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Initials

Environmental Literacy Carbon Assessment: --- High School Level, Form A ---

Science is easier to understand if you can make connections between what you know now and the new ideas that you are studying. This is a test that will help us to understand what you know now. Please answer these questions as carefully and completely as you can. If you are not sure of the answer, please write about any thoughts that you have. If you can help us to understand how you think about these questions, then we can do a better job of explaining science in ways that make sense to you.

Please put your initials (not your full name) in the boxes

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First Middle Last


Date _____

Class _____ Teacher _____

1. Sunlight helps plants to grow. Where does light energy go when it is used by plants? Please choose the ONE answer that you think is best.

- The light energy is converted into glucose of the plants.
- The light energy is converted into ATP in the plants.
- The light energy is used up to power the process of photosynthesis.
- The light energy becomes chemical bond energy.
- The light energy does not go into the plants' body.

Please explain why you think that the answer you chose is better than the others. (If you think some of the other answers are also partially right, please explain that, too.)

	<p>Purpose: <i>The purpose of this item is to know how students reason the event of plants using sunlight.</i></p> <p>Sophisticated answer: <i>A Sophisticated explanation describes energy transformation in photosynthesis – In photosynthesis, plants transform light energy into chemical potential energy of “foods” – carbon-containing organic substances (e.g. glucose).</i></p> <p>Naïve answers: <i>Students usually do not distinguish light from conditions of living such as being healthy or warmth. Students at higher levels can recognize that light provides energy for plants to make foods, but many tend to think that light energy is used up to power the process of photosynthesis.</i></p>
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2. Why do people use gasoline instead of water to run their cars? Please tell as much as you can about substances and chemical processes.

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Purpose: *The purpose of this item is to uncover students understanding about the difference between gasoline and water and whether they recognize gasoline is energy-rich material.*

Sophisticated Answer: *A sophisticated answer recognizes that gasoline is energy-rich material since gasoline's major component is hydrocarbons (octane), which contains high-energy bonds C-C and C-H.*

Naïve Answers: *Students may use function for reasoning – people use gasoline to run car, because gasoline lasts longer or because water will destroy the engine. Some students may recognize that gasoline and water have different chemical composition, but they may not recognize that is related to energy (e.g., gasoline has special chemicals).*

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3. When the car runs for some time, the front part of the car will become hot. When you are running for a while, you also feel very hot. When the wood is burning, it makes the air around it very hot. Why can you feel the heat in these events? Are the causes of the three events similar or different? Please explain why.

Purpose: *The purpose of this item is to uncover students understanding about energy degradation in various events.*

Sophisticated Answer: *A sophisticated answer identifies the chemical reactions underlying all the events (i.e., combustion and cellular respiration) and recognizes heat dispersion in all the processes.*

Naïve Answers: *Currently, we do not know enough what students would respond.*

4. When a person loses weight, where does the matter of the person's fat go? Please choose ONE answer that you think is best.

- The fat is broken down and leaves the person's body as water and gas.
- The fat is converted into energy.
- The fat is burned up providing energy for the person's body functions.
- The fat is broken down and leaves the person's body as feces and urine.

Please explain why you think that the answer you chose is better than the others. (If you think some of the other answers are also partially right, please explain that, too.)

Purpose: *The purpose of these questions is to understand whether and how students conserve mass when explaining changes in body weight in human beings. This is important since it deals with another conceptual area where students' ideas are often at odds with the scientific ones.*

Sophisticated Answer: *The sophisticated answer to the questions would be choice "a" with the explanation that the fat reacts with oxygen in cellular respiration and produce water and carbon dioxide. So, fat becomes gases – carbon dioxide and water vapor.*

Naïve Answers: *Many students tend to believe that food is converted into energy or "goodness". Some students may think of digestion as a process of extracting usable energy out of food. These students may think of loss of weight as a process where usable energy is extracted out of body fat, and then the 'energy-less' 'used' fat is excreted out of the body as feces. Such students are likely to pick "d". Some students may select the correct choice "a" but they may not use chemical reaction for explanation. Instead, they tend to construct that explanation based on their macroscopic observation: People lose weight by doing exercise. When people are doing exercise, they sweat and breathe heavily.*

5. How are the three things related to each other:

- a person plugs in an air conditioner in the US
- trees grow in the Amazon forest
- ice in the Arctic Ocean melts

Purpose: *The purpose of this item is to understand how students make connections among these events and whether they can identify and explain carbon cycling through the two processes – photosynthesis and combustion.*

Sophisticated answer: *A sophisticated answer to this question explains the connection of the events in terms of carbon cycling: On the one hand, using air conditioner*

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consumes electrical energy, most of which comes from combustion of fossil fuels. Combustion of fossil fuels releases a large amount of carbon dioxide into the atmosphere, causing global warming over time. As the result, ice in Antarctica melts. On the other hand, underlying the event of trees growing in Amazon is the process of photosynthesis: Trees use carbon dioxide in the atmosphere and water to make organic substances for their body structure. When the plants remove the carbon dioxide from the atmosphere, they help to slow global warming.

Naïve answers: *Students usually do not recognize the connection in terms of carbon cycling at atomic/molecular scale. They may also address connection at macroscopic scale. For example, heat released from air conditioner can be the reason for ice melting in Antarctica.*

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6. Three batches of radish seeds, each with a starting weight of 1.5g (dry) were placed in Petri dishes and provided only with light or water or both, as shown in the photo. After 1 week, the material in each dish was dried and weighed. The results (masses after drying) are shown below.



a) Which of the following processes contributed the most to the increased dry mass of the “Light, Water” treatment?

- a) Absorption of mineral substances by the roots.
- b) Absorption of organic substances by the roots.
- c) Absorption of carbon dioxide gas from the air by green leaves.
- d) Absorption of water by roots.
- e) Absorption of sunlight by leaves.

b) Explain why you think your choice contributed the most to the increase in mass. (If other processes also contributed to the mass, explain which ones they are, too.)

Purpose: The purposes of this question are to discover whether students can identify the conditions for plants to conduct photosynthesis and cellular respiration and to understand students’ ideas about matter transformation and energy transformation in photosynthesis and cellular respiration.

Sophisticated answers: The correct choice is c. Sophisticated answers should recognize that in the light and water treatment, the radish seeds undergo both photosynthesis and cellular respiration and photosynthesis contributes to the weight gain. In photosynthesis, carbon dioxide reacts with water and produce organic carbon-containing matter of plants and oxygen. From this chemical equation, we can find that the most increased matter of plants is in the form of organic carbon, which comes from carbon dioxide.

Naïve answers: Students may identify photosynthesis is involved in the light and water treatment, but they usually do not recognize that organic carbon constitute the major increased mass and that organic carbon is from carbon dioxide. They tend to think that the major increased matter comes from the substances absorbed through plants’ roots.

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c) The "No Light, Water" treatment lost mass (from 1.50g to 1.17g). What do you think happened to the mass that was lost?

Purpose: The purposes of this question are to discover whether students can recognize that plants are doing cellular respiration all the time.

Sophisticated answers: Sophisticated answer should recognize that in the no light and water treatment, the radish seeds only undergo cellular respiration, which contributes to the weight loss. In cellular respiration, the organic matter of the radish seeds reacts with oxygen to produce carbon dioxide and water. Thus, some organic matter becomes gases releasing into the air.

Naïve answers: Students usually do not think that plants also do cellular respiration, so they often do not know why the weight of the seeds is lost.

7. A remote island in Lake Superior is uninhabited by humans. The primary mammal populations are white-tailed deer and wolves. The island is left undisturbed for many years. Select the best answer(s) below for what will happen to the average populations of the animals over time. Please choose the ONE answer that you think is best.

- a. The deer will all die or be killed.
- b. The wolves will all die or be killed.
- c. On average, there will be a few more deer than wolves.
- d. On average, there will be a few more wolves than deer.
- e. On average, there will be many more deer than wolves.
- f. On average, there will be many more wolves than deer.
- g. On average, the populations of each would be about equal.
- h. None of the above. My answer would be: _____

Please explain why you think that the answer you chose is the best. (If you think some of the other answers are also partially correct, please explain that, too.)

Purpose: The purpose of the question is to understand students' conception about food chain and feeding relationships between species in an undisturbed ecosystem. To figure out the population of the species, students need to understand how food chain and energy trophic pyramid constrain the number of organisms.

Sophisticated answer: The answer for question 3 is e. Wolves feed on white-tailed deer, so the matter and energy of deer transfers to wolves. Deer and wolves are at different level of consumer in food chain and a food chain can be represented quantitatively (with numbers) in the form of a pyramid of numbers. Over time, there must be much fewer wolves than deer, because when one wolf eat one deer, the wolf only get about 10% energy from the deer and thus one wolf requires many deer to get enough energy to survive.

Naïve answers: Wolves eat deer and there are less deer than wolves or no deer. Students may not realize that the predator-prey relationship between wolves and deer has implications for the relative size of the populations.

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8. Which of the following is/are energy source(s) for plants? Circle yes or no for each of the following.

- | | |
|----------------------------------|----------|
| a. Water | Yes / No |
| b. Light | Yes / No |
| c. Air | Yes / No |
| d. Nutrients in soil | Yes / No |
| e. Plants make their own energy. | Yes / No |

Please explain ALL your answers, including why the things you circled “No” for are NOT sources of energy for plants.

Purpose: *The purpose of this item is to know whether and how students can identify light as the only energy source for plants.*

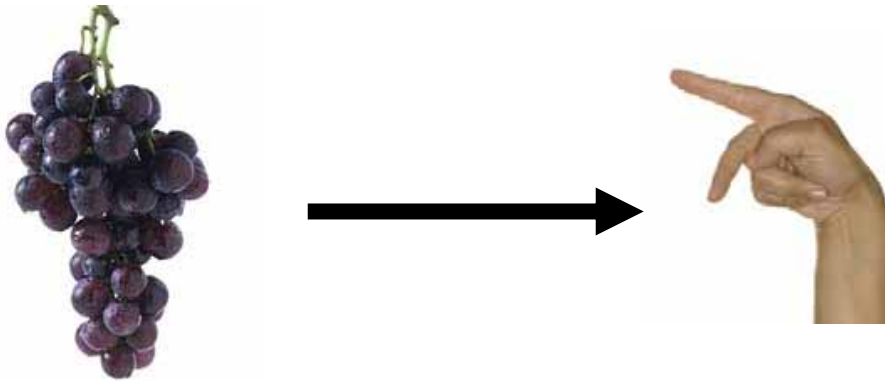
Sophisticated Answer: *The correct response is yes for b and no for all the other choices. Sophisticated explanation identify light as the only energy source and explains energy transformation in photosynthesis – In photosynthesis, plants transform light energy into chemical potential energy of “foods” – carbon-containing organic substances (e.g. glucose). Water and carbon dioxide are involved in photosynthesis, but they are not the energy source, because the chemical energy of glucose is transformed from the light energy. Minerals and Nutrients are not energy sources, because they are not involved in photosynthesis – the only process of plant harnessing energy into body structure.*

Naïve Answers: *Students tend to hold the idea that everything plants taking in is energy source for plants. Thus, they usually identify things plants absorbing from soil as energy sources. Students are familiar with the statement that plants make their own foods. Many students interpret this statement as plants make their own energy.*

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9. You eat a grape high in glucose content.



a) Please describe how one glucose molecule from the grape provides energy to move your little finger. Tell as much as you can about any biological and chemical processes involved in this event.

Purpose: *The purpose of this item is to investigate how students account for human body activities: whether students can identify the process of cellular respiration and whether they can explain matter transformation and energy transformation in cellular respiration. Although blood circulation is also involved, it is not the focus of this item.*

Sophisticated Answer: *The sophisticated explanation describes both blood circulation and cellular respiration – the substances (glucose) go through blood circulation to the cell of the little finger. Then, through cellular respiration, the chemical potential energy of glucose is transformed into kinetic energy of finger movement.*

Naïve Answers: *Students may identify blood circulation, but cellular respiration is much harder for them to identify. Even some students who recognize that there must be some chemical reactions happening, so that substances in the body can provide energy for finger movement, they usually cannot successfully explain energy transformation in cellular respiration. Usually, students tend to use matter-energy conversion for reasoning – the substances of grape are converted into energy to make the little finger move.*

b) Do you think the **SAME** glucose molecule can also help you maintain your body temperature, when it is used to provide energy to move your finger? Please explain your answer.

Purpose: *The purpose of this item is to know whether students can identify energy degradation in cellular respiration – heat is released from cellular respiration and the heat help people keep their body temperature.*

Sophisticated Answer: *Sophisticated answer addresses energy degradation in cellular respiration – In cellular respiration, only a small part of the chemical potential of the glucose molecule is transformed into kinetic energy. Most chemical potential energy dissipates as heat to increase our body temperature.*

Naïve Answers: *Students may not believe that the same molecule can provide energy*

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for both finger movement and body temperature.

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10. Carbon exists in different molecules or substances in nature. Please explain where carbon might exist in a forest. Complete the table below.

Question:	YES or NO	If YES, what substances or materials in these locations contain the carbon?
Do you think you would find carbon in trees?		
Do you think you would find carbon in the soil?		
Do you think you would find carbon in animals, like deer and wolves?		
Do you think you would find carbon in bacteria in the soil?		
Do you think you would find carbon in the air?		
Where else might you find carbon?		

Purpose: The purpose of this question is to understand students' ideas about the inorganic and organic compounds in which carbon is stored. Often, students will overlook certain forms in which carbon is stored. This leads to a greater misunderstanding of the carbon cycle. Organic carbon is stored sugar, starch, and cellulose that compose plants' body structure. Organic carbon is also stored in humus of plants/animals in the soil, but the minerals in soil do not contain carbon. Carbon is also stored as carbohydrates and lipids in the body structure of animals. Sugar is the most common form for bacteria to store carbon. Carbon is stored in the air in the form of carbon dioxide.

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Sophisticated answers: Sophisticated answers should indicate that carbon is stored in all organic matter (living or dead) as organic form and in the atmosphere as inorganic form. Furthermore students should indicate how carbon is stored in each of the options listed in the question.

Naïve answers: Students that possess a limited understanding of how carbon is stored in an ecosystem may answer “NO” to any of the questions. Furthermore, students may not understand that carbon can be stored in the molecules that make up organisms or as a gas in the atmosphere.

11. People need energy to live and grow. Which of the following is/are energy source(s) for people? Circle yes or no for each of the following and explain your answers.

- | | |
|--------------|----------|
| a. Water | Yes / No |
| b. Food | Yes / No |
| c. Nutrients | Yes / No |
| d. Exercise | Yes / No |
| e. Sunlight | Yes / No |

Please explain ALL your answers, including how each thing you circled “Yes” for supplies energy for people?

Purpose: The purpose of this item is to investigate how students identify energy source for humans

Sophisticated Answer: The correct answer is yes for d and no for all of the other choices. A sophisticated explanation describes digestion & biosynthesis as the process of humans gain energy from organic materials – Digestion and biosynthesis convert organic compounds of foods from one form to another, keeping most energy as chemical potential energy associated with organic substances (e.g. carbohydrates, fat, etc.) in human body.

Naïve Answers: Students tend to think that humans gain energy from multiple sources such as water, air, and sunlight. They also tend to think that energy is created in some events such as humans doing exercises.

12. A tree falls in the forest. After many years, the tree will appear as a long, soft lump barely distinguishable from the surrounding forest floor.



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- a. The mass of the lump on the floor is less than the mass of the original tree. Where do you think that the mass that is no longer in the lump has gone? In what form?

Purpose: The purpose of this question is to understand students' ideas about how matter changes in the event of decay and whether they identify the process of cellular respiration (decomposition) and trace matter in that process.

Sophisticated answers: A sophisticated answer identifies the process of decomposition – bacteria, termites, and fungi decompose the organic compound of the dead tree. The organic compound of the dead tree is first broken into simpler forms. Then, in the process of cellular respiration, the matter further reacts with oxygen and produce carbon dioxide and water. So, most mass of the dead tree is released as gases into the environment.

Naïve answers: Students may use the word “decomposition” in their explanation, but many of them cannot successfully trace matter in decomposition – they usually do not recognize that most mass of the tree becomes gases, carbon dioxide and water vapor. An example of naïve answers is that decomposers eat up the dead tree. Students may also think that the mass of the tree simply disappeared, or was absorbed directly by surrounding plants.

- b. What caused the changes in the wood? How did those changes happen? Give as many details as you can about what is breaking the wood down, and how this happens.

Purpose: The purpose of this question is to assess whether students identify decomposers in this event.

Sophisticated answers: Sophisticated answers should indicate that decomposers such as termites, bacteria and fungi decompose the remains of the tree: The organic compound of the dead tree is first broken into simpler forms. Then, in the process of cellular respiration, the matter further reacts with oxygen and produce carbon dioxide and water.

Naïve answers: Students often possess a limited understanding of the role of decomposers in an ecosystem. They may assume that the tree decomposed naturally or was eaten up by decomposers. It is also possible that some students may attribute decomposition to non-biological processes, such as rain or heat.

- c. Do you think that the process of decay involves energy? How?

Purpose: The purpose of this item is to uncover how students reason the phenomenon of decaying and whether they can identify the process of cellular respiration (decomposition) and trace energy in this process.

Sophisticated answers: A sophisticated explanation describes energy transformation and degradation in cellular respiration (decomposition) – in cellular respiration, bacteria use the energy of the dead tree for metabolism and heat is released at the same time. Finally the energy used for metabolism will also dissipate into environment in the form of heat.

Naïve answers: Students tend to reason based on their living experience with decay.

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They usually do not identify the process of cellular respiration underlying the event of decay. They tend to think that the energy always goes with matter: The matter of the dead tree becomes soil when the tree is decaying, so the energy of the dead tree must also go into the soil. They may also think that later other plants will get this part of energy by their roots.