LESSON 7: What does the myostatin protein do?

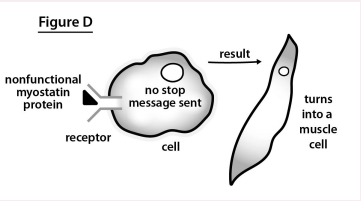
PREVIOUS LESSON

After considering the scale of chromosomes, students reassembled their cattle family trees with added information about each individual's chromosomes and which versions of the myostatin protein each has. Groups constructed initial models and then a classroom consensus model to explain the correlations they found. Finally, students read a summary of a genetic study to find evidence of causal relationships among allele, protein, and phenotype.

THIS LESSON

INVESTIGATION

1 day



Students evaluate and critically read an article about the function of the myostatin protein. They obtain information and communicate during class discussion using evidence from the text about how the structure of typical myostatin limits muscle growth, and the different shape of nonfunctional myostatin leads to greater muscle growth in some organisms.

NEXT LESSON

We will update our classroom consensus model to include our recent findings about the role genes, alleles and the myostatin protein play in making extra-big muscles. Updating our Progress Tracker with a partner, we will revise our initial model individually. Looking at a cattle family, we realize that the siblings don't look the same. We will discuss how this information impacts our model.

BUILDING TOWARD NGSS

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

WHAT STUDENTS WILL DO

Obtain, evaluate and communicate information from a scientific text about how the shape (structure) of the myostatin protein affects its function, which then influences the variation of a trait an individual shows (how much muscle an organism grows).

WHAT STUDENTS WILL FIGURE OUT

- Myostatin is a protein that typically limits muscle growth by sending a message telling cells not to turn into muscle cells.
- Myostatin has a different job than myosin and actin, which are building blocks.
- In organisms with a differently formed myostatin protein, that stop signal is not communicated, so more cells turn into muscle cells than they would typically.

Lesson 7 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	**USE PROGRESS TRACKERS TO UPDATE OUR MODEL FOR GENE-PROTEIN-PHENOTYPE** Students use their Progress Tracker entries from last time to update their consensus model so it shows the causal chain linking gene to protein to phenotype for myostatin and extra-big muscles.	A	classroom consensus model for gene-protein-phenotype from the previous lesson
2	8 min	**EVALUATE AN ARTICLE ABOUT THE FUNCTION OF MYOSTATIN** Students use the criteria they developed in a previous lesson to evaluate whether the article they will read today is a credible source of information.	B-D	*The Function of the Myostatin Protein*, checklist (chart) used to evaluate the articles in Lesson 3
3	10 min	**READ AN ARTICLE ABOUT THE FUNCTION OF MYOSTATIN** Students use a graphic organizer to guide their critical reading of an article about how the myostatin protein influences muscle growth.	E	*The Function of the Myostatin Protein*, *Reading Guide for Myostatin Protein Article*
4	12 min	**BUILDING UNDERSTANDINGS DISCUSSION ABOUT THE FUNCTIONS OF MYOSTATIN** Students participate in a Building Understandings Discussion about how myostatin works typically and in heavily muscled animals.	F	*The Function of the Myostatin Protein*, *Reading Guide for Myostatin Protein Article*
5	7 min	**UPDATE PROGRESS TRACKERS** Students summarize today's learning about how myostatin works by adding an entry to their Progress Trackers.	G	

End of day 1

Lesson 7 • Materials List

	per student	per group	per class
Lesson materials	• science notebook • *The Function of the Myostatin Protein* • *Reading Guide for Myostatin Protein Article*		• classroom consensus model for gene-protein-phenotype from the previous lesson • checklist (chart) used to evaluate the articles in Lesson 3

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.

Be sure the checklist (chart) used to evaluate the articles in Lesson 3 is in view.

Lesson 7 • Where We Are Going and NOT Going

Where We Are Going

The article students read in this lesson will connect the pieces they've already learned about genetic information leading to specific proteins, and the phenotype of extra-big muscles they saw in the anchoring phenomenon. They know from Lesson 6 that the myostatin protein is responsible for the heavily muscled phenotype, but they don't know how until they read about it in this lesson.

Where We Are NOT Going

The article students read in this lesson, while based on reliable research, is a very much simplified explanation of how myostatin influences muscle growth. Since this unit is focused on the genetics of myostatin, we are not digging into its function more than just the basics students need to know to understand the phenomenon.

LEARNING PLAN for LESSON 7

1 · USE PROGRESS TRACKERS TO UPDATE OUR MODEL FOR GENE-PROTEIN-PHENOTYPE

8 min

MATERIALS: science notebook, classroom consensus model for gene-protein-phenotype from the previous lesson

Update our classroom consensus model to reflect causation. Direct students to find their Progress Tracker entries from the previous lesson. Display **slide A**.

Say, *We made quite a bit of progress last time we were together - we figured out that chromosomes have specific regions called genes, and these genes can have different versions called alleles. The combination of alleles an individual has is his or her genotype. We know that animals get this genotype from their parents, because the chromosomes are one of the few things passed along in the sperm and egg. So we already established that our model can begin there. But then we read evidence linking a certain genotype to the heavily muscled phenotype we've seen in several animals. So, let's update our consensus model to show how the genotype is related to the myostatin protein and heavily muscled phenotype.*

Suggested prompt	Sample student response
Last time we had our model beginning with the double-blue-star genotype, because the animal got those alleles from its parents. But then we weren't sure which came next... the extra-big muscles or the myostatin protein. How should we change that now? What did you record in your Progress Trackers?	*I put the partial myostatin next "in line" because the scientists in that study changed the mice genes and got that differently shaped protein.* *Then the last piece is the heavily muscled phenotype, because the scientists raised mice who had two copies of the allele to make the partial myostatin, and they had extra-big muscles.*
Okay. Got it. Then how are we going to show the relationship between these components of our model?	*We need solid arrows from the genotype to the partial myostatin, and then from the partial myostatin to the animal with extra-big muscles. They only need the arrow point on one end, not both anymore.*
So what relationships are those arrows indicating?	*We know that each one causes the next one... it's like a chain of cause and effect.*

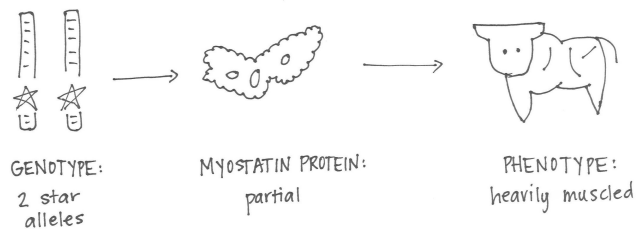
See example of final consensus model here.

Set the purpose of today's work. Say, *Okay, we have this causal chain in our model. But what about those arrows? What questions do we have about that part of our model?*

Elicit student responses such as, *We don't know how they're doing that. What's happening so that part causes the next?*

Say, *Let's start investigating one of these.* Point to the second arrow in the model. Say, *Today I have an article for you to read about this protein. If we are investigating this second cause today, then what specifically is our purpose for reading this article?*

Elicit student responses such as *We want to learn how myostatin makes big muscles* or *We want to know how the myostatin protein works.*



2 · EVALUATE AN ARTICLE ABOUT THE FUNCTION OF MYOSTATIN

8 min

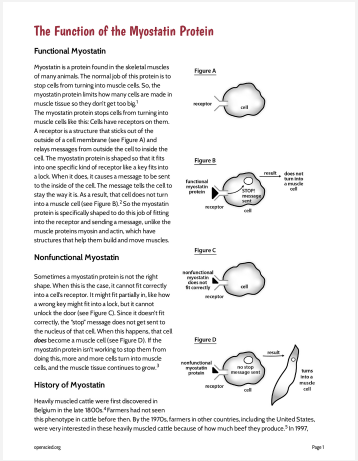
MATERIALS: science notebook, *The Function of the Myostatin Protein*, checklist (chart) used to evaluate the articles in Lesson 3

Review our checklist about evaluating a text's credibility. Say, *Okay, since we cannot do experiments here in the classroom ourselves about how myostatin works, we want to gather that information from this article. But if we are going to trust what this article says to be true, how can we tell that it's a credible source? Let's look back at this checklist we developed and see what kinds of things we could look for to determine if a source is credible.*

Display your chart from Lesson 3 and/or **slide B**.

Suggested prompt	Sample student response
What might we see in this article that would help us know it's trustworthy?	*We need the author to tell us where the information came from.* *We want to see evidence that's from actual scientific studies.*
What questions should we ask ourselves while reading to help us determine if this article is a credible source?	*What's the goal of this text - to share information or to sell us something?* *What claims is the article making? Do they fit with what we already know?*

Skim and scan with a partner to predict the credibility of this article. Instruct students not to read this article word-for-word right now, but just take a quick skim and scan to try to see if we think we can trust it. Students can turn and talk with a partner to discuss their evaluation of the article. Distribute *The Function of the Myostatin Protein*, display **slide C**, and give students 2 minutes to look it over and chat with a partner.



The Function of the Myostatin Protein

Functional Myostatin

Myostatin is a protein found in the skeletal muscles of many animals. The normal job of this protein is to stop cells from turning into muscle cells. So, the myostatin protein limits how many cells are made in muscle tissue so they don't get too big.[1]
The myostatin protein stops cells from turning into muscle cells like this. Cells have receptors on them. A receptor is a structure that sticks out of the outside of a cell membrane (see Figure A) and relays messages from outside the cell to inside the cell. The myostatin protein is shaped so that it fits into one specific kind of receptor like a key fits into a lock. When it does, it causes a message to be sent to the inside of the cell. The message tells the cell to stay the way it is. As a result, that cell does not turn into a muscle cell (see Figure B).[1] So the myostatin protein is specifically shaped to do this job of fitting into the receptor and sending a message, unlike the muscle proteins myosin and actin, which have structures that help them build and move muscles.

Figure A

receptor

cell

Figure B

functional myostatin protein

receptor

"STOP" message sent

cell

result

does not turn into a muscle cell

Nonfunctional Myostatin

Sometimes a myostatin protein is not the right shape. When this is the case, it cannot fit correctly into a cell's receptor. It might fit partially in, like how a wrong key might fit into a lock, but it cannot unlock the door (see Figure C). Since it doesn't fit correctly, the "stop" message does not get sent to the nucleus of that cell. When this happens, that cell *does* become a muscle cell (see Figure D). If the myostatin protein isn't working to stop them from doing this, more and more cells turn into muscle cells, and the muscle tissue continues to grow.[2]

Figure C

nonfunctional myostatin protein does not fit correctly

receptor

cell

Figure D

nonfunctional myostatin protein

receptor

no "stop" message sent

cell

result

turns into a muscle cell

History of Myostatin

Heavily muscled cattle were first discovered in Belgium in the late 1800s.[3] Farmers had not seen this phenotype in cattle before then. By the 1970s, farmers in other countries, including the United States, were very interested in these heavily muscled cattle because of how much beef they produce.[3] In 1997,

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Lead a quick share-out about the article's credibility. Display **slide D**.

Suggested prompt	Sample student response
Do you think this article is a reliable source? Why or why not?	*Yes, because it refers to several sources that seem trustworthy.* *Yes, the author used actual studies from science journals to find out this information.* *I didn't read the whole thing yet, but it doesn't seem like they're trying to sell us anything. The diagrams are scientific, not ads.*

3 · READ AN ARTICLE ABOUT THE FUNCTION OF MYOSTATIN

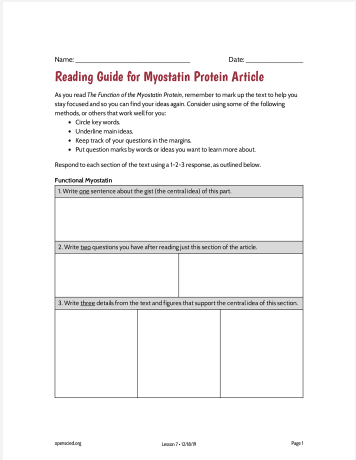
10 min

MATERIALS: *The Function of the Myostatin Protein*, *Reading Guide for Myostatin Protein Article*

Review our procedures for close reading. Display **slide E**.

Say, *We need to be sure we obtain all the scientific information in this article that will help us understand how the myostatin protein works. So, let's review what we'll do to closely read this article and dig out all its meaning. Take a look at the steps on this handout. What will you do as you read?*

Distribute *Reading Guide for Myostatin Protein Article*.



Name: _____ Date: _____

Reading Guide for Myostatin Protein Article

As you read *The Function of the Myostatin Protein*, remember to mark up the text to help you stay focused and so you can find your ideas again. Consider using some of the following methods, or others that work well for you:

- Circle key words.
- Underline main ideas.
- Keep track of your questions in the margins.
- Put question marks by words or ideas you want to learn more about.

Respond to each section of the text using a 1-2-3 response, as outlined below.

Functional Myostatin

1. Write one sentence about the gist (the central idea) of this part.

2. Write two questions you have after reading just this section of the article.

3. Write three details from the text and figures that support the central idea of this section.

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✱ ATTENDING TO EQUITY

If you have EL students or struggling readers in your class who would benefit from working with a partner and/or hearing the text read aloud, feel free to make these accomodations to support them.

Suggested prompt	Sample student response
What will you do to help you closely read this text?	*We should mark up the text so we remember our thinking.* *We'll "read" the figures as well as the text.* *We'll write one sentence of the gist for each section - that's like the main idea of that part.* *We're going to write questions we have after each section.... Two of them.* *We need three details to support the central idea for each section.*

Say, *Okay, it sounds like you're ready to read closely. In about 10 minutes, we'll use the notes you take on the text and the 1-2-3 boxes on the handout to discuss what you've figured out.*✱

4 · BUILDING UNDERSTANDINGS DISCUSSION ABOUT THE FUNCTIONS OF MYOSTATIN

12 min

MATERIALS: *The Function of the Myostatin Protein, Reading Guide for Myostatin Protein Article*

Lead a Building Understandings Discussion about how myostatin works. Display **slide F**.

Ask, *What have we figured out about how the myostatin protein works?*

KEY IDEAS

Purpose of this discussion: Use evidence from the article *The Function of the Myostatin Protein* to summarize how the myostatin protein typically works, and how nonfunctional myostatin causes a heavily muscled phenotype in animals.

Listen for these ideas:

- When its shape works, the myostatin protein fits into a receptor on the outside of a cell. Then that cell gets a message not to turn into a muscle cell.
- When myostatin works like usual, muscles do not get too big because cells are getting that "stop" message.
- If the myostatin protein has a different shape, it does not "work" in the receptor (it might fit in, like the wrong key in a lock). So, the "stop" message is *not* sent to that muscle cell.
- If myostatin isn't functioning typically, more cells turn into muscle cells, which leads to bigger muscles in that animal.

Suggested prompt	Sample student response
What have we figured out about how the myostatin protein works? *What in the text made you think that?*	*When its shape works, the myostatin protein fits into a receptor on the outside of a cell. Then the cell gets a message not to turn into a muscle cell. We can see this in Figure B in the article.* *When myostatin works like usual, muscles do not get too big because cells are getting that "stop" message. The article said that in the first section.* *If the myostatin protein has a different shape, it does not "work" in the receptor (it might fit in, like the wrong key in a lock). So, the "stop" message is not sent to that muscle cell. We can see how this works in Figure D.* *If myostatin isn't functioning typically, more cells turn into muscle cells, which leads to bigger muscles in that animal. The second section of the text said that.*
So what can you say about how myostatin's shape or structure affects its function (its job)?	*It has to have the right shape or structure to be able to do its job - the stop message won't get sent if it's not the right shape to fit into the receptor exactly right.*

Suggested prompt	Sample student response
That's interesting, because I'm remembering other proteins we know about in muscles: myosin and actin. They had very different shapes than myostatin has. Why would this be?	*The myosin has to be able to "grab on" to the actin and pull it along, so it has to have that grabber head to do its job.* *The actin and myosin are stringy because they are making the muscle pull along and contract or stretch - that's their job.* *Myostatin's job is to send a message, so it's shaped to fit into that receptor. Myosin and actin are what the muscle is actually built out of, so they have a different shape because their job is different.*
So how can we summarize the role of the alleles in these different variations of muscles?	*The different alleles cause different protein shapes to be built. If the protein has a different shape, it can't do its job. So we get extra-big muscles instead of typical muscles because the protein is shaped differently because the allele was different.*

ADDITIONAL GUIDANCE

Take a moment to dissect the word myostatin after students understand this protein's function. It was named purposefully! Point out that "stat" is a word partly derived from Greek, meaning "stand," "keep steady," or "stop" (as in thermostat). The word part "myo" relates to muscles; students may be interested to know that the strands of myosin (muscle protein!) and actin are called myofilaments, muscle cells are called myocytes, etc. Students may also notice that protein names often end in "in" (myosin, actin, myostatin).

5 · UPDATE PROGRESS TRACKERS

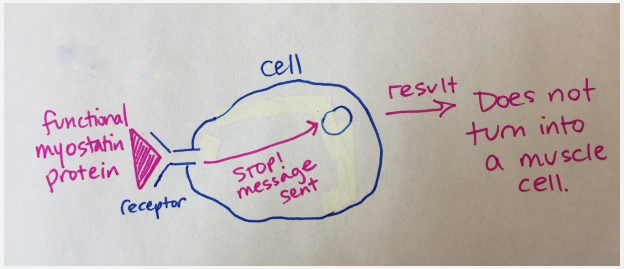
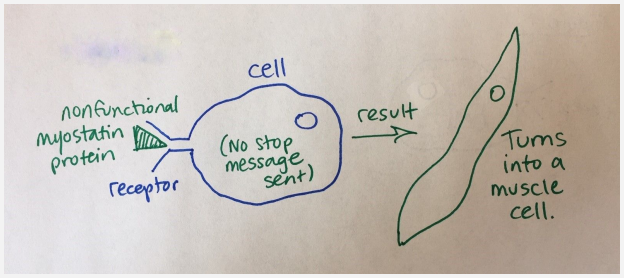
7 min

MATERIALS: science notebook

Update Progress Trackers. Say, *Let's use our Progress Trackers to summarize what we figured out today.*

Display **slide G** and give students about 3 minutes to work.

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
What does myostatin do?	 Myostatin usually works like a key in a lock, which sends a message to the cell to stay like it is.  If an animal has the allele to make nonfunctional myostatin, its shape will not fit into the receptor correctly, so the stop message doesn't get sent and more cells turn into muscles.

Additional Lesson 7 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

CCSS.ELA-LITERACY.RI.8.2
Determine a central idea of a text and analyze its development over the course of the text, including its relationship to supporting ideas; provide an objective summary of the text.

CCSS ELA-LITERACY.L.8.4.B
Use common, grade-appropriate Greek or Latin affixes and roots as clues to the meaning of a word.

The 3-2-1 structure of the handout guides students through reading *The Function of the Myostatin Protein* to find the central idea and supporting details for each section. During the discussion that follows the reading, students must summarize what they learned from the text as a whole. The protein myostatin was purposefully named, and after students understand its function, they can relate its word parts to its meaning.