3 Make a Dog Family and Bacteria Family

Unit Essential Question

How do the environment and genetics affect who we are and how we are similar or different?

Introduction

Offspring commonly resemble their parents: monkey babies look like their monkey parents, dog babies look like their dog parents, and human babies look like their human parents. The offspring usually don't look exactly like their parents—they tend to have some characteristics of the mother and some characteristics of the father. The question then arises as to what controls the traits, and how do they get mixed up to create offspring with some of the mother's traits and some of the father's traits?

In this activity, students will model the **cause and effect** of the inheritance of various genes on chromosomes from mother and father to offspring. After identifying the cause of variation in living organisms, students will model a very different situation in bacteria, where one parent bacteria produces offspring that are identical to the parent.

The concept of combining the genes of the parents to produce offspring is often taught with Punnett squares. Punnett squares can be effective when students first focus on the concepts involved in passing genes from parents to offspring. Unfortunately, if the Punnett squares are used first, students often don't associate the letter (T) with the the allele in the egg or sperm. The letter (T) simply becomes the letter (T), and the Punnett square becomes analogous to a multiplication table with a number (percent) for an answer.

This task is meant to help students learn the concept of passing down to offspring one allele from a pair of alleles for a trait in the egg and one allele from a pair of alleles for a trait in the sperm, resulting in variation of the offspring. After students understand the concept of alleles and gametes (eggs and sperm), Punnett squares can easily be taught as an extension task to calculate the probability of simple genetic outcomes. Having a conceptual understanding of gene inheritance also helps students understand more complex genetic situations in which there is more than one trait involved, and for which a Punnett square cannot be used to calculate probability.

Objectives

Students will be able to

Content

- Distinguish between sexual and asexual reproduction.

Science and Engineering Practices

- Develop a model to show how sexual reproduction results in variation of traits and asexual reproduction results in identical traits.

Equity and Groupwork

- Collaborate to identify patterns.

Language

- Use language to describe diagrams.

Academic Vocabulary

- allele
- asexual reproduction
- bacteria
- chromosome
- dominant
- gene
- recessive
- sexual reproduction
- trait
- variation

Language of Instruction

- aftermath
- combine
- domestic
- Venn diagram

Timing

This task can be completed in 8 class periods (based on 45-minute periods).

- Part I • Dog Traits (1 class period)
  (This part can be condensed into half a day, if short on time.)
- Parts II and III • Make a Dog Family and Dog Family Analysis (3 class periods)
  (If teaching Punnett squares [optional], you may need more time.)
- Part IV • Bacteria Traits (1 class period)
  (This part can be condensed into half a day, if short on time.)
- Parts V and VI • Bacteria Family and Bacteria Family Analysis (2 class periods)
  (This part can be condensed into 1 day, if short on time.)
- Part VII • Connect to the Culminating Project and Assessment (1 class period)

Student Materials

per student

Part II

- Dog Family Picture Frame handout (see Handout: VARHER_Task3_Handouts)

Part V

- Bacteria Family Picture Frame (see Handout: VARHER_Task3_Handouts)

per group

Part I

- Domestic Dog Pictures Resource Card (see Handout: VARHER_Task3_Handouts)
- Animal and Plant Reproduction Resource Card (see Handout: VARHER_Task3_Handouts)

Parts II and III

- Domestic Dog Pictures Resource Card (see Handout: VARHER_Task3_Handouts)
- Dog Traits and Alleles Resource Card (see Handout: VARHER_Task3_Handouts)
- 7 pennies with alleles attached to them (using paper and tape or stickers)
    - 2 pennies with a capital letter on each side of the coin
    - 2 pennies with a capital letter on one side and a small letter on the other side of the coin
    - 2 pennies with a small letter on each side of the coin
    - 1 penny with no letters (alleles) on it for flipping to identify (TT) or (Tt)

Part IV

- Bacteria Resource Card (See Handout: VARHER_Task3_Handouts)

Parts V and IV

- Bacteria Resource Card (See Handout: VARHER_Task3_Handouts)
- Bacteria Traits Resource Card (See Handout: VARHER_Task3_Handouts)
- Optional: A few pennies with only capital letters on each side and/or lowercase letters on each side of the coin

Teacher Materials

- "Variations and Heredity Task 3" digital slide presentation

Background Knowledge

In the Cells and Body Systems unit, students learned that a cell's nucleus contains instructions, called DNA, to make cell proteins. This task addresses the effects of different DNA, resulting in different proteins, resulting in different traits. Each person's cells contain DNA, which are the blueprints that code for specific proteins the cell will create. The DNA recipes are taken from the nucleus in the form of RNA to the ribosomes, where each three-base sequence codes for a specific amino acid. These amino acids then link together to form the correct protein. We are all made up of a multitude of proteins put together in a unique way to create the biodiversity of life on Earth. DNA is the foundation of variation of traits in living organisms.

Long ago, there was a scientist named Gregor Mendel (born in 1822) who studied pea plants. After 10 years of manipulating, analyzing, and watching pea plants grow, Gregor Mendel made some interesting conclusions. First, he determined that there must be something in the cells that control the pea plant characteristics. He called these "things" that control the plants' characteristics ***factors***. Second, Mendel determined that there must be two genes for every trait, one coming from the mother and one coming from the father. Lastly, Mendel determined that some traits must be dominant because they appear more often, and some traits must be recessive because they are often hidden by the dominant trait.

Today, scientists have come to the conclusion that the genetic information Gregor Mendel figured out was correct, although we now call the "things" that control characteristics ***genes*** and variations of those genes ***alleles***. We identify a dominant allele with a capital letter (T) and a recessive allele with a lowercase letter (t). And since we know that we get an allele from the mother and an allele from the father, our gene combination in our cells could be TT, Tt, or tt. If T represents tall, and t represents short, then:

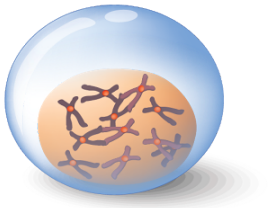
The Genes/Alleles You Have	What You Look Like
TT	Tall
Tt	Tall
tt	Short

The alleles (the Ts) are separated when making eggs and sperm through the process of meiosis and are randomly joined together to create a zygote, embryo, and eventually an offspring. Due to the random separation of genes in the process of meiosis and the random mixing of genes in the process of fertilization, there is a wide variation of phenotypes (looks) in the offspring. This variation results in the diversity of life on Earth and is important for the process of natural selection.

Genotype, meaning the genes that are found in an individual, and ***phenotype***, meaning the physical traits in an individual, are typically two words that are used with genetics. This task does not use these words because the focus is on the conceptual idea of genetics without the expectation of students memorizing academic vocabulary. Using the words ***genotype*** and ***phenotype*** is optional.

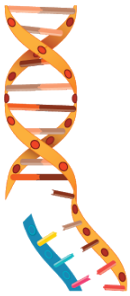
A visual summary of this background information is shown below.

The Central Dogma—DNA to Proteins

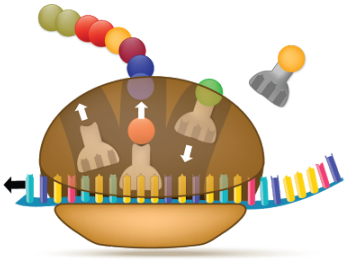


In each cell, the nucleus contains DNA instructions.

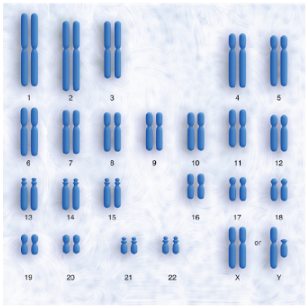
DNA is made up of a genetic sequence of base pairs.



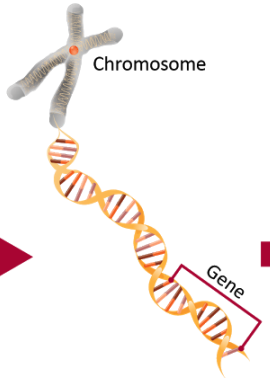
The recipes for these genetic sequences are sent out of the nucleus in the form of RNA.



The RNA makes its way to the ribosome, where each three-base sequence codes for a specific amino acid. These amino acids string together to make a protein.



Humans have 23 pairs of chromosomes, made up of DNA.



Each chromosome contains many genes, which code for certain proteins (see above).

There are two alleles for each gene, one on each chromosome in a pair, or one from each parent.

	B	b
B	BB	Bb
b	Bb	bb

Alleles from parents combine in offspring to give them their traits!

For more information about Mendel and genetics, preview this video that you will show during the slide presentation:
https://www.youtube.com/watch?v=cWt1RFnWNzk&feature=youtu.be

Introduction

1. Read the introduction from the Student Edition aloud as a class. The purpose of this introduction is to connect what students learned in the previous task to the upcoming task.
2. Have students answer the prior knowledge question on their own and then share with a partner in a think-pair-share format.
   - In the previous task, students learned about structures that aid in successful reproduction. In this task, students will delve more into the results of successful reproduction.
   - The questions provided ask students to access their own prior knowledge about where they come from and why they think they look the way they do. Student responses should revolve around the general understanding that because they came from two parents, they have a combination of their parents' traits.

   In discussions, make sure to be culturally sensitive toward students who are either adopted or do not have knowledge of the traits of one or more parents. Do not cold call on students to share aloud for this reason. Students in one of these situations can either skip this question or think about a friend and the friend's parents.

Part I • Dog Traits

1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
   - Domestic Dog Pictures Resource Card
   - Animal and Plant Reproduction Resource Card
3. Show Slide 3 of the "Variations and Heredity Task 3" digital slide presentation, which replicates the Domestic Dog Pictures Resource Card.
4. Ask students to discuss with their group the questions in their Student Edition about the Domestic Dog Pictures Resource Card.
5. Use Slides 4–5 of the digital slide presentation to lead a group discussion about the questions.
6. Have students discuss with their group the questions about the Plant and Animal Reproduction Resource Card.
7. Use Slides 6–8 to lead a group discussion about the questions.

Question	Focus of Answer
2a	***There are many variations of traits in the dogs. Try to elicit answers from as many students as possible. Note: It is important at this point to emphasize the difference between species and breed to avoid misconceptions in the next task. All the variations students see are breeds within a dog species. Examples of breeds are golden retriever, husky, German shepherd, etc. Because they are part of the same species, they are still able to reproduce together and produce fertile offspring. Cats and dogs, however, are different species so they cannot reproduce together to make fertile offspring. This idea will be emphasized again in Task 4.***
2b	***Variation exists because of DNA differences, genetic differences, DNA passed down from parents to offspring sexual reproduction, and environment (food, exercise, quality of life, disease). Note: This question emphasizes the crosscutting concept of cause and effect.***
3	***The goal is to lead students to the fact that sexual reproduction is the joining of the egg and sperm. Sexual reproduction is not defined as "having sex." Sexual reproduction is defined as "The process of producing offspring by joining the egg and sperm." There are many organisms that do not "have sex" but still produce eggs and sperm to reproduce. With salmon, for example, the female lays her eggs and then the male swims over and releases the sperm over the eggs. Some invertebrate species in the ocean are another example. These species simply release their eggs and sperm into the ocean at a certain time of the year, stimulated by moon and sunlight patterns. These organisms can only hope that one of their sperm meets another of the same species' eggs. Sea urchins and sea anemones exhibit this type of external fertilization (which still falls into the category of sexual reproduction).***

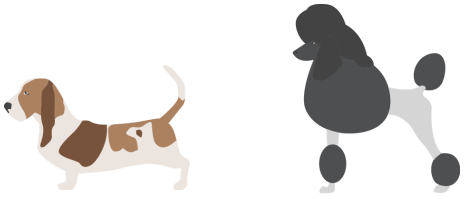
Part II • Make a Dog Family

1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
   - 7 pennies with alleles attached to them
     - 2 pennies with a capital letter (alleles) on each side of the coin
     - 2 pennies with a capital letter (allele) on one side and a small letter (allele) on the other side of the coin
     - 2 pennies with a small letter (alleles) on each side of the coin
     - 1 penny with no letters (alleles) on it for flipping to identify (TT) or (Tt)
   - Domestic Dog Pictures Resource Card
   - Dog Traits and Alleles Resource Card
3. Give to every student:
   - Dog Family Picture Frame

LANGUAGE SUPPORT: DISCUSSION SCAFFOLD

Go over the categories of domestic dogs briefly, since some students may not realize the differences depicted. Also, be mindful that some cultures and belief systems view dogs from a distance, not with familiarity.

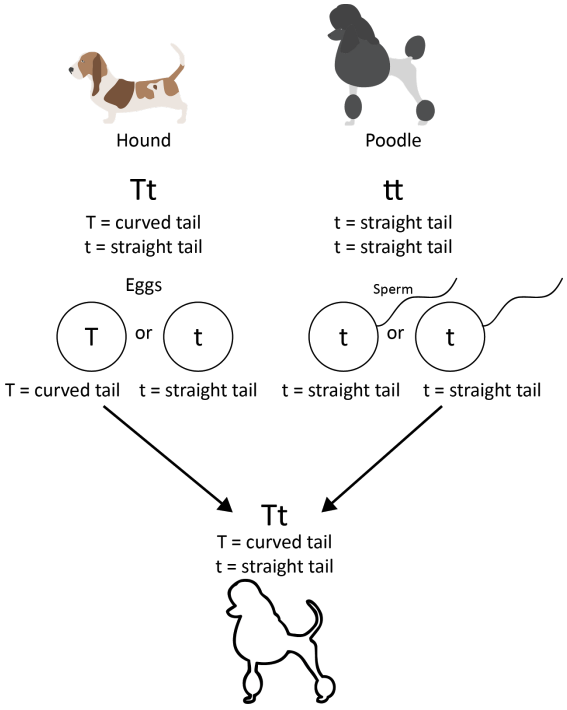
4. Show Slides 10–19 of the digital slide presentation to introduce concepts of heredity. It is recommended that students write the definitions of the vocabulary words and draw corresponding pictures in their science notebook for reference throughout the task and for use in the Independent Culminating Project. It is also recommended that students take notes in their science notebook about where genes come from as well as dominant vs. recessive traits. Try to use the vocabulary words during this task as often as possible to help the words become part of the student's natural vocabulary. The goal of the digital slide presentation is to:
   - Slide 10: Introduce Gregor Mendel.
   - Slides 11–15: Introduce (review) the words ***chromosome***, ***gene***, ***allele***, ***trait***, and ***heredity***.
   - Slide 16: Give a brief history of genetics with a slide about Gregor Mendel and a short video clip: https://www.youtube.com/watch?v=cWt1RFnWNzk&feature=youtu.be
   - Slide 17: Introduce the idea that DNA (genes) comes from both the mom and the dad.
   - Slide 18: Review dominant and recessive traits.
   - Slide 19: Introduce the idea that in genetics, a capital letter represents the dominant allele and a small letter represents a recessive allele. TT, Tt, and tt are possible gene combinations representing allele combinations.
5. Use Slides 20–21 to model the steps of the activity with one dog trait. Further detail is provided in the table below.

Step		Example
1	Pick a mom dog and a dad dog from the Domestic Dog Pictures Resource Card.	• Hound (mom) and poodle (dad)  Hound Poodle
2	Draw your mom and dad dogs in your Dog Family Picture Frame.	• Refer students to the Dog Family Picture Frame where they will draw their dogs.
3	Identify and record mom and dad dogs' **traits** in the Dog Data Table.	• Refer students to the Dog Traits and Alleles Resource Card • Show students the Dog Data Table. • Start with the Tail Shape trait as an example. • Hound: Curved • Poodle: Straight • Record the trait in Dog Data Table.
4	Identify and record mom and dad dogs' **alleles** in the Dog Data Table.	• Use the Dog Traits and Alleles Resource Card. • Hound, curved tail: Since she has a curved tail she is either (TT) or (Tt). To determine which, flip a regular penny to see if the hound is (TT) or (Tt). For example, tails = (Tt). • Record the resulting hound alleles (Tt) in the Dog Data Table. • Poodle, straight tail: A straight tail is always (tt). • Record the poodle alleles (tt) in the Dog Data Table.
5	Make a puppy with your penny alleles.	Recommend that each group pick a person to be the mom dog to always flip the mom penny and the dad dog to always flip the dad penny. • The mom dog flips the (Tt) coin to decide which allele from the mom will be passed on to the puppy. • The dad dog flips the (tt) coin to decide which allele from the dad will be passed on to the puppy. • Record the resulting traits and alleles in the Dog Data Table.
6	Repeat steps 3–5 for all traits of the puppy.	
7	Repeat steps 5–6 for a second puppy.	
8	Draw your two puppies in the Dog Family Picture Frame.	
9	Name the dogs in your dog family.	

6. Have students make their dog family.
   - Rotate through the room to check on students' progress and clarify steps as needed.
7. At the end of Part II:
   - Each **student** should have completed the Dog Data Table and a Dog Family Picture.
   - Display one student's Dog Family Picture from each group. By displaying the pictures, students will be surrounded by the resulting variation and diversity in the offspring (puppies).
   - Students should move directly into Part III after finishing their dog family.

Part III • Dog Family Analysis

1. Have students use their dog family to make a model of how sexual reproduction results in variation of traits.
   - Point out that they only need to include one of their dogs' traits in their model.
   - Provide the following example to make sure students understand what they need to do.

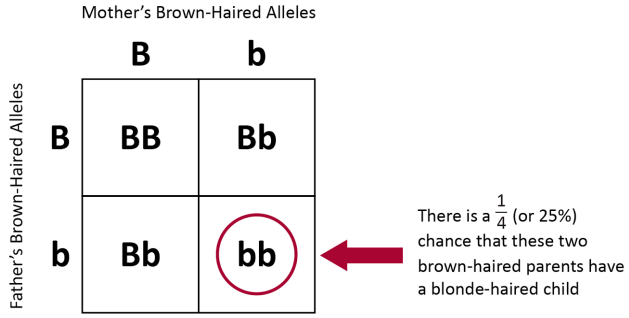


2. Have students answer question 2 in their Student Edition. This question emphasizes the crosscutting concept of **cause and effect**.

   A sample student response could be: Sexual reproduction results in variations because in each individual there are two alleles for each trait. These alleles may not be the same. Because only one allele is in the egg and one allele in the sperm, the offspring may end up with a different combination of allele pairs when compared to the parent allele pairs.

3. Have students answer question 3 in their Student Edition. ***Answer: b x Bb = bb***
4. Optional: Introduce Punnett squares and have students create a Punnett square for one trait in their dog family. (Note: By introducing Punnett squares after students have made their model, you avoid the misconception of students lacking the connection between parent allele and offspring allele.) Background information on Punnett squares is below.

Punnett Squares



In a Punnett Square, the parents' alleles go on the top and left side of the 4x4 box. In order to calculate offspring genotypes, the allele from the top parent (ex: mother) is pulled down to each corresponding box and the allele from the left-side parent (ex: father) is pulled across to each corresponding box. Each inside box will thus result in a two-allele genotype for the offspring. One can find the probability of inheriting each genotype by dividing by the total number of boxes (4). In this case, there is only a $\frac{1}{4}$ chance of bb or blonde hair.

Part IV • Bacteria Traits

1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
   - Bacteria Resource Card
3. Have students discuss in their groups the questions in the Student Edition about the Bacteria Resource Card.
4. Have students discuss in their groups the questions in the Student Edition about the Bacteria Reproduction Resource Card (the bottom part of the Bacteria Resource Card.)
5. Use Slides 23–26 of the digital slide presentation to lead a class discussion about the questions in Part IV.

Question	Focus of Answer
2a	***Review the parts of the bacteria on the top of the Bacteria Resource Card. There are many variations of traits in the bacteria. Try to elicit answers from as many students as possible.***
2b	***Variation exists in bacteria because of DNA differences, genetic differences, species differences, and the environment (maybe). Differences in bacteria also exist due to mutations. (Do not expect students to know about mutations—students are not required to learn this concept. However, if students do bring up the concept, encourage discussion, since mutations and the results of mutations are introduced in the eighth grade units.) Note that this question emphasizes the crosscutting concept of cause and effect.***
3	***The goal is to lead students to the fact that asexual reproduction is the splitting of the original parent into two new and exact copies of the parent. The offspring are exact copies because there is no mixing of DNA from two different parents. Asexual reproduction does not involve the joining of an egg and sperm.***

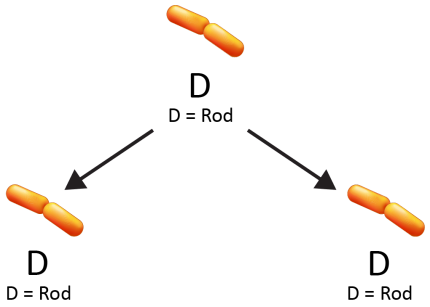
Part V • Bacteria Family

1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
   - Bacteria Traits Resource Card
   - Optional: Pennies (Bacteria reproduce asexually and only have one chromosome, so they only have one allele per trait. As a result, pennies really aren't necessary. You could, however, provide students with a few pennies with only capital letters on each side and/or lower case letters on each side of the coin to show that no matter what, bacteria will create exact copies of themselves [except when mutations occur].)
   - Students should already have on their tables:
     - Bacteria Resource Card
3. Give to every student:
   - Bacteria Family Picture Frame
4. Go through the directions for creating a bacteria family. Modeling this part of the activity is not important, since the activity is similar to the dog activity. The challenge for students here is to come up with a way to show the alleles that will be passed on from "parent" to "offspring" through asexual reproduction.
   - Begin with a whole-class discussion in which students discuss how they might simulate asexual reproduction. Bacteria only have one chromosome, so they only have one allele per trait. Since there is only one parent bacteria, and the parent bacteria only has one allele for each trait, students could either flip a coin that has the same allele on both sides, or just understand that the alleles will be the same in the parent and offspring. Students may get stuck on this concept, but allow them to be stuck and think for awhile. If necessary, use guiding questions such as the following:
     - Why does the coin have the same allele on both sides?
     - How is the reproduction process different from dog reproduction?
     - What is the result of this type of reproduction on the offspring?

     Some groups may "get it" right away—you may see the fabulous "AHA" moment!
5. Have students create their bacteria family. Display Slides 27–28 as they work to guide them.
6. At the end of Part V:
   - Each **student** should have completed the Bacteria Data Table and a Bacteria Family Picture.
   - Display one student's Bacteria Family Picture from each group. By displaying the pictures, students will be surrounded by the resulting similarity in the bacteria parents and offspring.
   - Students should move directly into Part VI after finishing their bacteria family in Part V.

Part VI • Bacteria Family Analysis

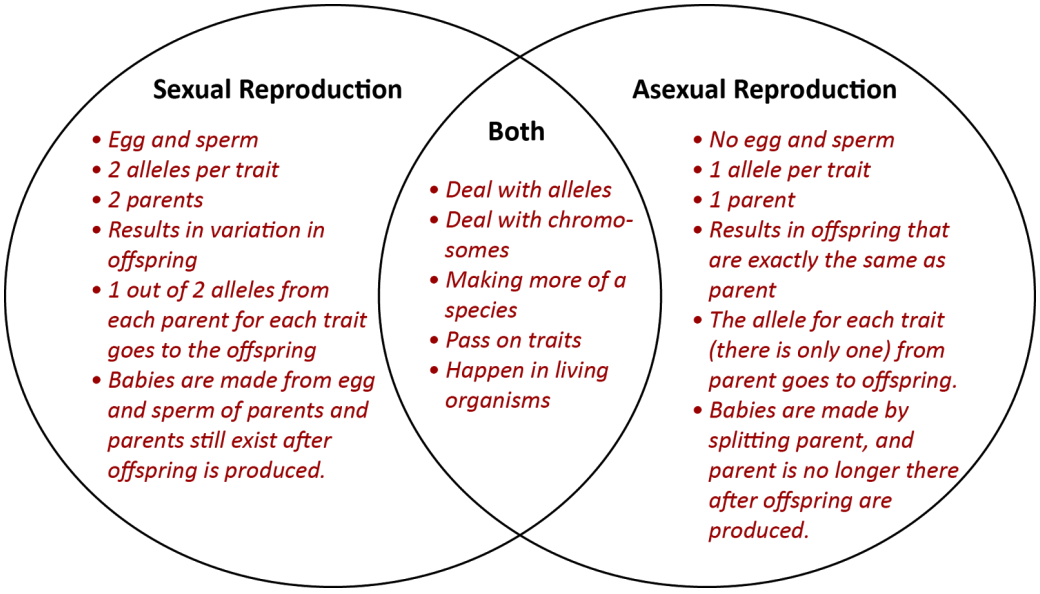
1. Have students use their bacteria family to make a model of how asexual reproduction does not result in variation.
   - Point out that they only need to include one trait in their model.
   - Provide the following example to make sure students understand what they need to do



2. Have students answer question 2 in their Student Edition. This question emphasizes the crosscutting concept of **cause and effect**.

   A sample student response could be: Asexual reproduction does not result in variation in bacteria for two reasons. First, bacteria only have one chromosome and, therefore, only one allele for each trait. Second, because bacteria split in two to reproduce, their one chromosome doubles and then splits in two. Therefore, new baby bacteria end up with the exact same chromosome (alleles) as the parent bacteria, and thus are identical to the parent bacteria.

3. Have students answer question 3 in their Student Edition. Below is an example of a Venn diagram. Students may think of more and different diagrams.



4. Extension question: Have students brainstorm about ways a bacteria with a flagellum might have a baby bacteria without a flagellum. ***The answer would be a genetic mutation.***

5. Display Slide 29. Have students watch the first 2:20 minutes of the following video clip for a review of sexual and asexual reproduction: http://study.com/academy/lesson/sexual-reproduction-inheriting-genes-from-each-parent.html

6. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following question from their Student Guide: At the beginning of this task, you tried to explain why you look identical or different from your parents. Look back at your response. After what you have learned about sexual and asexual reproduction, how could you change or add to your ideas?

   There is no right answer. Encourage students to look back at the prior knowledge question from the start of class. They should not change their initial answer, but rather use this reflection to modify their original idea or add evidence they have collected over the course of this task.

Part VII • Connect to the Culminating Project and Assessment

1. Have students independently complete the task 3 section of the Individual Project Organizer in class.
2. Collect the Individual Project Organizers and assess using these criteria:
   - The "Developing and Using Models" row of the Science and Engineering Practices Rubric
   - A criterion of your choice
3. Return the Individual Project Organizers. Give students time to make revisions based on one of these two options.
   - Have students make changes to their Individual Project Organizer according to your comments. (This could be done for homework, depending upon students' needs and/or class scheduling.)
   - Ask students to exchange their Individual Project Organizer with a partner, and give partners 5 minutes to provide written feedback. Then allow students time to make changes to their work according to the feedback.