

# LESSON 10: How do farmers control the traits of their livestock?

## PREVIOUS LESSON

Students investigated the inheritance patterns of the myostatin gene using pedigrees, and noticed interesting patterns in the proportion of offspring with different phenotypes and genotypes. They connected these patterns to how alleles are transferred and recombined during fertilization. They used mathematical models to help predict the outcome of known genetic crosses.

## THIS LESSON

### INVESTIGATION

2 days



In this lesson, we read about ways farmers breed animals for specific traits, and we run a computer simulation to try our hand at selective breeding. We figure out that by breeding animals with beneficial traits more often, we can increase the frequency they are seen in the population.

## NEXT LESSON

We will plan an investigation to break open cells and test if asexual organisms have genetic information using bananas and strawberries. Then we will carry out our investigations and discuss the results as a class.

## BUILDING TOWARD NGSS

MS-LS1-5, MS-LS3-1, MS-LS3-2, MS-LS4-5



## WHAT STUDENTS WILL DO

Obtain, evaluate, and communicate information regarding the effect of selective breeding in one type of sexually reproducing organism.

Use mathematics and computational thinking to determine the effect of selective breeding in sexually reproducing organisms by examining the frequency of certain trait variations and combinations in a population over time.

## WHAT STUDENTS WILL FIGURE OUT

- Farmers can use selective breeding to change the frequency of traits over time in a population of sexually reproducing organisms.
- Some mutations can have beneficial and harmful effects on an organism.
- In selective breeding, people choose which individuals with beneficial trait variations are bred (more often) together than individuals without those beneficial trait variations.

## Lesson 10 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	7 min	<b>CALCULATE PERCENTAGE OF HEAVILY MUSCLED CATTLE WORLDWIDE</b> Students determine the percentage of heavily muscled cattle found worldwide.	A	
2	5 min	<b>INITIAL IDEAS DISCUSSION ABOUT HEAVILY MUSCLED CATTLE</b> Students discuss how it is possible for heavily muscled cattle to be considered so rare in the population, but some farmers have entire herds of them.	B	
3	15 min	<b>READ ABOUT SELECTIVE BREEDING IN CATTLE</b> Students read two competing articles about selective breeding in cattle.	C	<i>Interview with Penny, Cattle Farmer, Raising Heavily Muscled Cattle to Reduce Environmental Impacts of Cattle</i>
4	10 min	<b>BUILDING UNDERSTANDINGS DISCUSSION ABOUT SELECTIVE BREEDING IN CATTLE</b>	D	
5	8 min	<b>INVESTIGATE SELECTIVE BREEDING IN OTHER ORGANISMS</b> Students brainstorm examples of selective breeding in other organisms and what requirements are needed in order for selective breeding to occur.	E-F	chart paper, marker, <a href="https://www.youtube.com/watch?v=wBZlxHZHO3k">https://www.youtube.com/watch?v=wBZlxHZHO3k</a>
<i>End of day 1</i>				
6	25 min	<b>USE SELECTIVE BREEDING SIMULATION</b> Students use an online simulation to selectively breed virtual birds.	G-H	computer with internet access, <i>Instructions for NetLogo Bird Breeder Simulation</i> , <a href="https://tinyurl.com/birdbreedersim">https://tinyurl.com/birdbreedersim</a> , <i>NetLogo Simulation Results</i>
7	10 min	<b>BUILDING UNDERSTANDINGS DISCUSSION ABOUT SELECTIVE BREEDING</b> Students discuss what they have figured out on how farmers can selectively breed organisms based on data from the simulation.	I	
8	10 min	<b>UPDATE PROGRESS TRACKERS</b> Students update their two-column Progress Trackers to reflect their new understandings.	J	
<i>End of day 2</i>				
9	15 min	<b>BRAINSTORM REQUIREMENTS FOR SELECTIVE BREEDING</b> Students work to create a list of requirements needed to selectively breed organisms.	K	chart paper, marker
10	5 min	<b>NAVIGATION</b> Students determine next steps.	L	
<i>End of day 3</i>				

## Lesson 10 • Materials List

	per student	per group	per class
Lesson materials	<ul style="list-style-type: none"><li>• science notebook</li><li>• <i>Interview with Penny, Cattle Farmer</i></li><li>• <i>Raising Heavily Muscled Cattle to Reduce Environmental Impacts of Cattle</i></li><li>• computer with internet access</li><li>• <i>Instructions for NetLogo Bird Breeder Simulation</i></li><li>• <a href="https://tinyurl.com/birdbreedersim">https://tinyurl.com/birdbreedersim</a></li><li>• <i>NetLogo Simulation Results</i></li></ul>		<ul style="list-style-type: none"><li>• chart paper</li><li>• marker</li><li>• <a href="https://www.youtube.com/watch?v=wBZIxHZHO3k">https://www.youtube.com/watch?v=wBZIxHZHO3k</a></li></ul>

### Materials preparation (20 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Have computers with internet connection available for day 2.

Make sure you can open the Birdbreeder Simulation <https://tinyurl.com/birdbreedersim> and test it yourself before introducing it to students. Alternatively, you can download the sim code file and run it directly from your computer. Instructions for different methods to access the Netlogo simulations are located at the field test website: <https://www.teachersopensciencedfieldtest.org/muscles>.

Be prepared to share the Birdbreeder simulation link (<https://tinyurl.com/birdbreedersim>) with students so that they will be able to run it on their own computers.

## Lesson 10 • Where We Are Going and NOT Going

### Where We Are Going

Students use prior knowledge about the role of pollination, from second grade, LS2.A, to discuss how farmers may use artificial selection in plants. They begin to develop this idea more deeply in Lesson 11. In order for students to understand that selective breeding results in a change in the distribution or frequency of desired traits in a population over time, students use mathematics and computational thinking to analyze data produced from a computer simulation.

### Where We Are NOT Going

While artificial insemination, AI, is mentioned in readings from the lesson, we are not discussing the process at length. The important takeaway students should have regarding AI is that humans are able to control exactly which organisms are reproducing by controlling which sperm will be used to fertilize an egg. Discussion of the genetics of the heavily muscled cattle is not required understanding to determine the effects of selective breeding. Students can see a symbolic representation of different alleles in the computer simulation to get a better understanding of the genetics behind selective breeding/artificial selection, at least for breeding for certain combinations of variations in single-gene traits.

# LEARNING PLAN for LESSON 10

## 1 · CALCULATE PERCENTAGE OF HEAVILY MUSCLED CATTLE WORLDWIDE

7 min

MATERIALS: science notebook

**Calculate percentage of heavily muscled cattle worldwide.** Remind students that in the last class, they wondered about how many heavily muscled cattle were found worldwide. Display **slide A**. Say, *Here is some data about the total number of cattle in the world and how many of those are heavily muscled. In your groups, determine the percentages of heavily muscled cattle and those that are not heavily muscled.* Allow students a few minutes to complete the calculations.

ADDITIONAL GUIDANCE	As groups work together to determine the percentage of heavily muscled and not heavily muscled cattle worldwide, rotate among groups and help as needed. Groups should determine the percentage of heavily muscled cattle by dividing 1.5 million by 1007 million. They should then subtract that number by 100% to determine the percentage of not heavily muscled cattle worldwide. Alternatively, some groups may decide to subtract 1.5 million from 1007 million and take this difference and divide it by 1007 million.
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**Share calculations.** Invite a few groups to share out how they calculated the percentages.

KEY IDEAS	Students should determine that 0.15% of cattle worldwide are heavily muscled and that 99.85% of cattle are not.
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## 2 · INITIAL IDEAS DISCUSSION ABOUT HEAVILY MUSCLED CATTLE

5 min

MATERIALS: science notebook

**Lead an Initial Ideas Discussion about heavily muscled cattle.** Display **slide B** and have students turn and talk with a partner to discuss the question, “How can farmers have whole herds of heavily muscled cattle if they are so rare throughout the world?” Give students a few minutes to discuss with a partner before sharing with the whole class. Have students record their ideas in their science notebooks.

Suggested prompt	Sample student response
How can farmers have whole herds of heavily muscled cattle if they are so rare throughout the world?	They buy the cattle that way and add them to their herds. Maybe the breed them so their herd is only heavily muscled. What if they are in a mixed herd, what happens if they breed with a non heavily muscled cow? How do farmers control what cow breeds with another cow?

3 · READ ABOUT SELECTIVE BREEDING IN CATTLE

15 min

MATERIALS: science notebook, Interview with Penny, Cattle Farmer, Raising Heavily Muscled Cattle to Reduce Environmental Impacts of Cattle

Identify goals for reading about selective breeding in cattle. Say, I have two articles about selective breeding in cattle. One is from the interview with our farmer from earlier lessons, and the second is from another source. Before we read the articles, let's think about what our goals are as readers, how we can compare the two and how we can identify and evaluate the claims made by each article.

Suggested prompt	Sample student response
What type of information are we hoping to figure out from these two articles?	We want to figure out how farmers breed cattle for the heavily muscled trait.
Okay, so we know what types of information we are looking for in the articles. How can we keep track of that information while we are reading?	I like to use a highlighter or underline the key ideas when I'm reading. I put question marks next to parts that I don't understand and need to come back to later.
How can we determine if the articles are reliable?	I try to make sure that I can explain what I've read to someone else. We need to look for the authors using evidence to support what they are saying. They might cite other sources where they got their information.
Those ideas sound great. While you read, mark up the text to track your thinking. And when we're finished reading, we'll discuss how the articles compare, so be ready to tell others what you learned from each of the articles.	They might say things like, "in my experience," or have firsthand knowledge.

ADDITIONAL GUIDANCE	Struggling readers may benefit from the following activities: reading with a partner, reading aloud, chunking the text, highlighting unknown words, or looking for key ideas.
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Use a checklist to compare the articles. Remind students of the checklist they used in Lesson 3 to evaluate two articles. Instruct students to use the checklist they developed in Lesson 3 to record information about the two articles as they read them.

\* SUPPORTING STUDENTS IN ENGAGING IN OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION

Students should use their checklist to determine the claims and conclusions of each of the two articles. While this checklist is similar to the one they used in Lesson 3, this time the articles are in agreement around the main claims they are making: that farmers are able to change the frequency of traits in their herd through selective breeding. The articles differ in the types of data used to support the claims, and in some of the techniques used to create the desired results. If students struggle, remind them to think about what information we decided as a class to look for as we read the articles.

A sample checklist with student responses based on these new readings is provided below.

	Article 1	Article 2
What is the goal(s) of the text?	<i>The text explains how farmers select for traits and use artificial insemination to control which animals are mating.</i>	<i>The text explains why farmers might want to choose to raise heavily muscled cattle over non heavily muscled cattle.</i>
What claims is the article making?	<i>The article claims that the farmers can change the occurrence of traits in their herd through selective breeding.</i>	<i>Artificial insemination and selective breeding have reduced some of the problems associated with heavily muscled cattle. Raising heavily muscled cattle is better for the environment.</i>
Are the claims supported by evidence?	<i>The farmer gives examples of how they were able to select for a trait (pelvic readings, in this case) so that their heavily muscled cattle didn't need to have a C-section in order to give birth.</i>	<i>The author provides data to support the claim.</i>
Where does the evidence come from?	<i>The evidence was from their firsthand experience.</i>	<i>Articles written by scientists that studied the breed and people that have raised the breed.</i>
Does the article provide a way for us to review the actual data its claims were based on for ourselves if we were interested?	<i>We would have to reach out to the farmer, so yes, we could review the evidence provided by the farmer.</i>	<i>We can search and find the articles the author cites.</i>
Does the article make sense or fit with what we already know?	<i>The article fits with the idea that while heavily muscled cattle can be a beneficial trait, that there are some problems associated with it, like having to have C-sections.</i>	<i>The article does fit with the idea that heavily muscled cattle have some problems associated with being heavily muscled, but it is also a good trait we want.</i>

#### ADDITIONAL GUIDANCE


Allow students to do a quick online search of the resources the second article cites so they can check for reliability.

Display **slide C**. Hand out *Interview with Penny, Cattle Farmer* and *Raising Heavily Muscled Cattle to Reduce Environmental Impacts of Cattle*. Give students 10 minutes to read through both articles and make notes.\*

4 · BUILDING UNDERSTANDINGS DISCUSSION ABOUT SELECTIVE BREEDING IN CATTLE

10 min

MATERIALS: science notebook

 **Lead a Building Understandings Discussion about selective breeding.** Lead students in a discussion about what they figured out from the two readings. Display slide D.

Suggested prompt	Sample student response
What was similar between the two articles?	<p>They both said that AI was used to breed the heavily muscled cattle so that they didn't need C-sections.</p> <p>They both said you get a higher yield of meat from the heavily muscled cattle.</p>
What was different between the two articles?	<p>They had different views on what beneficial traits in the heavily muscled cattle they were breeding for.</p> <p>Our farmer described looking for good hooves and legs because the cattle need to be able to walk around a lot on the farm.</p> <p>The farmer also said they looked for a wide pelvis so that birth was easier and didn't require a C-section.</p> <p>The other article said that there were some drawbacks of breeding the heavily muscled cattle, like babies being too big to be born, so moms had to have C-sections.</p> <p>They used different techniques. Sometimes they just let the cattle mate in the pens and other times they used artificial insemination. The other article said that they also controlled what the mother ate while she was pregnant.</p> <p>The second article focused on why the heavily muscled cattle are a good breed to have because they reduce environmental impact.</p>
Are the conclusions in both articles valid based on the information we already know?	<p>Both articles helped support the idea that while the heavily muscled trait is useful/helpful, there are some negative effects of the trait, like big babies that require C-sections.</p> <p>Both articles said that farmers can use techniques to help reduce the negative effects of the trait.</p> <p>I think both articles had valid conclusions because they used evidence.</p>



Suggested prompt	Sample student response
What can we say about the validity of the two articles?	<p>Both articles used evidence to support their claims.</p> <p>We are able to determine if both articles have accurate information because we could contact the person interviewed in the first article and we could look up the articles used in the second article.</p> <p>Both articles are valid because they used evidence to support their claims and the claims they made go with information we already know.</p>
What questions do you have?	<p>I was wondering how the farmer was able to breed the cattle over the course of 25 years so that they went from always having to have C-sections to not having to have C-sections. How were they able to do that so fast? How can farmers change traits over time in their own cattle?</p>
<b>KEY IDEAS</b>	<p><b>Purpose of this discussion:</b> Synthesize the main ideas about how farmers select for traits when breeding cattle, based on the evidence we have read in the articles.</p> <p><b>Listen for these ideas:</b></p> <ul style="list-style-type: none"> <li>• Many different traits are taken into consideration when breeding cattle.</li> <li>• Different farmers look for different traits depending on what the requirements of the cattle are.</li> <li>• While there are benefits to having heavily muscled cattle, like increased yield of meat, there are some harmful effects too, like complicated births and mobility issues.</li> <li>• Farmers can use different techniques like selective breeding and monitoring what a female cow eats while pregnant to help reduce negative effects of the trait.</li> </ul>
<b>ASSESSMENT OPPORTUNITY</b>	<p>Listen for students to discuss that while the mutation for the heavily muscled cattle had some benefits, there were also some harmful effects. Students should also identify that farmers think about many different traits while breeding cattle and use different methods for breeding based on what the goal for their herd is.</p>

## 5 · INVESTIGATE SELECTIVE BREEDING IN OTHER ORGANISMS

8 min

**MATERIALS:** science notebook, chart paper, marker, <https://www.youtube.com/watch?v=wBZlxHZHO3k>

**Motivate considering other organisms.** Say, *OK, so we've read about how this approach of selective breeding can be used to affect the trait variations in a cattle population. But what these breeders are describing they do through selective breeding isn't limited to working on just cattle. There are other kinds of organisms that people have selectively bred over time. Let's take a moment to brainstorm some of the other types of organisms that you think people may have selectively bred.*

**Investigate selective breeding in other organisms.** Display slide E. Give students 2 minutes to turn and talk with a partner to brainstorm examples and then have them share these with the whole class. Record their answers on a piece of chart paper.

Suggested prompt	Sample student response
<i>What are other types of animals do you think people may have tried to selectively breed, besides cows?</i>	<i>dogs cats pigs birds rabbits</i>
<i>Besides animals, what are some other types of organisms that you think people may have tried to selectively breed? Draw on your experiences from the grocery store to brainstorm some possibilities.</i>	<i>apples grapes lettuce tomatoes potatoes carrots</i>

**Discuss prior knowledge about plants.** Use the following discussion prompts to discuss students' prior knowledge about how plants could be selectively bred.

Suggested prompt	Sample student response
<i>So, let's say some farmers are breeding a few of the types of plants we identified. That means that those plants would have to sexually reproduce too... that is something that flowering plants do. Does anyone remember why bees and other pollinators are needed to help some plants produce more plants?</i>	<i>Accept all responses.</i>

**Describe the role of pollination in sexual reproduction in flowering plants.** Say, *Pollination is a way that pollen is moved from one flowering plant to a different flowering plant. This is an important step in how different kinds of flowering plants reproduce. This is because the pollen contains male sex cells, and these must be moved from a specialized male structure on the flower called the stamen so that the pollen comes into contact with female sex cells produced by the flowers of the plant in order for seeds to develop.*

The female sex cell, which is the equivalent of an egg cell in animals, is called an ovule, and it is found in a different specialized structure of the flower called the pistil of the plant. Let's watch a short video to see an example how people can selectively breed flowers by carefully moving pollen from the pistil of one flower to the stamen of another flower. This example is for just one kind of flowering plant—a strawberry—but the same technique can be used for other flowering plants, like apples, tomatoes, grapes, pumpkins, and peppers.

Show the pollination video at <https://www.youtube.com/watch?v=wBZlxHZHO3k>.

#### **ADDITIONAL GUIDANCE**

Students should know from second grade that plants need pollination to occur in order to make new plants. They may bring up that sometimes plants require a pollinator for this to occur. In Lesson 11, students will spend some time discussing how pollination can be influenced by humans through selective breeding and artificial selection.

**Transition to next investigation.** Say, *In many cases, breeding organisms also takes a lot of time. For example, the time it takes to produce a single generation of apples and seeds from a flowering tree is not just an entire season, there is also the time it takes for those seeds to grow into trees before they can produce their flowers. Or in the case of cattle, it takes 9 months from conception to birth, and still another 15 months on average before they mature enough to have babies of their own. We don't have that sort of time available in our own class to test out our ideas of what it takes to selectively breed for specific trait variations with real organisms. But I do have a computer simulation that we can use to see what else it might take to breed virtual organisms to try to change the proportions of traits in the population over time. In the case of the particular simulation we will use next time, you will have an opportunity to selectively breed virtual birds. This is another example of a type of sexually reproducing animal that people have bred.*

Show **slide F**. Have students turn and talk about the following prompts: What are some different types of birds you think people have selectively bred in the real world? What are some different traits or trait variations you think they may have been trying to selectively breed those birds for?

## End of day 1

### 6 · USE SELECTIVE BREEDING SIMULATION

25 min

**MATERIALS:** computer with internet access, science notebook, *Instructions for NetLogo Bird Breeder Simulation*, <https://tinyurl.com/birdbreedersim>, *NetLogo Simulation Results*

**Connect to the ideas we started generating last time.** Remind students that we were going to try to selectively breed a type of virtual organism ourselves today using a computer simulation. Ask students to recall what type of virtual organism we were anticipating on working with. Students should say birds. Ask students to share some example traits or trait variations they discussed last time that people might want to breed birds for. Accept all answers.

**Introduce the breeding simulation.** Say, *This simulation will let us breed birds for anywhere from 2 to 4 specific traits, depending on the difficulty level we choose to set the simulation to. At first you will spend 5 minutes just reading through the directions and doing some initial explorations of it.*

Hand out *Instructions for NetLogo Bird Breeder Simulation* and have students launch the simulation from <https://tinyurl.com/birdbreedersim>. Instruct them to follow the directions on the handout to explore the simulation for 5 minutes before we regroup to do more focused investigation.

After 5 minutes have all students pause the simulation (and clamshell their computers or turn off the monitors for now).

Hand out *NetLogo Simulation Results* Show **slide G**. Use this to introduce students to the type of data they will collect after they set the difficulty level they want to try, and press SETUP again. Show an example of this using the screenshot shown on **slide H**.

#### \* SUPPORTING STUDENTS IN ENGAGING IN USING MATHEMATICAL AND COMPUTATIONAL THINKING

If students struggle to use mathematical and computational thinking to analyze their data, support them by helping them visualize the data numerically. Have students use various groupings, like different colored highlighters, to identify individuals with the same genotypes. Once students have grouped individuals by genotypes, they can then count them and determine the percentage of each in the population.

This is what the example data will look like for the bird population shown on the slide:

		Before selective breeding		After selective breeding	
		# of birds	% of birds	# of birds	% of birds
For all difficulty levels	with no selected for trait variations	6	75%		
	with one selected for trait variation	2	25%		
	with two selected for trait variations				
For difficulty level 2 or 3 only	with three selected for trait variations				
For difficulty level 3 only	with four selected for trait variations				
Total birds		8	100%		100%

Then tell students that they will need to tally up these values at the start and at the end of their selective breeding, and use a calculator to determine the percentages for each category, which should add up to 100% for that column. Point out that there is an additional data table to record number of matings, number of offspring, and number removed at the end of their selective breeding investigation, as well as some additional making sense questions to respond to. Tell students that they will have 10 minutes to conduct their simulation, at which time you will give a signal to record the results for the current simulation and answer the questions on their handout in the last 5 minutes.\*

#### ALTERNATE ACTIVITY

Students can continue using the simulation to complete Levels 2 and 3, or they could use a simulation looking at fish breeding, which can be accessed through this website: [http://www2.open.ac.uk/openlearn/angel\\_fish/](http://www2.open.ac.uk/openlearn/angel_fish/).

## 7 · BUILDING UNDERSTANDINGS DISCUSSION ABOUT SELECTIVE BREEDING

10 min

MATERIALS: science notebook

**Lead a Building Understandings Discussion about selective breeding.** Say, *So we've figured out a lot of information from our readings and the simulation about how people use selective breeding in different organisms. Display slide I.*

#### KEY IDEAS

**Purpose of this discussion:** Summarize takeaways from the selective breeding simulation.

#### Listen for these ideas:

- People can control trait variations in organisms by choosing to mate individuals with desired traits.

Suggested prompt	Sample student response
By the end of the selective breeding simulation, you were able to increase the percentage of birds with beneficial trait variations. What sort of strategies did you use to do this?	<p>I turned on the see-alleles? which made it easier to choose specific birds.</p> <p>I stored extra birds in the mating areas to keep them for possible future use when I ran out of space in my cages.</p> <p>I picked birds that had at least one allele for each trait that I was trying to get in my birds.</p>
Why did it take so many matings and so many offspring to get to this point?	<p>I didn't have any birds to start with that had all the traits I was trying to achieve. This meant I needed to ask for birds from other breeders that had the traits I was looking for.</p>
How could people use these same strategies to change the characteristics over time of any sexually reproducing organism?	<p>I think this is what they did in the readings. Like, they chose cattle that had the traits they wanted and bred them together.</p> <p>I think we do this when we breed dogs too! My family likes to watch dog show competitions on TV and they are looking for specific traits in each type of dog.</p> <p>I wonder if they did this with plants too. Maybe farmers are choosing to pollinate watermelon plants that don't have a lot of seeds so that's how we got seedless watermelons?</p>
In the simulation and readings, there were traits that we desired and didn't desire. What are some variations of traits you think breeders try to avoid in our pets?	<p>Shedding! I know there are some dogs that shed a lot, so maybe they bred dogs that don't shed a lot.</p> <p>What about allergies? Like I've seen hairless cats, maybe people that are allergic to cats but like them could get a hairless cat?</p> <p>My friend has a pug and they have a lot of breathing problems. Maybe breeders try to breed pugs together that don't have a lot of breathing issues.</p>

## 8 · UPDATE PROGRESS TRACKERS

10 min

MATERIALS: science notebook



**Update Progress Trackers in science notebooks.** Direct students to add to their Progress Tracker, **slide J**, in their science notebooks. Explain that we need to record our new understandings on how people can use selective breeding to change traits in organisms.\*

### ASSESSMENT OPPORTUNITY

The Progress Tracker can be a valuable tool for formative assessment, giving you a clear picture of students' thinking and allowing you to direct your instruction accordingly. However, Progress Tracker entries should not be scored or graded (other than possibly for completion), because doing so would invalidate their purpose - to be a safe space for students to process and record their thoughts honestly and without worry about evaluation.

Since this chart is a loose structure, students can take up a lot of space or a little space for each entry in their Progress Trackers. When students complete their thinking for today, they can draw a line after their work to make space for the next time a teacher instructs them to write in their Progress Tracker.\*

In the example two-column Progress Tracker row for this lesson, each of the columns has been completed with *possible* student ideas.

Question	What I figured out in words/pictures
How do farmers influence the traits of their livestock?	<ul style="list-style-type: none"><li>• People breed for beneficial traits using selective breeding.</li><li>• Animals with desired traits are bred more often than animals without desired traits.</li><li>• The heavily muscled allele has some benefits, but also can lead to some harmful effects. People can use selective breeding to reduce the harmful effects that are associated with certain traits.</li><li>• By controlling what organisms are bred with other organisms, people can change traits over time so that the desired trait becomes more common in the population. Farmers in Denmark were able to go from over 50% C-sections to less than 10% C-sections over time.</li></ul>

### \* SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT

Students should identify that selective breeding is a way that farmers can control traits in their livestock, or system. The act of selective breeding leads to different effects in the population, such as a frequency change toward the desired traits. If students struggle to identify the cause-and-effect relationship, ask probing questions about how what they were doing caused different effects in the offspring that were produced.

### \* ATTENDING TO EQUITY

This Progress Tracker serves as teacher guidance for what students might say at various points throughout the unit. However, some students may say more and others may say less. It is important that what the students write in the two-column Progress Tracker reflects their own thinking at that particular moment in time.

End of day 2

9 · BRAINSTORM REQUIREMENTS FOR SELECTIVE BREEDING

15 min

MATERIALS: science notebook, chart paper, marker

**Brainstorm requirements for selective breeding.** Say, *So if we were to breed a certain type of animal, or flowering plant, what are some goals that breeders might have in any of these cases, and what are some steps they would need to follow to help ensure that they are making progress in meeting those goals?* Display **side K**. Give students 2 minutes to turn and talk with a partner before sharing. Record on a piece of chart paper what the class decides.

A sample requirements list is found below.

What are some goals that a breeder might have any time they are selectively breeding?  
What are some steps they would need to follow to help ensure that they are making progress toward meeting their goals?

1. They are trying to get certain traits or trait variations to show up in the offspring.
2. They need a place to house the offspring.
3. They need space to breed them.
4. They need other breeders or populations to mix up the mating; we don't want to breed closely related individuals.
5. They need a way to control which individuals are mating together; we don't want random matings.

10 · NAVIGATION

5 min

MATERIALS: science notebook

**Navigate to our next steps.** Say, *So these goals and steps are a good general description of what a breeder needs to consider when trying to selectively breed organisms. Sexual reproduction helps explain a lot of how farmers are controlling traits in a population, but I wonder about some of the plants that farmers grow that don't reproduce sexually, like potatoes.* Display **slide L**. Have students turn and talk about the prompt: If asexual plants and living things don't use sex cells to reproduce, how do they pass on their genetic material? Allow students 2 minutes to discuss the question before sharing out.

Suggested prompt	Sample student response
<i>If asexual plants and living things don't use sex cells to reproduce, how do they pass on their genetic material?</i>	<i>I think they make buds, like we forgot about some potatoes and they had these little buds coming out of them after a while.</i>  <i>I think they clone each other!</i>
<i>So it sounds like we aren't sure about how this works. We should take a deeper look at how plants can reproduce asexually.</i>	

## Additional Lesson 10 Teacher Guidance

### SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

**CCSS.ELA-LITERACY.RST.6-8.8** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

**CCSS.ELA-LITERACY.RST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Students work with SEP8 in order to evaluate the conclusions of two articles to determine the validity of the claims made in each. If students need additional guidance, refer them back to the checklist the class developed to identify the claims and evidence used to back up those claims.

### SUPPORTING STUDENTS IN MAKING CONNECTIONS IN MATH

**CCSS.MATH.CONTENT.7.RP.A.3** Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

Students use SEP5 to make sense of experimental data from a simulation. They also determine the overall percentage of heavily muscled cattle in the world using total number of cattle in the world and number of heavily muscled cattle. If students need additional guidance making sense of the experimental data, encourage them to identify and count the number of individuals with each genotype as a result of a mating. Once students have determined the number of each genotype, they can determine the percentage of the desired genotype in the population over time.