Stanford NGSS Integrated Curriculum

An Exploration of a Multidimensional World

UNIT 3

Mimicking Nature's Design

How does energy and matter flow within natural and designed systems?

SCALE

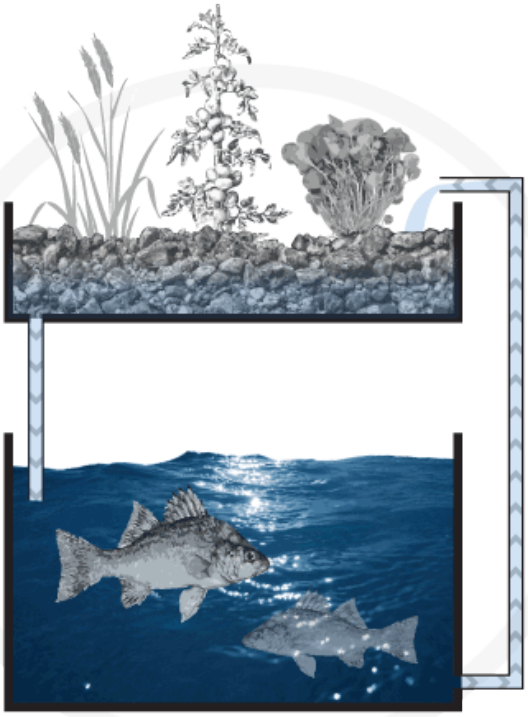
Stanford Center for Assessment, Learning & Equity

7th Grade Science Unit 3: Mimicking Nature's Design
Culminating Project

Unit Essential Question: *How does energy and matter flow within natural and designed systems?*

Challenge

Real ecosystems, like the river environment you saw in the Lift-Off, have natural cycles that keep them functioning and healthy all on their own! By studying real ecosystems, we can learn how to replicate these cycles in artificial environments of our own making. Aquaponics systems, like the one shown to the right, use our understanding of real ecosystems to create an environment that sustains itself (keeps itself going on its own). Matter and energy flow within and between the garden on top and the fish tank below, providing each environment with the factors it needs to thrive.



http://www.next.cc/journey/design/aquaponics

For this unit's project, your group's task is to use what you learn about how energy and matter flow through ecosystems in order to design and build a sustainable aquaponics system that mimics the properties of a river environment. Individually, you will then write an instruction manual that describes your aquaponics system and explains the science behind how it functions.

Group Project Criteria for Success

Your sustainable aquaponics system should include:

- ❑ A garden and a fish tank, connected
- ❑ Essential non-living parts of an environment needed to support life
- ❑ Living organisms that do cellular respiration and photosynthesis
- ❑ Heat-regulation devices to maintain the temperature of your fish tank

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Individual Project Criteria for Success

The instruction manual for your aquaponics system should include:

- ❑ A diagram of your aquaponics system
  - Label all living and non-living parts in your system

- ❑ Identify at least one organism that does cellular respiration in your aquaponics system
  - Model and describe the process of cellular respiration (using pictures, labels, arrows, and captions)
  - In your model, make sure to show and explain how matter is conserved in this chemical reaction

- ❑ Identify at least one organism that does photosynthesis in your aquaponics system
  - Model and explain the process of photosynthesis (using pictures, labels, arrows, and captions)
  - In your model, make sure to show all forms of energy and matter involved
  - Cite evidence from Task 3 to support your explanation

- ❑ Model and describe which processes of the rock cycle might occur in your aquaponics system over time
  - Identify the flow of energy that drives the processes you identify
  - Explain why some of the rock cycle processes you explored in Task 4 will not occur in your aquaponics system and are not seen in short time periods

- ❑ Identify and explain one physical and one chemical change that will occur in your aquaponics system
  - Use data from Task 1 to explain how looking at macroscopic properties of matter can help you determine whether physical or chemical changes are happening at the microscopic level
  - Describe any effects these changes will have on your system and propose potential solutions to minimize these effects

- ❑ Draw a diagram of the heat-regulation device you designed and explain how it will work in your aquaponics system
  - Describe the design process that led you to your final product

- ❑ Discuss the benefits and limitations of an aquaponics system
  - How does this model help us mimic a natural environment that sustains itself, like the river environment?
  - How does an aquaponics system not function exactly like a natural system?

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Instruction Manual Peer Review Feedback

Complete after you have a full first draft of your instruction manual.

Instruction Manual Owner's Name	
Instruction Manual Reviewer's Name	

Review the following sections of the Instruction Manual:

- ❑ A diagram of your aquaponics system
  - Label all living and non-living parts in your system

  ➢ Positive Comment:

  ➢ Constructive Comment:

- ❑ Identify at least one organism that does cellular respiration in your aquaponics system
  - Model and describe the process of cellular respiration (using pictures, labels, arrows, and captions)
  - In your model, make sure to show and explain how matter is conserved in this chemical reaction

  ➢ Positive Comment:

  ➢ Constructive Comment:

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- ❑ Identify at least one organism that does photosynthesis in your aquaponics system
  - Model and explain the process of photosynthesis (using pictures, labels, arrows, and captions)
  - In your model, make sure to show all forms of energy and matter involved
  - Cite evidence from Task 3 to support your explanation

  - ➢ Positive Comment:

  - ➢ Constructive Comment:

- ❑ Model and describe which processes of the rock cycle might occur in your aquaponics system over time
  - Identify the flow of energy that drives the processes you identify
  - Explain why some of the rock cycle processes you explored in Task 4 will not occur in your aquaponics system and are not seen in short time periods

  - ➢ Positive Comment:

  - ➢ Constructive Comment:

- ❑ Identify and explain one physical and one chemical change that will occur in your aquaponics system
  - Use data from Task 1 to explain how looking at macroscopic properties of matter can help you determine whether physical or chemical changes are happening at the microscopic level
  - Describe any effects these changes will have on your system and propose potential solutions to minimize these effects

  - ➢ Positive Comment:

- Constructive Comment:

- ❑ Draw a diagram of the heat-regulation device you designed and explain how it will work in your aquaponics system
  - Describe the design process that led you to your final product

  - Positive Comment:

  - Constructive Comment:

- ❑ Discuss the benefits and limitations of an aquaponics system
  - How does this model help us mimic a natural environment that sustains itself, like the river environment?
  - How does an aquaponics system not function exactly like a natural system?

  - Positive Comment:

  - Constructive Comment:

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3-Dimensional Individual Project Rubric

Overview: The following rubrics can be used to assess the individual project: the aquaponics system instruction manual. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on your Culminating Project Student Instructions. Use these rubrics to see if you are doing your best work on your individual project.

Rubric 1: Student develops a model to describe the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student develops an **incomplete** model to describe the process of cellular respiration that occurs within an animal in their aquaponics system. OR Student develops **a partial written explanation** to describe the process of cellular respiration that occurs within an animal in their aquaponics system.	Student develops a **partial** model to describe the process of cellular respiration that occurs within an animal in their aquaponics system. OR Student develops **a complete written explanation** to describe the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved.	Student develops a **complete** model to describe the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved.	Student develops a **complete** model to describe **in detail** the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved.

Rubric 2: Student describes that matter is conserved, specifically within the context of the cellular respiration chemical reaction.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student uses a model to describe that matter is **not** conserved within the context of the cellular respiration chemical reaction.	Student **explicitly** describes that matter is conserved, **but not** specifically within the context of the cellular respiration chemical reaction.	Student **implicitly** describes that matter is conserved, specifically **within the context** of the cellular respiration chemical reaction.	Student **explicitly** describes that matter is conserved, specifically **within the context** of the cellular respiration chemical reaction.

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3-Dimensional Individual Project Rubric

Rubric 3: Student describes photosynthesis, explaining how energy drives the cycling of matter and supporting the explanation with evidence from the tasks.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **partially** describes photosynthesis, but **does not** support the explanation with evidence from the tasks.	Student **partially** describes photosynthesis, supporting the explanation with evidence from the tasks.	Student **completely** describes photosynthesis, **implicitly** explaining how energy drives the cycling of matter and supporting the explanation with evidence from the tasks.	Student **completely** describes photosynthesis, **explicitly** explaining how energy drives the cycling of matter and supporting the explanation with evidence from the tasks.

Rubric 4: Student develops a model to show the cycling of Earth's materials in the aquaponics system and describes the flow of energy that drives this process.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student develops a **partial** model to show the cycling of Earth's materials in the aquaponics system with no descriptions.	Student develops a **partial** model to show the cycling of Earth's materials in the aquaponics system and **partially** describes the flow of energy that drives this process.	Student develops an **accurate** model to show the cycling of Earth's materials in the aquaponics system and **partially** describes the flow of energy that drives this process.	Student develops an **accurate** model to show the cycling of Earth's materials in the aquaponics system and **completely** describes the flow of energy that drives this process.

Rubric 5: Student explains why some rock cycle processes will not occur in their aquaponics system by examining each process at different time scales.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** explains why some rock cycle processes will not occur in their aquaponics system.	Student explains why some rock cycle processes will not occur in their aquaponics system **but does not** examine each process at different time scales.	Student **partially** explains why some rock cycle processes will not occur in their aquaponics system by examining each process at different time scales.	Student **completely** explains why some rock cycle processes will not occur in their aquaponics system by examining each process at different time scales.

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3-Dimensional Individual Project Rubric

Rubric 6: Student identifies a physical and chemical change that occurs in their aquaponics system, supporting identifications with an explanation of how macroscopic patterns allow them to determine the microscopic structure for each change.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student identifies **at least one accurate** physical and/or chemical change that occurs in their aquaponics system, **with no explanation**.	Student identifies **at least one accurate** physical and/or chemical change that occurs in their aquaponics system, supporting identifications with an explanation of macroscopic patterns **OR** microscopic patterns.	Student **accurately** identifies a physical and chemical change that occurs in their aquaponics system, supporting identifications with an **implicit** explanation of how macroscopic patterns allow them to determine the microscopic structure for each change.	Student **accurately** identifies a physical and chemical change that occurs in their aquaponics system, supporting identifications with an **explicit** explanation of how macroscopic patterns allow them to determine the microscopic structure for each change.

Rubric 7: Student shows and explains how their design uses a chemical reaction to release heat and describes their design process.

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **partially** shows and explains how their design uses a chemical reaction to release heat and **partially** describes their design process. OR Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **does not** describe their design process.	Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **partially** describes their design process.	Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **mostly** describes their design process.	Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **completely** describes their design process.

7th Grade Science Unit 3: Mimicking Nature's Design
Project Organizer

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

You will be creating a sustainable aquaponics system that mimics the properties of a river environment. After each task, you will return to the table below to organize what you learn as you go through the unit. By the end of the five tasks, you will have all this information to use for your culminating project. For each activity, be sure to include answers to **ALL** the questions provided.

Lift-Off Task: Changing Rivers	What did you see in the pictures that you might also want to include in your aquaponics system (garden and tank)?

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Project Organizer

Task 1: Types of Changes	Now that you understand physical and chemical changes on the molecular level, identify one physical change and one chemical change that you anticipate may occur in your aquaponics system. ❒ Draw a before and after picture of your aquaponics system for each change and write a caption explaining each. ○ Use data from this task, or research the properties of your own environmental change, to explain how you know what type of change it is. ❒ For each change, decide if it represents a threat to your aquaponics system. If it is a threat, describe a potential solution to prevent it.

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Project Organizer

Task 2: Matter Moves You	Identify or add an organism to your aquaponics system that does cellular respiration. ❒ Identify what molecules the organism requires for cellular respiration. How will your system provide these molecules? ❒ Identify what molecules the organism will create through this process. How will your system use up the products that it creates? ❒ Draw a picture of your organism and the molecules identified. Use arrows to show which molecules enter or leave the organism.
Task 3: Cycling Matter Through Living Things	Identify or add an organism to your aquaponics system that does photosynthesis. ❒ Identify what molecules it will need to have in order to do photosynthesis. How will your system provide what the organism needs? ❒ Identify what molecules it will create through this process. How will the system use up the products that it creates? ❒ Draw a picture of your organism and the molecules identified, using arrows to show whether the molecules enter or leave the organism. ❒ Make connections to the organism you chose after Task 2: How do the plant and animal work together to cycle matter and keep energy flowing through the system?

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Project Organizer

Task 4: Cycling Matter Through Rocks	Look back at the design sketch for your aquaponics system from Task 1: ❒ How might cycling of matter come into play in your aquaponics system? ❒ Describe which process(es) of the rock cycle might occur in your aquaponics system over time. ❒ What will the effects be on your system?
Task 5: Design a Thermal Device	Now that you have designed a heat-regulation device to help maintain river water temperature, you can use this knowledge to design your own heat-regulation devices that will work to maintain the temperature of your aquaponics fish tank. ❒ Draw the final heat-regulation device. ○ Label the materials used and explain how it works. ❒ Describe how you combined best characteristics of different designs to create a device that best meets the criteria and constraints. ○ Cite the data that supported your decisions.

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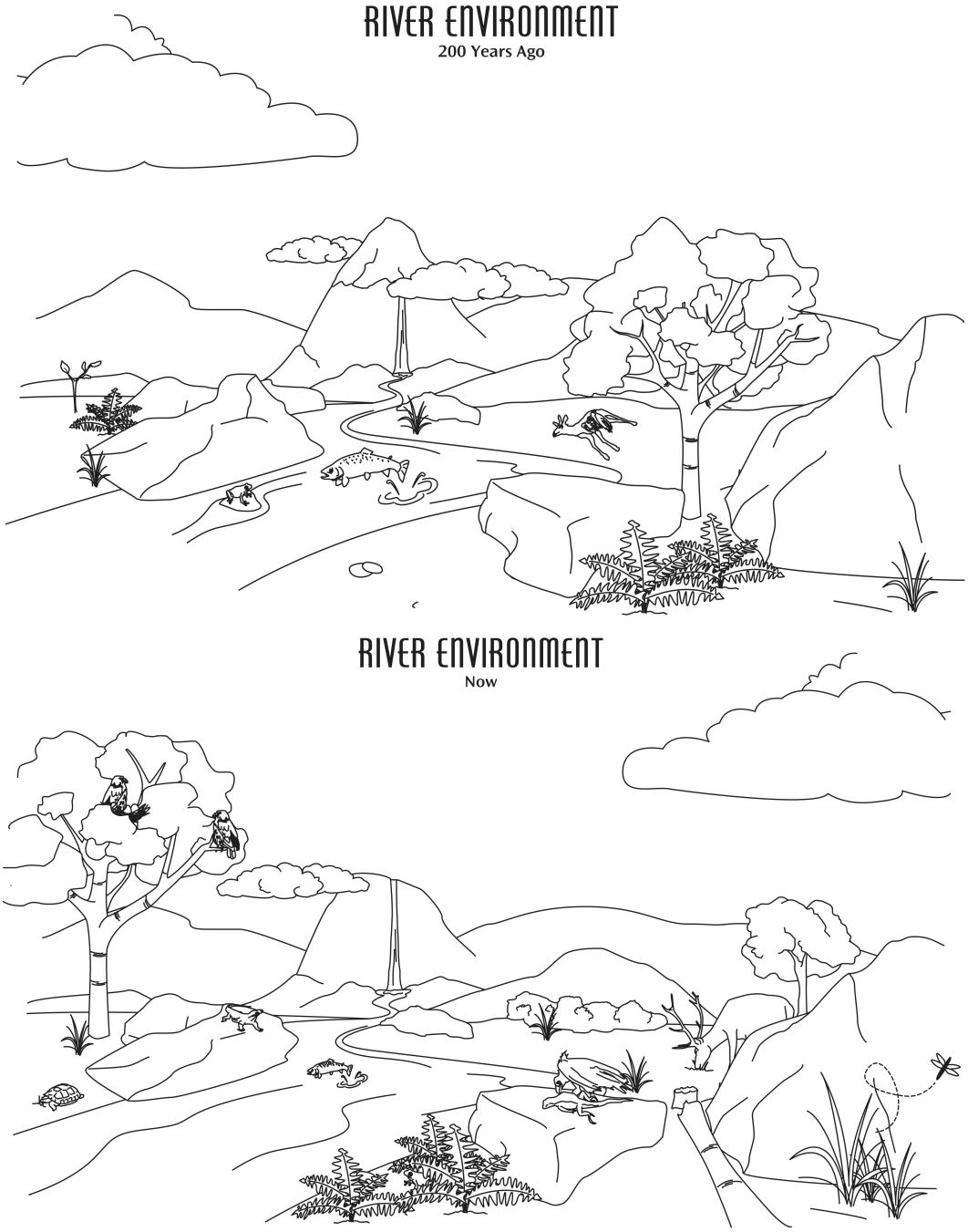
Lift-Off Task: Changing Rivers

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

The pictures below show what a river environment looked like 200 years ago and what it looks like today. What do you notice?



A river environment with diverse forms of living and nonliving matter. Source: Making Sense of Science Earth Systems course, courtesy of WestEd.

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Lift-Off Task: Changing Rivers

Part A: If you wanted to know more about what is happening in these pictures of the river environment, what questions would you ask? Individually record any questions you would need to ask to get a better understanding of this river environment over time.

Part B: As a group,

- Discuss what questions each member wrote on his or her list.
- On a large piece of poster paper:
  - Write the phrase "Past vs. Present River Environment" in the middle of your poster and draw a circle around it.
  - Around the circle, record the questions that were similar across your group members.
  - Draw lines to link together questions that relate to each other.
  - Draft possible answers to the questions, using your prior knowledge. Connect these to the questions on your poster.
- Post your group poster on the wall.
- Walk around and look at each groups' ideas.

Part C: As a whole class,

- Construct a class concept map with the phenomenon in the middle: "Past vs. Present River Environment".
  - Decide which key questions you want to have on the concept map.
  - Draw lines with arrows between two key questions to show that there is a relationship.
  - Make as many connections as you can between the questions on the concept map.
- It's important for everyone to share their ideas and it's okay if you don't agree.
- You will revise and add new questions and information to this concept map as you learn more about ecosystems.

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Lift-Off Task: Changing Rivers

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Connecting to the Culminating Project

You will be creating a sustainable aquaponics system that mimics the properties of the river environment you saw today. What did you see in the pictures that you might also want to include in your aquaponics system (garden and tank)?

This should be completed individually in your Project Organizer.

Reflection

Individually reflect on the Lift-Off Task, using the questions provided:

1. At the beginning of this task, you made a list of all the questions you have about the river environment in the past vs. the present. Look back at your list: think about the questions your peers asked that you did not initially write down. How are their questions different from the ones you originally asked?

2. In this unit, we will be focusing on three crosscutting concepts:
    - **Patterns**: Macroscopic patterns are related to microscopic structure.
    - **Energy and Matter**: The transfer of energy can be tracked as it flows through a system, is conserved, and drives the cycling of matter.
    - **Stability and Change**: Stability and change can be explained by looking at changes over time and at different scales.

    Looking at your class concept map, give one example of how a crosscutting concept came up in today's task.

3. Now that you understand what project you'll be working on over the course of this unit, what else do you need to know? What additional questions do you have?

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Task 1: Types of Changes

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Engage

In the Lift-Off Task, you likely observed many differences between the river environment 200 years ago and the river environment today. What processes are behind these differences? In this task, you will investigate the kinds of changes that happen in environments over time.

A river environment with diverse forms of living and nonliving matter. Source: Making Sense of Science Earth Systems course, courtesy of WestEd.

With a partner,

1. Make a list of all the differences you observe between the two images of the river environment.

2. Group the differences into similar types of changes and record those groupings below.

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Task 1: Types of Changes

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explore

As you saw in the river environment images, there are many different examples of changes that happen in environments over time. To investigate the processes involved in these changes, let's look at the data for two common changes in environments: Plant growth and fog rising off water.

Analyzing and Interpreting Data: As a group, analyze the data tables below and respond to the questions that follow.

Data Set 1 - Plant Growth: Plants use energy from the sun to create their own food.

Reactants substances at beginning of reaction		Products substances at the end of the reaction	
Carbon Dioxide (in air) (CO_2)	Water (liquid) (H_2O)	Glucose (in plant) ($C_6H_{12}O_6$)	Oxygen (in air) (O_2)
Properties density: 1.98 kg/m3 melting point: -56.6 C boiling point: -78.5 C	Properties density: 1 g/cm3 melting point: 0 C boiling point: 100 C	Properties density: 1.54 g/cm3 melting point: 146 C boiling point: decomposes before boiling	Properties density: 1.43 g/L melting point: -218.8 C boiling point: -183 C

1. What are the reactants in this change?

    a. Where would you find each reactant in an environment?

2. What are the products in this change?

    a. Where would you find each product in an environment?

3. Compare the properties of the reactants to the properties of the products. How are they the same or different?

Data Set 2 - Fog Rising Off Water: Water evaporates from the pond's surface and cools, condensing into a fog that looks like steam.

Reactants substances at beginning of reaction	Products substances at the end of the reaction
Pond Water (liquid) (H_2O)	Fog - Water (gas) (H_2O)
Properties density: 1 g/cm3 melting point: 0 C boiling point: 100 C	Properties density: 1 g/cm3 melting point: 0 C boiling point: 100 C

1. What are the reactants in this change?

    a. Where would you find each reactant in an environment?

2. What are the products in this change?

    a. Where would you find each product in an environment?

3. Compare the properties of the reactants to the properties of the products. How are they the same or different?

7th Grade Science Unit 3: Mimicking Nature's Design

Task 1: Types of Changes

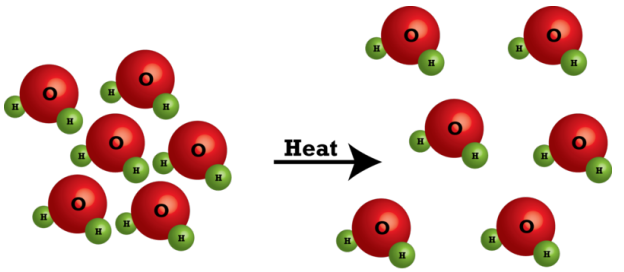
How does fog rising off water compare to plant growth?

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

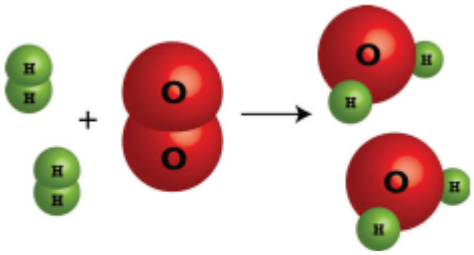
Explain

One of the changes you observed in the *Explore* is known as a physical change and the other change you observed is known as a chemical change. Take a look at the models below that show a physical change vs. a chemical change.

Physical Change



Chemical Change



With a partner, discuss and respond to the following questions:

1. Based on the models above, what seems to be the biggest difference between a physical and chemical change?

   a. Write your own definition for physical change.

   b. Write your own definition for chemical change.

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Task 1: Types of Changes

2. **Patterns:** Look back at the data from the *Explore*.
    a. What difference(s) did you notice between Data Set 1 (Plant Growth) and Data Set 2 (Fog Rising From Water)?

    b. Which change do you think is a physical change? Explain why.

    c. Which change do you think is a chemical change? Explain why.

3. Now return to your lists from the *Engage* of the differences between the past and present images of the river environment. Which changes do you think may have been physical and which do you think may have been chemical? Fill out the chart below:

Examples of Physical Changes	Examples of Chemical Changes

    a. Pick one example from each of the above columns and explain why you have categorized each as a physical or chemical change.

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Task 1: Types of Changes

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Elaborate

Return to the before and after pictures of the river environment. You may have noticed that there is a deceased deer in the first picture that is no longer present in the picture 200 years later. This is because the deer decomposed; in this process, fungi and bacteria break down dead organisms into smaller products.

For example, in every living organism, there are small molecules called amino acids. Decomposers break these molecules apart, releasing even smaller molecules like nitrogen into the soil. This is great because all plants need nitrogen to grow! However, it needs to be in a certain form. **Analyzing and Interpreting Data**: Take a look at one of the changes that occurs in this process and use your new knowledge to individually identify this type of change.

Reactants substances at beginning of reaction		Products substances at the end of the reaction	
Ammonia (NH_3)	Oxygen (O_2)	Hydroxylamine (NH_2OH)	Water (liquid) (H_2O)
Properties density: 1.98 kg/m3 melting point: -56.6 C boiling point: -78.5 C	Properties density: 1.43 g/L melting point: -218.8 C boiling point: -183 C	Properties density: 1.21 g/cm3 melting point: 33 C boiling point: 58 C	Properties density: 1 g/cm3 melting point: 0 C boiling point: 100 C

1. **Patterns:** Is this a physical or chemical change? Use information from the *Explain* and the data table above to explain your choice.

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Task 1: Types of Changes

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Evaluate: Connecting to the Culminating Project

You will be creating a sustainable aquaponics system that mimics the properties of the river environment, including any physical and chemical changes that may occur. Now that you understand physical and chemical changes on the molecular level, identify one physical change and one chemical change that you anticipate may occur in your aquaponics system.

- ✓ Draw a before and after picture of your aquaponics system for each change and write a caption explaining each.
  - Use data from this task, or research the properties of your own environmental change, to explain how you know what type of change it is.
- ✓ For each change, decide if it represents a threat to your aquaponics system. If it is a threat, describe a potential solution to prevent it.

This should be completed individually in your Project Organizer.

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Reflection

Individually reflect on Task 1, using the questions provided:

1. At the beginning of this task, you were asked to group the types of changes you observed in the river environment. Look back at your groupings: are they similar to groupings of physical vs. chemical changes? Explain how they are similar or different.

2. In this task, we focused on the crosscutting concept of:
   - **Patterns**: Macroscopic patterns are related to microscopic structure.

   Where did you see examples of **Patterns** in this task?

3. Now that you have learned more about two types of changes in environments, what questions do you still have?

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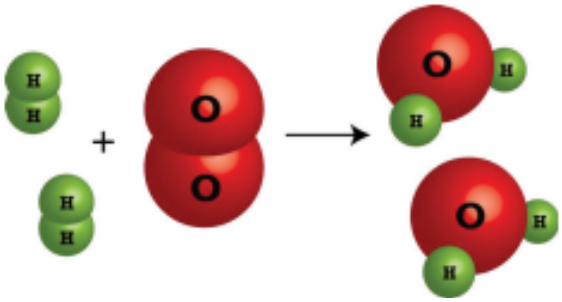
Task 2: Matter Moves You

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Engage

In Task 1, you investigated different types of changes that happen in an environment—both physical and chemical changes. When a chemical change, or chemical reaction happens, the initial molecules form new molecules, but we can't see this happening! In this task, you will explore different chemical reactions and develop a model to show what happens when an important chemical reaction in ecosystems occurs.

Remember this model of a chemical reaction from Task 1?



With a partner, analyze the model by responding to the questions below:

1. How do the molecules on the left side of the arrow differ from the molecules on the right side of the arrow?

2. Do you notice any similarities between the left side of the arrow and the right side of the arrow?

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explore

Let's investigate chemical reactions with a familiar example—a burning candle. When a candle burns, the methane gas from the melted candle wax is reacting with the oxygen in the air. This results in a flame, carbon dioxide, and water. Watch as your teacher covers the candle with a jar and record your observations below:

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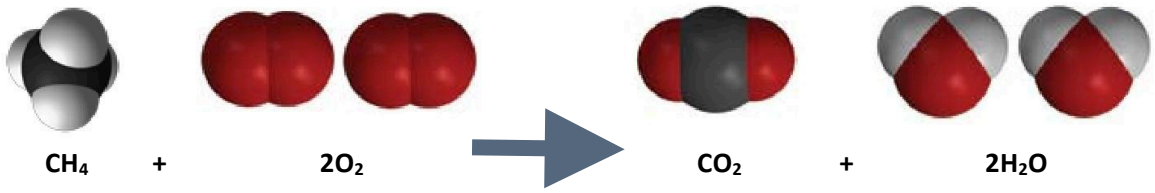
Task 2: Matter Moves You

In order to figure out the mystery of the extinguished candle, we need to better understand the chemical reaction occurring. This means looking at a chemical equation!



CH_4 + $2O_2$ → CO_2 + $2H_2O$

Developing and Using Models: As a group, count the atoms on the left side of the arrow and record in the table below. Then count the atoms on the right side of the arrow and record in the table below.

	Left Side	Right Side
Carbon (C)	1	1
Hydrogen (H)		
Oxygen (O)		

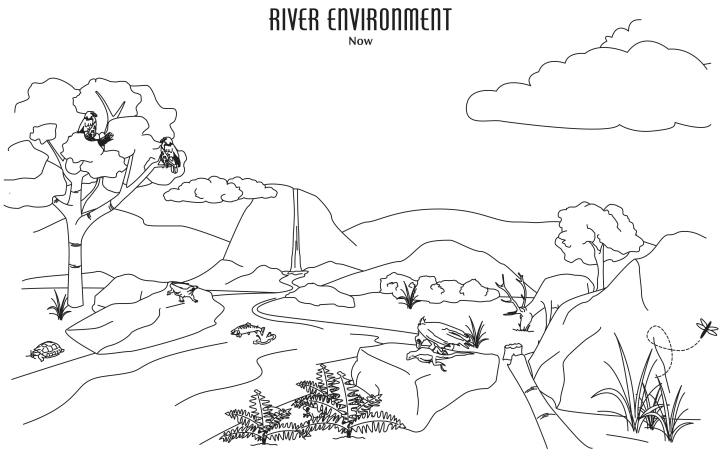
Energy and Matter: Can you now explain the mystery of the extinguished candle? With a partner, discuss: Why do you think the flame went out when the jar was put over the candle? (Hint: what molecule on the left did we take away by placing the jar on top?)

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explain

Now that we better understand how chemical reactions work, let's apply it to one we see in our river environment. In the present-day river environment, you may have noticed a fully-grown deer.

Discuss with a partner: What do all animals need in order to grow and do their daily activities?

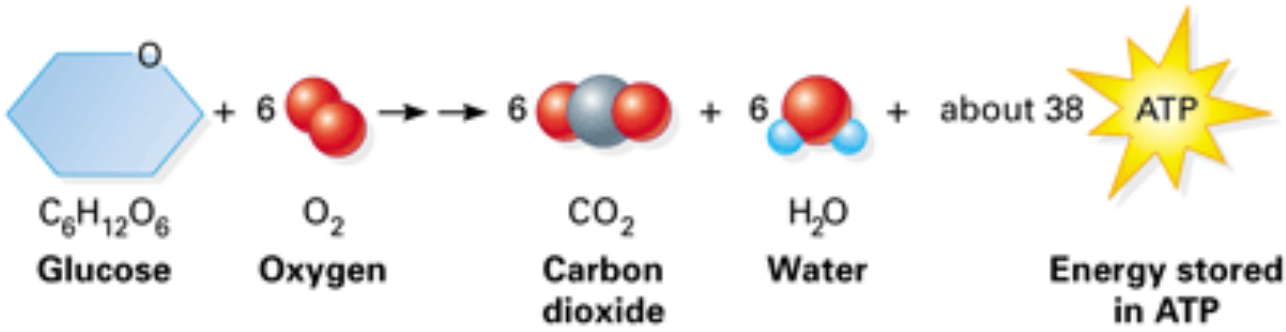


7th Grade Science Unit 3: Mimicking Nature's Design

Task 2: Matter Moves You

Animals, like deer, eat food to grow and get the energy they need. However, food needs to first be broken down into a form of energy that animals can use! This requires a chemical reaction known as cellular respiration.

Below is the chemical reaction for cellular respiration: Glucose is the sugar in the food we eat. ATP is the type of energy made and used by our body to do its many jobs.



1. **Developing and Using Models**: As a group, use the "Atom Pieces" and scale provided to develop a physical model of the cellular respiration chemical reaction above.

   a. Pick one color for each type of atom and record below:

Atom	Color
Carbon	
Hydrogen	
Oxygen	

   b. **Energy and Matter:** Place the atoms for the left side of the equation on the left side of the scale. Place the atoms for the right side of the equation on the right side of the scale. Observe what happens.

2. Individually, make a drawing of the model you just built with the scale and "Atom Pieces", using pictures, arrows, and labels. Then write a paragraph to explain it. Be sure to include the following in your drawing and/or explanation:

   - ✓ All the molecules involved in cellular respiration
   - ✓ The number and types of atoms before and after the reaction
   - ✓ How matter is rearranged during the reaction
   - ✓ Energy created by the reaction
   - ✓ A comparison of mass before and after the reaction (Draw the scale!)

7th Grade Science Unit 3: Mimicking Nature's Design

Task 2: Matter Moves You

Cellular Respiration Model (Visual Diagram)
Written Explanation of Cellular Respiration Model

7th Grade Science Unit 3: Mimicking Nature's Design

Task 2: Matter Moves You

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Elaborate

To help you refine your cellular respiration model and explanation, use the Stronger Clearer protocol to gather feedback from your peers.

1. **Individual Think Time:** Fold your last page in half so that you cannot see your explanation. Take a minute to think about how you will explain your model to a partner.

2. **Partner Discussion 1:** You will work in pairs with another student in a different group. One of you will be Student A and the other Student B. Student A will start first:
   - **Student A:** Without reading your explanation, describe your model using as many of the scientific concepts as you can remember.
   - **Student B:** Listen and ask clarifying questions. Ask questions to help Student A explain cellular respiration. For example, you might ask, "How does your model compare the reactants and the products of cellular respiration?" or "In your model, do you have all the relevant molecules?"
   - **Both Student A and Student B:** Write down any notes, thoughts, or questions that came up in this discussion.

   Now switch roles and repeat the steps above.

3. **Partner Discussion 2:** Repeat the partnering process with another student. Remember to try to clarify your explanation in order to strengthen your model. Write down new notes, insights, and questions.

4. **Partner Discussion 3:** Repeat the partnering process with another student. Remember to try to clarify your explanation in order to strengthen your model. Write down new notes, insights, and questions.

3. **Revision**: After you have worked with partners to clarify your model and explanation, review your notes. Then revise both your model and explanation based on what you learned from your partners.

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Evaluate: Connecting to the Culminating Project

You have been asked to create a sustainable aquaponics system that mimics the properties of the river environment, including any chemical reactions that may occur. Identify or add an organism to your aquaponics system that does cellular respiration.

- ✓ Identify what molecules the organism requires for cellular respiration. How will your system provide these molecules?
- ✓ Identify what molecules the organism will create through this process. How will your system use up the products that it creates?
- ✓ Draw a picture of your organism and the molecules identified. Use arrows to show which molecules enter or leave the organism.

This should be completed individually in your Project Organizer.

7th Grade Science Unit 3: Mimicking Nature's Design

Task 2: Matter Moves You

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Reflection

1. At the beginning of this task, you were asked to analyze a model of a chemical equation and compare the two sides of the equation. Look back at your comparisons: after exploring chemical reactions today, how would you change or add to your comparisons? Use evidence from the task to justify your changes or additions and record below.

2. In this task, we focused on the crosscutting concept of:
    - **Energy and Matter**: Matter is conserved because atoms are conserved.

   Where did you see examples of **Energy and Matter** in this task?

3. Now that you have learned about another important chemical reaction in environments—cellular respiration—and how matter is conserved in these types of reactions, what questions do you still have?

7th Grade Science Unit 3: Mimicking Nature's Design
Task 3: Cycling Matter Through Living Things

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Engage

Through previous tasks, you have recorded all the different changes you observed in the river environment over time. You may remember that some off these changes involved plants and animals of different sizes. Why do you think this is the case?

Energy and Matter: With a partner, discuss the following questions:

1. What do you think causes animals to grow and make energy?

2. What do you think causes plants to grow and make energy?

7th Grade Science Unit 3: Mimicking Nature's Design

Task 3: Cycling Matter Through Living Things

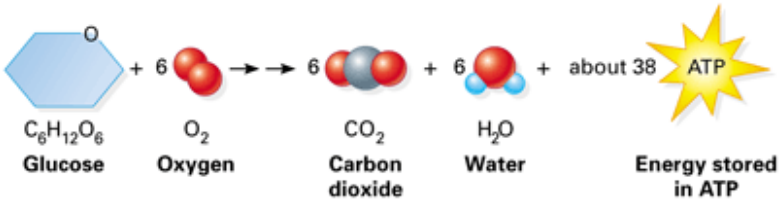
Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explore

In order to figure out what animals and plants need to survive and grow, and how these organisms must interact with their environments to get what they need, let's conduct some investigations!

Investigation 1:

In the last task, you modeled an important chemical reaction in ecosystems—cellular respiration. With your group, do a short investigation to provide evidence that this chemical reaction occurs in organisms! First, recall the chemical equation for cellular respiration, which is shown below:



Procedure

1. Retrieve a straw and a small beaker of Bromothymol Blue (BTB) solution.
    - Bromothymol Blue (BTB) is an indicator, meaning it "indicates" when a specific substance is present by changing color.
2. One group member: place the straw into the BTB solution and blow softly for as long as possible until you see a color change. DO NOT SUCK IN ON THE STRAW.
3. Record data below:

Original Color	Color After Exhaling

Data Analysis

1. Based on your prior knowledge and the chemical reaction for cellular respiration, what substance do you think Bromothymol Blue (BTB) indicates is present in the solution after you blow into it?

7th Grade Science Unit 3: Mimicking Nature's Design

Task 3: Cycling Matter Through Living Things

Investigation 2

If you hypothesized that Bromothymol Blue (BTB) is an indicator for carbon dioxide, you were correct! Bromothymol Blue turns yellow when carbon dioxide is present and returns to blue when carbon dioxide is removed. Let's use this same indicator to investigate another essential process for ecosystems that happens in plants.

As a group, follow the procedure on the investigation card provided by your teacher to set up your experiment. Record your observations immediately after setting up your investigation, and again after 24 hours. Draw your observations in the table below, and be sure to include labeled and colored sketches.

	Light		**Dark**	
Before	Observations	Sketch	Observations	Sketch
	Predict color of the BTB solution after 24 hours: _____		Predict color of the BTB solution after 24 hours: _____	
After	Observations	Sketch	Observations	Sketch

7th Grade Science Unit 3: Mimicking Nature's Design

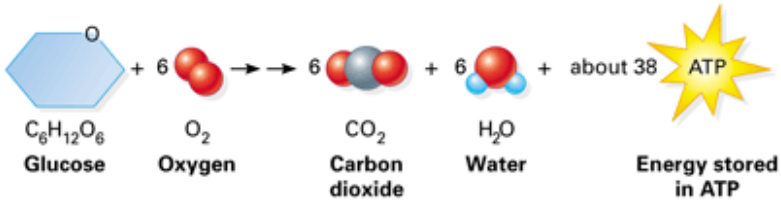
Task 3: Cycling Matter Through Living Things

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

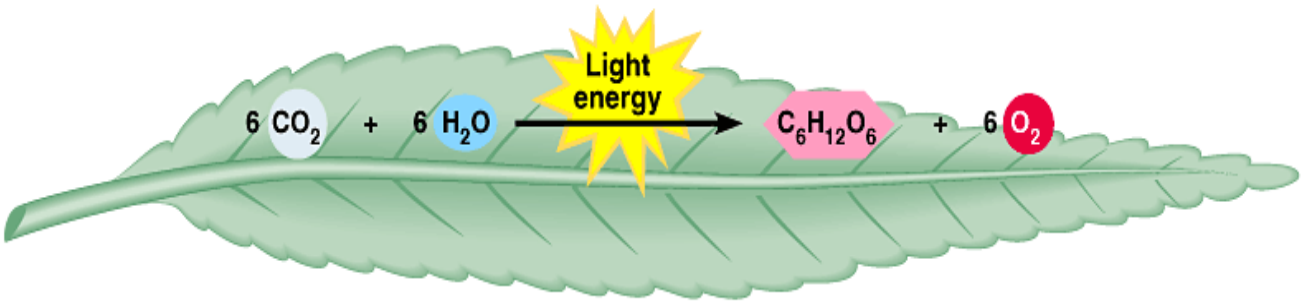
Explain

Energy and Matter: In Investigation 1, you were familiar with the chemical reaction happening—cellular respiration. But what was happening in Investigation 2? Individually, read and annotate the article below to learn more about another essential process in ecosystems—photosynthesis.

As you learned in the last task, all living organisms do **cellular respiration** to convert the food they eat into the energy they need. In Investigation 1, you saw evidence of one byproduct of cellular respiration. Circle the substance that made your BTB solution turn yellow in the chemical reaction below:



Plants, like other living organisms, do cellular respiration, but they also conduct another important chemical reaction for ecosystems, called **photosynthesis**. During photosynthesis, plants use energy from the sun, as well as atoms from water and carbon dioxide, to build a molecule called glucose, releasing oxygen in the process. This creation of glucose is what allows plants to grow! The photosynthesis chemical reaction looks like this:



Glucose stores the energy that was originally from the sun in chemical bonds until it is needed. To access this energy, plants break down glucose through the process of cellular respiration…just like animals do! The only difference is that animals have to eat food to get the glucose first.

7th Grade Science Unit 3: Mimicking Nature's Design

Task 3: Cycling Matter Through Living Things

In pairs, complete the lab conclusions questions below:

1. **Constructing Explanations**: Based on what you have learned from the article, explain what happened in the second investigation:

2. **Developing and Using Models:** To better support your explanation, draw models of each experimental set-up to show the cycling of matter and flow of energy through the Elodea plant.
    - Use arrows and labels to show all parts of each experiment, including the relevant molecules involved in each setting (CO_2, H_20, and O_2).

Elodea in the light	Elodea in the dark

7th Grade Science Unit 3: Mimicking Nature's Design

Task 3: Cycling Matter Through Living Things

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Elaborate

You just used what you learned from an experiment and an article to draw a model of photosynthesis, which is a very important reaction in ecosystems. However, we also know that cellular respiration is very important! How do you think photosynthesis and cellular respiration work together to make ecosystems function properly? Imagine you added a fish to your Elodea experimental set-up and placed it in the light. Individually, respond to the following questions:

1. What color do you think the solution would be after 24 hours? Why?

2. **Developing and Using Models:** Draw a new model that shows a fish and Elodea plant in BTB solution, placed in light. Use arrows and labels to show how energy and molecules cycle into and out of these organisms.

   a. How does this model show how cellular respiration and photosynthesis work together to keep matter cycling through an ecosystem?

b. How does this model show how cellular respiration and photosynthesis work together to keep energy flowing through an ecosystem?

3. **Energy and Matter**: What energy, or energy source, do you think drives this whole system? If you left it out of your model, add it now!

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Evaluate: Connecting to the Culminating Project

You have been asked to create a sustainable aquaponics system that mimics the properties of the river environment, including any chemical reactions that may occur. Identify or add an organism to your aquaponics system that does photosynthesis.

- ✓ Identify what molecules it will need to have in order to do photosynthesis. How will your system provide what the organism needs?
- ✓ Identify what molecules it will create through this process. How will the system use up the products that it creates?
- ✓ Draw a picture of your organism and the molecules identified, using arrows to show whether the molecules enter or leave the organism.
- ✓ Make connections to the organism you chose after Task 2: How do the plant and animal work together to cycle matter and keep energy flowing through the system?

This should be individually completed in your Project Organizer.

7th Grade Science Unit 3: Mimicking Nature's Design

Task 3: Cycling Matter Through Living Things

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Reflection

Individually reflect on Task 3, using the questions provided:

1. At the beginning of this task, you were asked to use your prior knowledge to explain why you think plants and animals grow over time. Look back at your explanations: after exploring photosynthesis and cellular respiration today, how would you change or add to your explanations? Use evidence from the task to justify your changes or additions and record below.

2. In this task, we focused on the crosscutting concept of:
   - **Energy and Matter**: The transfer of energy can be tracked as it flows through a system, is conserved, and drives the cycling of matter.

   Where did you see examples of **Energy and Matter** in this task?

3. Now that you have learned more about how cellular respiration and photosynthesis cycle matter and energy amongst living things in an ecosystem, what questions do you still have?

7th Grade Science Unit 3: Mimicking Nature's Design
Task 4: Cycling Matter Through Rocks

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Engage

In the last task, we saw how some matter is cycled through living parts of the environment. Today we will look at how other matter can cycle through the non-living parts of our environment, specifically through rocks!

Think back to the changes we observed in our river environment below. Find at least two changes in rock formations that occurred over 200 years (Hint: all the land in the environment is made of rock, not just the visible boulders!)

1. **Stability and Change:** In pairs, record any changes you see in rock formation below and explain why you think each change happened:

2. If you were to look at the riverbed 1 year ago instead of 200 years ago, how do you think it might look different? Draw pictures of the riverbed now, 1 year ago, and 200 years ago to show the difference.

7th Grade Science Unit 3: Mimicking Nature's Design

Task 4: Cycling Matter Through Rocks

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explore

Rock is an important non-living part of our environment and when it appears to go away, as in the pictures above, it doesn't just disappear! Earth's matter, like rock, is cycled through the environment. Sometimes it is easier to understand and believe something once you actually see it. Today, you will be modeling how rock formation and cycling works.

Developing and Using Models: As a group, use the materials provided and the directions on the resource card to model the way Earth's materials can cycle through an environment. Record observations in the table below.

Process	Describe the process in your own words	Describe the resulting "rock"	Discussion Questions
Weathering			In real life, wind and water cause weathering and erosion. Based on what you learned in 6th grade, what energy source is ultimately responsible for weather like wind and rain?
Sedimentation			Here we are applying pressure with our fingers. Where do you think this pressure comes from with real rocks?
Deformation			Heat and pressure are very important in the rock cycle. Hypothesize: where do you think this heat comes from in real life?

Crystallization			How is the process of crystallization different from deformation? Which one requires more heat?

Stability and Change: Return to your pictures from the *Engage* about the riverbed now, 1 year ago, and 200 years ago. The processes you just modeled are constantly happening, so why do you think you can see the effects on rocks after 200 years but not after 1 year?

7th Grade Science Unit 3: Mimicking Nature's Design

Task 4: Cycling Matter Through Rocks

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explain

You just learned about the rock cycle, which is one way that Earth's matter cycles through the environment.

Developing and Using Models: Using what you learned through crayon modeling, individually make a flowchart below that shows how Earth's matter cycles throughout the environment AND how the flow of energy drives all these processes.

- Draw and label all three types of rock and use arrows to connect them (Hint: arrows can be drawn between multiple types of rock!)
- On each arrow, write the name of the process and write captions to explain how each process works, including what kind of energy drives each process. Below is a list of terms you must include:

✓ Igneous Rock	✓ Weathering	✓ Cooling
✓ Sedimentary Rock	✓ Crystallization	✓ Melting
✓ Metamorphic Rock	✓ Sedimentation	✓ Erosion/Erodes
✓ Energy from Sun	✓ Deformation	✓ Heat and Pressure (from Earth's Interior)
✓ Water and Wind	✓ Pressure (from Gravity)	

7th Grade Science Unit 3: Mimicking Nature's Design

Task 4: Cycling Matter Through Rocks

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Elaborate

To help you improve your own model, let's critique a model that has some errors. In pairs,

1. Critique: Analyze the rock cycle model provided by your teacher. Identify and discuss error(s), parts that aren't clear, or ideas that are missing.

2. Correct: Write on the model provided to make it clearer and more accurate.

3. Clarify: Describe below how and why you corrected the model.

Now return to your own model in the *Explain* section above and make any revisions needed!

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Evaluate: Connecting to the Culminating Project

You have been asked to create a sustainable aquaponics system that mimics the properties of the river environment, including any cycling of matter that occurs through the rock cycle.

Look back at the design sketch for your aquaponics system from Task 1:

- ✓ How might cycling of matter come into play in your aquaponics system?
- ✓ Describe which process(es) of the rock cycle might occur in your aquaponics system over time.
- ✓ What will the effects be on your system?

This should be completed individually in your Project Organizer.

7th Grade Science Unit 3: Mimicking Nature's Design

Task 4: Cycling Matter Through Rocks

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Reflection

Individually reflect on Task 4, using the questions provided:

1. At the beginning of this task, you were asked to identify changes in rock formations of the river environment and make hypotheses as to why they happened. Look back at your hypotheses: after exploring the rock cycle today, how would you change or add to your response? Use evidence from the task to justify your changes or additions and record below.

2. In this task, we focused on the crosscutting concept of:
    - **Stability and Change**: Stability and change can be explained by looking at changes over time and at different scales.

   Where did you see examples of **Stability and Change** in this task?

3. Now that you have learned more about how rocks also cycle matter in ecosystems, what questions do you still have?

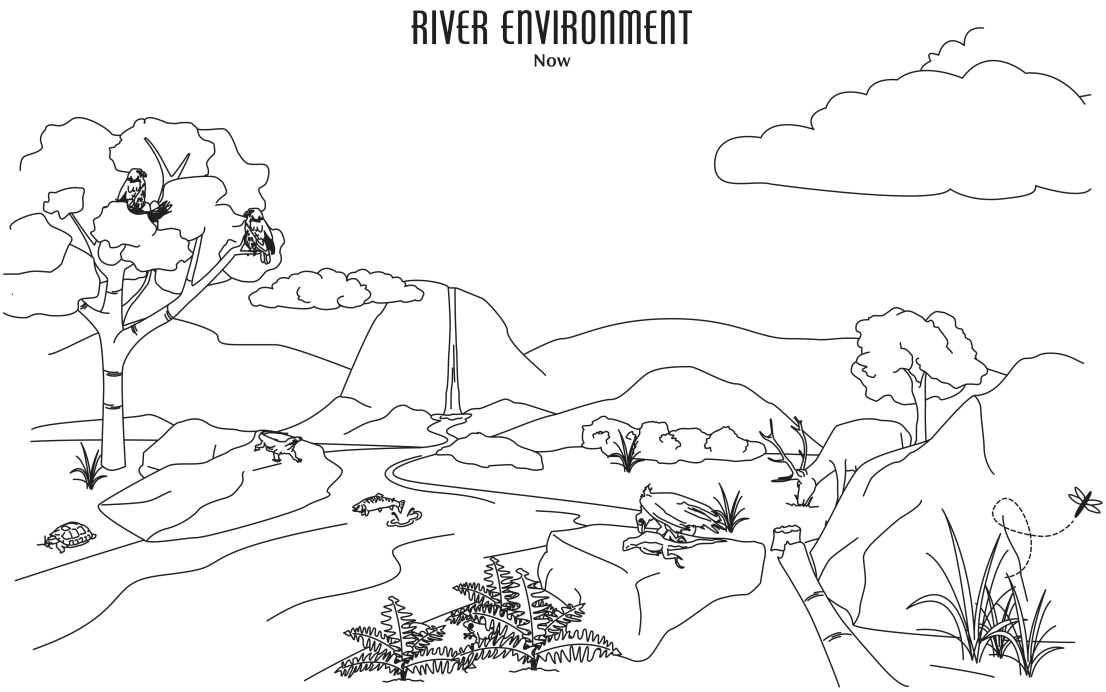
7th Grade Science Unit 3: Mimicking Nature's Design
Task 5: Design a Thermal Device

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Engage

Throughout this unit, you have seen that heat is either absorbed or released in the chemical reactions you have observed. Today we are going to use this knowledge to help address a problem that the river environment is facing today.

Blue catfish, as shown in the picture below, are very important to the river environment. However, in recent years the river environment has experienced climate change, leaving the river water a few degrees colder than normal. It turns out that colder water interferes with fish spawning, which only happens at a certain range in water temperature.



With a partner, hypothesize:

1. What happens if fish can't spawn (lay eggs)?

2. What other "domino" effects might this have on the river environment?

7th Grade Science Unit 3: Mimicking Nature's Design
Task 5: Design a Thermal Device

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explore

Your job will be to design devices that can keep the river water warm enough for fish spawning. For inspiration, let's think about how hot packs and cold packs work. Many instant hot packs and cold packs work by using chemical reactions that either absorb or release heat. Each of them uses different substances that when combined causes a chemical reaction to occur.

In groups, use the materials and Resource Card provided at your desk, and test each of the substances provided to decide which ones create chemical reactions that release heat and which ones create chemical reactions that absorb heat. You will be able to use this data in the design of your device!

Substances Combined	**Observations**	**Energy and Matter**: Does this reaction release heat or absorb heat?
Calcium Chloride and Water		
Sodium Bicarbonate and Water		
Potassium Chloride and Water		
Sodium Bicarbonate and Calcium Chloride and Water		
Sodium Bicarbonate and Vinegar		

7th Grade Science Unit 3: Mimicking Nature's Design
Task 5: Design a Thermal Device

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Explain

Designing Solutions: The Blue Catfish spawns in river water at 70-75 degrees Fahrenheit, but the pool where they spawn is currently at a temperature of 68 degrees Fahrenheit. Building on what you learned from the lab exploration, design a heat-regulation device as a group using the design questions below:

1. Before you begin designing your device, consider design criteria and constraints:
    a. **Criteria**: What does your device need to do? How will you measure its success?

    b. **Constraints**: How will you minimize the impact on the river environment? (Hint: you can't just pour chemicals straight into the river).

2. **Analyzing and Interpreting Data**: Which combinations of substances from the Explore would work best for a device that meets the criteria you described above? Why?

7th Grade Science Unit 3: Mimicking Nature's Design

Task 5: Design a Thermal Device

3. **Developing and Using Models**: Pick one chemical reaction from your above list. Using the list of materials provided by your teacher, design and draw models of two different heat-regulation devices that use the same chemical reaction, but have a different structure or material. **Energy and Matter**: In your model, include labels to show inputs and outputs, and captions to describe how each device would work. You will build and test these in the next part of this task.

Design Solution 1	Design Solution 2

7th Grade Science Unit 3: Mimicking Nature's Design

Task 5: Design a Thermal Device

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Elaborate

Now that you have used data from the *Explore* to design two potential heat-regulation devices, let's test and revise them to create the best device possible! As a group, use the Design Card and materials provided to build and test your devices.

1. Remember that the Blue Catfish spawns in river water at 70-75 degrees Fahrenheit, but the pool where they spawn is currently at a temperature of 68 degrees Fahrenheit. Use this information to test your two devices.
    a. Draw your experimental setup below, including labels that show all the materials used.

    b. Describe how you will run your experiment.

7th Grade Science Unit 3: Mimicking Nature's Design

Task 5: Design a Thermal Device

2. Run your experiment and collect data in the table below:

	Temperature at Start	**Temperature at End**
Design Solution 1		
Design Solution 2		

3. **Analyzing and Interpreting Data**: Which device worked better to meet the criteria of the problem? How do you know? Cite relevant data.

4. **Analyzing and Interpreting Data**: Other groups tested different materials, chemical reactions, and structures. You can learn from others' data to modify your own device. As other groups share, record features about designs you like, including the data to support them, in the space below:

7th Grade Science Unit 3: Mimicking Nature's Design

Task 5: Design a Thermal Device

5. Using what you learned from other groups' data, revise your device to combine best characteristics of designs you've seen. For your device that worked better, what adjustments can you make (types of materials, amount of substances used, structure of the device, etc.) so your device best meets the criteria and constraints of the problem? Draw a labeled model of your revised device below.

   a. Build and test your revised device to make sure it works. Record data below:

   b. If you could redesign your device again, what improvements would you make and why?

7th Grade Science Unit 3: Mimicking Nature's Design

Task 5: Design a Thermal Device

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Evaluate: Connecting to the Culminating Project

You have been asked to create a sustainable aquaponics system that mimics the properties of the river environment and regulates the temperature of the fish tank. Now that you have designed a heat-regulation device to help maintain river water temperature, you can use this knowledge to design your own heat-regulation device that will work to maintain the temperature of your aquaponics fish tank.

- ✓ Draw your final heat-regulation device.
  - Label the materials used and explain how it works.
- ✓ Describe how you combined best characteristics of different designs to create a device that best meets the criteria and constraints.
  - Cite the data that supported your decisions.

This should be completed individually in your Project Organizer.

Unit Essential Question: *How does energy and matter flow within natural and designed ecosystems?*

Reflection

Individually reflect on Task 5, using the questions provided:

1. At the beginning of this task, you were asked to consider the effects if fish can't spawn in the river environment. After designing a heat-regulation device today, how will these effects be reduced? Use evidence from the task to back up your explanation.

2. In this task, we focused on the crosscutting concept of:
   - **Energy and Matter**: The transfer of energy can be tracked as it flows through a system, is conserved, and drives the cycling of matter.

   Where did you see examples of **Energy and Matter** in this task?

3. Now that you have learned more about how we can use chemical reactions to regulate temperature, what questions do you still have?