ASSESSMENT SYSTEM OVERVIEW

Each OpenSciEd unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons, including pre-assessment, formative assessment, summative assessment, and student self assessment. Formative assessments are embedded and called out directly in the lesson plans. Please look for the "Assessment Icon" in the teacher support boxes to identify places for assessments. In addition, the table below outlines where each type of assessment can be found in the unit.

Overall Unit Assessment

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 1	Initial models in science notebooks Driving Question Board	**Pre-Assessment** The student work in lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas your students bring to this unit. Revealing these ideas early can help you be more strategic in how to build from and leverage student ideas across the unit. The initial models developed during lesson are a good opportunity to pre-assess student understanding of genetics. The two most important times to do this include: (1)after students have developed their initial models and (2) during the Consensus Discussion. For the initial cup system models, look and listen for: • agreement on difference in size of muscles between both animals • disagreement about what the cells of different sized muscled animals look like. Students might say the cells are bigger, or there are more numbers of cells in extra-big muscled animals, or maybe both. • disagreement about what caused the differences between musculature in animals. Possible causes include exercise, diet, parents, steroids, genetically modified animals etc. These disagreements will motivate the need for further investigations. The Driving Question Board is another opportunity for pre-assessment. Reinforce for students to generate open-ended questions, such as how and why questions, to post to the board, but celebrate any questions students share even if they are close-ended questions. Make note of any close-ended questions and use navigation time throughout the unit to have your students practice turning these kinds of questions into open-ended questions when they relate to the investigations underway.
Lesson 4	Progress Tracker Update	**Formative** This is a key formative assessment moment at the end of the first lesson set. This moment in the unit is important because students will learn later how the mutated form of myostatin works on creating more muscle cells compared to typical animals. So knowing that extra-big muscles have more muscle cells is key to this connection. Students have just revised part of their consensus model to explain what the cells of typical vs. extra-big muscles look like compared to one another. Then they work on a three-box progress tracker independently. Teachers can collect the trackers to check for student understanding.
Lesson 8	Student Assessment Key to the Student Assessment Rubric	**Formative or Summative** Students revise their original models from lesson 1 to explain how the animal they chose got their muscles. This is done independently and marks the end of the second lesson set. There is a rubric and key teachers can use to grade the assessment. This assessment is looking for students to articulate the process of genotype to phenotype for the myostatin gene in an animal of their choice. Look for: • Understanding of inheritance of chromosomes in offspring through the sex cells of the parents. • How the shape of the allele determines the shape of protein produced. • How the resulting shape of protein does it's job to influence muscle mass. • Further detail of what to look for is outlined in the rubric for this assessment.

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 13	Peer Feedback Self Assessment Reference: Peer Feedback Guidelines	**Peer Feedback** In this lesson students will have the chance to give feedback to their peers. There is a rubric students can use to assess how well they think they did at giving and receiving feedback to and from their peers. There is also a teacher reference that has extra support for achieving high quality peer feedback between students. The purpose of feedback is for students to get ideas from your peers about things they might improve or change to make their work more clear, more accurate, or better supported by evidence they have collected. It also helps students to communicate their ideas more effectively to others. The feedback students give should be specific and actionable and give specific ideas or changes that a group can make.
Lesson 16	Student Transfer Task L16 Assessment Scoring Guidance	**Summative** This lesson includes a transfer task to give students an opportunity to use the 3 dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and it gives teachers a grading opportunity. The task includes having students use the practice of obtaining, evaluating, and communicating information from a study about goldfish breeding to help students build a model of how the speckled pattern of goldfish is inherited, give a recommendation for selective breeding, determine the probability of certain phenotypes, and develop a model showing how the environment and genes affect goldfish growth. There is a scoring guidance document with sample student responses and a checklist that students can use to help them obtain and evaluate the results from the study. Students should use their knowledge learned during the unit and apply it in this new context.
After each lesson	Lesson Performance Expectation Assessment Guidance	**Formative Assessment** Use this document to see which parts of lessons or student activity sheets can be used as embedded formative assessments.
Occurs in most lessons	Progress Tracker	**Formative and Student Self Assessment** The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time. In this way, the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Tracker is meant to be a thinking tool for kids, we strongly suggest it is not collected for a summative "grade" other than for completion.
Anytime after a discussion	Student Self Assessment Discussion Rubric	**Student Self Assessment** The student self-assessment discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week. Initially, you might give students ideas for what they can try next time to improve such as sentence starters for discussions. As students gain practice and proficiency with discussions, ask for their ideas about how the classroom and small group discussions can be more productive.

When	Assessment and Scoring Guidance	Purpose of Assessment
After Students Complete Substantial, Meaningful Work	Peer Feedback Facilitation: A Guide	**Peer Feedback** There will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process. Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work, rather, peer feedback will be more valuable to students if they have time to revise after receiving the peer feedback. It should be a formative, not summative type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities where they can use these experiences as evidence for their feedback.

For more information about the OpenSciEd approach to assessment and general program rubrics, visit the OpenSciEd Teacher Handbook.

Lesson-by-Lesson Assessment Opportunities

Every OpenSciEd lesson includes one or more lesson-level performance expectations (LLPEs). The structure of every LLPE is designed to be a three-dimensional learning, combining elements of science and engineering practices, disciplinary core ideas and cross cutting concepts. The font used in the LLPE indicates the source/alignment of each piece of the text used in the statement as it relates to the NGSS dimensions: alignment to Science and Engineering Practice(s), alignment to Cross-Cutting Concept(s), and alignment to the Disciplinary Core Ideas.

The table below summarizes opportunities in each lesson for assessing every lesson-level performance expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments. Assessing every LLPE listed can be logistically difficult. Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher's discretion.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance

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Lesson 1	Develop and/or use a model to predict what is causing these animals to have extra-big muscles. Ask questions that arise from careful observation of pictures of animals with different musculature and living things that have variations in one or more of their features to seek information about what causes these variations in populations.	**Developing and Using Models; Cause and Effect** **When to look for it:** After students construct their initial models, and during the Consensus Discussion about initial models **What to look/listen for:** Look at students' initial models to highlight the range and diversity of ideas the class as a whole has. See more information about how to use initial models as a pre-assessment in the Overall Unit Assessment table above. Also, use the Consensus Discussion about the initial class model to assess which ideas students are bringing up in their models to explain the possible causes of these muscle differences. Look for the following ideas as components of the models: (1) exercise, (2) diet, and possibly (3) other animals in that individual's family might share this feature. **What to do:** If students are struggling to develop their initial models, remind them that we are using this model to predict and describe what we think may be causing this phenomenon, so the goal of this initial model is to get their thinking down on paper, not to have the "correct" answer. If they're having trouble thinking of ideas for possible causes, ask them to consider any background knowledge they have about muscles (not necessarily for that specific animal). Also, do not worry if students do not bring up the family connection around musculature; there will be other opportunities to raise this possible cause. **Asking Questions; Cause and Effect** **When to look for it:** During the construction of the Driving Question Board and when students are generating ideas for investigation **What to look/listen for:** Look for "how" or "why" questions about phenomena that seek to investigate possible causes for not just these extra-big muscles, but the variety of features found within living things that are otherwise generally the same. Students should be developing ideas for investigation around questions that are testable, and offering possible ways to explore cause and effect about those questions. **What to do:** If a student struggles with sharing, encourage him or her to go public with question(s) rather than focusing specifically on forming a "how" or "why" question. If students do not ask questions at this point, remind them that questions can be added to the DQB at any point in the unit. We recommend always having sticky notes or index cards on hand to capture students' evolving questions as the unit goes on. If a student struggles with ideas for investigation, try focusing on a few questions rather than the whole board full. You could offer a choice of two questions you've isolated from the board: "You could think about how to test this question or that one... which would make more sense to explore? What could you do to test the question?" Or, ask the student to consider what data we would need to gather to answer a question or two that you have pointed out.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 2	Obtain, evaluate, and communicate information about muscles in various media and visual displays, including models of complex protein structures, to describe (1) how the function of those proteins depends on their shape and (2) how the muscle cells of extra-big-muscled animals compare with those of typical animals.	**Obtaining, Evaluating, and Communicating Information; Structure and Function** **When to look for it:** (1) During students' work on the muscle proteins handout *Muscle Protein Questions* and in their Progress Tracker entries (2) During the Building Understandings discussion after the gallery walk, and on the handout *Update Model* **What to look/listen for:** (1) On *Muscle Protein Questions*, consider whether students can articulate the advantages or disadvantages of the video animations versus still images and printed text, specifically in regard to how either one better helped them understand the structure and function of the muscle cells and proteins. A quick glance at their Progress Tracker work can also inform you about their understanding of myosin's and actin's structure-and-function relationship. (2) After the gallery walk, look for students who can integrate information to describe differences between the larger and smaller muscle tissue photos or graphs. Listen for comments that synthesize the information from the various media in this lesson to explain the structure and function of muscle cells and proteins. On *Update Model*, look for drawings that indicate that the extra-big-muscled animal's muscle tissue is composed of more cells that are larger (they will be closer together) than cells on the typical animal. All three of the given statements are true. **What to do:** (1) If students are struggling to integrate information from so much media, guide them to focus on just a couple of sources of information and start with those (i.e., just one page of images in the handout, or just two pages in the gallery walk). More specific guidance is provided in the callout boxes within the lesson. (2) If students struggle to accurately draw muscle cells for the bigger-muscled animal, have them use one of the gallery walk image pages as an example. Also, they can refer to their notes from the gallery walk to complete the checkbox statements. If their gallery walk notes are not helpful, they should go back to the gallery walk pages and point to specific evidence that supports each of the three statements.
Lesson 3	Obtain, evaluate, and communicate information to determine the effect of exercise in the development of muscle tissue. Analyze and interpret data in graphs, charts, and images to identify patterns in the roles of diet and exercise in the development of muscle tissue.	**Obtaining, Evaluating, and Communicating Information; Cause and Effect** **When to look for it:** During the Building Understandings Discussion about muscle **What to look/listen for:** Look to see that students are able to successfully identify the second article *The Effect of Resistance Exercise on Muscles* as more credible than *How to Build Muscles* due to lack of bias and inclusion of additional resources for evidence. Look to see that students identify that exercising causes small tears in muscle fibers and the repair of these tears results in increased muscle size. See possible student responses in the sample checklist in the Building Understandings Discussion of muscle section for details. **What to do:** Scaffold this activity by co-constructing a class checklist to evaluate the credibility of each article and to determine the claims made by each article. If students need support, chunk the articles into smaller sections to read part-by-part and encourage students to identify key pieces of information. If students are struggling, ask probing questions and refer them to the checklist to refine their thinking. **Analyse and Interpret Data; Patterns** **When to look for it:** At the end of the lesson, when students are filling in their 2-Column Progress Trackers **What to look/listen for:** Look to see if students synthesize information presented in the lesson via images, readings, and data to identify the role of diet and exercise in building muscles. Look to see if students use specific pieces of information to support the claim that protein consumption can positively influence muscle growth but that exercise is key in building larger muscles. See possible student responses in the Progress Tracker section of the lesson for details. **What to do:** Scaffold this activity by building out one box at a time. If students need support, recommend that they list out key understandings from each piece of evidence presented in the lesson to organize their thoughts. If students are struggling, suggest they identify patterns in the evidence they've examined in the lesson.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 4	Develop and use a model to construct and predict a scientific explanation based on evidence for how different environmental factors (cause) influence variation in a trait (effect).	**Develop and Use Model: Cause and Effect** **When to look for it:** After the consensus model as students are working on their three-box Progress Tracker **What to look/listen for:** Look to see if students are able to make connections between the updates the class made to the consensus model and how these updates can change/influence musculature. Look to see if students are providing the proper evidence to support why these components were added to our model. See possible student responses in the Progress Tracker section of the lesson for details. **What to do:** Scaffold this activity by building out one box at a time. If students are struggling, recommend that they create a numbered list of the ideas/components that were added to the model. Suggest that they use the same numbering convention to link their evidence for each idea/component to their thinking in the first box. If students need support finding the evidence to connect with their thinking, refer them back to their 2-column Progress Tracker.
Lesson 5	Develop and use a model to describe the patterns that emerge between the number and types of chromosomes in the sex cells of parents and the body cells of offspring, and how the chromosomes in a muscle cell of the offspring consist of a subset of chromosomes from each parent. Use the patterns in the model to predict that each parent must randomly contribute half of their chromosomes to sex cells.	**Developing and Using Models; Patterns** **When to look for it:** (1) During students' work developing relationships between phenotype symbols and relatedness on the *Family Phenotype Graphic Organizer*, (2) During the Building Understanding Discussion after students work with the *Family Phenotype Graphic Organizer*, and (3) During partner work with the *Chromosomes in Sex Cells* and the *Karyotype of Lorenc's Muscle Cell* **What to look/listen for:** (1) During small group work with the *Family Phenotype Graphic Organizer*, listen for students using evidence from the images to support the assignment of phenotype symbols and look for the pattern to emerge that offspring who are heavily muscled must have at least one parent that is heavily muscled too.(2)During the Building Understanding Discussion after students work with the *Family Phenotype Graphic Organizer*, listen for students using evidence from the images to support the assignment of phenotype and listen for students to support their prediction of what offspring may look like using reasoning that includes offspring inheriting the phenotype from at least one parent. (3) During partner work with the *Chromosomes in Sex Cells* and the *Karyotype of Lorenc's Muscle Cell*, listen for students using evidence from the images to support the idea that the chromosomes that make up each pair of chromosomes in the karyotype each came from a parental egg or sperm cell. Look for annotations in the science notebook that link these chromosomes to each other. **What to do:** (1) If students are struggling to place cows into an assigned phenotype, ask them to voice their observations about what made them know the really big muscled cows had big muscles. Lift up the patterns in their thinking to help them apply these patterns to the cows that aren't as easy to categorize. (2) If students are struggling to focus due to the number of chromosomes in such a disorganized manner in the egg and sperm cell, it may help them make connections if they cut out the chromosomes from their handout and order them by size similar to how they are organized in the karyotype.(3) If students are not using evidence in their discussions about how to identify similar chromosomes, and if they are struggling with the task, pose questions to groups that help students identify characteristics on each chromosome that would help them find the similarities and ask if they have any other examples of unique characteristics they can attempt to match up.

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Lesson 6	Develop and use a model to describe correlational relationships among chromosome pairs containing two variants, specific proteins, and the trait of musculature. Obtain, evaluate, and communicate information by critically reading a scientific text adapted for classroom use to obtain evidence that a distinct gene is the cause for the production of a specific protein related to the trait of musculature.	**Developing and Using Models; Cause and Effect** **When to look for it:** Question #4 on the handout *Guiding Questions for Chromosome /Protein Data* asks students about correlation or causation. They develop initial models in their small groups and discuss correlation or causation when creating the classroom consensus model. **What to look/listen for:** On #4 of the handout, students should be able to identify that the relationship between the partial myostatin protein, the blue star chromosome symbol (allele), and the heavily muscled phenotype is a correlation: just because they appear together does not help us figure out if one of these components is causing the other(s). The small groups' initial models may predict which component in the pattern is "first," "next," or "last," but question marks or other indicators should show that possible thinking has not been proven. During the consensus model discussion, listen for students to say that we do not have evidence about which component is causing the others. During the discussion, students should reason that the chromosomes are the only thing passed on from parents (not the myostatin protein or the muscles). **What to do:** To support students while they're working on the handout questions and initial models, if/when they propose a causal relationship, ask them "What evidence do we have for that?" (the answer should be, "none, yet"). If the answer involves something like "because the heavily muscled cattle always have that," offer them another situation to consider: "I've noticed here at school that many of the teachers have cars. Are they teachers because they have cars? Do they have cars because they are teachers? Just because two things happen together doesn't mean I can assume one is the reason for the other. **Obtaining, Evaluating, and Communicating Information; Cause and Effect** **When to look for it:** When reading and discussing *Unknown material with identifier: ge.l6.rdg* **What to look/listen for:** Watch for indications that students are finding meaning in the text. They should indicate vocabulary that is new to them (specifically gene, allele, and genotype) including definitions from context. Students should also be able to identify the main ideas of the study summary: these scientists predicted that the myostatin gene and protein caused the heavily muscled phenotype, and their results confirmed that their prediction was correct. They might underline or highlight these pieces of the text itself, and/or share these key ideas during discussion. Students' questions about the study should be connected to the text and relevant to the discussion to show their comprehension, even partially, of the text. **What to do:** To support students who may struggle with this reading task, consider reading the article aloud once through before directing students to reread a second time individually or with a partner and mark up the text with their thinking. Also, students may benefit from reading a copy that you have annotated ahead of time, and considering why certain places were marked as they were.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 7	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).	**Obtaining, Evaluating, and Communicating Information; Structure and Function** **When to look for it:** During students' work on *Reading Guide for Myostatin Protein Article*, and during the Building Understandings Discussion about the function of myostatin **What to look/listen for:** While reading and taking notes about the function of myostatin, look for students to point out as a key detail that the protein must be shaped correctly in order to do its job. Related sub-ideas include: • Myostatin molecules come in different shapes. • One of these shapes fits into a receptor on cells. One of these shapes fits poorly into it. • The myostatin molecule that fits into the receptor causes the receptor to send a message to the inside of the cell, telling it not to turn into a muscle cell. • The myostatin molecule that does not fully fit into the receptor results in no message being sent into the cell to stop it from turning into a muscle cell. During the discussion, listen for students who can articulate the connection between the protein's structure and function. **What to do:** If students are struggling to make meaning from the text of the article, ask them to describe what the figures show them aloud to you or a partner. Have them 1) identify where the protein is shown in each diagram, 2) describe how the shape of the proteins shown in diagram B and C compare to the shape of the receptor, and 3) describe how the outcome in figure B compares to the outcomes in B and C. It's possible that talking about the figures will help students connect the lock and key analogy to how the myostatin protein does its job (or not). Some students may struggle with why myostatin is classified as a functional protein when its presence prevents something from happening in the end (preventing the cell from turning into a muscle cell). It may be helpful to introduce an example of functional key which can lock a door to prevent others from using what's inside.
Lesson 8	Develop and use a model to evaluate and construct a scientific explanation based on evidence for how different environmental and genetic (cause) factors influence variation in a trait (effect) at different scales.	**Develop and Use Model; Cause and Effect** **When to look for it**: After students have worked in their three-box Progress Tracker to revise their initial model and explain the range in musculature in other organisms, and when students complete the mid-point assessment *Revise Your Model* **What to look/ listen for:** Look to see if students are able to make connections between the updates the class made to the classroom consensus model and how these updates can change/influence musculature. Look to see if students are accurately using these components in their models and applying them to their organism. Students should also be able to explain their model in words. In the *Revise Your Model* Students revise their original models from lesson 1 to explain how the animal they chose got their muscles. This is done independently and marks the end of the second lesson set. There is a rubric and key teachers can use to grade the assessment. This assessment is looking for students to articulate the process of genotype to phenotype for the myostatin gene in an animal of their choice. Look for: • Understanding of inheritance of chromosomes in offspring through the sex cells of the parents. • How the shape of the allele determines the shape of protein produced. • How the resulting shape of protein does it's job to influence muscle mass. • Further detail of what to look for is outlined in the rubric for this assessment. **What to do:** Have students use their updated *Gotta-Have-It Checklist* to help them. Have them think about how the class organized the components for the classroom consensus model and think about how they might organize and make sure they are including all the necessary components to explain their organisms' musculature.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 9	Use mathematics and computational thinking to find patterns about genotypic and phenotypic outcomes resulting from crossing individuals with specific genotypes. Plan and carry out an investigation to collect data and uncover patterns that support the idea that alleles separate when sex cells form and then recombine at fertilization, so each parent contributes half of the genes acquired (at random) by the offspring.	**Using Mathematics and Computational Thinking; Patterns** **When to look for it:** (1) During students' work investigating family genotypes and phenotypes for myostatin on *Traditional Pedigree Graphic Organizer* and (2) During the individual calculation of genotype proportions and consequent small group talk related to the patterns uncovered *Traditional Pedigree Graphic Organizer* **What to look/listen for:** (1) During partner talk and the resulting share-out after constructing their initial family pedigrees *Traditional Pedigree Graphic Organizer*, listen for students using evidence from their work to support the identification of groups of genotypes that had similar phenotypes and (2) When students are calculating proportions of genotypes that result from certain crosses *Using Pedigrees to Make Predictions*, listen for students identifying groups with clear patterns and listen for them linking the phenotypic patterns to specific genotypes. **What to do:** (1) If students seem to be losing sight of the idea that the symbols we switched to (M, m) are alleles that are found on chromosomes; you may hear students referring only to "big m little m" or conversation about the relationships between the combination of alleles, with other physical things being absent. If this is the case, use a series of questions to get students to come back to the idea that these are physical pieces of chromosomes. It may also help to have them go back to drawing the chromosome and/or the sex cell in order to give them a concrete anchor and (2) If students are having trouble organizing their data to set up the calculations for all individuals included in the data set, create more structure at the pedigree level to have a space for students to record for only that tree. Then they can add the numbers for trees that are similar crosses to get the total numbers they will need to calculate. **Planning and Carrying Out Investigations; Patterns** **When to look for it:** When students are recording the genotypes generated from the poker chip activity in their science notebooks and again when they compile all of the data as a class. **What to look/listen for:** Students should be organizing their results in groups based on the genotypes of the parents that mated. They should be focused on looking for the patterns of genotype distribution they are generating with the simulation to see if the patterns are the same as what they found when they looked at the distribution of phenotypes that correspond to these genotypes in existing cow families. **What to do:** If you are not hearing discussion that compares these results to what they found in the cow families, ground student thinking with the questions that require them to restate the purpose of their investigation and what we hope to learn from this simulation.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 10	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.	**Obtaining, Evaluating, and Communicating Information; Cause and Effect** **When to look for it:** During the Building Understandings Discussion about selective breeding in cattle **What to look/listen for:** Listen for students to identify that conclusions in both sources, *Interview with Penny, Cattle Farmer* and *Raising Heavily Muscled Cattle to Reduce Environmental Impacts of Cattle*, are valid because of their use of data and firsthand knowledge. Listen for students to identify that selective breeding causes changes over time in the frequency of beneficial traits in a population of organisms. **What to do:** Scaffold this activity by using a checklist to evaluate the credibility of each article and to determine the claims made by each article. If students need support, chunk the articles and encourage students to identify key pieces of information. If students are struggling, ask probing questions and refer them to the checklist to refine their thinking. **Using Mathematics and Computational Thinking; Cause and Effect** **When to look for it:** When students update their Progress Trackers after running the computer simulation **What to look/listen for:** Look for students to identify that because of selective breeding of organisms with beneficial traits, the frequency of individuals with those traits increases in the population over time as evidenced by information found in *Interview with Penny, Cattle Farmer* and *Raising Heavily Muscled Cattle to Reduce Environmental Impacts of Cattle*, and data from the computer simulation. Look for students to cite specific data from either the readings or computer simulation to support their understanding. **What to do:** If students are struggling, ask probing questions and refer them to the data they recorded and analyzed in the computer simulation, or information from *Interview with Penny, Cattle Farmer* and *Raising Heavily Muscled Cattle to Reduce Environmental Impacts of Cattle*.
Lesson 11	Plan and carry out an investigation to produce data to serve as the basis for evidence that asexual organisms have genetic information inside their cells that can be visualized (scale) even though they are not produced from sperm and eggs.	**Planning and Carrying Out Investigations; Scale, Proportion, and Quantity** **When to look for it:** (1) Initial ideas discussion in the activity section "Brainstorm Ideas For How To Get At The Genetic Information," (2) During the lab investigation you can use their data table to and making sense questions in *Extracting Genetic Information Lab* as well as the class data table, and (3) Progress Tracker update **What to look/listen for:** (1) Look for students to use the CCC of scale when they are thinking about how to plan to get at the genetic information inside cells. They should reason that we would be working at a scale too small to see with our eyes, which would mean we need a tool or method to visualize the genetic information inside the nucleus of cells. (2) Students should be producing data as evidence that asexual reproducing organisms have genetic information in them as well. Look for completed predictions and accurate results - both the strawberries and bananas should yield genetic information. Then students should be connecting their findings to answer our investigation question. (3) Look for students to make connections to these ideas: There is genetic information inside asexual organisms even though they don't have sperm and eggs. Genetic information is a physical structure. We can use tools to see it with our eyes. The genetic information seems really long because there are thousands of genes. **What to do:** (1) If students are struggling, you can replay the cosmic eye video from Lesson 6 to remind students of the scale of genetic information. (2) You can pair groups with a different group that is investigating the same sample. The lab experiment itself does not take that long. Students can learn from a different group and then try the experiment again if there is time. (3) Hold up the DNA that a group collected to help students connect that this stuff we pulled out is a physical 3D structure. One feature about it's structure is that it's really long! So when it clumps together we can see it with our eyes. You can pull up slide D to remind students of the function of the alcohol in the protocol.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 12	Obtain, evaluate, and communicate information about how organisms reproduce asexually and transfer their genetic information to their offspring, which results in offspring with identical genetic information. Plan and carry out an investigation to see whether asexual reproduction causes offspring identical to their parent.	**Obtain, Evaluate, and Communicate Information; Cause and Effect** **When to look for it:** When students are researching and then sharing what they've learned about asexually reproducing organisms **What to look/listen for:** Look for students who are using reliable websites and finding just key ideas about asexual reproduction (not getting caught up in the other details of that organism or more complex mechanisms). Listen for students who are able to communicate effectively: be concise and clear when presenting organized, relevant information. **What to do:** If you anticipate that students will struggle to find appropriate, reliable sources of information, you might select a specific website or two for them to use, rather than asking them to do a general internet search. If students are struggling to find relevant information about their organism, you might suggest they print out their article and use a highlighter or other way of marking up the text as they read. A group mate or teacher could also read the text aloud for students who are struggling to make sense of the text. In order to scaffold students who might be nervous about sharing, be sure their slide is well-written. A template is provided in this lesson's slides if that would be helpful to share with students as a starting point. If you anticipate that students may struggle to present their information clearly, offer an opportunity for a "practice run" through the presentation before sharing in front of the class. If you would like to make sure that all students get a chance to share with a group (not as big as the whole class), set up a rotation where one group member stays at the computer to present the group's slide while other group members go around to learn from their classmates. Switch often enough that all students have a turn to tell about the slide. **Plan and Carry Out Investigations; Cause and Effect** **When to look for it:** Items #4, 5, and 6 on *Planaria Regeneration Lab Notes* **What to look/listen for:** Students should predict that the two new planaria will look exactly alike; we will not be able to tell them apart after they've fully regenerated. This prediction should be based on what they've figured out about asexual reproduction: that offspring are exact copies of their parent with identical genetic information. **What to do:** If students do not make the prediction described above, first check their evidence: if they think the planaeria might not look exactly alike because of differing environmental factors or another reasonable line of thinking, you may consider that an acceptable answer, and just need to ask that student directly about the typical results of asexual reproduction. If students are struggling to make a reasonable prediction at all, direct them to revisit the slide shared by the group that researched planaria to see if that prompts some ideas. If students have a reasonable prediction but don't explain evidence to support it, refer them to the chart you created with the asexual reproduction Punnett square. Ask the student what will be true about offspring produced by just one parent. Then ask, if the parent and offspring have identical genetic information, what can we expect about their phenotype?

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 13	Analyze and interpret data to find patterns in how structural changes in genes may affect proteins, which may result in harmful or beneficial effects to the organism. Obtain, evaluate, and communicate information about how structural changes in genes may cause changes to proteins, which may result in harmful or beneficial effects to the organism.	**Analyze and Interpret Data; Patterns** **When to look for it:** When students are in their article groups reading and pulling out the information from the text **What to look/listen for:** Students should be working together in their groups using the co-constructed purpose for reading list to guide their analysis of the data. Students will be discussing the similarities and differences between their example's gene-to-trait story and that of MSTN gene-to-trait story we have in our classroom consensus model. Students should be noticing a pattern that starts with gene(s), which produce protein(s) that influence the trait we observe. Students will also be keeping a record of how their example is different than what we've modeled. **What to do:** To support students who may be struggling, help reorient these students to the purpose for reading the article in the first place. We want to know if other genes work the same way as the MSTN gene. If needed, pull out the classroom consensus model from Lesson 8 and leave it visible for the whole class to see. Have these students use this model to articulate how the MSTN gene affected the trait we observed. Then redirect them to the co-constructed purpose for reading list to guide them in looking at the article. **Obtain, Evaluate, and Communicate Information; Cause and Effect** **When to look for it:** (1) In the models students bring to the new jigsaw group to provide and receive feedback and to communicate their learning with the rest of the group (2) In the whole-group discussion when the students come together to discuss the patterns they observed in the different traits **What to look/listen for:** (1) Students will be bringing their simple models to the group and providing peer feedback on sticky notes. Students should be trying to make sense of other student models and providing quality feedback about whether the cause-effect pattern is clear, and how it relates to what we already know. Then students will take this feedback and make alterations to their model. During each model presentation students will be recording on a T-chart the similarities and differences between their model and the one being presented and (2) In the Scientists Circle discussion students will be sharing out the patterns they observed from their jigsaw group's discussions. They will share how gene(s) always cause proteins, and these proteins then affect the trait observed. Students will also point out differences such as the number of genes involved and the different functions of the proteins. **What to do:** (1) To support students who may be struggling in providing quality feedback, refer to the *Reference: Peer Feedback Guidelines*, which has some sentence starters to provide some scaffolding to help students and (2) To support struggling students in the whole-group discussion if they're not sharing their ideas, have them do a quick turn and talk. In this turn and talk, have students compare their list of similarities and differences from their T-chart, then share out what they noticed from comparing these lists.
Lesson 14	Use mathematics and computational thinking with a digital tool to find patterns in a large set of trait variation data.	**Using Mathematics and Computational Thinking; Patterns** **When to look for it:** During the discussion of sunflower seed data and on students' Progress Trackers **What to look/listen for:** Students should identify the pattern of a bell-shaped curve in the sunflower seed data, and describe the ease of using the histogram website to graph that data (instead of having to do it by hand). While Progress Trackers should not be scored for a grade, it is an authentic formative assessment to be sure students have connected the bell-shaped curve pattern to other trait variation (not just sunflower seed length). **What to do:** Refer to the photo on **slide G** to confirm that students understand the shape of a bell-shaped curve. If needed, have students create a simple line plot of a smaller data set (such as the class arm spans) and then bracket around the individual lengths that will become the "bins" on the histogram so they can see more clearly where those numbers are coming from and how that graph is set up. If students are having trouble understanding that most of the sunflower seed lengths are represented by the highest part of the curve, ask them to imagine a pile of leaves in autumn or a pile of salt poured on a table. There is the most stuff piled up toward the top of the mound and only a few leaves or grains at the edges.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 15	Obtain, evaluate, and communicate information about how different traits and variations are affected differently by genes and environment. Develop and use models to show multiple causes of variation within a trait.	**Obtaining, Evaluating, and Communicating Information; Cause and Effect** **When to look for it:** While students are reading *Examples of Influences on Trait Variation*, when students share in their jigsaw groups, and during the Consensus Discussion **What to look/listen for:** Look for students who are able to mark evidence in the text of multiple causes of trait variation. Students should then be able to clearly communicate these causes when it's their turn to present to the small jigsaw group. **What to do:** If you anticipate that a student may struggle to comprehend the text of *Examples of Influences on Trait Variation*, assign that student to read about flamingo coloration - that is the shortest, most straightforward section. If students are having trouble making meaning from the text, you may choose to read it with the student(s), or set them up with a partner to read together. After one read-through, read it a second time to allow the students to mark up parts they know are important or parts that were especially hard to understand. The same-trait group meeting before jigsaw group sharing is intended as a scaffold, a practice run before students share by themselves in the mixed group. If you feel that students need more support to communicate their information, you may set up another time for them to share with you directly, apart from the group. **Developing and Using Models; Cause and Effect** **When to look for it:** During the revision of the classroom consensus model for cattle musculature and on *Trait Reading and Modeling Notes* **What to look/listen for:** When suggesting revisions to the model, students should point out the need to show multiple causes of both the heavily muscled and typical phenotype in cattle. These causes do not carry the same "weight" of influence on the different phenotypes, so students should suggest a way (such as larger or smaller arrows) to represent these different causes. Students should also be able to draw their own model on *Trait Reading and Modeling Notes*, following the same different-sized arrow convention, to show the approximate relative amounts of genetic and environmental causes of the trait variation they read about. **What to do:** Many students will likely need to experience the shared work of the classroom consensus model revision before they can develop a model of their own. Not all students will have a chance to voice their ideas during that discussion. So, make note of the students who were quiet during the Consensus Discussion and check in with them first during the individual reading and modeling time. If students are struggling to draw different-sized arrows to represent the different causes, ask if they would be more comfortable with another indicator of the relative impact of each factor; maybe the size or thickness of the lettering they're using, or heavy underlines or boxes around the more impactful factor(s) would make more sense to them.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 16	Obtain, evaluate, and communicate information to explain what causes living things to be different from one another. Construct an explanation using models or representations to describe how environmental and genetic factors influence the growth of organisms and why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation in the context of goldfish coloration and size.	**Asking Questions; Cause and Effect** **When to look for it:** While the class is revisiting the Driving Question Board on Day 1 **What to look/listen for:** Listen for students asking questions to clarify their models and explanations for how living things are different from one another. When working through to answer questions on the DQB, new questions may arise that help clarify the models students have been developing for how genetics and environment affect trait variation. Take the time to work through these new questions as it will help students prepare to demonstrate understanding in the assessment on Day 2. **What to do:** If students struggle, as you are discussing the various answers to DQB questions ask, "Do you have any questions about what _____ just said?" or "What questions do you have that can help us make our model more clear to everyone?" You can also give students question stems such as, "How does X part of our model affect Y?" "What evidence can you present for ___?" "Why is ____ significant?" **Constructing Explanations; Cause and Effect** **When to look for it:** During the student assessment *Summative Assessment* **What to look/listen for:** Students should be using everything they learned from the unit to explain coloration, breeding, and size patterns in goldfish in the summative assessment. Use the key *Summative Assessment Key* for expected student responses. **What to do:** If students need extra support you can choose to allow them to use their science notebooks or classroom consensus models to help them in the transfer tasks. Since the phenomenon they will be exposed to will be new, they will not find exact answers to the assessment in their notes. You can also help students extract information from the text in the assessment so then they can apply that information to explain and model the new phenomenon.