Formative Assessment Exemplar - BIO.2.3

Introduction:

The following formative assessment exemplar was created by a team of Utah educators to be used as a resource in the classroom. It was reviewed for appropriateness by a Bias and Sensitivity/Special Education team and by state science leaders. While no assessment is perfect, it is intended to be used as a formative tool that enables teachers to obtain evidence of student learning, identify gaps in that learning, and adjust instruction for all three dimensions (i.e., Science and Engineering Practices, Crosscutting Concepts, Disciplinary Core Ideas) included in a specific Science and Engineering Education (SEEd) Standard.

In order to fully assess students' understanding of all three dimensions of a SEEd standard, the assessment is written in a format called a cluster. Each cluster starts with a phenomenon, provides a task statement, necessary supporting information, and a sequenced list of questions using the gather, reason, and communicate model (Moulding et al., 2021) as a way to scaffold student sensemaking. The phenomenon used in an assessment exemplar is an analogous phenomenon (one that should not have been taught during instruction) to assess how well students can transfer and apply their learning in a novel situation. The cluster provides an example of the expected rigor of student learning for all three dimensions of a specific standard. In order to serve this purpose, this assessment is NOT INTENDED TO BE USED AS A LESSON FOR STUDENTS.

Because this assessment exemplar is a resource, teachers can choose to use it however they want for formative assessment purposes. It can be adjusted and formatted to fit a teacher's instructional needs. For example, teachers can choose to delete questions, add questions, edit questions, or break the tasks into smaller segments to be given to students over multiple days.

General Format:

Each formative assessment exemplar contains the following components:

1. Teacher Facing Information: This provides teachers with the full cluster as well as additional information including the question types, alignment to three dimensions, and answer key. Additionally, an example of a proficient student answer and a proficiency scale for all three dimensions are included to support the evaluation of the last item of the assessment.
2. Students Facing Assessment: This is what the student may see. It is in a form that can be printed or uploaded to a learning platform. (Exception: Questions including simulations will need technology to utilize during assessment.)

Accommodation Considerations:

Teachers should consider possible common ways to provide accommodations for students with disabilities, English language learners, students with diverse needs or students from different cultural backgrounds. For example, these accommodations may include: Providing academic language supports, presenting sentence stems, or reading aloud to students. All students should be allowed access to a dictionary.

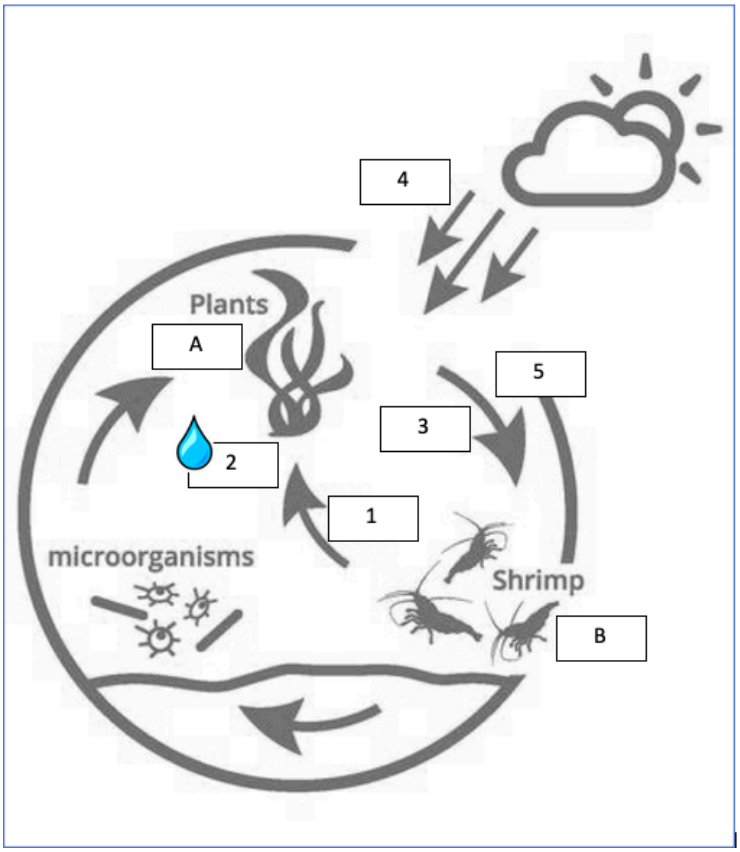
References:

Moulding, B., Huff, K., & Van der Veen, W. (2021). *Engaging Students in Science Investigation Using GRC*. Ogden, UT: ELM Tree Publishing.

Teacher Facing Information

Standard: BIO.2.3

Assessment Format: Printable or Online Format (Does not require students to have online access)

Phenomenon	
A teacher bought a Shrimp Bubble Ecosystem Kit, which is a self-sustaining aquatic ecosystem. It has minimum maintenance required: no daily feeding, no filtration and no frequent water changes. The system is a closed system--nothing goes in, nothing comes out (after initial set up). The kit includes 3 to 4 live opae ula marine shrimp, live algae, microorganisms, and natural decorations. The following year, a sibling of a student that saw the Shrimp Bubble Ecosystem last year was amazed that the shrimp are not only still alive, but they are getting bigger and thriving. Using what you know, **develop and use a model** to illustrate the cycling of matter and flow of energy through living things in this ecosystem. 	Proficient Student Explanation of Phenomenon:  image from bubbleshrimp.org Process: ● A--Photosynthesis ● B--Cellular Respiration Components: ● 1--CO_2 ● 2--Water H_2O ● 3--O_2 or Glucose $C_6H_{12}O_6$ ● 4--Light energy ● 5--O_2 or Glucose $C_6H_{12}O_6$ Energy flows: Light energy → chemical energy → mechanical energy → thermal

	energy Matter cycles: the products of one process become the reactants of the other process and the cycle is continuous (goes on and on and on) Label the model and write a description of what is shown in the drawing.

Cluster Task Statement

(Represents the ultimate way the phenomenon will be explained or the design problem will be addressed)

In the following questions, you will use data provided to **develop and use a model** to illustrate the cycling of matter and flow of energy through living things in this ecosystem.

Supporting Information

The algae are photosynthetic organisms. The shrimp feed on algae and microorganisms and release waste and carbon dioxide into the water. Microorganisms feed on shrimp's waste and break it down into dissolved simple nutrients. The algae use the nutrients and the carbon dioxide for growth. ramp-alberta.org

The opae ula shrimp (*Halocaridina rubra*) originates from Hawaii Islands, where they live in brackish water pools formed in inland lava depressions close to the ocean shoreline, which are connected via underground tunnels to the ocean as well as groundwater. These brackish water pools are considered extreme living environments, where the water undergoes (gradual) wide swings in salinity, temperature and exposure to UV radiations from the sun. The opae ula shrimp have adapted to survive in this harsh environment.

Figure 1

To better understand the Shrimp Bubble ecosystem, students ran an analogous experiment using Elodea aquatic plants and snails in a closed system. Students placed an Elodea sprig AND a snail in test tube A. Students placed an Elodea sprig in test tube B. Students placed a snail in test tube C. The students didn't place any organisms in test tube D. Below are the results after 24 hours.

Figure 2

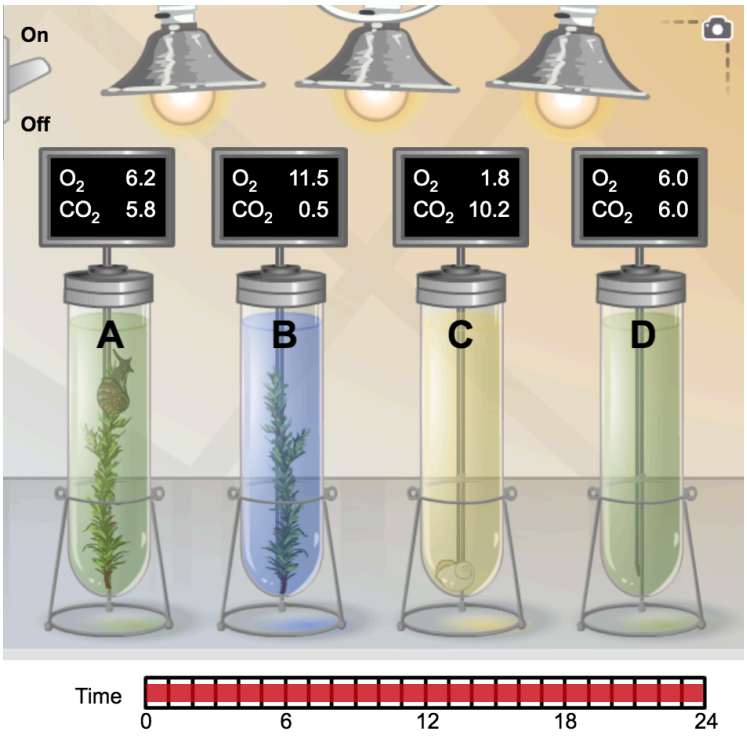


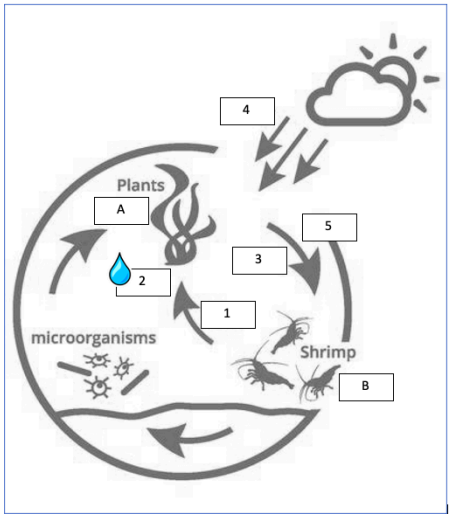
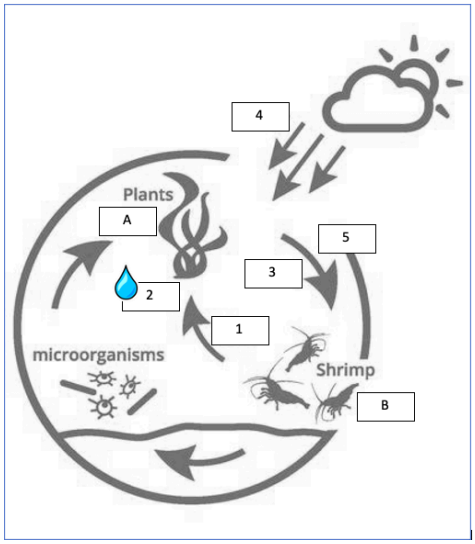
Image adapted from Gizmos labs. Explorelearning.org

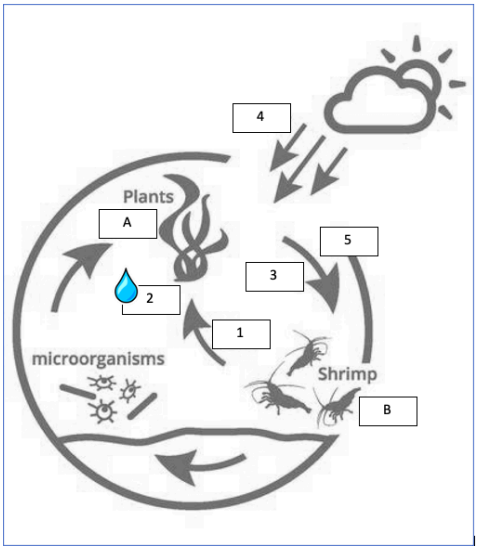
Figure 2 Is an image of an experiment that some students performed in the lab. A sprig of Elodea and a snail were placed in the first test tube. Only Elodea was included in the second test tube. Only a snail was included in the third test tube. No living organisms were included in the last test tube. Bromothymol blue was also placed in the test tube water in all 4 test tubes.. Bromothymol blue (also known as BTB) is a commonly used indicator that indicates carbon dioxide levels in water. In high levels of CO2 the indicator turns yellow, while in low levels of CO2 the indicator turns blue. (See figure 3)

Figure 3

Carbon Dioxide Levels	Color (with bromothymol blue indicator)
High Co_2 Levels	Yellow
Normal CO_2 levels	Green
Low CO_2 levels	Blue

Cluster Questions	
Gather: Cluster Question #___1___ Question Type: **short Answer:** Fill in the blank Addresses: __X__ DCI	Question 1: Using the text and Figures above: **Identify process A (plants)**. **Identify process B (animals)**.

_____ SEP __x__ CCC- Energy and Matter Answer: A--photosynthesis B--cellular respiration *word bank could be provided	
Gather: Cluster Question #___2___ Question Type: **short Answer:** Fill in the blank Addresses: __X__ DCI __X__ SEP- Modeling __x__ CCC- Energy and Matter Answer: 1--CO_2 2--Water H_2O 3--O_2 or Glucose $C_6H_{12}O_6$ 4--Light energy 5--O_2 or Glucose $C_6H_{12}O_6$ *word bank could be provided	Question 2: Using the text and Figures above: **Identify components 1-5** 
Reason: Cluster Question #___3___ Question Type: Table Match Addresses: __X__ DCI _____ SEP __X__ CCC -Matter and energy Answer: 1. Light energy 2. Chemical energy 3. Mechanical energy	Question 3: What energy transformations take place during the various chemical changes (process A and process B) in the system? Place the types of energy in order as they would occur in the system 1. Light energy 2. Chemical energy 3. Mechanical energy 4. Thermal energy *Teachers: define these terms at your own discretion.

4. Thermal energy	
Reason: Cluster Question #___4___ Question Type: **Short Answer:** short sentences Addresses: __X__ DCI _____ SEP __X__ CCC -Matter and energy Answer: Photosynthesis-- converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. Cellular Respiration-- Cellular respiration is a chemical process whereby the bonds of glucose molecules and oxygen molecules are broken and new compounds are formed that can transport energy.	Question 4: Using one of the processes (A or B) from question 1, describe how the atoms in the molecules are rearranged into different molecules.
Communicate: Cluster Question #___5___ Question Type: Addresses: __X__ DCI __X__ SEP- Modeling __X__ CCC-Matter and energy Answer: The energy from the sun drives the cycles. The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. As a result of these chemical	Question 5: Referencing the model used in the previous questions, describe how the flow of energy between process A and process B drives the cycling of matter between plants and animals? Include both the processes and the molecular components. 

reactions, energy is transferred from one system of interacting molecules to another and releases energy to the surrounding environment and to maintain body temperature. Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	

Proficiency Scale

Proficient Student Explanation:

The energy from the sun drives the cycles. The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.

As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and releases energy to the surrounding environment and to maintain body temperature.

Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

Level 1 - Emerging	Level 2 - Partially Proficient	Level 3 - Proficient	Level 4 - Extending
SEP: Does not meet the minimum standard to receive a 2.	**SEP:** Evaluate limitations of a model for a proposed object or tool. Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. Use and/or develop a model of simple systems with uncertain	**SEP:** Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. Design a test of a model to ascertain its reliability.	**SEP:** Extends beyond proficient in any way.

	and less predictable factors. 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 and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. Develop a complex model that allows for manipulation and testing of a proposed process or system. Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	
CCC: Does not meet the minimum standard to receive a 2.	**CCC:** Recognizes that matter is conserved because atoms are conserved in physical and chemical processes. Can track the transfer of energy drives the motion and/or cycling of matter, within a	**CCC:** Recognizes that the total amount of energy and matter in closed systems is conserved. Describes changes of energy and matter in a system in terms of energy and matter	**CCC:** Extends beyond proficient in any way.

	natural or designed system. Recognizes energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). Understands that the transfer of energy can be tracked as energy flows through a designed or natural system	flows into, out of, and within that system. Recognizes that energy cannot be created or destroyed because it only moves between one place and another place, between objects and/or fields, or between systems. Understands that energy drives the cycling of matter within and between systems. Recognizes that In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	
DCI: Does not meet the minimum standard to receive a 2.	**DCI:** 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.	**DCI:** The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules	**DCI:** Extends beyond proficient in any way.

		to another and releases energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.	

(Student Facing Format on following page)

Name: _____ Date: _____

Stimulus

A teacher bought a Shrimp Bubble Ecosystem Kit, which is a self-sustaining aquatic ecosystem. It has minimum maintenance required: no daily feeding, no filtration and no frequent water changes. The system is a closed system--nothing goes in, nothing comes out (after initial set up). The kit includes 3 to 4 live opae ula marine shrimp, live algae, microorganisms, and natural decorations.

The following year, a sibling of a student that saw the Shrimp Bubble Ecosystem last year was amazed that the shrimp are not only still alive, but they are getting bigger and thriving.

Figure 1: Shrimp Bubble Ecosystem

Figure 1 is an image of the shrimp bubble ecosystem with water, shrimp and decorations shown.

The algae are photosynthetic organisms. The shrimp feed on algae and microorganisms and release waste and carbon dioxide into the water. Microorganisms feed on shrimp's waste and break it down into dissolved simple nutrients. The algae use the nutrients and the carbon dioxide for growth. (ramp-alberta.org)

The opae ula shrimp (*Halocaridina rubra*) originates from Hawaii Islands, where they live in brackish water pools formed in inland lava depressions close to the ocean shoreline, which are connected via underground tunnels to the ocean as well as groundwater. These brackish water pools are considered extreme living environments, where the water undergoes (gradual) wide swings in salinity, temperature and exposure to UV radiations from the sun. The opae ula shrimp have adapted to survive in this harsh environment.

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FIgure 2: Results from Student Experiment

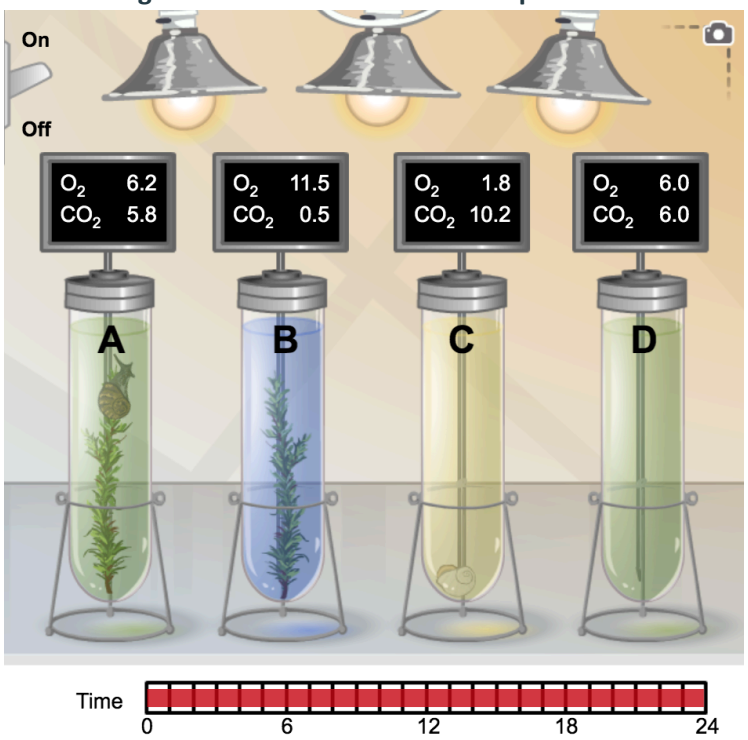

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Table 1: Carbon Dioxide Levels and Bromothymol Blue Color

Carbon Dioxide Levels	Color (with bromothymol blue indicator)
High Co_2 Levels	Yellow
Normal CO_2 levels	Green
Low CO_2 levels	Blue

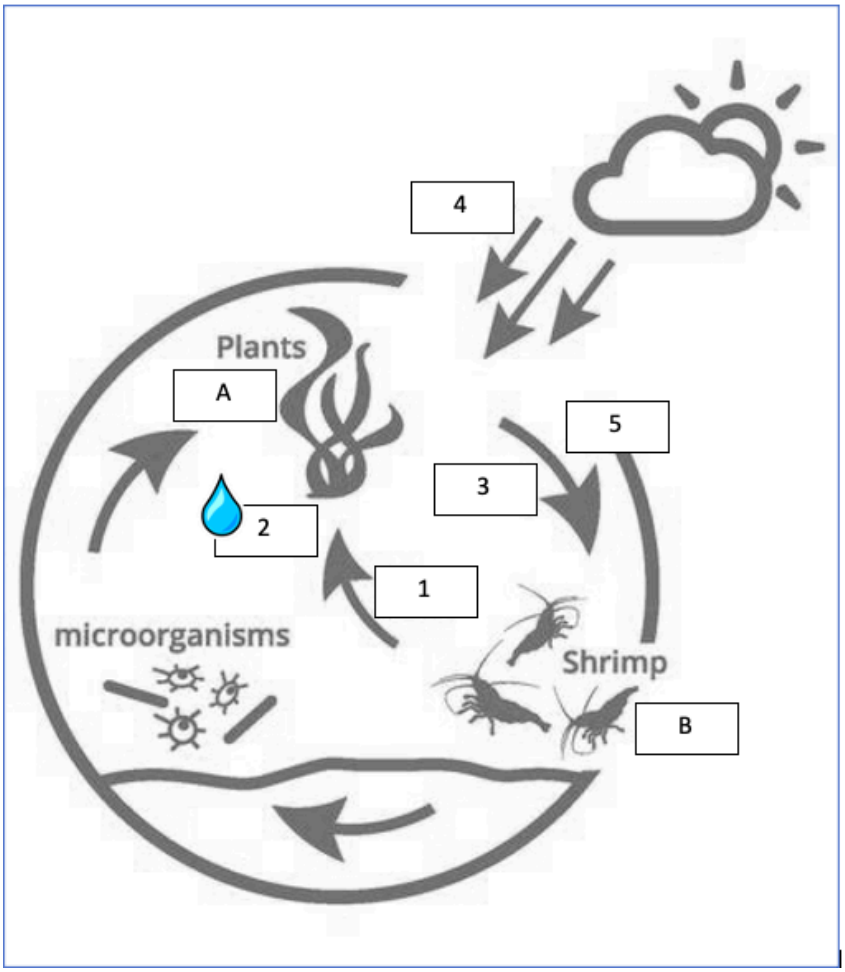
Table 1 shows the color of the indicator Bromothymol Blue with different levels of carbon dioxide present.

Your Task

In the following questions, you will use data provided to **develop and use a model** to illustrate the cycling of matter and flow of energy through living things in this ecosystem.

Question 1

Model of Shrimp Bubble Ecosystem

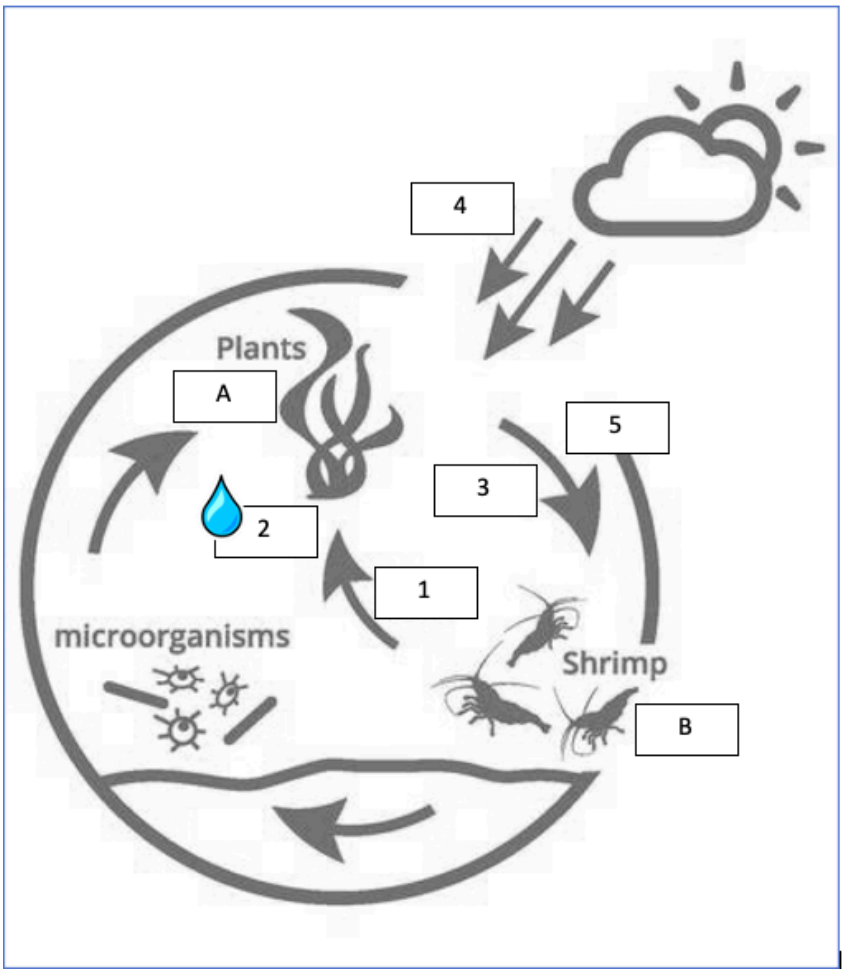


Identify process A in the model above (plants): _____

Identify process B in the model above (animals): _____

Question 2

Model of Shrimp Bubble Ecosystem



Identify components 1-5 in the model above.

1. _____
2. _____
3. _____
4. _____
5. _____

Question 3

What energy transformations take place during the various chemical changes (process A and process B) in the system? Place the types of energy in order as they would occur in the system:

1. Light energy
2. Chemical energy
3. Mechanical energy
4. Thermal energy

Question 4

Using one of the processes (A or B) from the model in question 1, describe how the atoms in the molecules are rearranged into different molecules.

_____

_____

_____

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_____

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Question 5

Referencing the model used in questions 1 and 2, describe how the flow of energy between process A and process B drives the cycling of matter between plants and animals? Include both the processes and the molecular components.

_____

_____

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_____