
Initials

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

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

First Middle Last

Date _____

Class _____ Teacher _____

1. When you turn on a lamp, you can see the light. Where does the light energy come from? Trace the energy back as far as you can. You may or may not fill up all of the spaces in the table.

	What form of energy was it? Where was it?
	Light energy of the light
Before that…	
Before that…	
Before that…	
Before that…	
Before that…	

Purpose: *The purpose of the question is to understand to what extend, students trace energy back to energy resources.*

Sophisticated answer: *The sophisticated answer recognizes that light energy of the lamp comes from the electrical energy of the wires. Most electrical energy is transformed from the chemical energy of fossil fuels in power plants. Chemical energy of fossil fuels came from plants and animals living millions of years ago. That energy was transformed from the light energy of sunlight.*

Naïve answers: *Students may have difficulty tracing energy back to its resources. They may not have the knowledge that most electricity comes from burning fossil fuels.*

Initials

2. NASA scientists invented the EcoSphere – inside a sealed glass container, there are air, water, gravel, and three living things – algae, shrimp, and bacteria. Usually, these three living things can stay alive in the container for two or three years until the shrimp become too old and die. The picture above shows an EcoSphere and its inside part. The EcoSphere is a *closed* ecosystem and has no exchange of matter with the outside environment.

a) Do you think the EcoSphere has energy exchange with the outside environment?

Circle one: YES / NO

b) If your answer is NO, how do the living things stay alive without energy exchange with the outside world?

c) If your answer is YES, what is the energy input of the EcoSphere? What is the energy output of the EcoSphere? Please explain your answer.

Purpose: *The purpose of this item is to uncover students' understanding of energy in ecosystem – whether they can recognize energy degradation in ecosystem.*

Sophisticated Answer: *The correct choice is YES. Although the closed ecosystem has no exchange of matter with the outside environment, it must have energy exchange with the outside world. A sophisticated explanation recognizes both energy transformation and degradation in ecosystem: On the one hand, energy flows in food chain – shrimps and bacteria gain their energy from photosynthetic algae. On the other hand energy always degrades – the living things in the ecosystem are constantly doing cellular respiration to keep normal body function and physical activities and in cellular*

Initials

respiration, there is always part of energy lost as heat and becomes unavailable for the organisms to use. Thus, the useful energy of the ecosystem always degrades and the ecosystem requires constant energy input from outside to keep the organisms living. That energy comes from algae harvesting light energy through photosynthesis. In brief, the input energy is the sunlight energy and the output energy is heat released from cellular respiration.

Naïve Answers: *Students may think that energy always goes with matter. Thus, when there is no matter exchange with the outside world, there should not be energy exchange with the outside world. Students may also hold the idea that, since energy cannot be destroyed, the closed ecosystem does not require extra energy from outside world. This reasoning does not recognize that the total quantity of energy conserves, but the quality of energy decrease – the available energy degrades.*

Initials

3. When the baby was five months old, she weighed 15 lb. After 7 years, the tiny baby has grown into a big girl, weighing 50 lb.

	
The baby weighed 15 lb when she was 5 months old.	The baby has grown into a big girl, weighing 50 lb.

a) The baby gained weight as she grew. Where did the matter that she is made of come from? Please circle Yes or No for each of the following and explain your choices.

a. Sunlight Yes / No
b. Water Yes / No
c. Air Yes / No
d. Food Yes / No
e. Exercise Yes / No

b) Please explain your answer. Try to explain what happens inside the girl's body to each of the materials that you circled "Yes."

Purpose: *This purpose of this question is to explore the students' ideas about human growth and foods for humans.*

Sophisticated Answer: *The correct response should circle yes for foods and no for all the other choices. A sophisticated explanation addresses organic matter transformation in digestion and biosynthesis – organic compounds of foods are broken down into simpler compounds and go through digestive system and blood circulation to cells in different parts of human body. Then, these simpler organic compounds will be reassembled into more complicated organic compounds (e.g., fat), which are the building blocks for human body growth.*

Naïve Answers: *Students may hold the idea that everything taken in will contribute to the weight increase. They usually do not recognize organic carbon-containing substances as the major building blocks of human body. Thus, they may think that air and water become the body structure. They may recognize digestion, but they usually do not identify biosynthesis as the process involved in the event of animal and human growth. They may also think that the carbs/lipids/protein go directly to parts of the body without being broken down and reassembled.*

4. How are these three events related to each other:

- a person plugs in an air conditioner in the US
- trees grow in the Amazon forest

Initials

- ice in Antarctica 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 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.*

Initials

5. When you are riding in a car, the car burns gasoline to make it run. Eventually the gasoline tank becomes empty.

a) What happened to the **matter** the gasoline was made of?

Purpose: *The purpose of this question is to know how students reason the event of car consuming gasoline for moving and whether they can identify matter transformation in combustion of gasoline.*
Sophisticated Answer: *Sophisticated answer explains matter transformation in combustion of gasoline – the gasoline reacts with oxygen and produce carbon dioxide and water. So, the gasoline becomes gases and is released into the air after the reaction.*
Naïve Answers: *Based on their experience with car running, many students understand that gasoline is used to provide energy for car running, but they usually do not understand combustion in terms of chemical reaction. They may think that gasoline becomes energy to make the car run.*

b) When the gasoline tank becomes empty and the car stops, what happens to the **energy** of gasoline? Where does it go? Do you think the energy of gasoline still exists somewhere? Please explain your answers.

Purpose: *The purpose of this question is to know how students reason the event of car consuming gasoline for moving and whether they can use energy degradation in combustion for reasoning.*
Sophisticated Answer: *Sophisticated answer explains energy degradation in combustion – in combustion, a small part of the chemical potential energy of gasoline transforms into kinetic energy for car running and most chemical potential energy of gasoline dissipates as heat into the environment. The kinetic energy of car moving will finally transforms into heat into the environment. So, all the energy of gasoline finally dissipates into the environment as heat.*
Naïve Answers: *Based on their experience with car running, many students understand that gasoline is used to provide energy for car running. But, they usually do not identify combustion as the process underlying the event or do not understand energy transformation or degradation in combustion. As the result, they tend to think that energy of gasoline is used up to make the car run. Or, they may also think that energy always goes with matter and since gasoline becomes exhaust, energy must exits from the tailpipe with exhaust. Due to traditional ways of teaching energy and "work" in physics, we also expect some students think that energy of gasoline becomes "work" of car running. This idea does not recognize "work" as a process variable and has no meaning when the process ends.*

c) Do cars need air in order to run? Yes / No

Please explain your answer.

Purpose: *The purpose of this question is to know whether students can identify all the reactants in combustion of gasoline.*
Sophisticated Answer: *Sophisticated answer describes matter transformation in combustion of gasoline and recognizes oxygen as one reactant – the gasoline reacts with oxygen and produce carbon dioxide and water. So, the car needs oxygen in the air to run.*
Naïve Answers: *Based on their experience with car running, many students understand*

Initials

that gasoline is used to provide energy for car running, but they usually do not understand combustion in terms of chemical reaction. They may not recognize that oxygen is one of the reactants in combustion. They may think that gasoline becomes energy to make the car run.

Initials		

		
A. Eating a hamburger	B. Filling up a car with gasoline	C. Watering plants

6. The pictures above show three things happening.

a) Are these three events alike or different? Please explain your answer.

Purpose: *The purpose of these two items is to understand whether students can identify that plants gaining energy from sunlight while humans and car gain energy directly from energy-rich materials.*

Sophisticated Answer: *A sophisticated answer recognizes that A and B are similar events in the sense that both people and car gain energy from energy-rich materials (i.e., food and gasoline) and C is a different event since plants cannot gain energy from water. Plants need water to make organic materials, but the energy of plants comes from sunlight.*

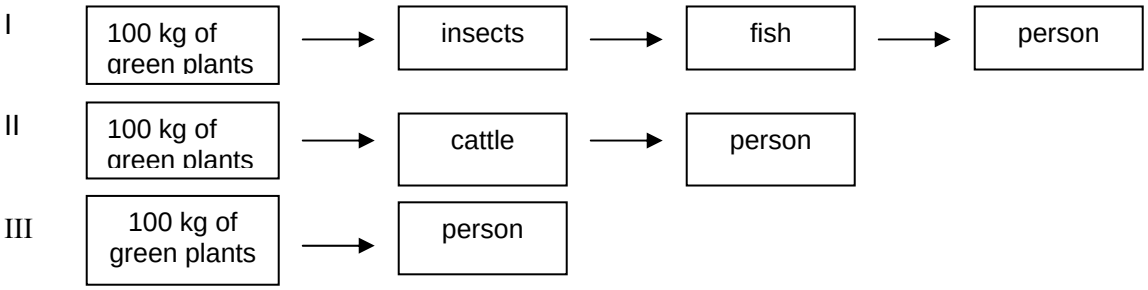
Naïve Answers: *Students tend to think that these events are similar since they all gain things from outside to make them function properly. They may also think that A and C are similar because they are about living systems, as opposed to B, which is about nonliving systems.*

b) A scientist says that A and B are similar events, but picture C is different from A and B. What reason do you think the scientist might have for saying that?

See above

Initials

7. Consider the three diagrams below. They represent three situations in which 100 kg of green plants serve as the original source of food for each of the food chains. In situation II, for example, cattle eat 100 kg of green plants and then people eat the beef that is produced by the cattle as a result of having eaten the plants.



In which of the three situations is the most energy available to the person?

a) I
b) II
c) III
d) Situations I and II will roughly tie for the most energy.
e) The same amount of energy will be available to the person in all three situations.

Please explain your answer.

Purpose: *The purpose of this item is to understand students ideas about matter transformation and energy transformation in ecosystem and the physical environment. In particular, we want to know how they understand the following two aspects: 1) Matter recycles because, although it transforms, it can always be used by organisms. 2) Energy degrades because, when energy transform, there is always part of the energy lost as heat and cannot be used by any organisms.*

Sophisticated Answers: *The correct choice is a. Sophisticated answers should include the idea of energy degradation in each tropic level. That is, each organism on the food chain requires energy for metabolic functions. This part of energy comes from the chemical energy of their body structure and will be ultimately dissipate into environment as heat. Thus, at each of the trophic levels, only a small part of energy will be passed on to the next trophic level.*

An example of sophisticated answer is:
In all of the three situations, the amount of incoming energy is the same – the energy contained in 100 kg green plants. While in situation I and II, insects, fish, and cattle will use a large part of the incoming energy for their metabolic function. This part of energy will ultimately dissipate into environment as heat and thus will not be passed on to the person. So, only in situation III, the food chain loses the least amount of energy to environment and thus pass on the largest amount of energy to the person.

Naïve answers:
1. a). I. b). Energy accumulates in food chain/web. In situation I, the person can gain the largest amount of energy, because energy accumulates along the food chain. The more organisms on the food chain, the more energy the top organism can gain.
2. a). II b). In situation II, because cow is bigger than fish and grass, so it contains more energy than fish and grass and thus can pass on more energy to the person.

Initials

8. 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.

a. The light energy is converted into glucose of the plants.
b. The light energy is converted into ATP in the plants.
c. The light energy is used up to power the process of photosynthesis.
d. The light energy becomes chemical bond energy.
e. 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.)

Purpose: *The purpose of this item is to know how students reason the event of plants using sunlight.*

Sophisticated answer: *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).*

Naïve answers: *Students usually do not distinguish light from conditions of living such as being healthy or warmth. Students at higher levels can recognize that light provide energy for plants to make foods, but a lot of them tend to think that light energy is used up to power the process of photosynthesis.*

Initials

9. When an apple is left outside for a long time, it rots.

a) What causes the apple to rot?

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 bacteria decompose the apple: The organic compound of the apple 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. They may assume that the apple 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.*

b) The weight of the apple decreases as it rots. What do you think happens to the mass/stuff that was once in the apple?

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 decompose the organic compound of the apple. The organic compound of the apple 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 apple 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 apple. Students may also think that the mass of the apple simply disappeared, or was absorbed directly by soil.*

c) Do you think that energy is involved when the apple rots? Yes / No
Please explain your answer.

Purpose: *Most middle and high school students recognize that food contains energy. The purpose of this item is to understand how students account for energy when the food is decaying.*

Sophisticated Answer: *A sophisticated answer identifies cellular respiration in the event of apple rotting and explains energy transformation and degradation in cellular respiration (decomposition) – in cellular respiration, bacteria use the energy of the apple 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. Their understanding of decay is usually context dependent. For example, when apply rots, its matter and energy goes to the air. But when tree decays, its matter and energy*

Initials

becomes soil. Students 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 apple must go to the air somehow, so the energy of the apple must also go to the air.

Initials

10. A small oak tree was planted in a meadow. After 20 years it has grown into a big tree, weighing 250 kg more than when it was planted.

the small oak tree

The big oak tree weighing 250 kg more than it was planted

a. Where did MOST of the extra 250 kg come from? Please circle the ONE source that contributed most to the tree's weight gain.

a. Soil
b. Air
c. Sunlight
d. Water
e. Minerals in soil
f. Other (Please list _____)

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.) Try to explain what happens inside the tree as it grows wood and leaves.

Purpose: *The purpose of these questions is to understand students' reasoning about plant growth and foods for plants.*

Sophisticated Answer: *The correct response is b. The sophisticated answer explains organic carbon production through photosynthesis – the increase in weight comes primarily from conversion of carbon dioxide and water into organic matter as a result of photosynthesis. Water and soil minerals also contribute some to the tree's mass (but only about 10-15% of the tree's total mass).*

Naïve Answers: *Students may not recognize that photosynthesis is the primary process enabling plants to build body structure. They may think that, plants, like people, gain their foods by taking in various solid and liquid materials such as nutrients in the soil, water, and so on. Students may also see sunlight as plant food, which is aligned with their idea about foods for humans. Students also tend to confuse minerals with organic substances produced in photosynthesis such as carbohydrates. Students who hold these alternative conceptions usually do not believe the scientific idea that CO_2 (a gas) can contribute to the weight gain of plants.*

b. Where did the oak tree get energy to grow and change? Please circle Yes or No for each of the following and explain your choices.

a.	Air	Yes	/	No
b.	Sunlight	Yes	/	No
c.	Water	Yes	/	No
d.	Minerals in soil	Yes	/	No
e.	Nutrients in soil	Yes	/	No

Initials

f. Plants make their own energy Yes / No

Please explain your answers. In particular, explain why the ideas you circled "No" for are NOT sources of energy for the tree.

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, and 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 take in is energy source for plants. Thus, they usually identify things plants absorb from soil as energy sources. Students are familiar with the statement that plants make their own foods, so many students interpret this statement as plants make their own energy.*

11. Do you think that wood is a mixture of different things? (Circle one) YES / NO

Please explain your ideas about what materials or substances are in wood.

Purpose: *The purpose of this item is to know whether and how students understand the atomic/molecular structure of wood.*
Sophisticated Answer: *The correct response is yes. Sophisticated answer explains that wood is a mixture of various substances and should identify some major substances including organic carbon-containing substances (such as cellulous) and water.*
Naïve Answers: *Students may recognize that wood is mixture but they usually cannot identify organic carbon-containing substances as the major component of wood.*

12. How is the air you breathe out different from the air you breathe in? Where does it change and how does it change?

Purpose: *The purpose of this item is to know how students understand cellular respiration as the chemical reaction underlying breathing.*
Sophisticated Answer: *The sophisticated explanation recognizes cellular respiration underlying breathing and explains matter transformation in cellular respiration – humans inhale oxygen, which reacts with the organic substances of our body structure and produce carbon dioxide and water. Thus, the air we breathe out has more carbon dioxide and water vapor but less oxygen.*
Naïve Answers: *Students may not recognize that air we breathe in is different from the air we breathe out. Or, they may understand breathing as a process of gas exchange – oxygen becomes carbon dioxide and thus do not recognize that the air we breathe out has more water vapor.*

13. An apple is eaten by a child and digested in his body.
a) What happens to the substances in the apple when it is digested?

Purpose: *The purpose of this item is to know how students understand digestion in human body.*
Sophisticated Answer: *The sophisticated answer recognizes that digestion happens in the child' body after he eats the apple. The apple is digested and its organic substances,*

Initials

most of which is sugar, are broken down into simpler molecules such as glucose.
Naïve Answers: *Students may not have limited knowledge on digestion and thus do not recognize that the substances of apple is broken down into simpler molecules by enzyme.*

b) How can the child's body use the substances in the apple to help his feet grow?

Purpose: *The purpose of this item is to know how students understand biosynthesis in human body.*
Sophisticated Answer: *The sophisticated answer recognizes that after digestion, the process of biosynthesis happens to synthesize substances from food into human body structure – after digestion, the simpler organic molecules are reassembled into more complex molecules such as fat molecules.*

Naïve Answers: *Students usually do not recognize biosynthesis or cannot identify it from digestion. They tend to think that things the child eats will becomes part of the child's body, but they may not know why and may not identify the matter transformation in the processes of digestion and biosynthesis.*