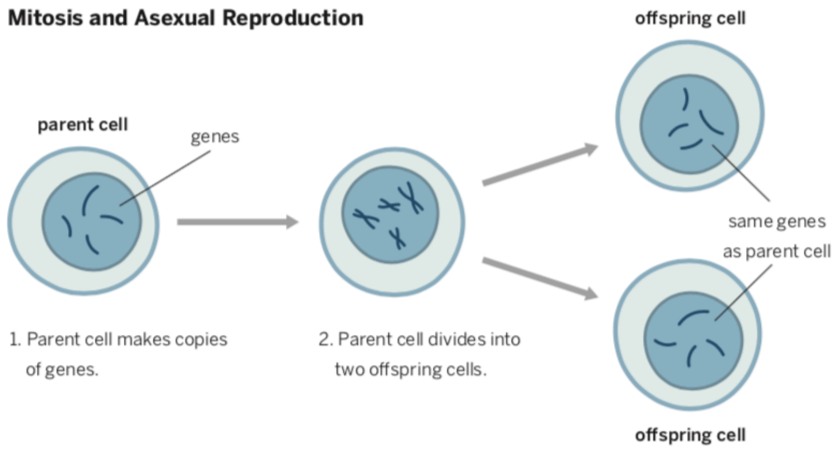
Aggregating sea anemones can reproduce asexually by splitting in half.

Splitting in half is a kind of asexual reproduction. Aggregating sea anemones can reproduce in two ways: through asexual reproduction and sexual reproduction. Either way, the end result is a new offspring sea anemone, so what difference does it make which way they reproduce?

Actually, it makes a big difference. When a sea anemone reproduces asexually, the offspring anemone is identical to the parent anemone, with exactly the same traits. However, when anemones reproduce sexually, the offspring are similar to their parents, but not exactly the same. Offspring produced through sexual reproduction will have variations from their parents—differences in their traits that could make a big difference to their survival.

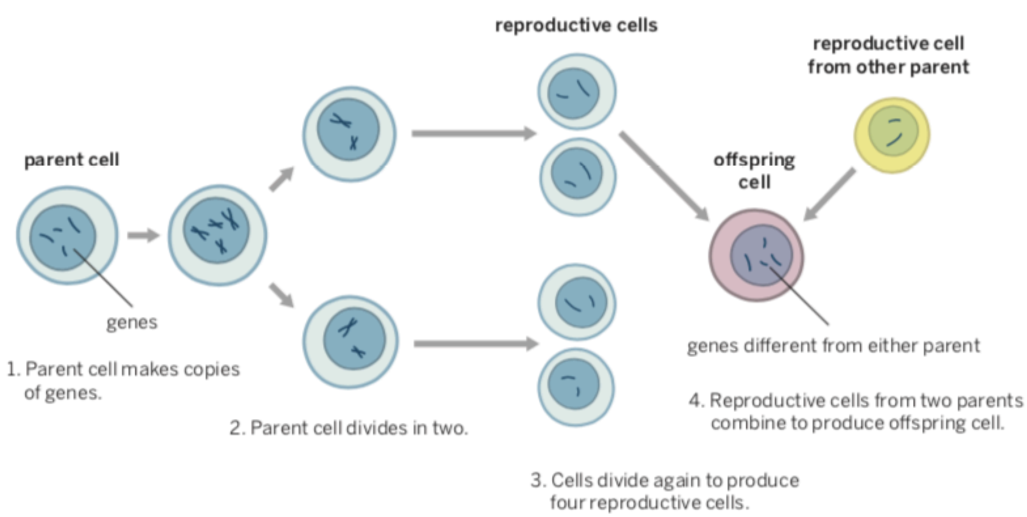
To understand the difference between sexual reproduction and asexual reproduction, we need to get down to the level of cells. All living things are made of tiny cells—they are the basic building blocks of life, and they contain the genes that determine an organism's traits.

Asexual reproduction begins with a cell from the parent (you only need one parent for asexual reproduction!) dividing to become two cells. This kind of cell division is called mitosis (my- TOE-sis). Before it divides, the parent cell makes copies of the chromosomes that contain all its genes, so the new offspring cell contains a complete set of chromosomes (and genes) that are the same as the parent cell. This new offspring cell is what will develop to become the offspring organism. As the offspring organism grows, it will have the same traits as its parent organism because it has the same genes. Asexual reproduction is simple and convenient: the sea anemone doesn't even need to find a mate in order to reproduce.



Mitosis is one way that cells can divide in order to reproduce. Asexual reproduction involves mitosis.

Sexual reproduction also begins with parent cells dividing, but the process is more complicated. For one thing, sexual reproduction requires two parent organisms instead of just one. In each parent organism, a cell copies its chromosomes and then divides in two—and then those two cells divide in two again. This kind of cell division is called meiosis (my-OH-sis), and it results in four special reproductive cells from each parent. A reproductive cell only has half of the genetic information that an ordinary cell from the organism does.



Meiosis is another way that cells can divide in order to reproduce. Sexual reproduction involves meiosis.

After the reproductive cells have formed, there's still one more step to sexual reproduction. In a process called fertilization, two reproductive cells—one from each parent— come together to form a new offspring cell. This new offspring cell is what will develop to become the offspring organism. That new offspring has a full set of genes: half the genes came from one parent, and the other half came from the other parent.

Because the offspring gets half its genes from one parent and half from the other, the new offspring cell has a unique combination of genes, different from either one of its parents. This new offspring cell is what will develop to become the offspring organism. With a new combination of genes, the offspring will also have a new combination of traits. As it grows, the offspring organism will be similar to its parents, but it won't be exactly the same as either one of its parents.

Sexual reproduction helps produce variation in the traits of the organisms in a population, and variation is important because different traits may be helpful to survival in different conditions. That's why many organisms that can reproduce asexually (like aggregating sea anemones) also reproduce sexually.

1. How is asexual reproduction different from sexual reproduction?

2. How does a sea anemone reproduce asexually?

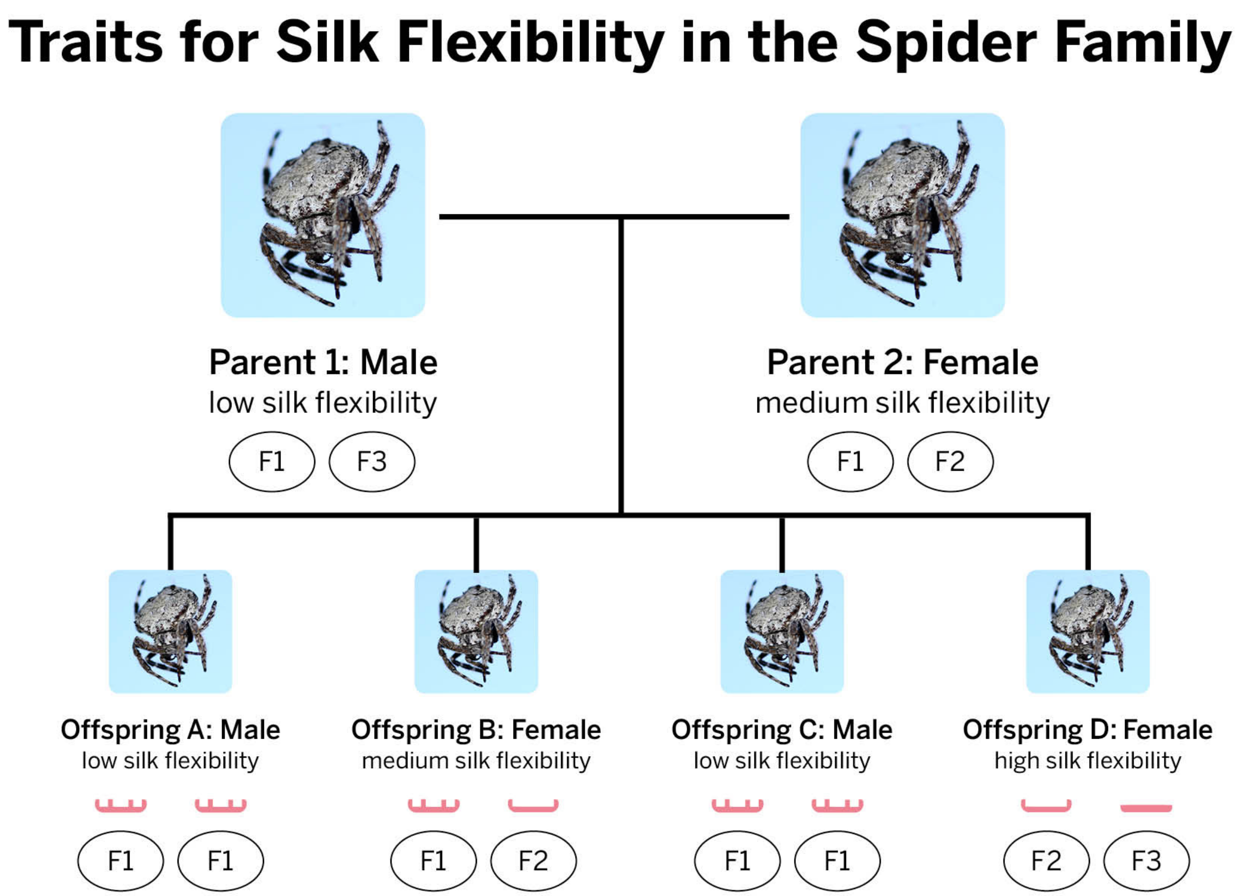
3. Why doesn't asexual reproduction result in variation among offspring?

Task 11: Breeding Spiders

LT: I can use various evidence sources to establish a claim explaining why the trait for silk flexibility varies within the spider family.

These are claims about why the trait for silk flexibility varies within the spider family.

Question: Why do traits for silk flexibility vary within this family of Darwin's bark spiders? Claim 1: The offspring have mutations that affect their traits. Claim 2: The offsprings' traits depend on which parent the offspring received more traits from. Claim 3: The offspring received different combinations of traits from their parents.



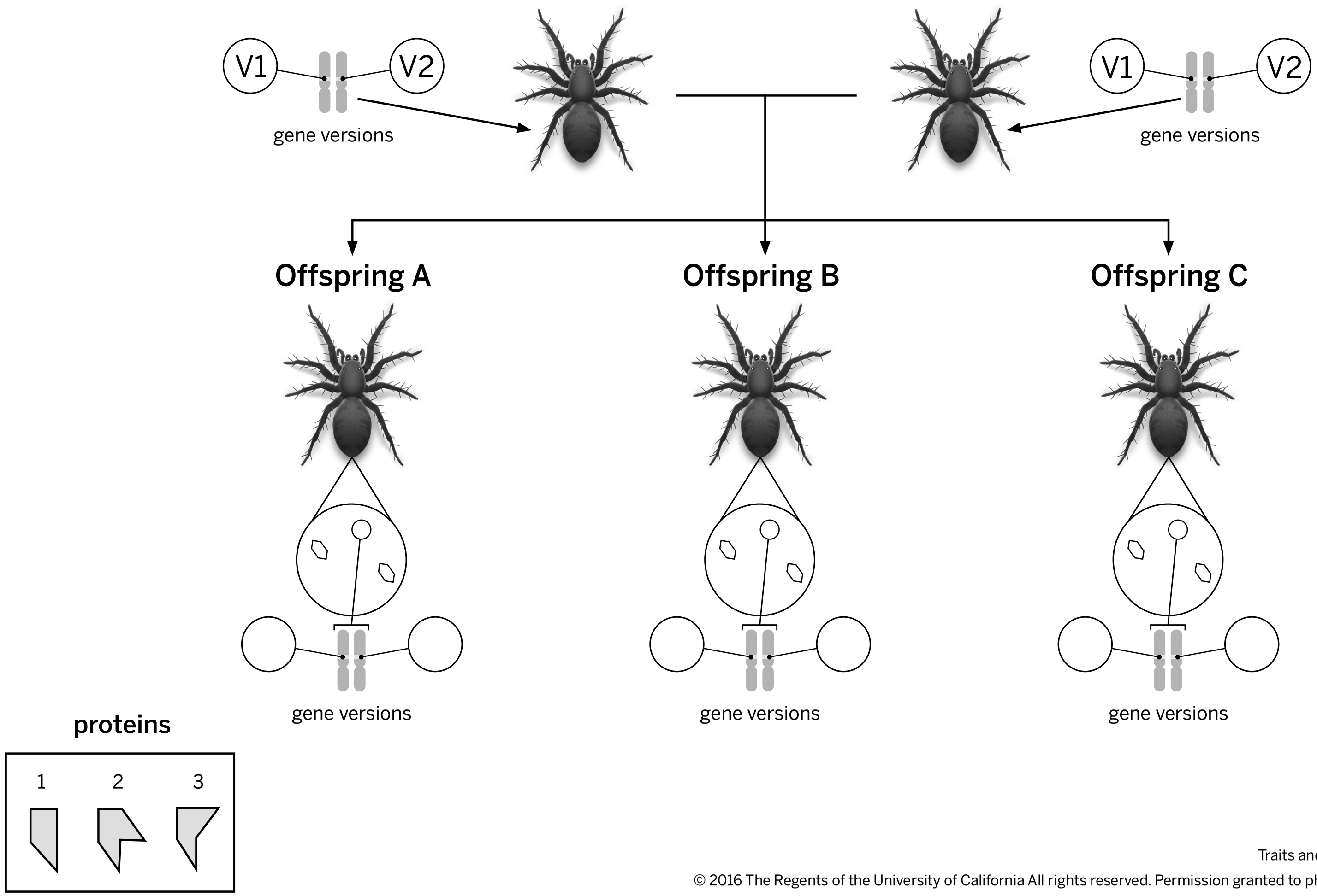
Task 12: Venom Inheritance

LT: I can show how gene versions of siblings can be different from each other and their parents.

Name: ______________ Date: ____________

Venom Inheritance Model

Using venom as an example, show how the gene versions of siblings can be different from each other and from their parents.



Task 13:

LT: I can describe how proteins and genes can determine running ability.

To: Student Researchers
From: Dr. Ada Sattari, Lead Scientist at Bay Medical Company
Subject: Research on Human Muscle Proteins
46 BAY MEDICAL COMPANY

At Bay Medical Company, we are working on several projects. So far, you have been helping us with our spider silk research. However, we now want to introduce you to another project.

One of our teams is conducting research on human muscle proteins. I want your team to take a look at the initial findings from their work with a protein called ACTN3 (ak-tin-in three). ACTN3 protein molecules connect muscle fibers, helping them contract more rapidly. As a result, the researchers think this protein might help people run faster.

To understand if the ACTN3 protein affects running ability, researchers conducted a test. They recruited a group of competitive runners and measured the level of ACTN3 protein molecules each runner had in their bodies. Then, they had the runners participate in a sprint (a short-distance run). During the test, the runners sprinted as fast as they could for 100 meters.

Scientists found that the runners who sprinted the fastest had the highest amount of ACTN3 protein molecules in their bodies; Runners who sprinted at an average pace had half the amount of ACTN3 protein molecules as the runners who sprinted the fastest. Runners in the test who sprinted the slowest had no ACTN3 protein molecules in their bodies.

Bay Medical Company have also identified two commonly known gene versions that help determine the traits for the feature of running ability: Al and A2. Al instructs for the ACTN3 protein. This is the protein that helps muscles contract more rapidly so runners can go faster.

Researchers tested three runners to see what proteins they had in their cells.
For the running ability feature, runner 1 had only ACTN3 proteins in her cells.
Runner 2 had ACTN3 as well as another type of protein in his cells.
Runner 3 had no ACTN3 protein in her cells. A different protein for the running ability feature was found.

Evidence Card A—Test Results: ACTN3 Protein in Runners

The genetic researchers at Bay Medical Company tested 100 elite sprinters and 100 elite long-distance runners to see if they had ACTN3 protein in their cells. The results are recorded in the table below.

Group	**Only ACTN3 Protein** (likely gene versions: A1A1)	**ACTN3 Protein and Nonfunctional Protein** (likely gene versions: A1A2)	**Only Nonfunctional Protein** (likely gene versions: A2A2)
Elite sprinters	98	2	0
Elite long-distance runners	3	25	72

What are your thoughts on the results of the tests we completed?

1. Do you think that this evidence shows that the ACTN3 protein determines running ability?
2. Based on the proteins that were found in runners' cells, what can you say about their genes?

Explain your ideas for question 1 using the words protein, trait, and feature in your response.
Explain your ideas for question 2 using the following words: gene versions, heterozygous, and homozygous.

Task 14:
LT: I can analyze and describe evidence in order to support a claim about variant traits present in a family.

Can Genes Affect Running Ability?
The Human Muscle lab at Bay Medical Company has been studying the Alpha-actinin-3 protein (ACTN3 for short) found in the muscle cells of some people. They believe this protein molecule may affect the trait of running ability. Researchers think that the ACTN3 protein molecules help muscles move quickly. The experiments in their lab suggest that people with high amounts of ACTN3 protein are more likely to be sprinters (people who can run short distances very quickly).

During their research, they came across the case of the Smith family.
Jackie Smith is 16 years old. She is a champion long-distance runner. She is training for the Olympics.

Jackie's 20-year-old brother, Lincoln, is also a runner. He is a sprinter. He earned a college scholarship for sprinting and hopes to win a college race.

Jackie and Lincoln's mother was a sprinter in high school and college. She competed in many races.

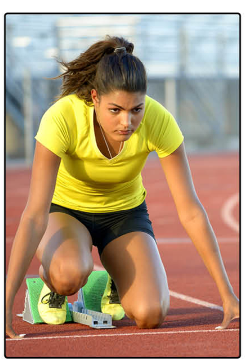
Jackie and Lincoln's father has never been a serious runner.

It is unusual to find a family that has three competitive runners. It's especially puzzling that Jackie is a long-distance runner, unlike her brother and mother, who are sprinters.

The lab contacted the family, but only Jackie, Lincoln, and their father agreed to participate in the Human Muscle lab's study. Jackie and Lincoln's mother decided not to participate in this research study, so information about her is not available.

Currently, researchers are working to understand why Jackie is a champion distance runner when no one else in her family has this trait.

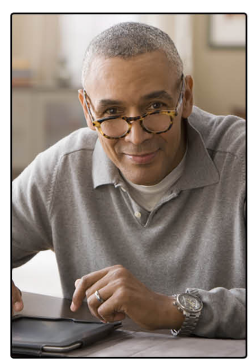
The Smith Family



Jackie:
long-distance runner

Lincoln:
sprinter

Jackie and Lincoln's mother:
sprinter



Jackie and Lincoln's father:
not an athlete

We do not have Jackie's mother's test results, but we can reason about the combination of gene versions she likely has based on her husband and Lincoln's gene combinations. We can also deduce this based on the mother's trait for running ability. What combinations of gene versions do you think Jackie's mother might have? Record possible combinations of gene versions for Jackie's mother.
Use this information to reason about and record Jackie's possible combinations of gene versions.

Evidence Card B—Smith Family Functional ACTN3 Protein Test

Family Member	Results	Possible Combinations of Gene Versions A1 = instructs for functional ACTN3 protein; A2 = instructs for nonfunctional protein; Am = gene mutation
Father (not an athlete)	The father has a low amount of functional ACTN3 protein (approximately half of Lincoln's).	A1A2
Mother (sprinter)	ACTN3 data is not available.	
Lincoln (sprinter)	Lincoln has a high amount of functional ACTN3 protein.	A1A1
Jackie (long-distance runner)	ACTN3 data is not available.	

Select and record a claim that best describes why Jackie is a champion distance runner when no one else in her family has this trait:
Claim 1: Jackie's trait is due to her training.
Claim 2: Jackie has a different combination of gene versions. Jackie's trait can be explained by the combination of gene versions she inherited from her parents.
Claim 3: Jackie has a mutation in her gene for the ACTN3 protein. This mutation instructs for a protein that results in the long-distance running trait instead of the sprinting trait.

Consider why Jackie has a different trait for the running ability trait than the rest of her family.
Analyze each of the additional evidence cards in order to support a claim.

Evidence Card C—Training Routines of Runners in the Smith Family

	Long-Distance Training	Sprinting Training	Other Training
Jackie	6 days a week	1 day a week	none
Lincoln	1 day a week	4 days a week	weight lifting with legs
Mother	1 day a week	6 days a week	weight lifting with legs

Evidence Card D—Jackie's Running History

- When Jackie was in middle school, she wanted to be a sprinter. She ran sprints (short-distance runs) three days a week, but her sprint times were not very good, and she never won any races.
- When she switched to long-distance running, she started winning races.
- Jackie's father said she has always been able to run and play for long periods of time without getting tired.

Evidence Card E—Information About Alpha-actinin-3 (ACTN3)

- There are two common gene versions for this running ability feature: A1 and A2.
- A1 provides instructions for a protein called alpha-actinin-3 (ACTN3). ACTN3 connects muscle fibers and helps muscles contract more rapidly and more powerfully. This contraction uses a lot of energy. Scientists think ACTN3 might help people become good sprinters.
- A2 gives instructions for a protein that does not connect, and, therefore, does not help muscles contract more rapidly. As this protein does not help muscles contract, less energy is used. Scientists think saving energy might help people run longer distances.

Evidence Card F—Information About Mutations

- A mutation is a random change to a gene.
- Mutations that result in a different protein are uncommon. The chance of a new mutation resulting in change to a trait is very small (only about 1 in 40 million).
- In rare cases, mutated genes provide instructions for a new version of a protein. This new protein can affect a person's trait.

Write a scientific argument that addresses the question:
Why is Jackie an elite distance runner when no one else in her family has that trait?

To make your argument more convincing, be sure to answer the following questions:

- Which combinations of gene versions do you think Jackie's mom has? Explain your thinking.
- Which combinations of gene versions do you think Jackie has? Explain your thinking.
- How do Jackie's gene versions relate to her trait for running ability?