Pictures from National Geographic.

Middle School Integrated Science:

Cycling of Matter and Energy in Plants

6th Grade

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Anchoring phenomenon:
The largest (most massive) tree in the world is called "The President" which is in Sequoia National Park.

Essential question about phenomenon/unit:
How does this tree grow from a tiny seed? How did it get so big? Where did it gets its energy and matter for its mass? Why does a plant make sugar?

Scientific explanation:

The President tree obtains energy from its environment and uses that energy to grow, develop, and reproduce. All organisms require energy to build the substances that make up their cells. This **energy** exists in the form of radiant energy from the sun which transforms into chemical energy in the bonds of molecules.

The President tree grew from a seed. It is a sequoia tree which is a type of gymnosperm. Unlike angiosperms, gymnosperm seeds develop inside of a scale on a cone or modified leaf. The word gymnosperm comes from Greek and means "naked seed." The seeds do not develop inside of fleshy fruit as angiosperms do. The seeds of gymnosperms are also different. They do not contain cotyledons, but do have nutritive material ("food") that develops from the female gametophyte tissue. Like angiosperms, gymnosperm seeds have seed coats which first break open by the radicle when the seedling emerges.

The **roots** of the President are likely only 20 feet deep, but about 100 feet wide. The sequoia tree root system intertwine with other sequoias to prevent being easily knocked over. These roots absorb both water and dissolved minerals from the soil. Minerals needed are nitrogen, phosphorus, potassium, calcium, etc. The nitrogen is imperative for building lignin which make trees rigid and able to grow tall. Tiny root hairs stick out of the root, helping in the absorption, but fungus on the roots help the tree get those minerals. The President's trunk (stem) is 247 ft tall and 54,000 cubic feet of wood. The trunk is where the xylem transports water and dissolved minerals up and the phloem transports sugar up and down the tree. Sequoia tree **bark** is especially filled with a chemical called tannin which aids in their longevity. This gives the President resistance to fire and rot. It also helps to ward off insects and mammals that would otherwise take easy advantage of the sugar-rich sap or the wood that it surrounds. The President has roughly two billion leaves. This is where the President makes its food through a process called photosynthesis. During **photosynthesis**, plants convert the sun's energy into chemical energy which is captured within the bonds of carbon molecules built from atmospheric carbon dioxide and water. The carbon from carbon dioxide in the air we breathe out ends up in "food" molecules (called glucose) each of which contains 6 carbon atoms (and 12 hydrogen atoms and 6 oxygen atoms).

Plants use the energy in some of the carbon molecules they make for the activities to keep themselves alive and to reproduce. This process is called cellular respiration, which all living things do. But there are carbon molecules (**glucose**) left over. These left-over glucose molecules are used to form the complex structures of plants, such as leaves, stems, branches and roots as well as fruits, seeds, nuts or vegetables. Each year trees use the left-over carbon molecules to add to themselves, making themselves bigger in mass (size). Most of the mass of a tree is carbon. That carbon comes from carbon dioxide used during photosynthesis.

Some environmental conditions that allow Sequoia and Redwood trees to grow so tall are: large amounts of rain (60-140 inches per year), mostly from November-April; summer fog which reduces evapotranspiration; temperate climate, average temperatures between 45 degrees and 61 degrees Fahrenheit; rich soil in river bottom flats; few natural enemies; burl sprouts, which promote growth after injury by fire or toppling; wind protection by other redwoods.

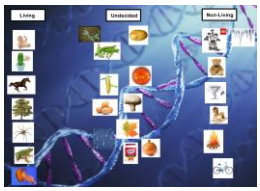
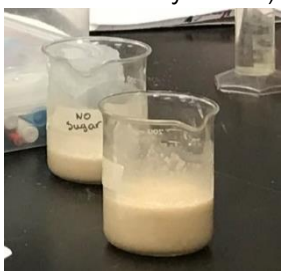
NGSS *Performance Expectations* addressed in this unit:

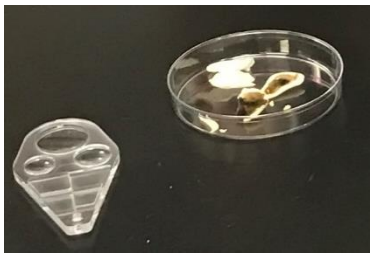
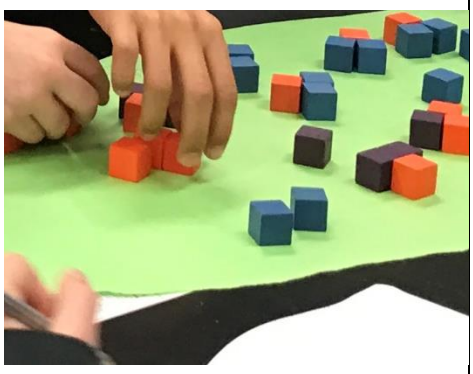
Standard	PE	DCI	CCC
MS-LS1-1	**Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.** [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]	LS1.A: Structure and Function • 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).	Scale, proportion, and quantity
MS-LS1-3	**Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.** [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]	LS1.A: Structure and Function • 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.	Systems and system models
MS-LS1-5	**Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.** [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include … species of grass affecting growth. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions...]	LS1.B: Growth and Development of Organisms • Genetic factors as well as local conditions affect the growth of the adult plant.	Cause and Effect

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.** [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.]	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. (secondary)	Energy and Matter

Summary Table of Activities in Unit

Activity	***Evidence Students Could Gain***	***Connection to Phenomenon***	**Questioning Strategies/ Discussion Points**
Activity 1: Initial Model ***Learning Target:*** I can model my initial idea about how this tree got so big.	Students can gain strategies for modeling and record initial ideas.	*Model scaffold is directly related to phenomenon.*	How could we draw things we cannot see? How could we use color to help us model?
Activity 2: Living vs. nonliving card sort and discussion (Modified FOSS Diversity of life activity)	Growth and Development is one of the factors that determines if something is living or non-living.	A tree is a living thing because it has all characteristics of life.	*How did you sort the cards? What characteristics do you use to determine if something was living or nonliving?*

 *Optional additional resource:* Science Court: Living Things (available on YouTube) ***Learning Target:*** I can determine if something is living or nonliving based on its characteristics.			
Activity 3: Yeast experiment (Modified from FOSS Diversity of Life)  ***Learning Target:*** I can apply my knowledge of the characteristics of life to explain my observations with the yeast experiment.	The yeast got energy from the sugar.	Living things get energy from sugar to carry out life processes. They release carbon dioxide when they break down sugar.	Is yeast a living thing? How do you know? What characteristics of life can we see? What observations can be made about the experiment? How do we know something happened?
Activity 4: Energy reading and discussion ***Learning Target:*** I can explain what energy is and why energy is important.	Every living thing needs energy. Sunlight is the initial source of all energy. Different organisms get their energy in different ways.	The President must be getting all the energy it needs to carry out life processes specifically growth and development.	Why is energy so important? Where do we get energy?
Activity 5: Pocket plant ***Learning Target:*** I can analyze data from a plant growth experiment using different conditions inside a closed system.	Seeds will only germinate when in the right conditions (water, light, oxygen, warmth). Soil is not a necessary component.	The President germinated because it had the right conditions like water, oxygen, and warmth.	How is a plant able to grow without soil? How does soil aid in plant growth?
Activity 6: Seed dissection and	Seeds have the energy and matter stored inside	The President got energy and the matter	Why are angiosperms and gymnosperms

angiosperm/gymnosperm seed comparison  ***Learning Target:*** I can conduct an investigation with different seeds to determine how they are similar and different.	of them to allow a seedling to grow without any other resources.	to grow from the seed as a seedling. Once it sprouted leaves it got energy from the sun and matter from its roots and the air.	different? How are their seeds different? How are they the same?
Activity 7: Seedling environment experiment ***Learning Target:*** Using what I learned in my pocket plant experiment, I can develop another experiment and analyze data a new plant growth experiment.	As long as seeds get water, air (carbon dioxide), and light the seedling can grow.	The President can continue to grow as long as it gets water, air (carbon dioxide), and light.	What environmental factors affect plant growth? What are some factors that may influence the President's growth?
Activity 8: Roots, stems, and leaves reading (pages 244-245 in frog textbook) ***Learning Target:*** I can explain how each plant structure aids in The President's growth.	Leaves, stems, and roots are specialized structures that allow grown plants to get the energy and matter that they need to get bigger.	The President has these structures such as leaves, stems, and roots that allow it to get the energy and matter it needs to grow.	Do all plants need roots? How about stems or leaves? Why or why not?
Activity 9: Photosynthesis reading (pages 261-263 frog textbook) and modeling with blocks 	Inside leaves, plants take in CO2 and H2O. Using the energy from the sun, plants can convert those molecules into glucose (sugar) and oxygen.	Plants are taking in energy and matter and therefore, get bigger.	Why is this process of photosynthesis so important? Why would a plant build sugar molecules only to break it down?

Learning Target: I can model the chemical reaction of photosynthesis. Also, I can contrast photosynthesis and cellular respiration.			
Activity 10: Transpiration lab ***Learning Target:*** I can plan an investigation to show that plants carry out cellular respiration.	Plants break down the sugar they make and release carbon dioxide and water back into the air. Like humans, breaking down the sugar is what allows things to grow.	The President is breaking down the sugars it is making and releasing carbon dioxide and water. The President grows when it breaks down its sugar.	What are the products of the reaction of cellular respiration?
Activity 11: Plant data analysis activity ***Learning Target:*** I can construct an argument to explain which molecules are essential for plant growth.	Soil provides nutrients to a plant, but the amount of soil around a tree stays mostly the same over the life of a tree.	The soil around the President is not decreasing by much over time. So the soil is not giving the President much of the matter to grow.	What molecules are essential for plant growth? How and where does the President gather those molecules?

(*Add Rows as Necessary*)

Model Template

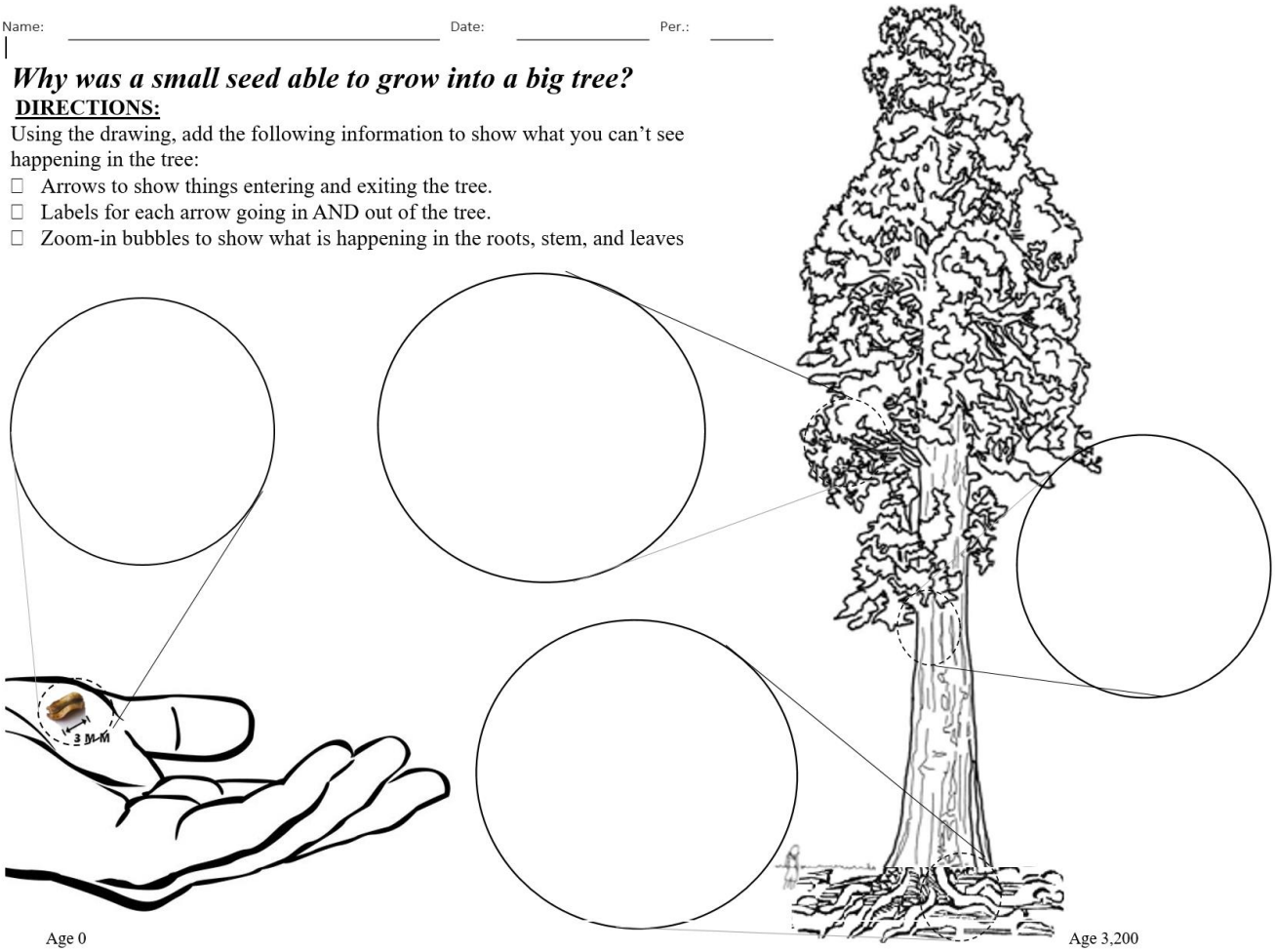
Name: _____ Date: _____ Per.: _____

Why was a small seed able to grow into a big tree?

DIRECTIONS:

Using the drawing, add the following information to show what you can't see happening in the tree:

- Arrows to show things entering and exiting the tree.
- Labels for each arrow going in AND out of the tree.
- Zoom-in bubbles to show what is happening in the roots, stem, and leaves



Additional Web Resources

https://sway.com/HAnWzV1pvEIrR4Y0?ref=Link

http://www.richleebruce.com/biology/redwood.html

http://podcastnotes.org/2016/09/20/radiolab-from-tree-to-shining-tree/ (CONTAINS A CURSE WORD)

http://www.pinsdaddy.com/gymnosperm-structure_tBXxfivRSaMfKnTJDRKESgOurslFJYuwJA21SIwHo0Q/2

http://www.sites.ext.vt.edu/virtualforest/modules/photo.html

https://sway.com/9msrNHDgdrb8OjDI?ref=Link