PLANNED INSTRUCTION

A PLANNED COURSE FOR:

Grade 7 Honors Science

STEELS: Science, Technology and Engineering,
Environmental Literacy and Sustainability

Curriculum writing committee:
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Date of Board Approval: _______________

Course Weighting:

Unit Diagnostic Checks (determined by PLC)	20%
Unit Formative Assessments (at least 1 per unit)	30%
Unit Summative Assessments (1 per Unit)	50%
Total	100%

Course Description:
7th Grade Life Science is a course that presents and examines concepts in scientific thinking and problem solving through experimental design, data collection and analysis of variables. Students will explore phenomena in cellular biological science such as metabolism, matter cycling through photosynthesis and cellular respiration and genetics as wells as the development of organisms in ecological systems. Each concept that is covered in this course is taught for mastery. The intent of this curriculum is to provide all 7th grade students with a sound and firm foundation in its topics to better prepare our students to master the concepts that will be presented to them on their 8th grade PSSA Science exam.

Honors Differentiation of OpenSci Ed - STEELS Integration
Differentiating OpenSci Ed for honors students involves deepening content, accelerating the pace, and promoting greater autonomy. This includes exploring advanced scientific concepts, encouraging critical thinking and problem-solving through challenging scenarios, and fostering independent research projects. Honors students engage with more complex problems, analyze real-world applications, and participate in discussions that require higher-level analysis. Resources like scientific journals and simulation software enhance their learning, while assessments focus on conceptual understanding rather than rote memorization. Collaboration, peer review, and opportunities for competitions further encourage deeper engagement with science.

Goals:

1. **Marking Period One:** Over a 45-day period of time, students will be able to understand:
   Unit 0: Nature of Science (~20 days)
   - Scientific Method
   - Variables
   - Data Analysis
   - Microscopes
   - Long Term Science Project

   Unit 1: Cells & Systems (~25 days)
   - Characteristics of Living Things
   - Organization of Life
   - Body Systems
   - Role of Cells in Systems

2. **Marking Period Two:** Over a 45-day period of time, students will be able to understand:
   Unit 2: Metabolic Reactions (~30 days)
   - Metabolism Overview
   - Energy Transfer
   - Chemical Reactions
   - Cellular Respiration
   - Role of Enzymes in Reactions

   Unit 3: Matter Cycling and Photosynthesis (~15 days)
   - Structure and Function
   - Matter and Nutrient Cycling

3. **Marking Period Three:** Over a 45-day period of time, students will be able to understand:
   Unit 3 (continued): Matter Cycling and Photosynthesis (~15 days)
   - Energy Flow in Ecosystems

   Unit 4: Genetics (~30 days)
   - Sexual Reproduction
   - Asexual Reproduction
   - Rules of Heredity
   - Environmental Influence on Genes
   - Genetic Diversity

4. **Marking Period Four**: Over a 45-day period of time, students will be able to understand:
   Unit 5: Natural Selection & Common Ancestry (~22 days)
   - Evidence of Evolution
   - Natural Selection
   - Survival of the Fittest

Unit 6: Ecosystem Dynamics (~23 days)

- Biodiversity
- Human Impact
- Fluctuations of Populations

Unit 0 Curriculum Map

Overview: This major concept is designed to inform students that scientific thinking skills are very useful both inside and outside of their Science classroom. Students will master the steps involved in the process of solving valid testable questions in a methodical way, learn to interpret their results and data, and use those interpretations to correct experimental flaws, draw conclusions and make inferences about the world around them. Students will receive hands on experience with experimental design as it applies to the laboratory as well as their everyday lives. Students will also learn how to measure liquids and solids in a scientific manner while learning and using various scientific tools.

Big Ideas: All scientists use an organized method to attempt to solve problems.

Unit 0: Nature of Science

Standards (by number):	Essential Questions: ● What is a scientist? ● What is science? ● What makes a question an acceptable and testable scientific question? ● What are the basic steps that scientists use to attempt to solve any problem that the pose? ● What are the basic parts of a scientific experiment? ● What happens to the outcome of scientific experiments? ● Why is it crucial for scientists to analyze and record their data accurately?
Science:	3.1.6-8.A Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells.
Technology and Engineering:	3.5.6-8.O Interpret the accuracy of information collected. 3.5.6-8.X Defend decisions related to a design problem. 3.5.6-8.U Evaluate and assess the strengths and weaknesses of various design solutions given established principles and elements of design. 3.5.6-8.P (ETS) Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Environmental Literacy and Sustainability:	

Students will know…. (DCI)	Students will be able to… (SEP)	Students will apply…(CCC)
All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.	Planning and Carrying Out Investigations: Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. Developing and Using Models: Develop and use a model to describe phenomena. Engaging in Argument from Evidence: Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.	Phenomena that can be observed at one scale may not be observable at another scale. Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/ systems can be analyzed to determine how they function. Systems and Systems Models: Systems may interact with other systems; they may have sub systems and be a part of larger complex systems.

Core Activities and Corresponding Instructional Methods: **Various External Resources**

Core Activities / Corresponding Instructional Methods
Unit Question: What makes someone a scientist? (DOK 2)
1. Give students a sample of a scientific experiment and have them identify the controlled, independent and dependent variables as well as experimental flaws. (DOK 3) 2. Lead a class discussion that prompts students to compare and contrast different known hypotheses, scientific theories and laws based on their knowledge of those terms. (DOK 4) 3. Have students work through a graded laboratory experiment, beginning with a testable question and working through the steps in the scientific method to conclusion where they have to produce a summary of their experiment. (DOK 3) 4. Successfully be able to integrate pertinent mathematics concepts into their data recording and analysis (graphing, charting, averaging) (DOK 2) 5. Formulate well thought out conclusions following scientific experiments (DOK 3) 6. Present all unit vocabulary to students in a format that they can study for retention and application of knowledge. (DOK 1) 7. Be able to identify the parts of a modern microscope and be able to successfully use that tool to examine different types of cell specimen Successfully create a wet mount slide of their own cell specimen, including staining that cell specimen (DOK 2) 8. Be able to identify the parts of a modern microscope and be able to successfully use that tool to examine different types of cell specimen (DOK 2) 9. Successfully create a wet mount slide of their own cell specimen, including staining that cell specimen. (DOK 2) 10. **Long Term Project** – Students will design and complete an experiment. This project will last up and through the 2nd marking period. For this project students will exemplify a complete understanding of the scientific thought process and all of its steps, ability to design an experiment from scratch to test a scientific question and ability to critique and analyze conclusions in order to either obtain an answer to the original scientific question or revise the thought process in order to attempt to achieve an acceptable answer to that question. (DOK 4)

Correctives:

1. Give students extra practice identifying variables in an experiment.
2. Re-teach and retest important concepts including mandatory vocabulary.
3. Have students complete their body of work according to a skeleton outline that the teacher provides with clues along the way to help students follow the steps of the scientific method
4. Give students practical hands-on practice in stations using scientific measuring tools

5. Have students properly observe, analyze and draw specimen visuals while using a compound light microscope.
6. Students will be asked to create flash cards, quizlet, and concept maps if necessary.
7. Re-teach concepts using online lessons provided by the text.

Extensions:

1. Optional recommended Inquiry Lab.
2. Students will be asked to read experimental designs and indicate flaws within the experimental design.
3. Students will be given different cards containing various parts of a scientific experiment and they will need to identify what parts of the scientific method are indicated while adding parts that are missing.
4. Lesson Review and end of Lesson in text.
5. Alternative Assessments provided by the text.

Assessments:

Diagnostic	Formative	Summative
Diagnostic assessments can be in the form of the following: ● KWL charts/summary tables ● Concept mapping ● Open-ended questioning ● Drawing diagrams/model making ● Quick quizzes on key concepts drawing diagrams to explain a process ● "Think-Pair-Share" discussions on the phenomena in question ● Analyzation of real-world data to identify variables and potential relationships	The following can be used for formative assessments throughout the unit: ● Progress Tracker ● Short Quizzes ● Exit Tickets ● Graphic organizers ● Lab notebooks with observations/journal entries ● CERs ● Illustration of a concept/Comic strip explanation ● Self-Assessment and Peer feedback	To evaluate students'mastery of the unit's scientific concepts, the following assessments can be utilized to measure their understanding: ● Two-part Student Assessment/Mid-Point Assessment ● Exit Ticket: Written argument ● Self-Assessment and Peer Feedback ● Project presentation ● Unit test ● Research paper essay ● Design challenge ● Final concept mapping with unit vocabulary terms ● Presentation on real-world applications

Unit 1 Curriculum Map

Overview: This unit launches with students hearing about an injury that happened to a middle school student that caused him to need stitches, pins, and a cast. They analyze doctor reports and develop an initial model for what is going on in our body when it heals. Students investigate what the different parts of our body are made of, from the macro scale to the micro scale. They figure out parts of our body are made of cells and that these cells work together for our body to function.

Once students have figured out what their bodies are made of and how the parts of their body work together to be able to move, they wonder how the parts of our body heal. They start by watching a timelapse of a knee scrape and notice that over time the part that was scraped is filled in with new skin cells. Students investigate what happens when cells make more cells, what cells need to make more cells, and how cells get what they need to make more cells. Students return to the healing timeline they made at the start of the unit and apply what they have figured out about the interactions between the different systems in the body to explain the various events of healing that took place for the injury at the start of the unit. Finally, they apply their model for healing to explain growth at growth plates in children's bodies as they become adults.

Big Ideas:

- Organisms have characteristic structures that enable functions and behaviors that allow them to grow, reproduce, and die.
- Animals have external and internal sensory receptors that detect different kinds of information that then gets processed by the brain.

Textbook and Supplemental Resources: OpenSciEd Unit 6.6 Cells & Systems, ThinkCentral Science Fusion textbook series

Unit 1: Cells & Systems

Standards (by number):	Essential Questions: • How do the structures of organisms enable life's functions? • How do organisms detect, process, and use information about the environment? • How do living things heal?
Science:	3.1.6-8.A Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells. 3.1.6-8.B Develop and use a model to describe the function of a cell as a whole and the ways that parts of cells contribute to the function.

	3.1.6-8.C Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. 3.1.6-8.H Gather and synthesize information about how sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
Technology and Engineering:	3.5.6-8.II Predict outcomes of a future product or system at the beginning of the design process. 3.5.6-8.O Interpret the accuracy of information collected. 3.5.6-8.X Defend decisions related to a design problem. 3.5.6-8.U Evaluate and assess the strengths and weaknesses of various design solutions given established principles and elements of design. 3.5.6-8.P (ETS) Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. 3.5.6-8.E Consider the impacts of a proposed or existing technology and devise strategies for reducing, reusing, and recycling waste caused by its creation. 3.5.6-8.D Analyze how the creation and use of technologies consumes renewable, non- renewable, and inexhaustible resources; creates waste; and may contribute to environmental challenges. 3.5.6-8.C Hypothesize what alternative outcomes (individual, cultural, and/or environmental) might have resulted had a different technological solution been selected. 3.5.6-8.H Evaluate trade-offs based on various perspectives as part of a decision process that recognizes the need for careful compromises among competing factors. 3.5.6-8.Z Analyze how different technological systems often interact with economic, environmental, and social systems.

Environmental Literacy and Sustainability:	

Students will know…. (DCI)	Students will be able to… (SEP)	Students will apply…(CCC)
All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.	Planning and Carrying Out Investigations: Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. Developing and Using Models: Develop and use a model to describe phenomena. Engaging in Argument from Evidence: Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.	Phenomena that can be observed at one scale may not be observable at another scale. Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/ systems can be analyzed to determine how they function. Systems and Systems Models: Systems may interact with other systems; they may have sub systems and be a part of larger complex systems.

Core Activities and Corresponding Instructional Methods: Unit 1 Video Links, Unit 1 Overview, Unit 1 Activities

Core Activities / Corresponding Instructional Methods
Unit Question: How do living things heal? (DOK 3)
Lesson Set 1 (Lessons 1-7) - What are the different parts of our body made of?

Lesson 1 - What happened in the student's foot so they could walk again? (DOK 3) Core Activity: Students hear about an injury that happened to a middle school student, analyze doctor reports, and develop a model for what is going on in the body when it heals. (DOK 3) 1. Discuss experiences when our bodies don't move like we anticipate them to. (DOK 1) 2. Read doctor's notes and observer images of the student's injury. (DOK 1) 3. Create a timeline of important events that show evidence of healing. (DOK 3) 4. Develop models to show how the part of the foot works together so the patient can walk again. (DOK 4) 5. Brainstorm phenomena of other times we have seen healing in humans and other living things. (DOK 2) 6. Students will discuss multi-celled vs unicellular organisms. (DOK 2) 7. Students will discover what composes a cell through a cell organelle activity. (DOK 2) 8. Students do an activity to understand the difference between prokaryotic and eukaryotic cells. (DOK 2) 9. Students will discuss illnesses with respect to viruses vs. bacteria. (DOK 2) 10. Students will create an argument to identify a virus as living or nonliving.(DOK 3) 11. Students will explore real-world disease case studies (i.e. COVID-19). (DOK 3) 12. Introduce epidemiological data analysis using graphs and statistical trends. (DOK 3)
Lesson 2 - What do our bones, skin, and muscles do for us? (DOK 1) Lesson 3 - How can medical images and diagrams help us figure out more about the structures in our body?(DOK 2) Lesson 4 - Why is there blood in all of these places in the body? (DOK 2) Lesson 5 - What do nerves do, and why are they in different parts of the body? (DOK 2) Lesson 6 - What will we see if we look at skin, bone, and muscle with the microscope, too? (DOK 2) Core Activity: Students investigate what the different parts of our body are made from the macro to the micro scale. (DOK 3) 1. Investigate the parts that make up a chicken wing and how they work together when moving. (DOK 3) 2. Watch a video of the dissection of its skin, muscle, and bone. (DOK 1) 3. Map the parts of the chicken wing to the parts of the human foot to make sense of how these parts work together in similar ways. (DOK 2) 4. Revise the investigation to figure out how function can be affected because of an injury. (DOK 3) 5. Observe different types of medical images of a body. (DOK 1) 6. Analyze various scientific diagrams to help us interpret the different structures within the images we observed. (DOK 2) 7. View an image of blood vessels to determine that blood circulates everywhere in the body. (DOK 1) 8. Observe that blood in test tubes settles into layers. (DOK 1)

9. Use a microscope to investigate human and mammal blood on prepared slides. (DOK 2)
10. Observe that blood is composed of several different smaller structures. (DOK 1)
11. Read an article to make sense of the patterns seen in the prepared slides. (DOK 1)
12. Use the summary table to explain how the structures of blood and its components support their function in the body. (DOK 2)
13. Investigate nerves under a microscope and notice that nerves have unique and intricate structures. (DOK 2)
14. Read about nerves and learn that the nerve cell's structure suits its function. (DOK 1)
15. Engage in stimulus/response activities to help understand the role nerves play in our bodies. (DOK 4)
16. Use the summary table to revisit the foot injury and explain how nerves play a role in the healing process of the skin, muscles, and bone. (DOK 2)
17. Students will model levels of cellular organization from cell to organism. (DOK 2)
18. Students will be able to explain the connection between multiple body systems. (DOK 2)
19. Students will demonstrate through identifying and modeling multiple organs within body systems.(DOK 3)
20. Presentation on Body Systems - Students will present on various body systems in a jigsaw activity. (DOK 3)

Lesson 7 - Are all things made of cells? (DOK 1)

Core Activity: Students draw connections between what our body is made of and how parts of our body work together for our body to be able to move. (DOK 3)

1. Plan an investigation to collect data to determine if other things are made of cells. (DOK 2)
2. Analyze microscopic images of living and non-living things to look for evidence of cells. (DOK 4)
3. Create an argument from evidence that parts of living things are made of cells whereas non-living things are not made of cells. (DOK 3)
4. Students will create a debate on whether items are living or non-living. (DOK 3)
5. Students will create a debate on cell ownership.(DOK3)

Lesson Set 2 (Lessons 8-14) - How do the parts of our body heal? (DOK 3)

Lesson 8 - What happened as the skin on top of the foot healed? (DOK 3)
Lesson 9 - What is happening at the site of an injury to fill the gap? (DOK 2)
Lesson 10 - What do cells need to grow to make more of themselves? (DOK 2)
Lesson 11 - How do cells get what they need to grow? (DOK 3)

Core Activity: Students investigate what happens when cells make more cells in addition to what cells need to make more cells and how cells get what they need to make more cells. (DOK 3)

1. Revisit the healing timeline using our new knowledge of cells to explain and revise with respect to what the foot is made of and how these parts work together to help us function. (DOK 4)
2. Observe a time-lapse video of a skin wound healing to gather more information about what must be happening in the healing process. (DOK 1)
3. Revise the model to include what happens with cells when skin heals. (DOK 3)
4. Analyze a video and microscopic images of cells splitting and growing in different organisms. (DOK 2)
5. Use the summary table to create an explanation to explain how our body fills a gap at the site of an injury. (DOK 3)
6. Recall what resources humans need to grow. (DOK 1)
7. Investigate what cells need to grow by looking at data from a scientist, who grew bacteria on agar plates with different nutrient levels. (DOK 3)
8. Analyze the data to determine bacterial growth in comparison to resource availability. (DOK 3)
9. Read about other unicellular organisms to understand that all living things need food. (DOK 2)
10. Observe onion cells using a microscope under different conditions. (DOK 2)
11. Using the summary table explains how different environmental conditions cause the cell to gain and lose water. (DOK 2)
12. Students will be able to model and explain the cell cycle (interphase, mitosis, and cytokinesis). (DOK 2)
13. Students will discuss the cell membrane and the macromolecules that compose the cell membrane. (DOK 2)
14. Students will identify the properties of the lipid bi-layer to understand the characteristics of semi-permeability. (DOK 2)
15. Students will be introduced to homeostasis and the importance of homeostasis through case studies and non-fiction text. (DOK 2)
16. Students will work on an activity to demonstrate feedback loops. (DOK 2)

Lesson 12 -How do the structures and systems in the body work together to heal the injury? (DOK 3)

Core Activity: Students explain how the different systems of the body play a role in the different events of the healing process. (DOK 3)

17. Revisit the timeline of healing from lesson 1 and develop explanations for how healing happens. (DOK 4)
18. Discuss as a class and come to a consensus about how the healing in the foot happened. (DOK 2)
19. Explain how the systems of the body interact to support the healing process. (DOK 3)
20. Students will discuss the role of the nervous system in the healing process (stimulus/response). (DOK 3)
21. Students will model the nervous system to add it to their catalog of body systems. (DOK 2)

Lesson 13 - How is the process of growing similar to healing? (DOK 2)
Lesson 14 - How can shifting our perceptions of ability and disability allow us to be more thoughtful about how we make our environments more accessible? (DOK 3)

Core Activity: Students apply their model for healing to explain growth at growth plates in the bodies of children as they become adults. (DOK 4)

1. Revise our main question about how living things heal to include growth. (DOK 3)
2. Discuss how cells act in a similar manner during organism growth as they do in the healing process. (DOK 2)
3. Revise our definition of healing to include the fact that different individuals function differently. (DOK 3)
4. Read and hear about five stories from people with disabilities, the challenges they face, as well as the perceptions of their disability. (DOK 1)
5. Brainstorm ways to adapt and re-design our environment in order to make it more accessible to people with disabilities. (DOK 2)
6. Students will discuss cell division as asexual reproduction and how this differs from sexual reproduction. (DOK 2)
7. Students will be introduced to different methods of asexual reproduction to understand genetically identical offspring. (DOK 2)

Words that "Might be Encountered" throughout the Unit:

System	Function	Cell
Platelet	Structure	Tissue
Plasma	Nerves	Organ
Plant Cell	Bone	Organ System
Animal Cell	Muscle	Organism
Bacterial Cell	Skin	Cytoplasm
Single-Celled Organism	Multi-Celled Organism	Nucleus
Cell Division	Slide Base	Cell Membrane
Mitosis	Objective lenses	Cell Wall
Stimulus	Stage clips	Vacuole
Homeostasis	Base	Cross-Section
Response	Arm	Eyepiece Stage
Organelle	Diaphragm	Ocular lens
Osmosis	Light Source	Fine focus
Cell Transport	Selectively permeable	Coarse focus
Pores	Equilibrium	Prokaryotic
Chromosome		Eukaryotic

Correctives:

Lesson 1: Students should focus on what is happening at the macroscopic level for the first 3 lessons, it is not necessary to consider the microscopic level at this point. This lesson focuses on how the injury affected function, not on how the injury occurred, or any medical treatment involved.

Lesson 2: This lesson only focuses on the structures that affect how the chicken wing and human foot move identified in Lesson 1, tendons, ligaments, and joints are not included in this investigation.

Lesson 3: Students will not be identifying different types of cells in this lesson, this will come in later lessons.

Lesson 4: Students will not be defining what a cell is, but identifying specific cell types. The role of platelets and plasma in the healing process is covered in lesson 12.

Lesson 5: This lesson focuses on building an understanding of structure and function, not on the communication process between nerves and the brain or the parts of the nervous system.

Lesson 6: Cells will be discussed in this lesson but key parts of cells (organelles, chromosomes, etc) will be names and identified in later lessons or units.

Lesson 7: Focus of this lesson is not on identifying common structures among the specimens being observed. Students do not need to argue that all living things are made out of cells at this point, this will come in lesson 10.

Lesson 8: This lesson focused on visual observations in order to infer what happens at the cellular level.

Lesson 10: Purpose of this lesson is to use this data to figure out if food is needed for cells to make other cells, not how cells can be grown outside of the body. Time does not need to be spent on differentiating between prokaryotic and eukaryotic organisms at this point.

Lesson 11: This lesson does not focus on the naming of organelles, identification of cell parts is not necessary to understand the function of the nucleus. Focus on the fact that there are mechanisms that allow materials to enter and leave the cell rather than naming the processes.

Lesson 12: This lesson explains how swelling helps the healing process but not how swelling is an immune process.

Lesson 13: We are only concerned with growth of bones in an individual from toddler years to physical maturity, not the overall process from childhood to adulthood.

Lesson 14: Not an engineering task, only engagement in design as a thought experiment.

Extensions:

To extend or enhance the unit, consider the following

Lesson 2: If you wish, you could conduct the dissection as a demonstration investigation with your students instead of watching the video of the dissection. This would allow students to make closer observations and ask questions about the structures of the chicken wing that might be able to be answered through closer investigations of the parts of the chicken wing.

Lesson 5: Instead of sharing microscopic images of nerves with students, if you have slides of nerve smear available, you could allow students to use the microscopes and look at them with a partner to make observations.

Lesson 7: The first part of the assessment asks students to plan for an investigation that would help them figure out whether other things in their world are made of cells. Due to the open-ended nature of this question, in the second part of the assessment students analyze microscopic images of 6 different objects to look for evidence of whether they are made of cells or not. If you have the materials and time, you could allow students to carry out the investigation they plan for in part 1 of the assessment.

Assessments: Assessments for Unit 1, Summary Table

Diagnostic	Formative	Summative
Diagnostic assessments can be in the form of the following: ● KWL charts/summary tables ● Concept mapping ● Open-ended questioning ● Drawing diagrams/model making ● Quick quizzes on key concepts drawing diagrams to explain a process ● "Think-Pair-Share" discussions on the phenomena in question ● Analyzation of real-world data to identify variables and potential relationships	The following can be used for formative assessments throughout the unit: ● Progress Tracker ● Short Quizzes ● Exit Tickets ● Graphic organizers ● Lab notebooks with observations/journal entries ● CERs ● Illustration of a concept/Comic strip explanation ● Self-Assessment and Peer feedback	To evaluate students'mastery of the unit's scientific concepts, the following assessments can be utilized to measure their understanding: ● Two-part Student Assessment/Mid-Point Assessment ● Explanation (*How do the systems in the body interact during the healing process?)* ● Student Transfer Task Assessment: Explaining Growth ● Exit Ticket: Written argument ● Self-Assessment and Peer Feedback ● Project presentation ● Unit test ● Research paper essay ● Design challenge ● Final concept mapping

		with unit vocabulary terms ● Presentation on real-world applications

Unit 2 Curriculum Map

Overview: This unit on metabolic reactions in the human body starts out with students exploring a real case study of a middle-school girl named M'Kenna, who reported some alarming symptoms to her doctor. Her symptoms included an inability to concentrate, headaches, stomach issues when she eats, and a lack of energy for everyday activities and sports that she used to play regularly. She also reported noticeable weight loss over the past few months, in spite of consuming what appeared to be a healthy diet. Her case sparks questions and ideas for investigations around trying to figure out which pathways and processes in M'Kenna's body might be functioning differently than a healthy system and why.

Students investigate data specific to M'Kenna's case in the form of doctor's notes, endoscopy images and reports, growth charts, and micrographs. They also draw from their results from laboratory experiments on the chemical changes involving the processing of food and from digital interactives to explore how food is transported, transformed, stored, and used across different body systems in all people. Through this work of figuring out what is causing M'Kenna's symptoms, the class discovers what happens to the food we eat after it enters our bodies vocabulary and how M'Kenna's different symptoms are connected.

Big Ideas:

- Organisms have characteristic structures that enable functions and behaviors that allow them to grow, reproduce, and die.
- The characteristic structures, functions, and behaviors of organisms change in predictable ways as they progress from birth to old age (through the life cycle).
- The structures, functions, and behaviors of organisms allow them to obtain, use, transport, and remove the matter and energy needed to live.
- All forms of matter exist as a result of the combination or rearrangement of atoms.
- The atoms of some substances combine or rearrange to form new substances that have different properties.

Textbook and Supplemental Resources: OpenSciEd Unit 7.3: Metabolic Reactions, ThinkCentral Science Fusion textbook series

Unit 2: Metabolic Reactions

Standards (by number):	Essential Questions:
	• How do the structures of organisms enable life's functions? • How do organisms grow and develop? • How do organisms obtain and use the matter and energy they need to live and grow? • How do particles combine to form the variety of matter one observes?

	• How do substances combine or change (react) to make new substances? • How does one characterize and explain these reactions and make predictions about them? • How do things inside our bodies work together to make us feel the way we do?
Science:	3.1.6-8.C Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. 3.1.6-8.E Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS1-5 3.1.6-8.G Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.MS-LS1-7 3.2.6-8.A Develop models to describe the atomic composition of simple molecules and extended structures.MS-PS1-1 3.2.6-8.D Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS1-2
Technology and Engineering:	3.5.6-8.M Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. 3.5.6-8.N Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. 3.5.6-8.O Interpret the accuracy of information collected. 3.5.6-8.FF Demonstrate how systems thinking involves considering relationships between every part, as well as how the systems interact with the environment in which it is used.
Environmental Literacy and Sustainability:	

Students will know…. (DCI)	Students will be able to… (SEP)	Students will apply…(CCC)
In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. Genetic factors as well as local conditions affect the growth of the adult plant. Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary). Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with	Engaging in Argument from Evidence: Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. Constructing Explanations and Designing Solutions:Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Developing and Using Models: Develop a model to describe unobservable mechanisms. Developing and Using Models: Develop a model to predict and/or describe phenomena. Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings.	Systems and Systems Models: Systems may interact with other systems; they may have sub systems and be a part of larger complex systems. Cause and Effect: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. Energy and Matter: Matter is conserved because atoms are conserved in physical and chemical processes. Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. Patterns: Macroscopic patterns are related to the nature of microscopic and atomic level structure.

repeating subunits (e.g., crystals). Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.		

Core Activities and Corresponding Instructional Methods: Unit 2 Video Links, Unit 2 Overview, Unit 2 Activities by Lesson

Core Activities / Corresponding Instructional Methods
Unit Question: How do things inside our bodies work together to make us feel the way we do? (DOK 3)
Lesson Set 1 (Lessons 1-8) - What happens to the food we eat and does that work the same for all people? (DOK 2)
Lesson 1 - What is going on inside out bodies to make us feel the way we do? (DOK 3) Core Activity: Students will analyze a case study of a girl who is sick and is unsure why. (DOK 4) 1. Analyze and consider what is causing her symptoms. (DOK 2) 2. Students will use evidence and identify patterns to generate ideas as to what might be causing her symptoms. (DOK 2) 3. Develop a model of the parts of the system that are needed to explain many of the patterns we have identified. (DOK 3) 4. Students will identify which body systems were being impacted by drawing on Unit 1 conversation, and then draw connections about how this phenomenon fits what we already know. (DOK 3)

5. Students will revisit conversation about what illnesses were discussed from Unit 1. (DOK 1)

Lesson 2 - Do you observe any differences between a healthy vs unhealthy person's endoscopy report? (DOK 1)
Lesson 3 - Why do molecules in the small intestine seem like they are disappearing? (DOK 2)
Lesson 4 - What happens to food molecules as they move through the small and large intestine? (DOK 2)
Lesson 5 - Why do large food molecules, like complex carbohydrates, seem to disappear in the digestive system? (DOK 2)
Lesson 6 - What happens to the different substances in food as it travels through the digestive system? (DOK 2)

Core Activity: Students investigate and analyze data that shows what happens to food as it travels through the digestive system in both a healthy and unhealthy person. (DOK 3)

1. Gather and analyze information from endoscopy reports and graphs that show what happens to food as it travels through the digestive system for both a healthy and unhealthy person. (DOK 4)
2. Plan and conduct an investigation to determine whether food molecules can pass through or travel across a surface with a structure similar to the small intestine using dialysis tubing. (DOK 3)
3. Make an argument for how the results of the investigation and the molecular models of the substances used help to explain how some kinds of food molecules could be absorbed into the body. (DOK 3)
4. Investigate and Analyze food data from the mouth to the large intestine to distinguish any patterns and what those patterns may mean for a healthy vs unhealthy person. (DOK 4)
5. Analyze poop data to determine what molecules are present at the end of digestion and what molecules are no longer present. (DOK 4)
6. Investigate and analyze data on complex carbohydrates and fiber using a graham cracker lab to observe what happens to complex carbohydrates and other fibers in the mouth. (DOK 3)
7. Students will learn about large organic macromolecules (carbohydrates, lipids, proteins, and nucleic acids) if not previously discussed in Unit 1. (DOK 1)
8. Students will work on extension activities about the cell membrane and what large organic macromolecules make up the cell membrane if not previously discussed in Unit 1. (DOK 2)

Lesson 7 - What is the function of the digestive system, and how is the unhealthy digestive system we have been investigating different? (DOK 2)
Lesson 8 - What does the surface of the small intestine look like in a healthy person in comparison to the unhealthy person? (DOK 2)

Core Activity: Students build written arguments about which conditions the unhealthy person, who's data we have observed, is most likely to have or not have based on the evidence collected. (DOK 4) 1. Develop a model to represent the inputs, processes, and outputs of the digestive system. (DOK 3) 2. Revise a model to represent the role the system plays in breaking down matter through chemical reactions, absorbing food, and excreting unused matter. (DOK 3) 3. Construct an argument, based on evidence, to eliminate two of the five possible conditions that could be causing the symptoms presented in the unhealthy individual. (DOK 3) 4. Develop a model of the digestive system. (DOK 2) 5. Identify structures in the small intestine called villi that line the small intestine using an interactive simulation. (DOK 1) 6. Students will discuss all organs of the digestive system and model the digestive system in their notebook. (DOK 2) 7. Energy movement in an ecosystem introduction. Through non-fiction texts students are presented with information on heterotrophs, autotrophs, and energy movement. (DOK 1) 8. Nutrient cycling activity about the movement of carbon and other nutrients (biogeochemical cycles). (DOK 2)
Lesson Set 2 (Lessons 9-13) - How can a problem in one body system cause problems in other systems? (DOK 3)
Lesson 9 - How can a problem in one body system cause problems in other systems? (DOK 3) Core Activity: Students ask questions in order to problematize investigating the other symptoms they cannot yet explain, such as weight loss and fatigue. (DOK 3) 1. Revisit summary table to address what has been observed, patterns present, and on-going questions about the core phenomena. (DOK 3) 2. Investigate data on an unhealthy person's symptoms to draw connections between systems beyond that of the digestive system. (DOK 4) 3. Students will revisit what causes illness; however, they will focus on lack of enzyme production and what happens to a person who is lactose intolerant. (DOK 3) 4. Students will be able to explain the role of enzymes in chemical reactions. (DOK 2)
Lesson 10 - Why would someone lose weight if eating the same things as a healthy individual? (DOK 2) Lesson 11 - What happens to matter when it's burned? (DOK 2) Lesson 12 - Does this chemical reaction to burn food happen inside our bodies? (DOK 2) Core Activity: Students investigate what happens when fat is burned. Students explore gas movement within the body to discover metabolic reactions. (DOK 3) 1. Analyze trends in weight by looking at images of weight loss over time. (DOK 4) 2. Read an article about fat being 'burned'. (DOK 1)

3. Investigate using an experiment in which students light different types of fat on fire, weigh them, and compare their properties before and after they burn. (DOK 4) 4. Students will discuss fermentation and what our bodies do in order to maintain energy in the absence of oxygen. (DOK 3)
Lesson 13 - How does a healthy body use food for energy and growth, and could this differ in an unhealthy individual? (DOK 3) Core Activity: Students put pieces together to show how food is rearranged for energy, stored for later use and used for growth within a body system. (DOK 3) 1. Develop a model to show how food is rearranged in the body in terms of matter inputs, processes, outputs, and energy flows within a body system. (DOK 2) 2. Construct an explanation to explain the relationships between differences in an unhealthy vs healthy person's digestive system to predict symptoms. (DOK 3) 3. Students will discuss energy acquisition and movement of energy in an ecosystem if not discussed previously in this unit. (DOK 2) 4. Students will discuss nutrient cycles if not previously discussed in a prior lesson. (DOK 1)
Lesson Set 3 (Lessons 14 & 15) - Do all animals use chemical reactions to get energy from food like humans? (DOK 2)
Lesson 14 - Do all animals do chemical reactions to get energy from food like humans? (DOK 2) Core Activity: Students are able to argue that organisms might have different structures that have a similar function of obtaining energy through chemical reactions. (DOK 3) 1. Investigate an organism of choice to see if it does metabolic reactions similar to the way humans do. (DOK 3) 2. Create an argument from the evidence of the unit as to whether organisms do chemical reactions to break down and burn food molecules the same way as humans. (DOK 3) 3. Create an argument from the evidence of the unit as to whether animals have the same structures as humans inside their bodies to work together to do those processes. (DOK 3) 4. Discuss as class the findings and arguments constructed from the investigation and arguments created. (DOK 4) 5. Students will discuss chemical reactions in the body that take place such as cellular respiration. (DOK 2) 6. Apply the chemical reaction to chemical reactions that take place in other organisms like plants and other animals (photosynthesis). (DOK 3)
Lesson 15 - What questions from our summary table can we now address at the conclusion of our unit? (DOK 3)

Core Activity: Students apply scientific ideas and evidence to explain a new phenomenon of bear survival during hibernation. (DOK 3)

1. Revisit the summary table and questions to discuss questions we have answered. (DOK 3)
2. Assessment - Students will be assessed on the culmination of the unit. (DOK 4)

Words that "Might be Encountered" throughout the Unit:

Absorption	Enzymes	Organ
Active Transport	Equilibrium	Organ
Amino Acids	Esophagus	Organ System
Amylase	Exocytosis	Organism
Benedict's Solution	Facilitated Diffusion	Osmosis
Biogenesis	Fatty Acids	Passive Transport
Celiac Disease	Feedback Loops	Pores
Cell	(Positive/Negative)	Protein
Cell Theory	Fiber	Protein Pumps
Cells	Fluid Mosaic Model	Reproduce
Chemical Reaction	Food Molecules	Response
Chemical Reaction	Function	Saliva
Colitis	Gastrointestinal Conditions	Salivary Gland
Complex Carbohydrate	Glucose	Secrete
Concentration Gradient	Homeostasis	Selectively Permeable
Crohn's Disease	Hypertonic	Small Intestine
Development	Hypotonic	Spontaneous Generation
Dialysis Tubing	Interaction	Starch
Diffusion	Iodine	Stimulus
Digestion	Irritable Bowel Syndrome	Stomach
Digestion	Isotonic	Structure
Diverticular Disease	Large Intestine	System
Endocytosis	Molecule	Tissue
Endoscopy	Movement	Tissues
	Organ	Villi

Correctives:

Lesson 1: Students do not need an understanding of each body system prior to starting this unit, only conceptual understanding of how cells form tissues and tissues form specialized organs. Students may need extra instruction on what cells are at this point.

Lesson 2: Students do not need a deep understanding of the anatomy of the digestive system in order to understand the basic structure and function of the organ system (many organs working together to perform a specific function). Focus should be on identifying which of M'kenna's organs is not functioning properly, not on memorization of organs and their structures.

Lesson 3: Students will not identify the effects of concentration gradients on this system here, Students will also not identify where matter that is not absorbed during digestion goes until Lesson 4. Students will not identify the structural differences between M'kenna's intestine and that of a healthy one until Lesson 8. Analysis of molecular structure focuses on how large molecules such as carbohydrates can be broken down into smaller ones; it is not necessary to understand atoms or bond arrangements at this point.

Lesson 4: Students do not need to understand the molecular structure of fiber and starch, only that fiber has multiple connections that make it more difficult to break down. They also do not need to know that starch is being broken down during digestion, this will come in Lessons 5 and 6. Ensure that students know that, in a healthy person, poop only contains fiber and water.

Lesson 5: Students do not need to know of the substances that aid the chemical reactions during digestion, where they are produced or that they are catalysts to these reactions, it is sufficient to know that there are substances produced in the mouth that react with food molecules to break them into smaller parts.

Lesson 6: Focus should be on familiarizing students with the organs involved in the digestive system, not studying the mechanisms of the system in depth. Students also do not need to know the specific chemical reactions taking place in order to achieve the goals of this lesson.

Lesson 7: Students do not need to identify the location or what mechanisms cause the breakdown of molecules during digestion, or be able to differentiate between carbohydrates, proteins, and fats at this point. During the assessment, the goal is for students to eliminate possible causes of the symptoms based on evidence gathered, not providing a diagnosis.

Lesson 8: Students should have background knowledge of cells and cell membranes in order to achieve the goals outlined in this lesson.

Lesson 9: Focus should be on students connecting the differences in the walls of M'Kenna's small intestine back to a change in the absorption rate of food molecules, not how her digestive problems cause her various symptoms.

Lesson 10: Students should understand that atoms are rearranged to form new molecules, they do not need to know the process of bonds being broken and formed.

Lesson 11: This lesson does not address the rearrangement of matter by plants, this comes in Unit 7.4. Students do not need to understand the role of bonds being broken and reformed has on this process. In addition, students are not expected to be able to balance chemical equations at this point, only to understand the conservation of mass in a closed system.

Lesson 12: Students do not need to know the details of cellular respiration or how energy is used in our cells.

Lesson 13: The chemical reactions involved, such as cellular respiration or the breakdown of excess glucose into fat do not need to be studied or understood at this point. Emphasis should be on describing how food molecules are broken down, which releases energy.

Lesson 14: This lesson is not focused on photosynthesis or how simple molecules are rearranged into complex molecules.

Lesson 15: Students don't need to understand genes and their role in our cells at this point.

Extensions:

Lesson 8: During the simulation "Connecting the Structure of Villi to Their Function", you could extend students' explanation to include the idea of surface area. There are additional experiments around surface area to volume ratio and the size of cells that is most efficient for absorption using agar cubes of various sizes, a PH indicator and vinegar or other acid. Cut agar cubes made with a pH indicator of different sizes and place them into vinegar. Over time you will see how much of the solution diffusers into each cube. The simulation in the unit shows the size of cells remaining constant when the villi height is increased, but surface area to volume experiments could help answer additional questions such as, "What would happen to percent absorption if the size of the individual cells was increased?" or "Why are cells inside our body so small?" Make sure your students have the necessary math skills needed to understand the surface to volume ratio concept.

Lesson 13: In the activity section "Develop individual explanations for M'Kenna's other symptoms" you could enhance this by building out a more robust model for the nervous system as a class for explaining her symptom of brain fog. This could answer questions such as, "What does our brain need? What makes up our nervous systems and how is it connected to the other body systems?" as well as providing opportunities for connections back to *OpenSciEd Unit 6.6: How do living things heal? (Healing Unit)*.

Assessments: Unit 2 Assessments, Summary Table

Diagnostic	Formative	Summative
Diagnostic assessments can be in the form of the following: ● KWL charts/summary tables ● Concept mapping ● Open-ended questioning ● Drawing diagrams/model making	The following can be used for formative assessments throughout the unit: ● Progress Tracker ● Short Quizzes ● Exit Tickets ● Graphic organizers ● Lab notebooks with	To evaluate students'mastery of the unit's scientific concepts, the following assessments can be utilized to measure their understanding: ● Two-part Student Assessment/Mid-Point Assessment

• Quick quizzes on key concepts drawing diagrams to explain a process • "Think-Pair-Share" discussions on the phenomena in question • Small Group Argument from Evidence • Analyzation of real-world data to identify variables and potential relationships	observations/journal entries • CERs • Illustration of a concept/Comic strip explanation • Self-Assessment and Peer feedback • Small Group Argument from Evidence • Tasks Part 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence • Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms	• Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms • Exit Ticket: Written argument • Self-Assessment and Peer Feedback • Project presentation • Unit test • Research paper essay • Design challenge • Final concept mapping with unit vocabulary terms • Presentation on real-world applications • Brown Bear Hibernation Tast (version 1 or 2)

Unit 3: Curriculum Map

Overview: This unit on the cycling of matter and photosynthesis begins with 7th grade students reflecting on what they ate for breakfast. Students are prompted to consider where their food comes from and consider which breakfast items might be from plants. Then students taste a common breakfast food, maple syrup, and see that according to the label, it is 100% from a tree.

Based on the preceding unit, students argue that they know what happens to the sugar in syrup when they consume it. It is absorbed into the circulatory system and transported to cells in their body to be used for fuel. Students explore what else is in food and discover that food from plants, like bananas, peanut butter, beans, avocado, and almonds, not only have sugars but proteins and fats as well. This discovery leads them to wonder how plants are getting these food molecules and where a plant's food comes from.

Students figure out that they can trace all food back to plants, including processed and synthetic food. They obtain and communicate information to explain how matter gets from living things that have died back into the system through processes done by decomposers. Students finally explain that the pieces of their food are constantly recycled between living and nonliving parts of a system.

Big Ideas:

- The structures, functions, and behaviors of organisms allow them to obtain, use, transport, and remove the matter and energy needed to live.
- The cycling of matter and the flow of energy within ecosystems occur through interactions among different organisms and between organisms and the physical environment.
- The atoms of some substances combine or rearrange to form new substances that have different properties.

Textbook and Supplemental Resources: <u>OpenSciEd Unit 7.4 Matter Cycling & Photosynthesis</u>, ThinkCentral Science Fusion textbook series

Unit 3: Matter Cycling & Photosynthesis

Standards (by number):	Essential Questions: • How do organisms obtain and use the matter and energy they need to live and grow? • How do matter and energy move through an ecosystem? • How do substances combine or change (react) to make new substances? • How does one characterize and explain these reactions and make predictions about them? • Where does food come from and where does it go next?

Science:	3.1.6-8.F Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. 3.1.6-8.K Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. 3.2.6-8.C Gather and make sense of information to describe how synthetic materials come from natural resources and impact society.
Technology and Engineering:	3.5.6-8.F Analyze examples of technologies that have changed the way people think, interact, live, and communicate. 3.5.6-8.M Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. 3.1.6-8.H Evaluate trade-offs based on various perspectives as part of a decision process that recognizes the need for careful compromises among competing factors. 3.1.6-8.G Analyze how an invention or innovation was influenced by the context and circumstances in which it is developed. 3.1.6-8.L Design methods to gather data about technological systems. 3.1.6-8.J Use tools, materials, and machines to safely diagnose, adjust, and repair systems. 3.1.6-8.Q Apply a technology and engineering design thinking process.
Environmental Literacy and Sustainability:	3.4.6-8 A Develop a model to describe how agricultural and food systems function, including the sustainable use of natural resources and the production, processing, and management of food, fiber, and energy. 3.4.6-8 B Analyze and interpret data about how different societies (economic and social systems) and cultures use and manage natural resources differently.

	3.4.6-8 C Develop a model to describe how watersheds and wetlands function as systems, including the roles and functions they serve. 3.4.6-8 D Gather, read, and synthesize information from multiple sources to investigate how Pennsylvania environmental issues affect Pennsylvania's human and natural systems. 3.4.6-8 G Obtain and communicate information to describe how best resource management practices and environmental laws are designed to achieve environmental sustainability. 3.4.6-8 H Design a solution to an environmental issue in which individuals and societies can engage as stewards of the environment.

Students will know…. (DCI)	Students will be able to… (SEP)	Students will apply…(CCC)
Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. The chemical reaction by which plants produce complex food molecules (sugars) requires energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary).	Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter. Energy and Matter: The transfer of energy can be tracked as energy flows through a natural system. Obtaining, Evaluating, and Communicating Information: Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence. Structure and Function:

Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.		Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Core Activities and Corresponding Instructional Methods **Unit 3 Video Links**, **Unit 3 Overview**, **Unit 3 Activities by Lesson**

Core Activities / Corresponding Instructional Methods
Unit Question: Where does food come from and where does it go next? (DOK 2)

Lesson Set 1 (Lessons 1-8) - Where and how do plants get food molecules? (DOK 2)
Lesson 1 - Where does this stuff come from? (DOK 2) Core Activity: Students will taste maple syrup and maple sap or other foods produced from plants. They will identify patterns in the food molecules on nutrition labels for other food from plants. Students will be able to question and investigate how plants get their food. (DOK 3) 1. Brainstorm food we eat that comes from plants, animals, or other sources. (DOK 2) 2. Watch a video of sap being extracted from a tree and taste the products of food from plants in the form of sap and syrup. (DOK 2) 3. Review nutrition labels for the plant foods we eat. (DOK 2) 4. Analyze how plants get food to produce what it is we eat. (DOK 4) 5. Develop a model to try to explain how plants get food. (DOK 3) 6. Students work on a summary table to help draw connections and create questions about the phenomena presented. (DOK 4)
Lesson 2 - Do plants get their food molecules by taking them in? (DOK 1) Lesson 3 - What other inputs could be sources of food molecules for the plant? (DOK 3) Core Activity: Students use hydroponic plant systems and indicators of food molecules to investigate several potential sources of food molecules in plants. Students will determine that none of those sources contain whole food molecules but they wonder if parts of the food molecules might be there. (DOK 3) 1. Investigate whether soil, plant food, water, or air could be potential sources of food molecules in plants using a hydroponic plant system and indicators of food molecules. (DOK 3) 2. Develop a list of variables that come in contact with the hydroponic system (above and below) that could impact plant growth and production. (DOK 1) 3. Revisit and analyze the composition of air and light to look for possible sources of food molecules for the plant. (DOK 3) 4. Draw conclusions about the lack of whole food molecules in any of the variables that come in contact with the hydroponic system. (DOK 3) 5. Create questions about how whole food molecules for the plant may form. (DOK 4) 6. Students will complete a computer simulation on photosynthesis to demonstrate resource availability and the process of photosynthesis. (DOK2) 7. Students will read graphs and analyze why the outcome in computer simulation changed as a result of change is resource availability. (DOK 3) 8. CER assessment to assess depth of student understanding on resource availability computer simulation and data analysis. (DOK 1)

Lesson 4 - Are any parts that make up food molecules coming into the plant from above the surface? (DOK 2)
Lesson 5 - How are these gases getting into and out of the leaves? (DOK 2)
Lesson 6 - How are all these things interacting together in this part of the plant? (DOK 3)
Lesson 7 - Why do plants need light? (DOK 2)

Core Activity: Students analyze data from investigations with plant leaves to find changes in the amount of water, carbon dioxide, and oxygen when plant leaves are exposed to light. Students use a simulation to investigate how changing the amount of one of these inputs affects the outpost of the plant cell. (DOK 4)

1. Conduct an investigation to produce data showing how the presence of carbon dioxide and water impact plant growth. (DOK 3)
2. Analyze and interpret data from the above investigation, confirm carbon dioxide and water patterns, and discover that oxygen levels are increasing around the plant. (DOK 4)
3. Observe the surface of real leaves along with microscopic leaf images and a video. (DOK 2)
4. Discuss the presence of the stomata and the role it plays in gas exchange in the plant. (DOK 2)
5. Read and gather information about the repeating structures in plant cells, chloroplasts, and movement with response to light. (DOK 2)
9. Discuss how light and chloroplast fit in our plant model and review the other inputs and outputs in photosynthesis. (DOK 3)
10. Students utilize a simulation to further understand the process of photosynthesis as it pertains to reactants and products. (DOK 4)
11. Analyze data from the simulation and create an argument explaining how limited reactants decrease the amount of oxygen and sugar production during photosynthesis. (DOK 3)
12. Investigate the role of sunlight in photosynthesis by examining food labels to figure out how much energy water, carbon dioxide, and glucose can provide for the body. (DOK 2)
13. Analyze the outcome of photosynthesis producing glucose gives us energy in the form of calories; however, the inputs or reactants to photosynthesis do not have energy therefore the energy must come from an outside source to create the product of glucose. (DOK 3)
14. Create an argument from the evidence focusing on sunlight being the source of energy for plants to rearrange carbon, hydrogen, and oxygen through the chemical reaction of photosynthesis to produce glucose (an energy source). (DOK 3)
15. Students will discuss energy transformation in the process of photosynthesis in comparison to cellular respiration. (DOK 1)
16. Students will be given a knowledge base on where each of these processes take place in cells. (DOK 1)
17. Students will model the biochemical cycle of the movement of carbon dioxide, water, and glucose through both cellular respiration and photosynthesis. (DOK 3)

Lesson 8 - Where are plants getting food from? (DOK 1) Core Activity - Students revise their models to explain where plants are getting their food by doing chemical reactions using the inputs of carbon dioxide, water, with exposure to light to make glucose and oxygen. (DOK 3) 1. Revisit the summary table to highlight the necessities of plants for the process of photosynthesis. (DOK 3) 2. Assessment - revisit the model of how plants obtain food and revise according to what we have learned throughout lessons 1-7. Models include key inputs and outputs and differentiate between matter and energy. (DOK 4)
Lesson Set 2 (Lessons 9-11) - Why does a plant need to make food in the first place? (DOK 2)
Lesson 9 - Where do the food molecules in the maple trees come from? (DOK 2) Core Activity: Students try to explain how maple trees can produce sap in the winter, but their models predict that plants only make food molecules when leaves are present. Students realize their models cannot yet explain how food molecules are found in plants when necessary inputs or structures are missing, such as during winter or in the dark. (DOK 3) 1. Apply models to explain how maple trees can produce sap in the winter. (DOK 3) 2. Develop an initial explanation for how food molecules can be found in plants when leaves aren't present. (DOK 1) 3. Revisit the summary table to reflect on the investigation and models of photosynthesis created thus far. (DOK 4)
Lesson 10 - Why don't plants die at night? (DOK 2) Lesson 11 - Why don't plants die when they can't make food? (DOK 3) Core Activity: Students will carry out an investigation and interpret data in order to figure out that plants release carbon dioxide and water and take in oxygen and in the dark. Students investigate seeds to determine that they use energy from stored food molecules and release carbon dioxide before they have green leaves that can do photosynthesis. (DOK 3) 1. Use the model to predict when plants don't make food molecules and wonder why plants don't die at night. (DOK 2) 2. Conduct an investigation and produce data showing that plants release carbon dioxide and water when in the dark. (DOK 2) 3. Analyze and interpret data and discover that plants take in oxygen in the dark. (DOK 2) 4. Create an argument based on the evidence from the unit to show photosynthesis doesn't happen in the dark (DOK 3) 5. Compare findings from the investigation to humans and theorize that maybe pants burn stored food through cellular respiration when they can't make food molecules through photosynthesis. (DOK 4)

6. Investigate - plan and carry out an investigation to see whether plants without leaves are doing cellular respiration. (DOK 3) 7. Analyze the outcome of the investigation and create an argument from the evidence that shows food plants make is able to provide them energy. (DOK 3) 8. Read an article about where cellular respiration happens in plant and animal cells and what plants do with extra food they produce from photosynthesis. (DOK 2) 9. Construct an explanation using evidence from the investigation and reading to explain what is happening to a maple tree in a time-lapse video filmed over many years. (DOK 3) 10. Students will revisit the chemical reactions of photosynthesis and cellular respiration to model the role that mitochondria and chloroplast play in each process. (DOK 3) 11. Students will create an argument to explain how plants need to be able to complete both cellular respiration and photosynthesis. (DOK 4) 12. Students are introduced to the concept of white light spectrum through a computer simulation utilizing different wavelengths of light for photosynthesis. (DOK 2)
Lesson Set 3 (Lessons 12-15) - Where does all our food come from? Where does it go next? (DOK2)
Lesson 12 - Where does the rest of our food come from? (DOK 2) Core Activity: Students will be able to obtain information from ingredients lists of common processed foods and argue that they are all made of matter in food from plants and/or animals, even if the food is synthetic. Students will be able to trace all of their food back to plants, they wonder what happens to food that does not get eaten. (DOK 3) 1. Create an argument by gathering information from ingredients lists for common processed foods and argue that they are made of matter from plants and /or animals. (DOK 3) 2. Obtain and analyze information and data from nutrition facts about animal diets. (DOK 4) 3. Create an argument that animals have food molecules in them that come from eating plants or other animals that once ate plants. (DOK 3)
Lesson 13 - What happens to food that doesn't get eaten? (DOK 2) Core Activity: Students investigate and communicate what is happening when decomposers recycle plant and animal matter back into the system. (DOK 2) 1. Watch a video of decomposers that recycle matter and transfer energy from dead plants and animals. (DOK 2) 2. Examine and analyze data from bread mold (a decomposer) in the light and dark. (DOK 3) 3. Read about decomposers in systems around the world. (DOK 1) 4. Revise the model to include decomposers as living parts of the system. (DOK 3) 5. Students will scaffold food chains in different biomes around the world. (DOK 3)

6. Students will present findings on differing biomes (benefits of each and the requirements of each). (DOK 3) 7. Students will create an argument explaining what would happen(s) when a food chain in one biome is disrupted including what the expect the result to be in such scenarios. (DOK 4)
Lesson 14 - Where does food come from and where does it go next? (DOK 2) Lesson 15 - Where does food come from, and where does it go next? (DOK 2) Core Activity: Students explain the story of what happens to the matter and energy of a food they ate as it moves through living and nonliving parts of a system. Students apply this knowledge to explain a new phenomenon in an aquatic ecosystem. (DOK 4) 1. Observe photographs of decomposers in our own lives. (DOK 1) 2. Revisit the initial model to include arrows representing the continuous cycling of matter and energy. (DOK 3) 3. Revisit the summary table to include any answers to previous questions. (DOK 3) 4. Assessment - complete a summative assessment on photosynthesis and cellular respiration as they pertain to matter and energy cycling in an ecosystem. (DOK 4)

Words that "Might be Encountered" throughout the Unit:

ATP	Ecosystem	Mitochondria
Autotroph	Energy	Natural
Biomass	Energy Flow	Outputs
Calories	Energy Transformation	Oxygen
Carbohydrates	Enzyme	Oxygen Cycle
Carbon Cycle	Fats System	Photosynthesis
Carbon Dioxide	Fermentation	Producer
Cellular Respiration	Food Molecules	Products
Chemical Energy	Food WebGlucose	Proteins
Chemosynthesis	Heterotroph	Reactants
Chlorophyll	Hydroponics	Relative Humidity
Chloroplast	Inputs	Stomata/Stoma
Chloroplasts	Light Energy	Synthetic
Consumer	Matter	Transpiration
Consumers	Matter Cycling	Trophic Levels
Decomposers	Metabolism	Water
		Yields

Correctives:

Lesson 1: Avoid pushing back on any student ideas on how plants get what they need to grow, students will solidify this understanding throughout this unit and will need to use this prior knowledge.

Lesson 2: Instead of eliminating soil and plant food from the “candidate list”, students will test the hydroponic system with food indicators to solidify understanding that these are not the main source of atoms for plants to make food molecules. Students will find that the main source is CO2 in the next lesson.

Lesson 3: This lesson does not confirm that air molecules enter plants (Lesson 4), cover the role of light for plants (Lessons 5 and 6), or the role of animals and decomposers in matter cycling.

Lesson 4: Students will most likely already know the important role light plays in plant life, and may want to investigate how plants are affected when put in the dark. Encourage students to record these questions, but that investigation will be done in Lesson 10.

Lesson 5: This lesson and overall unit do not address how plants move water in gases within their structures. Mitochondria is mentioned in the reading, but students will dive deeper into the structure and function of mitochondrion in Lesson 11.

Lesson 6: This lesson shows the smaller sequences involved in photosynthesis such as light reactions and the Calvin cycle, but these sequences are not covered in depth. The simulation does not show what happens in the mitochondria of plants, this will be discovered in later lessons.

Lesson 7: Students will investigate cellular respiration in plants and how plants use food in Lessons 10 and 11, they are only creating a model that tracks the flow of matter and energy through photosynthesis. They will identify the role of decomposers in Lesson 13.

Lesson 8: This lesson will not add cellular respiration to the model, this will happen in Lesson 9. This lesson does not explain that all food comes from plants, this will come in Lesson 12.

Lesson 9: Students may realize that their models do not account for sugar or other food molecules found in trees after they have shed their leaves (sugar found in maple trees during winter), students will learn in later lessons that trees store sugars to be used later.

Lesson 10: Students will be able to confirm how plants cellular respiration in the absence of sunlight in Lesson 11.

Lesson 11: This lesson focuses only on the matter cycling and flow of energy in regards to the reactants and products of photosynthesis and cellular respiration.

Lesson 12: Focus of this lesson should be on identifying how the original carbohydrate molecule breaks apart in order to form a new substance, students do not need to know the details of the chemical reactions at this point.

Lesson 13: It is important that students understand that decomposers are more like animals than plants, in that they cannot make their own food but must take in energy from an outside source. However, students do not need to separate decomposers into their more specific categories such as detritivores, scavengers, or those that perform anaerobic respiration. Students will identify the role of decomposers in matter cycling in the next lesson.

Lesson 14: Students will develop a model that represents a small ecosystem, but this is not the goal of the lesson nor will ecosystems be discussed, this will come in the next unit.

Lesson 15: Students do not need to understand populations or interactions in ecosystems, this discussion comes in the next unit.

Extensions:

Lesson 2: Instead of jigsawing the different food indicators, student groups could test each of the indicators with the corresponding type of food.

Lesson 11: Provide time for students to work on the alternate activity described in the *Teacher Guide* where students dissect one of the seeds to look for evidence of that sprouting starting. You can also give students the option to each take three seeds from the investigation home, put them back in a wet paper towel in a ziplock bag as they were when students got them, and tape the bag to a window in their house to watch them sprout.

Lesson 13: Students can carry out the *What Happens to Uneaten Food?* investigation in the classroom using BTB (like in Lessons 7 and 11) or the carbon dioxide/relative humidity detector (like they used in Lessons 4 and 10).

Lesson 13: Students could spend more time researching details of their chosen decomposer and/or students could communicate the information they've learned in a different format than the suggested slide or to a different audience than just their peers.

Assessments: Assessment Breakdown Unit 3, Summary Table

Diagnostic	Formative	Summative
Diagnostic assessments can be in the form of the following: ● KWL charts/summary tables ● Concept mapping ● Open-ended questioning ● Drawing diagrams/model making ● Quick quizzes on key concepts drawing diagrams to explain a process	The following can be used for formative assessments throughout the unit: ● Progress Tracker ● Short Quizzes ● Exit Tickets ● Graphic organizers ● Lab notebooks with observations/journal entries ● CERs	To evaluate students'mastery of the unit's scientific concepts, the following assessments can be utilized to measure their understanding: ● Two-part Student Assessment/Mid-Point Assessment ● Exit Ticket: Written argument ● Self-Assessment and

● Student Self-Assessment ● "Think-Pair-Share" discussions on the phenomena in question ● Analyzation of real-world data to identify variables and potential relationships	● Illustration of a concept/Comic strip explanation ● Self-Assessment and Peer feedback ● Comparing & Critiquing Arguments about water in plants. ● Maple Tree through the Seasons Explanation. ● Obtaining and Communicating Information from Scientific Text Checklist ● Story of a Food Atom	Peer Feedback ● Project presentation ● Unit test ● Research paper essay ● Design challenge ● Final concept mapping with unit vocabulary terms ● Presentation on real-world applications ● Whale Fall Task (end of unit assessment)

Unit 4 Curriculum Map

Overview: This unit on genetics starts out with students noticing and wondering about photos of two cattle, one of whom has significantly more muscle than the other. The students then observe photos of other animals with similar differences in musculature: dogs, fish, rabbits, and mice. After developing initial models for the possible causes of these differences in musculature, students explore a collection of photos showing a range of visible differences.

In the first lesson set, students use videos, photos, data sets, and readings to investigate what causes an animal to get extra-big muscles. Students figure out how muscles typically develop as a result of environmental factors such as exercise and diet. Then, students work with cattle pedigrees, including data about chromosomes and proteins, to figure out genetic factors that influence the heavily muscled phenotype and explore selective breeding in cattle. In the second lesson set, students use what they've learned from explaining cattle musculature to help them explain other trait variations they've seen. They investigate plant reproduction, including selective breeding and asexual reproduction (in plants and other organisms) and other examples of traits that are influenced by genetic and environmental factors. Students figure out that environmental and genetic factors together play a role in the differences we see among living things.

Big Ideas:

- The characteristic structures, functions, and behaviors of organisms change in predictable ways as they progress from birth to old age (through the life cycle).
- Offspring resemble, but are not identical to, their parents due to traits being passed from one generation to the next via genes.
- Variation among individuals of the same species can be explained by both genetic and environmental factors.
- In any environment individuals with particular traits may be more likely than others to survive and produce offspring.

Textbook and Supplemental Resources: OpenSciEd Unit 8.5: Genetics, ThinkCentral Science Fusion textbook series

Unit 4: Genetics

Standards (by number):	Essential Questions: • Why are living things different from one another? • How do organisms grow and develop? • How are the characteristics of one generation related to the previous generation? • Why do individuals of the same species vary in how they look, function, and behave?

	• How does genetic variation among organisms affect survival and reproduction?
Science:	3.1.6-8.E Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS1-5 3.1.6-8.M Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. MS-LS3-1 3.1.6-8.N Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. MS-LS3-2 3.1.6-8.R Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. MS-LS4-5 3.1.6-8.D Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. MS-LS1-4
Technology and Engineering:	3.5.6-8 Q Apply a technology and engineering design thinking process. 3.5.6-8 R Develop innovative products and systems that solve problems and extend capabilities based on individual or collective needs and wants. 3.5.6-8 S Illustrate the benefits and opportunities associated with different approaches to design. 3.5.6-8 T Create solutions to problems by identifying and applying human factors in design. 3.5.6-8 U Evaluate and assess the strengths and weaknesses of various design solutions given established principles and elements of design.

	3.5.6-8 Y Compare, contrast, and identify overlap between the contributions of science, technology, engineering, and mathematics in the development of technological systems. 3.5.6-8 Z Analyze how different technological systems often interact with economic, environmental, and social systems.
Environmental Literacy and Sustainability:	3.4.6-8 D Gather, read, and synthesize information from multiple sources to investigate how Pennsylvania environmental issues affect Pennsylvania's human and natural systems.

Students will know…. (DCI)	Students will be able to… (SEP)	Students will apply…(CCC)
Genetic factors as well as local conditions affect the growth of the adult plant. Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to chromosomes (and therefore genes) inherited. In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others	Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Developing and Using Models: Develop and use a model to describe phenomena. Obtaining, Evaluating, and Communicating Information: Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and	Cause and Effect: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/ systems. Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.

harmful, and some neutral to the organism. Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary) Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed onto offspring. Animals engage in characteristic behaviors that increase the odds of reproduction.	describe how they are supported or not supported by evidence. Engaging in Argument from Evidence: Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	

Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.		

Core Activities and Corresponding Instructional Methods: Unit 4 Videos, Unit 4 Overview, Unit 4 Activities by Lesson

Core Activities / Corresponding Instructional Methods
Unit Question: Why are living things different from one another? (DOK 3)
Lesson Set 1 (Lessons 1-10) - What causes an animal to get extra-big muscles? (DOK 3)
Lesson 1 - How do organisms get their differences? (DOK 3) Core Activity: Students explore animals with extra-big muscles and describe other examples of trait variations from their lives. (DOK 2) 1. Observe animals with extra large muscles such as cattle. (DOK 2) 2. Develop a model to explain what could be causing this phenomenon. (DOK 2) 3. Identify variations in traits other than musculature in different organisms. (DOK 3) 4. Create questions using the summary table for future investigation. (DOK 4)
Lesson 2 - How do extra-big muscles compare to typical ones up close? (DOK 3) Lesson 3 - How do diet and exercise affect muscle size? (DOK 3) Core Activity: Students investigate environmental factors such as diet and exercise that influence muscle growth. (DOK 3) 1. Observe images and video animations about what muscles look like up close and how muscles work. (DOK 2) 2. Compare photos and data about muscle cells from extra-big-muscled animals and typical ones.(DOK 3) 3. Evaluate information in texts, images, graphs, and tables in order to determine the effect of diet and exercise on muscle growth. (DOK 3)

Lesson 4 - What is different about the food and exercise for cattle with extra-big muscles? (DOK 2)
Lesson 5 - Where do the babies with extra-big muscles get that trait variation? (DOK 2)
Lesson 6 - How do chromosomes cause cattle to be born with extra-big muscles? (DOK 2)
Lesson 7 - How does an animal get extra-big muscles? (DOK 3)

Core Activity: Students discover patterns in cattle pedigrees, proteins, and chromosomes to determine how genetic factors influence phenotypes. (DOK 4)

1. Revisit the model to include findings about the role diet and exercise play in making muscles. (DOK 3)
2. Listen to a farmer who raises cattle to find out more about the diet and habits of cattle and to find out that calves that grow up to be heavily muscled are bore with more muscles than calves that don't grow up to be heavily muscled. (DOK 2)
3. Revisit the summary table and our model to discuss how this new information revises previous knowledge. (DOK 3)
4. Discuss revisions to the model and questions that have come up. (DOK 4)
5. Analyze cattle family photos to find patterns between relatedness and musculature. (DOK 2)
6. Observe chromosomes inside sperm and egg cells. (DOK 2)
7. Develop connections between the karyotypes of an offspring's muscle cell and chromosomes in the sex cells of parents. (DOK 4)
8. Develop connections between chromosomes inherited from parents to protein production in offspring. (DOK 4)
9. Identify patterns in chromosome inheritance and phenotypic outcome in offspring. (DOK 2)
10. Read and synthesize articles to find evidence of cause-effect relationships among alleles, protein, and phenotype. (DOK 2)
11. Revisit model to update and revise with new information learned about genes and alleles. (DOK 3)
12. Students will be able to differentiate between chromosome, chromatin, gene, homologous pairs, and sister chromatids. (DOK 1)
13. Students will be able to model the structure of DNA (parts of nucleotide and base pairing). (DOK 2)
14. Students will be given direct instruction on meiosis and the role of gametes in heredity. (DOK 1)

Lesson 8 - Why don't offspring always look like their parents or their siblings? (DOK 1)
Lesson 9 - How do farmers control the variation in their animals? (DOK 2)
Lesson 10 - How can we use our model to explain a different trait variation? (DOK 4)

Core Activity: Students calculate the probability of offspring genotypes from various parental crosses and explore outcomes of artificial selection. (DOK 2)

1. Investigate the inheritance patterns of the myostatin gene by comparing the proportion of different genotypes collected from pedigrees that shows the results of known crosses. (DOK 3)

2. Use simple mathematical models to help predict the outcome of genetic crosses. (DOK 2) 3. Read articles about how farmers breed animals for selected-for trait variations.(DOK 1) 4. Run a computer simulation to control breeding in order to create individuals with selected-for trait variations. (DOK 2) 5. Assessment - demonstrate understanding through goldfish breeding tasks. (DOK 4) 6. Students will be able to understand the advantages of selective breeding and genetic manipulation. (DOK 2)
Lesson Set 2 (Lessons 11-17) - How can we explain variations we see in other living things? (DOK 3)
Lesson 11 - How can we answer the rest of our questions? (DOK 3) Core Activity: With having background on the causes that result in certain traits like big muscles in cattle, students will revisit and investigate questions about variations in other traits. (DOK 3) 1. Revisit summary table to see where the knowledge base is on inheritance of genes and outcome of phenotypes. (DOK 3) 2. Discuss what we have learned and what questions we now have as a class. (DOK 2) 3. Sort images of other organisms other than cattle showing traits other than musculature and discover that their variations encompass a continuous range rather than a few distinct phenotypes. (DOK 3) 4. Students will discuss mendelian and non-mendelian forms of inheritance. (DOK 3) 5. Students will demonstrate their knowledge of Mendelian inheritance through using punnett squares. (DOK 2)
Lesson 12 - Do plants have genetic material? (DOK 2) Lesson 13 - How do plants reproduce? (DOK 2) Lesson 14 - How do other organisms reproduce without sperm and eggs? (DOK 3) Core Activity: Students investigate how plants reproduce, including asexual reproduction, which leads students to investigate asexual reproduction in other organisms. Students will begin to question and investigate other influences on phenotypes. (DOK 3) 1. Watch a video of a scientist isolating genetic material from animal cells. (DOK 1) 2. Investigate whether plants have genetic material like animals by breaking open plant cells and see if we can isolate genetic material. (DOK 2) 3. Observe and analyze results of the investigation. (DOK 3) 5. Discuss the outcome of the investigation with the class and discuss how it confirms or changes our thought process. (DOK 4) 6. Investigate the structures of flowers and compare their structures to reproductive structures in humans. (DOK 3) 7. Gather information on how structures of flowers can interact specifically with different pollinators. (DOK 2)

8. Read and watch videos about how farmers breed and propagate plants. (DOK 1)
9. Research and share about an organism that uses asexual reproduction. (DOK 3)
10. Discuss how genetic information of offspring from asexual reproduction compares to that of the parent. (DOK 3)
11. Observe a video of planarian regeneration and discover that the resulting planarians do not always look identical. (DOK 1)
12. Students will discuss the benefits and costs of both asexual and sexual reproduction. (DOK 3)

Lesson 15 - How do we get variations if the genetic information is exactly the same? (DOK 2)
Lesson 16 - How much of trait variation in a population is controlled by genes or by the environment? (DOK 2)
Lesson 17 - Why are living things different from one another? (DOK 3)

Core Activity: Students explore how environmental and genetic factors both influence the trait variation we see and realize that phenotypic variation is complex and multifactorial. (DOK 4)

1. Analyze information from images and text about how planaria color is affected by light exposure. (DOK 3)
2. Discuss how environmental factors like light influence other ranges of variation we have seen.
3. (DOK 3)
4. Analyze scientific information from non-fiction texts about color variation in apples and flamingos. (DOK 2)
5. Construct a model to explain the different environmental factors that cause the range of variation we see in apple and flamingo colors. (DOK 2)
6. Investigate the variation found in wheat kernel coloration to learn this trait is controlled by more than one pigment-producing gene. (DOK 3)
7. Revisit and update our model explaining variation and environmental influence. (DOK 3)
8. Investigate the distribution of human arm span lengths and independently use our model to explain which factors affect arm span. (DOK 4)
9. Share and discuss models in small groups and as a class to better understand what influences traits. (DOK 4)
10. Revisit the summary table to address what we have done, learned, and questions we still have.
11. (DOK 3)
12. Assessment - Redwood tree task to allow students to demonstrate understanding of inheritance. (DOK 3)
13. Students will research genetic diseases or disorders and present their findings to the class. (DOK 4)

Words that "Might be Encountered" throughout the Unit:

Acquired	Genetic Code	Mutation
Adaptation	Genetic Engineering	Natural Selection
Allele	Genetic Modification	Pedigree
Artificial Selection	Genetics	Phenotype
Biotechnology	Genotype	Probability
Chromosome	Gregor Mendel	Protein
Codominance	Heredity	Punnett Square
Dna (Deoxyribonucleic Acid)	Heterozygous	Recessive Allele
Dominant Allele	Homozygous	Selective Breeding
Gene	Incomplete Dominance	Sexual Reproduction
Generation	Inherited	Trait
		Variation

Correctives:

Lesson 1: If students do not immediately make the connection between the muscular structure and the genes they receive for their parents, they will explore and identify this in the next couple of lessons. It is not necessary to include questions about inheritance of genes on the DQB here.

Lesson 2: This lesson focuses on students identifying the relationship between the structure and function of proteins, not on the anatomy and movement of muscles. Animals are described as having "extra big muscles" rather than MSTN mutated organisms as they will learn about the MSTN mutation in Lesson 6.

Lesson 3: Focus of this lesson is that microtears are formed during exercise, and the repair of these tears is what leads to muscle growth and development.

Lesson 4: Avoid calling factors such as diet and exercise "environmental factors" at this point, the goal of this lesson is for students to identify that there are other factors (genes) playing a role in making the cattle heavily muscled.

Lesson 5: This lesson will describe the process of sexual reproduction in cattle and humans only, students will discover that plants also reproduce sexually in Lesson 13, and differentiate between sexual and asexual in Lesson 14.

Lesson 6: The reading refers to the protein being studied as GDF-8 as that was the name used during that study, it has since been named myostatin and this is what it is referred to as in the rest of the unit. The procedure in which scientists used to selectively breed the mice is not discussed here but in Lesson 9.

Lesson 7: This lesson focuses on the genetic factors that influence physical traits. Other than the role of diet and exercise, environmental factors are not considered. Students will build their understanding of the relationship between genetic and environmental factors in future lessons. In order to foster student curiosity, stop the model before the genotypes of the parents are identified. In the next lesson, students will investigate the genotypes of the parents after they notice that siblings from the same parents do not look alike.

Lesson 8: Students will investigate and identify the phenotype for a heterozygous individual, but will not identify the type of inheritance or define incomplete dominance in this lesson. In addition, changes in DNA are discussed, but the specific types (deletion, insertion, substitution) will not be defined in this lesson, but are not necessary to understand the phenomena. Although capital and lowercase letters are used to represent alleles in this lesson, they are not being used to differentiate between dominant or recessive at this point.

Lesson 9: Artificial insemination is mentioned in the readings, but isn't discussed in depth. Students should understand that humans are able to control which sperm fertilizes which egg during the selective breeding process.

Lesson 10: The assessment involves a trait that exhibits an incomplete dominance pattern like myostatin, but students are not required to identify this or the different types of dominance in this lesson. Focus of the assessment is on how genotypes affect phenotypes, but students are asked to propose examples of environmental factors that could affect goldfish size.

Lesson 11: This lesson does not address natural selection, but encourages students to add any related questions to the DQB, and keep them up for the next unit which will cover natural selection.

Lesson 12: This lesson will not cover the physical makeup of DNA, and students will not identify the type of reproduction being shown in the plants. Students may notice that the strawberries are using runners to start new plants, which will be covered in future lessons, so allow them to include these questions on their DQB.

Lesson 13: Some examples of asexual reproduction will be observed (tulips and strawberries) but details of asexual reproduction will come in Lesson 14. The names of the important structures of plants will be labeled and their function identified, but students do not need to memorize these at this point. For simplicity, pollen will be used as an analog to sperm and ovules to egg.

Lesson 14: This lesson does not go into the details of mitosis or meiosis, or the advantages and disadvantages of asexual reproduction. Reproduction via spores is not covered in this lesson, but should be addressed.

Lesson 15: Students will discuss how and why there is color variation in the planaria, how this variation benefits them will be discussed in the next unit.

Lesson 16: Ensure that students understand that genetic and environmental factors influence traits in an integrated way, not that a certain amount of each trait is controlled by one or the other. This lesson does not address classical dominant & recessive inheritance patterns. State assessments may require recognition of this vocabulary, so teachers may want to introduce those terms and processes at this point.

Lesson 17: This assessment focuses on coastal redwoods, not giant sequoias. In addition the effects of climate change are not addressed, but there is an extension available for this.

Extensions:

Lesson 14: Students could spend more time researching details about organisms that reproduce asexually and/or students could communicate the information they've learned in a different format than the suggested slide or to a different audience than just their peers.

Lesson 16: Let your students explore the Arm Span Data Set and online data tool by themselves before discussing it as a class.

Lesson 16 or 17: Students can return to the specific examples of trait variations they brought in during Lesson 1 and apply the model they've developed in this unit to explain those. As additional practice with "obtaining, evaluating, and communicating information", students could do additional research to find details about those trait variations, such as the function of specific protein(s), the number of genes, and/or the specific environmental factors that influence that trait variation.

Lesson 17: Provide time for students to work on the alternate activity described in the *Teacher Guide* where students obtain and evaluate information about how climate change is affecting redwood trees and then communicate that information to an audience of their choice in a format appropriate for that audience.

Assessments: Unit 4 Assessments, Summary Table

Diagnostic	Formative	Summative
Diagnostic assessments can be in the form of the following: ● KWL charts/summary tables ● Concept mapping ● Open-ended questioning ● Drawing diagrams/model making ● Quick quizzes on key	The following can be used for formative assessments throughout the unit: ● Progress Tracker ● Short Quizzes ● Exit Tickets ● Graphic organizers ● Lab notebooks with observations/journal	To evaluate students' mastery of the unit's scientific concepts, the following assessments can be utilized to measure their understanding: ● Two-part Student Assessment/Mid-Point Assessment ● Exit Ticket: Written

concepts drawing diagrams to explain a process ● "Think-Pair-Share" discussions on the phenomena in question ● Analyzation of real-world data to identify variables and potential relationships	entries ● CERs ● Illustration of a concept/Comic strip explanation ● Model/Diagram Revision Explaining Phenomenon ● Self-Assessment and Peer feedback	argument ● Self-Assessment and Peer Feedback ● Project presentation ● Unit test ● Research paper essay ● Design challenge ● Final concept mapping with unit vocabulary terms ● Presentation on real-world applications ● Goldfish Assessment and Checklist for Obtaining and Evaluating Information From Scientific Text ● Redwoods Assessment

Unit 5 Curriculum Map

Overview: At the beginning of this unit, students hear about the surprising fossil of an ancient penguin (nicknamed "Pedro") in a podcast from the researchers who found and identified the fossil. Students analyze data about modern penguins and Pedro to develop initial explanations for how these penguins could be connected. They brainstorm about 1) Where did all the ancient penguins go? 2) Where did all the different species of modern penguins come from? and 3) What other organisms alive today might also be connected to organisms that lived long ago?

After exploring variations in body structures and behaviors in modern penguins and ancient penguins, they also analyze data from ancient and modern species of horses, whales, and horseshoe crabs to see whether these organisms have similar patterns. Then, to figure out the cause of the changes they have observed in populations, students explore more recent cases of changing heritable trait distribution in populations and explain them by developing a model for natural selection.

In the last part of the unit, students use their model for natural selection to explain how some body structure variations in different species of modern penguins could result from natural selection and how they could descend from a common ancient ancestor penguin population. They analyze embryological data to their argument supporting how different species may be connected. Finally, students take stock of all the questions they answered in this unit and previous OpenSciEd units and identify questions they look forward to figuring out in high school.

Big Ideas:

- The characteristic structures, functions, and behaviors of organisms change in predictable ways as they progress from birth to old age (the life cycle).
- Comparisons between species provides evidence that species evolved from common ancestors which explains the similarities and differences between species.
- In any environment individuals with particular traits may be more likely than others to survive and produce offspring.
- When the environment changes, some individuals in a population may have traits that provide a reproductive advantage which over many generations can change the make-up of a population.

Textbook and Supplemental Resources: OpenSciEd Unit 8.6: Natural Selection & Common Ancestry, ThinkCentral Science Fusion textbook series

Unit 5: Natural Selection & Common Ancestry

Standards (by number):	Essential Questions:

	- How could things living today be connected to the things that lived long ago? - How do organisms grow and develop? - What evidence supports that different species are related? - How does genetic variation among organisms affect survival and reproduction? - How does the environment influence populations of - organisms over multiple generations?
Science:	3.1.6-8.D Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. MS-LS1-4 3.1.6-8.O Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. MS-LS4-1 3.1.6-8.P Apply scientific ideas to construct an explanation for anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. MS-LS4-2 3.1.6-8.Q Analyze displays of pictorial data to compare patterns of similarities in anatomical structures across multiple species to identify relationships not evident in the fully formed anatomy. MS-LS4-3 3.1.6-8.S Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. MS-LS4-4 3.1.6-8.T Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. MS-LS4-6
Technology and Engineering:	3.5.6-8 Q Apply a technology and engineering design thinking process.

	3.5.6-8 R Develop innovative products and systems that solve problems and extend capabilities based on individual or collective needs and wants. 3.5.6-8 S Illustrate the benefits and opportunities associated with different approaches to design. 3.5.6-8 T Create solutions to problems by identifying and applying human factors in design. 3.5.6-8 U Evaluate and assess the strengths and weaknesses of various design solutions given established principles and elements of design. 3.5.6-8 Y Compare, contrast, and identify overlap between the contributions of science, technology, engineering, and mathematics in the development of technological systems. 3.5.6-8 Z Analyze how different technological systems often interact with economic, environmental, and social systems.
Environmental Literacy and Sustainability:	

Students will know…. (DCI)	Students will be able to… (SEP)	Students will apply…(CCC)
Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary	Engaging in Argument from Evidence: Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings. Constructing Explanations	Cause and Effect: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. Patterns: Graphs, charts, and images can be used to identify patterns in data. Patterns: Patterns can be used to identify cause and effect relationships. Cause and Effect: Phenomena

layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy. Natural selection leads to the predominance of certain traits in a population, and the suppression of others. Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the	and Designing Solutions: Apply scientific ideas to construct an explanation for real world phenomena, examples, or events. Analyzing and Interpreting Data: Analyze displays of data to identify linear and nonlinear relationships. Obtaining, Evaluating, and Communicating Information: Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. Using Mathematics and Computational Thinking: Use mathematical representations to support scientific conclusions and design solutions.	may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

distribution of traits in a population changes.		

Core Activities and Corresponding Instructional Methods: Unit 5 Videos, Unit 5 Overview, Unit 5 Activities

Core Activities / Corresponding Instructional Methods
Unit Question: How could things living today be connected to the things that lived long ago? (DOK 4)
Lesson Set 1 (Lessons 1-6) - How are modern organisms connected to ancient organisms? (DOK 3)
Lesson 1 - How could penguins and other things living today be connected to the things that lived once ago? (DOK 4) Core Activity: Students notice and wonder about the fossil of an ancient giant penguin found in present day Peru. (DOK 2) 1. Observe fossil records and analyze data about penguins living today. (DOK 2) 2. Develop explanations of how the penguin represented in fossil records and today's penguins could be connected. (DOK 3) 3. Brainstorm possible mechanisms to explain where ancient penguins went as well as where modern species of penguins came from. (DOK 2) 4. Create a summary table to identify what was learned from observations and analysis of data as well as what questions students have. (DOK 4)
Lesson 2 - How similar or different are different species of penguins? (DOK 2) Lesson 3 - How do the body structures of other ancient penguins compare to modern penguins? (DOK 2) Lesson 4 - Why are there similarities and differences in the body structures of modern and ancient penguins? (DOK 3) Core Activity: Figure out whether modern penguins are related to ancient penguins by looking at heritable characteristics and behaviors of modern penguins. (DOK 4) 1. Analyze data sets of heritable external structures and behaviors in modern penguins to look for patterns and infer connections about them and the fossil remains. (DOK 2) 2. Develop questions on how other heritable internal structures would compare for these penguins in comparison to the fossil remains of ancient penguins. (DOK 2) 9. Analyze data tables of bone structures for ancient penguin fossils and modern penguins. (DOK 3) 10. Develops a time-line based representation of the patterns from the data of bone structure. (DOK 2)

11. Analyze images, maps, and descriptions of where these fossils formed. (DOK 2)
12. Revisit the summary table and revise the initial explanation to account for patterns in data we observed. (DOK 3)
13. Develop questions that still remain regarding ancient vs modern organisms. (DOK 3)

Lesson 5 - How might other living things be connected to ancient organisms? (DOK 4)
Lesson 6 - How could organisms living today be connected to organisms that lived long ago? (DOK 3)

Core Activity: Students investigate and create explanations as to whether patterns of connections exist between ancient and modern organisms. (DOK 4)

1. Investigate organisms other than penguins to see if patterns exist that show connections between ancient and modern organisms. (DOK 3)
2. Sort data cards for ancient and modern horseshoe crabs, horses, and whales to see what patterns of similarities and differences exist in their body structures. (DOK 2)
3. Discuss how patterns that were noticed in body structure might be connected to when or where the organism lived. (DOK 4)
4. Create an argument distinguishing whether or not fossil evidence represents only what is found in one individual or rather can be generalized as what is typical across a population. (DOK 3)
5. Revisit the summary table and revise explanations for how modern organisms are connected to ancient organisms. (DOK 3)

Lesson Set 2 (Lessons 7-11) - How does our General Model for Natural Selection help us explain changes to populations of organisms? (DOK 3)

Lesson 7 - How do traits found in a population change over a shorter amount of time? (DOK 3)

Core Activity: Students figure out the cause of changes in populations through observing and exploring multiple case studies where trait distributions in a population change over time. (DOK 4)

1. Explore five cases where trait distributions in the population changed over a few generations. (DOK 2)
2. Jigsaw activity to analyze data from different studies on a group's assigned case. (DOK 4)
3. Develop a model to explain what was causing the shift in trait distribution over time for each individual case. (DOK 3)
4. Students will model organism fitness. (DOK 3)
5. Students will be able to explain how natural selection leads to survival of the fittest and in turn evolutionary changes. (DOK 3)

Lesson 8 - How can we model what is causing the changes in the populations happening across all our case studies? (DOK 2)

Lesson 9 - How well does our general model predict and explain the changes happening over time in a different population? (DOK 2) Lesson 10 - Why does our general model tend to produce different outcomes in different environmental conditions? (DOK 3) Core Activity: Students compare numerous case studies to create explanations and models about interactions between cases indicating what they have in common while also identifying patterns of changes in a population over time. (DOK 3) 1. Compare case-specific system models (finches, moths, swallows, etc…) (DOK 3) 2. Create an argument identifying which parts and interactions each case has in common (DOK 3) 3. Develop a general model to explain what causes changes in the population (DOK 2) 4. Use the general model to make predictions about what would happen in any population, in any environment, and over a different number of generations. (DOK 3) 5. Investigate using two computer simulations to gather data on how changes in environment can lead to trait variation. (DOK 3) 6. Create an argument using the data from the simulations to explain why we get different outcomes when we simulate different types of white blood cells in the environment with the same starting population of bacteria. (DOK 3) 7. Plan and carry out an investigation using a bacteria simulation to test what will happen when we change the environment by a different factor other than predation. (DOK 4) 8. Revise our general model for natural selection to incorporate and explain results from the simulations (DOK 3) 9. Students will be able to explain an example of survival fo the fittest given a non-fiction reading. (DOK 2)
Lesson 11 - Can we use our general model for natural selection to explain changes over time in green anole lizards? (DOK 3) Core Activity: Students test their general model of natural selection on a new phenomenon to explain how traits in a population of green lizards change over time. (DOK 3) 1. Assessment - Students will use a population of Anole Lizards to demonstrate what they have learned. (DOK 3) 2. Peer review - Students will give and receive peer feedback on their explanations. (DOK 4) 3. Revision - Students will revise explanations based on peer feedback. (DOK 3)
Lesson Set 3 (Lessons 12 & 13) - How can we use natural selection to explain changes in species over millions of years? (DOK 4)
Lesson 12 - Can our model explain changs over really long periods of time? (DOK 4) Core Activity: Students will explain how new trait variations can enter a population. (DOK 2) 1. Revisit the summary table and update it to include an explanation on how mutations are a source of new trait variation. (DOK 3)

2. Explain differences in body structure in horses and horseshoe crabs over a very long period of time. (DOK 4) 3. Students discuss Linnaean Taxonomy. (DOK 2) 4. Students will be able to read and create cladograms to help show evolutionary changes.(DOK 3) 5. Students will be able to utilize dichotomous keys to find latin names of organisms. (DOK 2)
Lesson 13 - Can we apply the general model for natural selection over millions of years to explain how all the ancient and modern penguins are connected? (DOK 4) Core Activity: Students use what they know about natural selection and mutation to develop a model to show how modern penguins could be connected to each other and to ancient penguins. (DOK 3) 1. Develop a model to show how modern penguins could be connected to one another and to ancient penguins. (DOK 3) 2. Using the summary table revise your explanations to explain how modern and ancient penguins are connected. (DOK 3)
Lesson Set 4 (Lessons 14) - How can we use additional evidence for how modern organisms are connected to ancient organisms to explain more of our related phenomena? (DOK 4)
Lesson 14 - What do the patterns in embryo development tell us about how things living today could be connected to the things that died long ago? (DOK 3) Core Activity: Students analyze sketches of embryos at different points in development for a variety of living things in order to compare and contrast physical traits that different organisms have in common during embryological development. (DOK 3) 1. Analyze sketches of embryos at different points in embryological development for a variety of living things (chicken, turtle, rabbit, human). (DOK 3) 2. Construct an argument pertaining to the similarities and differences in embryological development of the various organisms and why they would be similar or different. (DOK 3) 3. Use a summary table to establish what we learned and questions about how and why different organisms share so many physical structures in common in their embryological development. (DOK 3) 4. Discussion as a class to identify what students agree on as similarities, differences, and questions that arose. (DOK 4)

Words that "Might be Encountered" throughout the Unit:

Adaptation	Embryology	Mutation
Allele	Eukarya	Natural selection
Analogous structures	Evolution	Plantae
Animalia	Extinction	Protista
Archaea	Extinction	Selective pressure
Artificial Selection	Fitness	Speciation
Bacteria	Fossil	Species
Biodiversity	Fossil record	Survival of Fittest
Common ancestry	Fungi	Trait
Comparative anatomy	Gene	Variation
Dichotomous Key	Genetic drift	Vestigial structure
Domain	Genetic variation	
Heredity	Genus	
Homologous structures		

Correctives:

Lesson 1: The mechanisms of natural selection will be addressed in Lesson 9, but do allow students to add their ideas to the initial model as ideas to consider.

Lesson 2: Students may be confused as they use their knowledge from the Muscle Unit to make conclusions as to why there is variation between penguin species. If students identify that the different species have different alleles, agree that there are differences in the genes, but explain that a better way to compare different species is to use broader terms such as body structure and behavior, while comparing alleles is most useful when comparing individuals of the same species. In addition, the traits being observed are affected by more than one allele, so keeping track of all those alleles would be complicated.

Lesson 3: Focus of this lesson is not to understand or memorize the geologic time scale, just to use these time periods as a reference. Students will work with the data cards again in Lesson 13, when they use them as evidence to propose lines of descent and common ancestry. If students propose these ideas in this lesson, avoid telling if their inferences are correct or not at this point. If words such as adapt or evolve arise during discussion, allow them to add them to the DQB and encourage them to keep looking for correlations between species.

Lesson 4: This lesson defines population as a group of the same species of organisms in an area, the use of "species" here is another step toward students understanding the word which they will build further in Lesson 13.

Lesson 5: Focus of this lesson is to identify patterns and correlations among those patterns in regards to time and environment, although arguments can be formed supporting common ancestry based on analogous structures, they will not do this here. Students may think that change over time occurs at the individual level at this point. In Lessons 7-10, students will be able to identify that change occurs in populations over time.

Lesson 6: This is the final lesson of this set, but students will continue to explore common ancestry in Lessons 12-14.

Lesson 7: Lesson 8 will allow students to compare the models made in this lesson in order to identify patterns, which will lead them to the idea of natural selection, which is not discussed here.

Lesson 8: Natural selection will be identified on day 2 of this lesson when the class derives the idea as a group from their models. The importance of environmental changes will be addressed in the next lesson.

Lesson 9: Students may want to explore or alter the code of the simulation, allowing them to do this after the next lesson. Although students will be able to generate investigations, these changes can detract from the goals of this lesson at this point.

Lesson 10: Student Predictions are only based on trait variation that is already present in the studied population, no introduction of new traits or mutations.

Lesson 11: This lesson does not include any specific genetic information as DNA is not the focus of the unit.

Lesson 12: Ensure students understand what a mutation is as discovered in the Muscles Unit (small change in the structure of a chromosome). They do not need to know the different types of mutations at this point.

Lesson 13: Focus of this lesson is identifying lines of descent, not speciation events. Students will develop a deeper understanding of what a species is, but will not discover the mechanisms that drive speciation at this point.

Lesson 14: Support students' ideas that suggest that different species may have a common ancestor, although this is not the focus of this lesson, this will lay the foundation needed for future exploration into these ideas.

Extensions:

Lesson 2: If students are curious about what the Latin names are for some of those structures, that further detail is provided in the teacher reference Extended Key for Penguin Structures and Behaviors.

Lesson 3: All students will experience sorting cards and data for ancient and modern penguins. However, there are also data strips for more-incomplete ancient penguin fossils for interested students or, if time allows, your whole class. Additionally, students may complete Reading: How do scientists use fossils to figure out what an organism that lived millions of years ago may have looked like? in class as opposed to home learning.

Lesson 4: Highly interested students may challenge using the word “all” when referring to all adult king penguins being taller than all adult Galápagos penguins, even after examining the distribution of variation in each population. If so, you might take a moment to discuss how scientists come up with the ranges of size that are listed (even though the statistics involved are beyond what we need to know for this lesson).

Lesson 13: If you have students who are curious about the environmental factors that influenced changes in the ancient penguins millions of years ago, the Penguin Environments - Ancient and Modern reading is provided.

Lesson 14: There are two versions of the non-egg-laying embryo handout. Consider using the one with humans to give students additional data and encourage students to think about connections between all living multicellular organisms.

Lesson 15: If time allows, consider making this a two-day lesson and giving students more time to reflect in their Progress Tracker.

Assessments: Unit 5 Assessments, Summary Table

Diagnostic	Formative	Summative
Diagnostic assessments can be in the form of the following: ● KWL charts/summary tables ● Concept mapping ● Open-ended questioning ● Drawing diagrams/model making ● Quick quizzes on key concepts drawing diagrams to explain a process ● "Think-Pair-Share" discussions on the phenomena in question ● Analyzation of real-world data to identify variables and potential relationships	The following can be used for formative assessments throughout the unit: ● Progress Tracker ● Short Quizzes ● Exit Tickets ● Graphic organizers ● Lab notebooks with observations/journal entries ● CERs ● Illustration of a concept/Comic strip explanation ● Self-Assessment and Peer feedback ● Utilize Models to Make Predictions ● *“How are penguins*	To evaluate students’mastery of the unit’s scientific concepts, the following assessments can be utilized to measure their understanding: ● Two-part Student Assessment/Mid-Point Assessment ● Exit Ticket: Written argument ● Self-Assessment and Peer Feedback ● Project presentation ● Unit test ● Research paper essay ● Design challenge ● Final concept mapping with unit vocabulary terms

	today connected to penguins from long ago?" Argument and Self-Assessment ● Model for changing Bacteria Populations ● Different Environmental Conditions and Results ● New Ideas and Questions Connected to Embryo Comparisons	● Presentation on real-world applications ● Green Anole Lizard Explanation (transfer task) ● Ancient and Modern Penguin Explanation (two versions)

Unit 6 Curriculum Map

Overview: This unit on ecosystem dynamics and biodiversity begins with students reading headlines that claim that the future of orangutans is in peril and that the purchasing of chocolate may be the cause. Students then examine the ingredients in popular chocolate candies and learn that one of these ingredients--palm oil--is grown on farms near the rainforest where orangutans live. This prompts students to develop initial models to explain how buying candy could impact orangutans.

Students spend the first lesson set better understanding the complexity of the problem, which cannot be solved with simple solutions. They will figure out that palm oil is derived from the oil palm trees that grow near the equator, and that these trees are both land-efficient and provide stable income for farmers, factors that make finding a solution to the palm oil problem more challenging. Students will establish the need for a better design for oil palm farms, which will support both orangutans and farmers. The final set of lessons engage students in investigations of alternative approaches to growing food compared to large-scale monocrop farms. Students work to design an oil palm farm that simultaneously supports orangutan populations and the income of farmers and community members.

Big Ideas:

- As the environment and populations of species change, there are resulting changes in ecosystems.
- Ecosystems are complex systems that include both living (biotic) and non-living (abiotic) components that interact with each other.
- Humans depend on biodiversity, the variety of species and ecosystems, for resources. Human actions can impact the diversity of species.
- Human activities in agriculture, industry, and everyday life have an impact on the land, rivers, ocean, and air.

Textbook and Supplemental Resources: <u>OpenSciEd Unit 7.5 Ecosystem Dynamics</u>, ThinkCentral Science Fusion textbook series

Unit 6: Ecosystem Dynamics

<u>Standards (by number):</u>	<u>Essential Questions:</u> ● How does a change in environment impact ecosystems? ● How do organisms interact with the living and nonliving environments to obtain matter and energy? ● How do humans affect biodiversity, and how does it affect humans? Mutually impact? ● How do humans change the planet? ● How does changing an ecosystem affect what lives there?

Science:	3.1.6-8.L Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.MS-LS2-4 3.1.6-8.J Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. MS-LS2-2 3.1.6-8.U Evaluate competing design solutions for maintaining biodiversity and ecosystem services.MS-LS2-5 3.3.6-8.M Apply scientific principles to design a method for monitoring and minimizing human impact on the environment. MS-ESS3-3
Technology and Engineering:	3.5.6-8 B Use instruments to gather data on the performance of everyday products. 3.5.6-8 D Analyze how the creation and use of technologies consumes renewable, non-renewable, and inexhaustible resources; creates waste; and may contribute to environmental challenges. 3.5.6-8 H Evaluate trade-offs based on various perspectives as part of a decision process that recognizes the need for careful compromises among competing factors. 3.5.6-8 I Examine the ways that technology can have both positive and negative effects at the same time. 3.5.6-8 L Design methods to gather data about technological systems. 3.5.6-8 M Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. 3.5.6-8 N Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. 3.5.6-8 O Interpret the accuracy of information collected.

	3.5.6-8 P Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. 3.5.6-8 Q Apply a technology and engineering design thinking process. 3.5.6-8 R Develop innovative products and systems that solve problems and extend capabilities based on individual or collective needs and wants. 3.5.6-8 S Illustrate the benefits and opportunities associated with different approaches to design. 3.5.6-8 T Create solutions to problems by identifying and applying human factors in design. 3.5.6-8 U Evaluate and assess the strengths and weaknesses of various design solutions given established principles and elements of design. 3.5.6-8 Y Compare, contrast, and identify overlap between the contributions of science, technology, engineering, and mathematics in the development of technological systems. 3.5.6-8 Z Analyze how different technological systems often interact with economic, environmental, and social systems.
Environmental Literacy and Sustainability:	3.4.6-8 A Develop a model to describe how agricultural and food systems function, including the sustainable use of natural resources and the production, processing, and management of food, fiber, and energy. 3.4.6-8 B Analyze and interpret data about how different societies (economic and social systems) and cultures use and manage natural resources differently. 3.4.6-8 D Gather, read, and synthesize information from multiple sources to investigate how Pennsylvania environmental issues affect Pennsylvania's human and natural systems. 3.4.6-8.E Collect, analyze, and interpret environmental data to describe a local environment. 3.4.6-8.F Obtain and communicate information on how integrated pest management could improve indoor and outdoor environments. 3.4.6-8 G Obtain and communicate information to describe how best resource management practices and environmental laws are designed to achieve environmental sustainability.

	3.4.6-8 H Design a solution to an environmental issue in which individuals and societies can engage as stewards of the environment.

Students will know…. (DCI)	Students will be able to… (SEP)	Students will apply…(CCC)
Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary).	Engaging in Argument from Evidence:Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Constructing Explanations and Designing Solutions: Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. Engaging in Argument from Evidence: Evaluate competing design solutions based on jointly developed and agreed upon design criteria. Constructing Explanations and Designing Solutions: Apply scientific principles to design an object, tool, process or system.	Stability and Change: Small changes in one part of a system might cause large changes in another part. Patterns: Patterns can be used to identify cause and effect relationships. Cause and Effect: Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Connections to Engineering, Technology, and Applications of Science: The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.		

Core Activities and Corresponding Instructional Methods: Unit 6 Video Links, Unit 6 Overview, Unit 6 Activities

Core Activities / Corresponding Instructional Methods
Unit Question: How does changing an ecosystem affect what lives there? (DOK 3)
Lesson Set 1 (Lessons 1-5) - What is the problem we are trying to solve? (DOK 1)
Lesson 1 - How could buying candy affect orangutan populations in the wild? (DOK 3) Core Activity: Students watch, read about, and discuss orangutan populations decline and palm oil in products. (DOK 2) 1. Read articles that claim that candy-buying could affect orangutan populations in the wild. (DOK 1) 2. Investigate if candy-buying can affect orangutan populations by examining candy ingredients. (DOK 2) 3. Create a model identifying that palm oil produced in the same location where orangutans reside is used as an ingredient in candy. (DOK 3)

4. Read an article about tropical rainforests in Indonesia being cut down to grow oil palm (DOK 1)
5. Use a summary table to revise the model to explain how oil palm trees can lead to a decrease in the orangutan population. (DOK 3)
6. Develop questions that remain about the effect of candy-buying on orangutan population numbers. (DOK 3)
7. Students will discuss cause and effect relationships of resource availability. (DOK 3)

Lesson 2 - Can we replace palm oil with something else? (DOK 2)
Lesson 3 - Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests? (DOK 3)
Lesson 4 - Why do people cut down tropical rainforests when they know it is harmful to the animals that live there? (DOK 3)
Lesson 5 - How have changes in our community affected what lives here? (DOK 3)

Core Activity: Students investigate simple ways to solve a complex problem and realize it is much more complicated. (DOK 3)

1. Explore other crops as a substitute for palm oil. (DOK 2)
2. Analyze data for soybean and canola oil in comparison to palm oil. (DOK 2)
3. Compare and contrast soybean, canola, and palm oils with respect to function and land required for growing. (DOK 3)
4. Explore options that may be alternatives to taking over land to grow palm oil in order to limit the impact to the orangutan population. (DOK 3)
5. Gather information about what oil palm plants need to grow and examine maps of areas that contain these resources. (DOK 2)
6. Watch interviews with farmers to learn that cutting down tropical rainforests to sell or grow resources is a means of survival for some. (DOK 1)
7. Revisit the original problem of disrupting the orangutan population numbers in order to ensure our solution allows for sustainability of all stakeholders. (DOK 3)
8. Revisit the summary table to determine if there is a better way for farmers to grow oil palms that could save tropical rainforest animals without impacting human survival. (DOK 3)
9. Brainstorm and observe evidence of changes in our own community that resulted from human disturbance. (DOK 2)
10. Discussion with the class to share what evidence of change we observe and how it has impacted humans in the area. (DOK 4)
11. Compare the changes in our own community to those in Indonesia. (DOK 3)
12. Revisit the summary table to progress through what we have learned and questions that still remain. (DOK 3)
13. Students will discuss carrying capacity and limiting factors (independent and dependent). (DOK 3)
14. Students will apply the concept of limiting factors to situational scenarios. (DOK 2)

Lesson Set 2 (Lessons 6-10) -What does it mean to have a healthy population? (DOK 2)

Lesson 6 - If palm oil is not going away, how can we design palm farms to support orangutans and farmers? (DOK 4) Core Activity: Students define the problem, criteria, and constraints for successful farm design. (DOK 1) 1. Reflect and discuss as a class on what we have figured out to define the problems associated with palm oil farms. (DOK 3) 2. Brainstorm a design for a better palm farm system that will support both the farmers and the orangutan and tiger populations. (DOK 2)
Lesson 7 - How many orangutans typically live in the tropical rainforest? (DOK 1) Lesson 8 -Why do orangutans need so much forest space? (DOK 1) Lesson 9 -Would planting more rainforest fruit trees help the orangutan population increase? (DOK 2) Lesson 10 - How do changes in the amount of resources affect populations? (DOK 3) Core Activity: Students will investigate how to support orangutan populations and apply what they have learned to other organisms. (DOK 3) 1. Examine a StoryMap that presents information about the number of orangutans in four protected areas with intact tropical rainforests. (DOK 2) 2. Calculate how many orangutans are in 1km^2 for each park and compare across all parks. (DOK 2) 3. Gather data from a computer simulation in which individual orangutans compete with each other for food resources (fruit and termites). (DOK 2) 4. Construct class histograms using data from the simulation trials. (DOK 2) 5. Analyze averages and ranges of energy points for orangutans to examine how the individual orangutans and the orangutan population overall responded to the resource availability. (DOK 4) 6. Conduct an experiment in a simulation by manipulating the amount of food resources over time to observe how orangutan population size fluctuates. (DOK 3) 7. Use the summary table to make claims about food resources and competition between individuals within the populations. (DOK 3) 8. Analyze other cases where population numbers changed due to a change in resource availability. (DOK 4) 9. Identify patterns that connect the population of an organism to the availability of resources that organism needs. (DOK 2) 10. Assessment - in which students explain why the loss of short and tall grass prairies has caused monarch butterfly populations to decrease. (DOK 3) 11. Students will revisit, through an application activity, the importance of biodiversity and how it plays a role with respect to limiting factors as well as organism fitness in particular ecosystems. (DOK 3)
Lesson Set 3 (Lessons 11-13) - How can we make ecosystems more resilient to disruptions? (DOK 4)

Lesson 11 - How does planting oil palm affect other populations? (DOK 2) Lesson 12 - What would happen if orangutans go extinct? (DOK 2) Lesson 13 - How does an ecosystem change when the plants change? (DOK 3) Core Activity: Students investigate various populations in the rainforest and study their interactions. (DOK 3) 1. Develop system models for the oil palm system to identify if other populations are affected by the oil palm industry. (DOK 3) 2. Identify the components and interactions of the oil palm system within the rainforest system. (DOK 2) 3. Create an explanation that explains how competition helps to keep populations at a stable size. (DOK 3) 4. Create a claim about what would happen as a result of orangutan population numbers plummeting. (DOK 3) 5. Read an interview with Andrea Blackburn, who studies orangutans. (DOK 1) 6. Watch videos, examine images, and look at data tables from her research. (DOK 1) 7. Revisit the summary table including information regarding the impact to the rainforest if the orangutan population numbers declined in addition to any predictions or ideas about different kinds of disruptions to the rainforest and oil palm systems. (DOK 3) 8. Assessment - disruption in a monocrop system will impact all populations in a system. (DOK 3)
Lesson Set 4 (Lessons 14-20) - How can we use land in ways that work for peoples and other living things? (DOK 4)
Lesson 14 -Are there ways people can grow food without harming the tropical rainforest? (DOK 3) Lesson 15 - How can people benefit from growing food in ways that support plants and animals in the natural ecosystem? (DOK 3) Lesson 16 - What approach to growing food works for everyone and why? (DOK 3) Core Activity: Students will compare traditional pesticide use with Integrated Pest Management and identify ways IPM can be used to improve local environments and manage real life pest populations in our area. (DOK 2) 1. Read an article from the US Fish & Wildlife Service on the effects of DDT use on bald eagle populations. (DOK 1) 2. Read a brochure from Penn State University on Integrated Pest Management to define IPM, identify the different methods, and examine its overall effect on indoor and outdoor environments. (DOK 1) 3. Research a pest or invasive species that affects or has affected Pennsylvania in the past (spongy moth, spotted lantern fly, emerald ash borer, etc) and work in small groups to report how their pest harms our environment, where they came from, and suggest the best method of IPM to control the population of their pest. (DOK 3) 4. Discuss findings using class discussion norms established. (DOK 4)

Core Activity: Students investigate approaches to growing food that benefit humans and other living organisms. (DOK 3) 1. Read about diversified farming, where farmers grow multiple crops together. (DOK 1) 2. Read about sustainable oil palm, where farmers don't clear forest and include wildlife habitat on the farm. (DOK 1) 3. Read about customary forests, where people cultivate and harvest plants from intact forests. (DOK 1) 4. View StoryMaps that include people's perspectives about the reading topics above. (DOK 1) 5. Summarize what we know about monocropped farms. (DOK 2) 6. Jigsaw activity to synthesize information about different approaches to growing food. (DOK 4) 7. Discuss and rank how the approaches work for plants, animals, and people (DOK 3) 8. Discuss the trade-offs between each approach and clarify claims about which approach we think will work best. (DOK 3) 9. Brainstorm how to test our claims in a simulation. (DOK 2)
Lesson 17 - How can we redesign the way land is used in Indonesia to support orangutans and people at the same time. (DOK 4) Lesson 18 - How do our designs work for orangutans and people in Indonesia? (DOK 3) Core Activity: Students design oil palm farms and evaluate how well they work for humans and orangutans. (DOK 3) 1. Utilize a computer simulation to redesign the way land is used in Indonesia to support orangutans and people at the same time. (DOK 3) 2. Evaluate design solutions created by peers. (DOK 3) 3. Revise and optimize their own design solution to obtain the best fit simulation to support orangutans and humans. (DOK 3) 4. Peer reflection and review of best-fit design. Students need to identify how well each design would work in the real world and trade-offs made in the design process. (DOK 4) 5. Discuss peer evaluations using class discussion norms established. (DOK 4)
Lesson 19 -How can we inform others in our community about the palm oil problem and convince them to take action? (DOK 3) Lesson 20 - What should we do to take care of our local land, plants, and animals? (DOK 3) Core Activity: Students will research the characteristics of our local environment in order to better understand the interactions of the local ecosystem and the interconnectedness of plant and animal life in our area. (DOK 2) 1. Use web sources to collect environmental data including but not limited to: average temperature, rainfall, invasive species, and common plant and animal populations. (DOK 1) 2. Categorize our local environment and identify the type of ecosystem we live in. (DOK 1)

3. Identify at least two actionable steps the community can take to improve our local environment based on the data collected. (DOK 3)
4. Discuss findings and actionable steps using class discussion norms established. (DOK 4)

Core Activity: Students communicate about the problem to their community or apply ideas to a local population of organisms. (DOK 4)

1. Create a public service announcement to inform stakeholders in our community about the palm oil problem and how they can act to address the problem. (DOK 4)
2. Present public service announcements to peers, teachers, and/or stakeholders and receive feedback on the approach presented. (DOK 4)
3. Investigate a local phenomenon - declining local population or way our community is currently caring for the land. (DOK 3)
4. Use readings, videos, interviews with community members. (DOK 2)
5. Analyze how we can take action in our community to address the challenge with this local phenomenon (i.e. habitat restoration, monitoring biodiversity, etc.). (DOK 4)
6. Take action in the community and document actions taken to address the local phenomenon. (DOK 4)
7. Students will demonstrate their knowledge of primary and secondary succession after a natural disaster, human disturbance, etc. (DOK 3)
8. Students will demonstrate their knowledge of exponential and logistic population growth curves and why each would result. (DOK 3)

Words that "Might be Encountered" throughout the Unit:

Abiotic
Atmosphere
Binomial nomenclature
Biodiversity
Biomes
Biosphere
Biotic
Camouflage
Carnivore
Carrying capacity
Commensalism
Community
Competition
Consumer
Decomposer
Disturbances
Ecological succession
Ecology

Extinction
Food chain
Food web
Fresh Water
Growth limits
Habitat
Herbivore
Human impact
Integrated Pest Management
Invasive species
Keystone species
Limiting factors
Migration
Mutualism
Niche
Omnivore
Parasitism

Pioneer species
Population
Predator
Prey
Primary consumer
Primary succession
Producer
Resilience
Salt Water
Secondary consumer
Secondary succession
Soil
Species
Symbiosis
Tertiary consumer
Trophic levels
Wetland

Correctives:

Lesson 1: Population is used throughout this lesson, but students have not been introduced to this term yet. Students will develop an understanding of this definition in future lessons. Students should come in with previous knowledge of food webs.

Lesson 2: Land use management is discussed throughout this unit, this lesson serves as an intro to this. Lesson 5 will expand beyond farming in the local area, so keep those questions open until then.

Lesson 3: Distinction between organisms, populations, and communities will be made in Lesson 7. This lesson uses “nonliving” instead of “abiotic”, so reinforcement of abiotic vs biotic factors may be necessary.

Lesson 4: For this lesson, students only need to focus on how people use the resources from tropical rain forests to support themselves and their community, not on the deeper issues faced by the people living in these developing countries,

Lesson 5: Students will make observations that can be used to generate hypotheses that may explain population changes. These hypotheses can be investigated in later lessons.

Lesson 6: Students should have an understanding of what is meant by criteria and constraints from previous lessons, if not, teachers will need to review these definitions and explain how to come up with these factors for a design challenge.

Lesson 7: Although students are calculating ratios of orangutans to land areas, the term population density is not used.

Lesson 8: Avoid making the connection between energy points and the potential for survival for students as this will be the focus of Lesson 9. Use these ideas to motivate students to investigate the survival rates of individuals in the next lesson.

Lesson 9: This lesson introduces students to the idea that changes in resource availability have a large impact on populations, but does not address disruption of resources by humans, this will come in Lesson 11.

Lesson 10: Human-caused disruptions will be addressed in lesson 11, ecosystem health in lesson 13.

Lesson 11: The ecosystem models created do not address abiotic factors, but can be added if time allows. Abiotic factors would be most useful for plant population models. The intention of this lesson is for students to identify that a tropical rainforest has more components than the oil palm system.

Lesson 12: Arguments such as Orangutans being a national icon in Indonesia or the 97% identical DNA between orangutans and humans is not included in this lesson, but are useful as a response to why it matters if they disappear beyond the environmental factors. Symbiosis and the types of relationships are not addressed in this lesson.

Lesson 13: Economic disruptions are not addressed here, they may emerge in Lesson 15.

Lesson 14: Students will share in mixed jigsaw groups in Lesson 16, and complete the remaining rows of their handout at that point as well.

Lesson 15: Students will develop an understanding of ecosystem services in Lesson 16, if the teacher would like to add it to the Word Wall, wait until that point.

Lesson 16: The farm design simulation is introduced here but the design process will come in Lesson 17. Focus is on stability and change, but using scale as an option that may be beneficial as well.

Lesson 17: Students focus on the practice of developing explanations and designing solutions in this lesson.

Lesson 18: Students will evaluate their design solutions and construct an argument for which solutions are best, but do not actually engage in argumentation.

Lesson 19: There are many large and small solutions and actions to be considered, take the school and community into account in order to guide students towards reasonable ideas for their audience.

Lesson 20: Decisions in this lesson are mostly made by the teacher, it may be useful to find ways to involve students in the decision making process using what they've learned throughout the unit.

Extensions:

Lesson 1: support your students in better understanding plantation systems over time compared to farms, with a particular look at labor practices and the enslavement of people.

Lesson 3: explore the financial costs of design and building greenhouses to grow oil palm. This extension allows you to engage your students in understanding limitations of designs, as well as using mathematics and computational thinking to solve problems.

Lesson 10: The case studies provided in this moment allow you to step outside of orangutans to apply science ideas to a new context. Use this opportunity to extend science ideas to a local case.

Lesson 12: explore local cases of seed dispersal.

Lesson 13: An home learning assignment can be turned into a community photo-documentation activity for students to document examples of biodiverse plant communities and monocrop plant communities in their everyday lives.

Lesson 19 and 20: These lessons offer two pathways to extend student learning.. Lesson 19 supports a communication project focused on communicating about palm oil to local community members. Lesson 20 offers an option to move away from palm oil into a local case where a population is struggling and/or land is being used in unproductive ways to support living things.

Assessments: Unit 6 Assessment, Summary Table

Diagnostic	Formative	Summative
Diagnostic assessments can be in the form of the following: ● KWL charts/summary tables ● Concept mapping ● Open-ended questioning ● Drawing diagrams/model making ● Quick quizzes on key concepts drawing diagrams to explain a process ● "Think-Pair-Share" discussions on the phenomena in question ● Analyzation of real-world data to identify variables and potential relationships	The following can be used for formative assessments throughout the unit: ● Progress Tracker ● Short Quizzes ● Exit Tickets ● Graphic organizers ● Lab notebooks with observations/journal entries ● CERs ● Illustration of a concept/Comic strip explanation ● Self-Assessment and Peer feedback ● Palm Farm Diagrams ● Monarch Butterflies on the shortgrass prairie ● Instructionally embedded design task (land use to support wildlife and humans)	To evaluate students'mastery of the unit's scientific concepts, the following assessments can be utilized to measure their understanding: ● Two-part Student Assessment/Mid-Point Assessment ● Exit Ticket: Written argument ● Self-Assessment and Peer Feedback ● Project presentation ● Unit test ● Research paper essay ● Design challenge ● Final concept mapping with unit vocabulary terms ● Presentation on real-world applications ● Southwestern Willow Flycatcher