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Tree Mass

NGSS EARLY IMPLEMENTERS

WestEd

A Collaboration of the K-12 Alliance @ WestEd,
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Introduction

The California K–8 NGSS Early Implementation Initiative, developed by the K–12 Alliance at WestEd with close collaborative input on its design and objectives from the State Board of Education, the California Department of Education, and Achieve is a fast-start demonstration project to build local education agency (LEA) capacity to fully implement the Next Generation Science Standards (NGSS) as a core subject in the elementary grades (K–5) and as the SBE's preferred integrated model in grades 6–8.

The four-year Initiative provides teachers and administrators with in-depth, content-rich professional development to build leadership capacity and teacher acumen to deliver high-quality 3-dimensional learning for K–8 students. In addition, through collaborations among the K–12 Alliance, Achieve, and others, the LEAs in the Collaborative have opportunities to pilot test new NGSS-aligned tools, processes, assessment item prototypes, and digital and other instructional materials. The LEAs serve as resources for NGSS implementation across California, and in other NGSS-adopting states as well.

This resource presents the conceptual storyline for a unit of instruction at a specific grade level, then focuses on a portion of the storyline called a learning sequence. The learning sequence uses the three dimensions of the NGSS (disciplinary core ideas—DCI; science and engineering practices—SEP; and crosscutting concepts—CCC) to build and deepen student understanding of natural phenomena and design challenges.

Participants in the CA NGSS K–8 Early Implementation Initiative developed and field-tested the lessons in the learning sequence. The sequences were vetted by the Science Peer Review Panel using Achieve's EQuiP rubric and found to be aligned with the intent of the NGSS.

Overview

This unit builds around the idea that energy flows and matter cycles through living systems. The anchoring phenomenon for the unit is a time-lapse animated video of a seedling growing into a tree. This phenomenon leads students to ask, "Where does it come from?" Students investigate the energy flow and matter cycling in a seedling as it gathers matter through chemical reactions to grow into a large oak tree.

Prior to this unit, students would already have had some middle-school-level instruction in physical science. Specifically, students would enter this lesson after completing units related to DCI PS1.A (Matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter) and PS1.B (Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy).

Students will have had middle-school-level instruction on some portions of PS3.B (The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter) in grade 6. Other aspects of PS3.B (Kinetic energy can be distinguished from the various forms of potential energy and is proportional to the mass of the moving object and grows with the square of the speed) will be explored in grade 8 This unit focuses on a small component of PS3.B (Energy changes to and from each type can be tracked through physical or chemical interactions).

Students would have had instruction in LS1.A (All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.) Students will extend their learning about energy and matter flow within a single tree to the cycling of atoms between living and nonliving parts of an ecosystem and how matter and energy are transferred between organisms within an ecosystem (LS2.B) in later units in grade 7.

The Performance Expectation that is addressed in this unit is:

MS-LS1-6 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.

Learning Sequence Narrative

The Learning Sequence Narrative briefly describes what students do in each lesson and links the learning between the lessons as a conceptual storyline. At the end of each learning sequence, students make connections to their understanding of the investigative phenomenon (and to the anchoring phenomenon if appropriate).

The anchoring phenomenon of a seedling growing into a larger tree is used throughout the learning sequence.

Anchoring Phenomenon: Tiny seedlings grow and transform into trees with a great quantity of matter.

Students figure out this phenomenon by:

Science and Engineering Practices (SEPs)

Planning and Carrying Out Investigations

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurement will be recorded, and how many data are needed to support a claim.

- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.
- Conduct an investigation ~~and/or evaluate and/or revise the experimental design~~ to produce data to serve as the basis for evidence that meet the goals of the investigation.

Developing and Using Models

- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
- Develop and/or use a model to predict and/or describe phenomena.
- Develop a model to describe unobservable mechanisms.
- Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.

Constructing Explanations and Designing Solutions

- Construct an explanation using models or representations.

Obtaining, Evaluating, and Communicating Information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

Engaging in Argument from Evidence

- Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.

Disciplinary Core Ideas (DCIs)

LS1.C: Organization for Matter and Energy Flow in Organisms

- 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.

PS3.D: Energy in Chemical Processes and Everyday Life

- The chemical reaction by which plants produce complex food molecules (sugars) requires an 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.

Crosscutting Concepts (CCCs)

Cause and Effect

- Cause and effect relationships can be used to predict phenomena in natural or designed systems.

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes.
- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
- The transfer of energy can be tracked as energy flows through a designed or natural system.

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.
- Systems may interact with other systems; they may have sub-systems and be part of larger complex systems.

Lesson 1: Tree Matter

In this lesson, students will observe a time-lapse video of a seedling growing into a large tree to develop an initial model to explain how plants transform matter from the surrounding environment to create new plant material.

Lesson 2: Planning Plant Investigations

This lesson follows Lesson 1: Tree Matter where students modeled their thinking of where the matter that makes up a tree comes from. The students build on their thinking by planning an investigation to test where the matter of a tree comes from. The students will not carry out the investigation but will connect their own plan to historical scientific investigations.

Lesson 3: Historical Investigations

In this lesson, students will obtain information about historical investigations that lead to an understanding that plants change the composition of air. In the next lesson, students will carry out an investigation to gain evidence that a gas exchange is involved when plants gain matter (live and grow).

Lesson 4: Investigating Gases

In this lesson, students will build on the learnings from the previous lesson that plants need sunlight to add mass, but soil and water are not part of the additional mass. In this lesson, students investigate the gases that are exchanged within the plant.

Lesson 5: Matter Models

In this lesson, students will think about what is accumulated in the plant due to photosynthesis. Students use candy and toothpicks to model the creation of glucose and cellulose through chemical processes.

Lesson 6: Return to Seedling Growth Models

This is the final lesson of the sequence. Students will revise their initial models from the Lesson 1: Tree Matter and apply the learning they gained from the previous lessons.

Learning Sequence 3-Dimensional Progressions

SEP Progression

Only SEPs that have a strong progression are detailed here. While other SEPs are included in the sequence and important to the lesson in which they are used, if they do not appear in multiple lessons, they are not outlined here.

SEP PROGRESSION	
Developing and Using Models	
Lesson 1	Students use their prior knowledge about the practice Developing and Using Models. Students are asked to develop an initial model to explain the additional mass in a grown tree compared to when it was a seedling. This initial model provides an opportunity for teachers to assess students' ability to use aspects of this SEP, *Develop and/or use a model to predict and/or describe phenomena*, that were introduced in grades 3–5 and continue in grades 6–8.
Lesson 4	Students return to the models they developed in Lesson 1 and the SEP of Developing and Using Models. In Lesson 4, students add to their previous models based on the new information obtained from reading about historical investigations and data from their own. Students' new use of the practice includes *evaluating the limitations of their models and modifying their models based on evidence to match what happens if a variable or component of the systems is changed*.
Lesson 5	Students again revise their model with information gained through their investigations of photosynthesis and respiration. Using physical models to represent the creation of glucose and cellulose molecules, they can now *develop and revise a model to describe unobservable mechanisms*.
Lesson 6	Students return to their models one last time to revise their models individually and then collaboratively. In this last lesson, students *develop and revise a model to show the relationships among variables, including those that are not observable but can be used to predict observable phenomenon.*

Learning Sequence 3-Dimensional Progressions (continued)

SEP PROGRESSION (continued)	
Planning and Carrying Out Investigations	
Lesson 2	This practice is first seen in Lesson 2 when students plan an investigation to test where the matter of a growing tree comes from. This is a chance for students' prior knowledge and skills of this practice to be assessed including their ability to *identify independent and dependent variables and controls, what tools are needed to gather data, how measurements will be recorded, and how many data are needed to support the claim, all while collaboratively planning an investigation.*
Lesson 4	Through group planning and teacher facilitation, students continue their skill with this practice when they again plan an investigation about the gases that are exchanged within a plant. Previous foci of the practice are again emphasized (*collaboratively design and in the design, identify independent and dependent variables and controls, tools needed to do the gathering, and how measurements will be recorded*). This time their use of the practice is expanded to include an additional emphasis on *collecting data* as they conduct the investigation they planned for the *collection of data to serve as the basis for evidence to answer scientific questions*.
Obtaining, Evaluating and Communicating Information	
Lesson 3	Students read a series of short texts about historical investigation that lead to an understanding that plants change the composition of air. During this lesson, students will engage in the practice to *evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts* as they compare the historical investigations to those that they planned in Lesson 2. Students will *critically read these scientific texts adapted for classroom use to obtain scientific information to describe patterns in and/or evidence about the natural world* to come to conclusions about what they will investigate in Lesson 4.
Lesson 5	Students engage in this practice again after they have developed their own physical models to describe what materials are inputted, accumulated, and released (outputs) in a plant during photosynthesis and cellular respiration. Students will *critically read a scientific text adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s)* to revise their own models about how trees acquire mass as they grow.

DCI PROGRESSION	
Lesson 1	Plants transform matter from the surrounding environment to create new plant material (from Grades 3–5).
Lesson 2	A tree requires energy from the sun as a source of energy, and other materials are rearranged so the tree can grow. (LS1.C)
Lesson 3	Historical investigations can provide evidence that trees require light and water and exchange gases as they grow. (LS1.C)

Learning Sequence 3-Dimensional Progressions (continued)

DCI PROGRESSION (continued)	
Lesson 4	Trees rearrange carbon dioxide and water into complex molecules to support growth. (LS1.C)
Lesson 5	Plants take in energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. (PS3.D)
Lesson 6	Trees take in and rearrange carbon dioxide and water into complex food molecules, which are used for energy and growth. (LS1.C)

CCC PROGRESSION	
Matter and Energy Systems and System Models	
Lesson 1	Students use prior knowledge about the processes trees use to get energy AND how matter flows into living systems (trees). In particular, in grades 3–5 *students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances do not change.*
Lesson 2	Students consider how they would investigate where the matter in a growing tree comes from by adding new components in their use of the CCC: *Matter flows and cycles* to their investigation of tree growth including *matter can be tracked in terms of the weight of the substances before and after a process occurs, the total weight of the substances does not change, and matter is transported into, out of, and within systems.* Students consider how to collect evidence about matter that enters, accumulates and exits the tree system. Matter and Energy and Systems and System Models are used as students collaboratively plan their investigations.
Lesson 3	Students continue to use Matter and Energy and Systems and System Models as they consider tree growth (*matter is transported into, out of, and within systems*) as they analyze texts about historical investigations and how each set of findings relates to how *matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs*. This includes considering how *the total weight of the substances does not change as matter is transported into, out of, and within the system. Students consider evidence collected from each investigation to develop and understanding of the inputs, processes and outputs of matter flowing within the plant system*.
Lesson 4	Students combine the crosscutting concept Energy and Matter with Systems and System Models to plan and conduct their own investigations about what gases are exchanged within the tree and the processes that drive that exchange. Students consider aspects of the CCCs such as *within a natural system, the transfer of energy drives the motion and/or cycling of matter* as they think about what matter is cycling through the tree during growth and how these changes occur at different scales within the system over time. (They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems).

Learning Sequence 3-Dimensional Progressions (continued)

CCC PROGRESSION	
Lesson 5	Students use physical models to investigate how molecules enter into a plant and are rearranged and accumulated or released back into the environment. In this task, they deepen their understanding and use of the crosscutting concept, Energy and Matter, to include elements such as *matter is conserved because atoms are conserved in physical and chemical processes and within a natural system, the transfer of energy drives the motion and/or cycling of matter*. Students also discuss how processes within the cell affect the plant's system overall, using the crosscutting concept of System and System Models (*that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems*).
Lesson 6	Students develop their final model, both individually and collaboratively, as they use their full understanding of Energy and Matter to explain the phenomenon of tree growth.

References

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Grade 7 Tree Mass Conceptual Flow

Anchoring Phenomenon

Tiny seedlings grow and transform into trees with a great quantity of matter.

Energy flows and matter cycles through living and nonliving systems.

Investigative Phenomenon

Tiny seedlings grow and transform into trees with a great quantity of matter.		Data from historical investigations show that plants don't add mass from water or soil but they do purify the air when in sunlight.	The amount of carbon dioxide in the water surrounding aquatic plants increases and decreases depending on the amount of light.	When matter exits a plant, the molecules are in a different arrangement than when the matter entered.	Tiny seedlings grow and transform into trees with a great quantity of matter.
LS1.C, PS3.D	LS1.C	LS1.C, PS3.D	LS1.C, PS3.D	LS1.C, PS3.D	LS1.C, PS3.D
Plants transform matter from the surrounding environment to create new plant material.	A tree requires energy from the Sun as its source of energy. Other materials are rearranged as the tree grows.	Historical investigations can provide evidence that trees require light and water and exchange gases as they grow.	Trees exchange carbon dioxide and water into complex molecules to support growth.	Plants take in energy from light to make sugars (food) from carbon dioxide and water through the process of photosynthesis which releases oxygen.	Trees take in and rearrange carbon dioxide and water into complex molecules which are used for energy and growth.
Developing and using models	Planning and carrying out investigations	Obtaining, evaluating, and communicating information	Developing and using models	Developing and using models	Developing and using models
			Planning and carrying out investigations	Obtaining, evaluating, and communicating information	

Energy and Matter

Systems and System Models

Cause and Effect