3D Science Performance Assessment Tasks

HIGH SCHOOL

MATTER AND ENERGY TRANSFORMATIONS IN ORGANISMS AND ECOSYSTEMS

In Partnership with

3DSPA Assessment Tasks were developed by

A member of

In collaboration with

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Task Title	Matter and Energy Transformations in Organisms and Ecosystems

Standards Bundle Information
Performance Expectations • HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. • HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
Science and Engineering Practices • Developing and Using Models
Cross-Cutting Concepts • Systems and System Models • Energy and Matter
Disciplinary Core Ideas • LS1.C: Organization for Matter and Energy Flow in Organisms • LS2.B: Cycles of Matter and Energy Transfer in Ecosystems. • PS3.D: Energy in Chemical Processes
CCSS ELA • RST.11-12.1 Cite specific textual evidence to support analysis of science. • WHST.9-12.2 Write informative/explanatory texts, including scientific procedure/experiments or technical processes. • WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting or trying a new approach, focusing on addressing what is most significant for a specific purpose or audience. • WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection and research.
CCSS Mathematics: • MP.2 Reason abstractly and quantitatively • MP.4 Model with mathematics

Overview / Introduction of the Assessment Task
In this task students will model the flow of energy and matter through organisms and the ecosystem by following a radiolabeled carbon molecule from the hydrosphere through the foodweb and ultimately ending up in the

muscle of an eagle. During the process students will also be required to account for conservation of energy and matter.

Teacher Background
Teachers should understand photosynthesis, cellular respiration and the flow of energy and matter through an ecosystem (up through trophic levels).
Information for Classroom Use
Connections to Instruction: The purpose of this task to summatively assess student learning for standards HS-LS1.7 and 2.5 after students have been engaged in your classroom instruction. This is not meant as a classroom lesson plan, but as a final assessment. Your instruction/ plan should also include lessons that will prepare students for the formative assessment tasks leading up to the final assessment.
Approximate Duration for the Summative Task: This summative assessment should take about two class periods to complete. This does not include the days leading up to the formative assessments of which there will be several prior to the summative assessment where teachers will present information and use the formative assessments.
Assumptions: Prior to the summative task, students should have knowledge of food webs, ecological pyramids, photosynthesis, cellular respiration and an understanding of basic chemistry. The 3D-SPA was designed to assess students' ability to perform the task by applying previous knowledge learned to the new phenomena in the performance assessment without having been exposed to this specific phenomena in advance. Students must understand the equilibrium between bicarbonate, protons and carbonic acid in water leading to the ability of aquatic plants to use bicarbonate as an inorganic carbon source for photosynthesis. The following interactive does a good job of addressing carbon cycling in aquatic environments http://www.mhhe.com/biosci/bio_animations/MH13_CarbonCycle_Web/
Materials Needed: Varies depending on model chosen. Recommend poster board, markers for simplest model.
Supplementary Resources: Please see individual assessments.

Learning Performances
LP1: Students create a model to represent interactions between the inputs and outputs (energy and matter) of photosynthesis and cellular respiration between an organism (system) and its surroundings. LP2: Students model the relationship between photosynthesis and the organic carbon that makes up all biological molecules. LP3: Students demonstrate the relationship between photosynthesis, cellular respiration and the energy requirements of life at the level of organism (system).

LP4: Students analyze data in order to extrapolate that all living things transfer energy through the process of cellular respiration (aerobic/anaerobic) in living things.

LP5: Students use a model to demonstrate the conservation of matter during the breaking and formation of chemical bonds to create new molecules (ie protein, carbohydrates…) and whether they are assimilated into biomass or are burned for energy or released as waste.

LP6: Students use a model to demonstrate that the breaking and formation of chemical bonds transfers energy (aerobic and anaerobic; catabolic vs anabolic; endergonic vs exergonic).

LP7: Through the use of a model, students will be able to account for energy, as it flows, and mass, as it cycles, through ecosystems, organisms and the biosphere (ultimately leading to demonstration of understanding of the Laws of Conservation of Energy and Matter).

LP8: Students must model the result of cellular respiration inefficiency with respect to energy and the effect that has on the need for food.

LP9: Students must model the relationship between cellular respiration, thermoregulation and the production of heat as a result of energy loss.

Performance Assessments

<table>
<tr><th colspan="3">Student Performances</th></tr>
<tr><td rowspan="4">Formative Assessment Task 1</td><td>Learning Performance:
LP1: Students create a model to simulate interactions between the inputs and outputs (energy and matter) of photosynthesis and cellular respiration between an organism (system) and its surroundings.</td><td rowspan="4">Expected Duration:
One class Period</td></tr>
<tr><td>Description: A closed aquatic system containing a plant, fish and decomposer in a water filled jar is able to survive for long periods of time without adding food or air.</td></tr>
<tr><td>Directions:

1. The teacher shows a diagram /picture or sample of a biome in a bottle that includes a fish, plant and decomposer.
2. Share article of very old biome in a bottle.
3. Students watch cellular respiration and photosynthesis animations. The following are good resources.
Cellular Respiration Animations
http://www.sumanasinc.com/webcontent/animations/content/cellularrespiration.html
https://concord.org/stem-resources/cellular-respiration

Photosynthesis Animation:
https://concord.org/stem-resources/leaf-photosynthesis

4. Students break into groups to discuss what is really occurring in the bottle.
5. Students will then individually label the Photosynthesis and Cellular Respiration Big Picture Organizer.</td></tr>
<tr><td>Scoring / Teacher Look-For's:
Diagram must be complete with correct terminology.</td></tr>
<tr><td rowspan="3">Formative Assessment Task 2</td><td>Learning Performance:
LP4: Students analyze data in order to extrapolate that all living things transfer energy through the process of cellular respiration</td><td rowspan="3">Expected Duration:
30 minutes</td></tr>
<tr><td>Description: Students will analyze text and data in order to determine the universal prevalence of cellular respiration.</td></tr>
<tr><td>Directions: Please see attached Metabolic Rate Activity.</td></tr>
</table>

	Scoring / Teacher Look-For's: Look for understanding that all organisms do cellular respiration in one form or another and that cellular respiration is essential to provide energy for life processes.	
Formative Assessment Task 3	**Learning Performance:** LP6: Students use a model to demonstrate that the breaking and formation of chemical bonds transfers energy (endergonic vs exergonic).	**Expected Duration:** 80 minutes
	Description: Creation of molecular models	
	Directions: Have students work in groups to draw or create models of monosaccharides and amino acids. Students will then build proteins and polysaccharides. They will model both condensation and hydrolysis reactions while tracking energy transfers. One possible resource is this Building Macromolecules Activity	
	Scoring / Teacher Look-For's: Look for demonstration of hydrolysis, condensation reactions and endergonic and exergonic reactions.	
Formative Assessment Task 4	**Learning Performance:** LP8: Students must model the result of cellular respiration inefficiency with respect to energy and the effect that has on the need for food. LP9: Students must model the relationship between cellular respiration the production of heat as a result of energy loss.	**Expected Duration**: 47 -90 minutes
	Description: Students analyze food pyramids including the energy at each trophic level. Students model where all of the energy goes.	

	Directions: Hand out food pyramids that include the energy amounts at each level. Have students work in pairs to create a model that superimposes information about where the energy moves (heat loss, muscle production, ingestion, excretion). The size of the arrow should correspond to the amount of energy moving via that pathway. Have students exchange models and peer review. Two nice resources that combine webs and pyramides for this lesson are ● The HHMI Biointeractive site is Creating Chains and Webs to Model Ecological Relationships. ● "Food Chains and Food Webs - Balance within Natural Systems - Lesson." *Www.teachengineering.org*. N.p., n.d. Web. 03 Dec. 2016. <https://www.teachengineering.org/lessons/view/van_biomimicry_less2>.	
	Scoring / Teacher Look-For's: Look for only 10% of energy moving on to the next trophic level. Students need to account for the remainder of the energy.	
Final Task:	**Learning Performances:** LP1: Students create a model to represent interactions between the inputs and outputs (energy and matter) of photosynthesis and cellular respiration between an organism (system) and its surroundings. LP2: Students model the relationship between photosynthesis and the organic carbon that makes up all biological molecules and demonstrate the conservation of matter during the breaking and formation of chemical bonds to create new molecules (ie protein, carbohydrates…) and whether they are assimilated into biomass or are burned for energy or released as waste. LP6: Through the use of a model, students will be able to account for energy, as it flows, and mass, as it cycles, through ecosystems, organisms and the biosphere (ultimately leading to demonstration of understanding of the Laws of Conservation of Energy and Matter).	

<table>
<tr><td rowspan="4"></td><td colspan="2">Phenomena:
Carbon and energy move through organisms and ecosystems and can be followed through methods such as radiolabeling.</td><td rowspan="4">Expected Duration:
2 class periods</td></tr>
<tr><td>Goal: Student will develop a model that demonstrates their understanding of energy and matter transfer through cellular respiration and photosynthesis at the organism and ecosystem levels.</td><td>Role: A DNR, department of natural resources, officer studying the Bald Eagle population in Northern Lower Michigan.</td></tr>
<tr><td>Audience: The producer and director for a news broadcast.</td><td>Situation: A baking soda manufacturer, who shall remain nameless, has been accused of depositing radioactive bicarbonate (HCO_3^-) into a river in Northern Michigan. The DNR, department of natural resources, is concerned about where the radioactivity will end up. You test for evidence of radioactivity in and around the river and find high concentrations of radioactive carbon in the breast muscle of Bald Eagles.</td></tr>
<tr><td colspan="2">Product / Performance: Students will produce a model that shows the flow of the radioactive carbon and energy through the ecosystem that resulted in this finding starting with the bicarbonate in the hydrosphere and ending with carbon atoms in eagle muscle protein. Inputs and outputs of energy and matter at all organizational levels (organism, ecosystem, biosphere) need to be included.</td></tr>
</table>

Directions : Link to Student Direction Sheet

A baking soda manufacturer, who shall remain nameless, has been accused of depositing radioactive bicarbonate (HCO_3^-) into a river in Northern Michigan. The DNR is concerned about where the radioactivity will end up. You test for evidence of radioactivity in and around the river and find high concentrations of radioactive carbon in the breast muscle of Bald Eagles. As a Michigan DNR Officer, you must create an explanatory model that shows how the radioactive carbon cycled and energy flowed from the river, through the ecosystem ultimately ending up in the eagle muscle. Remember to be thorough. You will be presenting this to the producer and director of the news station.

Your model must:

- Simulate interactions between the inputs and outputs (energy and matter) of photosynthesis and cellular respiration between an organism (system) and its surroundings.
- Reminder: You will be showing what is happening both within each organism as well as between organisms and their surrounding.
- In your model, cellular respiration and photosynthesis must be shown in each organism in which they occur.
- Demonstrate the relationship between photosynthesis and the organic carbon that makes up all biological molecules.
- Demonstrate what happens to matter and energy during the breaking and formation of chemical bonds to create new molecules (i.e. protein, carbohydrates…) and whether they are assimilated into biomass or are burned for energy or released as waste.
- Account for energy, as it flows, and mass, as it cycles, through organisms and the ecosystem.
- Account for the inefficiency of energy conversions.
- Include at least three trophic levels.
- Include both narrative and a pictorial representation of relationships.

CheckBric

<table>
<tr><td colspan="5">Learning Performance:
LP1: Students create a model to represent interactions between the inputs and outputs (energy and matter) of photosynthesis and cellular respiration between an organism (system) and its surroundings.</td><td>Comments</td></tr>
<tr><td colspan="5">Evidence Statements below:</td><td rowspan="5"></td></tr>
<tr><td>● In the model the inputs and outputs of photosynthesis (CO_2, H_2O, sunlight energy, glucose, oxygen) are represented.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>● In the model the inputs and outputs of cellular respiration (Glucose, oxygen, ATP energy, heat, CO_2 and H_2O) are represented.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>● Model shows the cyclic nature of the relationship between the products and reactants of both individual processes.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>LP Total:</td><td colspan="4"></td></tr>
<tr><td colspan="5">Learning Performance:
LP2 and 5: Students model the relationship between photosynthesis and the organic carbon that makes up all biological molecules and demonstrate the conservation of matter during the breaking and formation of chemical bonds to create new molecules (i.e. protein, carbohydrates…) and whether they are assimilated into biomass or are burned for energy or released as waste.</td><td>Comments</td></tr>
<tr><td colspan="5">Evidence Statements here:</td><td rowspan="5"></td></tr>
<tr><td>● The model should include the role of storing carbon in organisms as biomass (molecules like protein, lipids...) within the carbon cycle.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>● The model should include the exchange of carbon (through carbon-containing compounds) between organisms (at least three trophic levels) and the environment(hydrosphere and atmosphere).</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>● The model will demonstrate that, as energy and matter flow through different organizational levels, molecular rearrangement leads to energy transfer.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>LP Total:</td><td colspan="4"></td></tr>
<tr><td colspan="5">Learning Performance:
LP7: Through the use of a model, students will be able to account for energy, as it flows, and mass, as it cycles, through ecosystems, organisms and the biosphere (ultimately leading to demonstration of understanding of the Laws of Conservation of Energy and Matter).</td><td>Comments</td></tr>
<tr><td colspan="5">Evidence Statements here:</td><td rowspan="5"></td></tr>
<tr><td>● The model will demonstrate that during the chemical reactions, matter and energy are neither created nor destroyed.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>● The model will demonstrate that the process of cellular respiration releases energy because the energy released when the bonds that are formed in CO2 and water is greater than the energy required to break the bonds of sugar and oxygen.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>● The model will demonstrate that food molecules and oxygen transfer energy to the cell to sustain life processes,
○ including the maintenance of body temperature
○ despite heat loss to the surrounding environment.</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>LP Total:</td><td colspan="4"></td></tr>
<tr><td>Checkbric Total:</td><td colspan="5"></td></tr>
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4 Exemplary	Work at this level is of exceptional quality. It is both thorough and accurate. It exceeds the standard. It shows a sophisticated application of knowledge and skills.
3 Proficient	Work at this level meets the standard. It is acceptable work that demonstrates application of essential knowledge and skills. Minor errors or omissions do not detract from the overall quality.
2 Developing	Work at this level does not meet the standard. It shows basic, but inconsistent application of knowledge and skills. Minor errors or omissions detract from the overall quality. Your work needs further development.
1 Emerging	Work at this level shows a partial application of knowledge and skills. It is superficial (lacks depth), fragmented or incomplete and needs considerable development. Your work contains errors or omissions.

Item Production Information

Copyrighted Material and Sources

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