Mimicking Nature's Design

Unit 3

This slide deck is intended to help guide you and your students through the sequence of this unit. While you may choose to use these slides as a helpful tool to prompt and facilitate students, all detailed information for each unit is in the student and teacher unit booklets.

Unit Essential Question

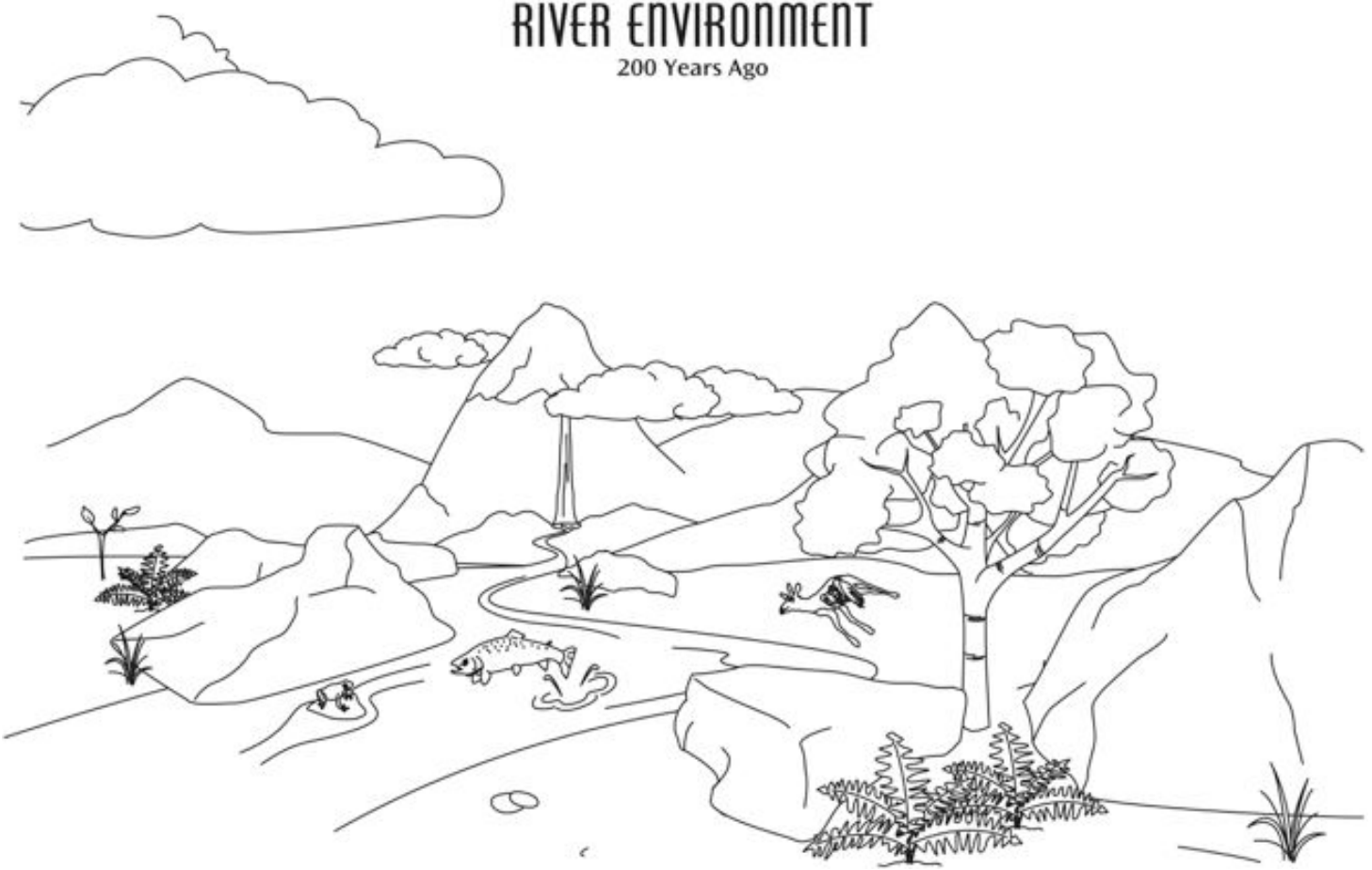
How does matter and energy flow within natural and designed systems?

Changing Rivers

Lift-Off Task

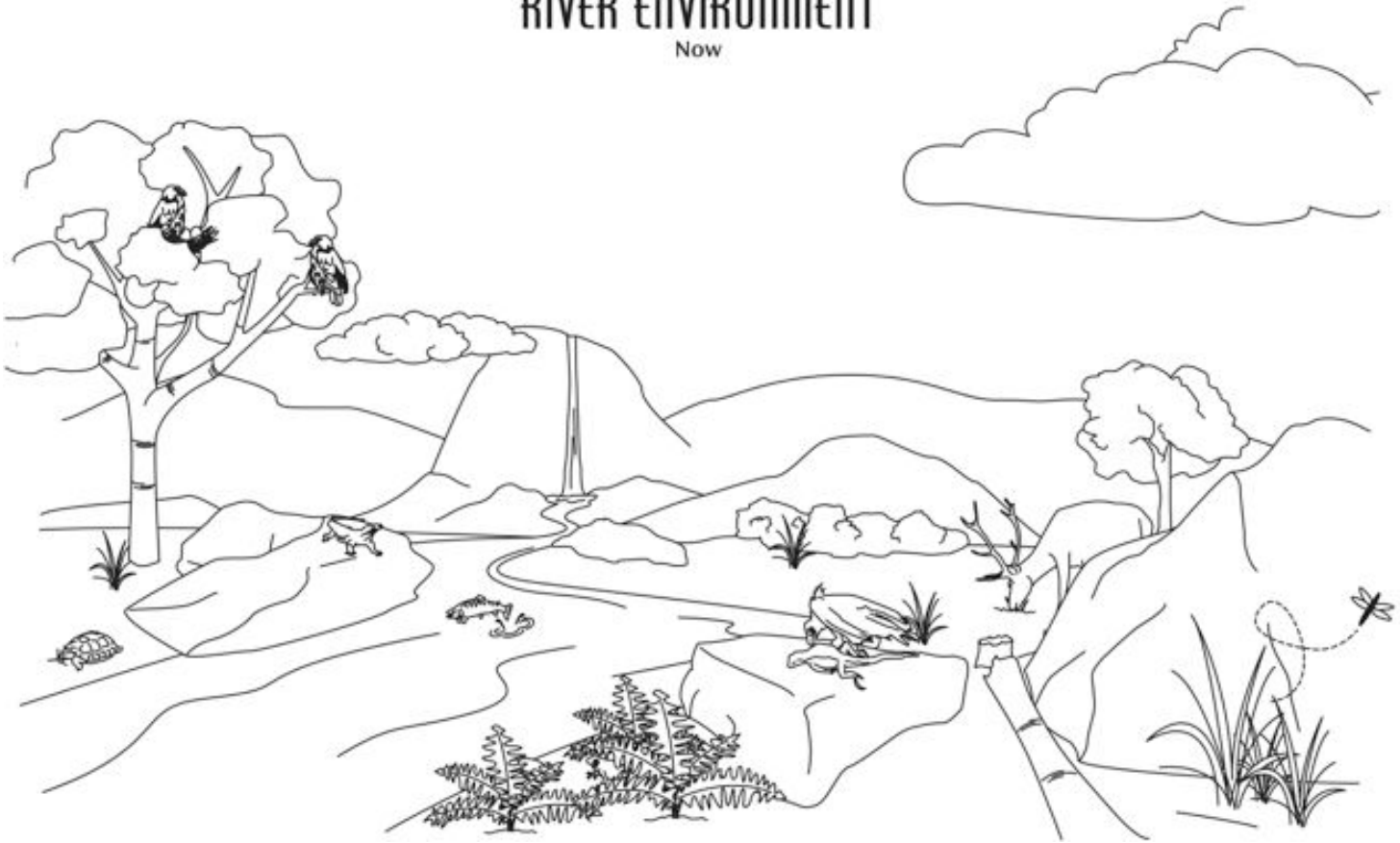
RIVER ENVIRONMENT

200 Years Ago



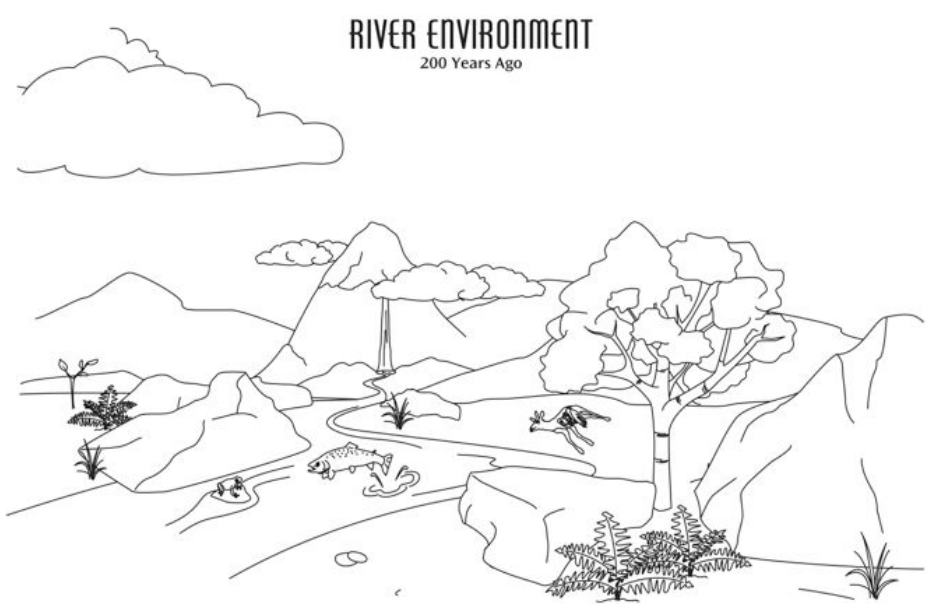
RIVER ENVIRONMENT

Now



Generate Questions!

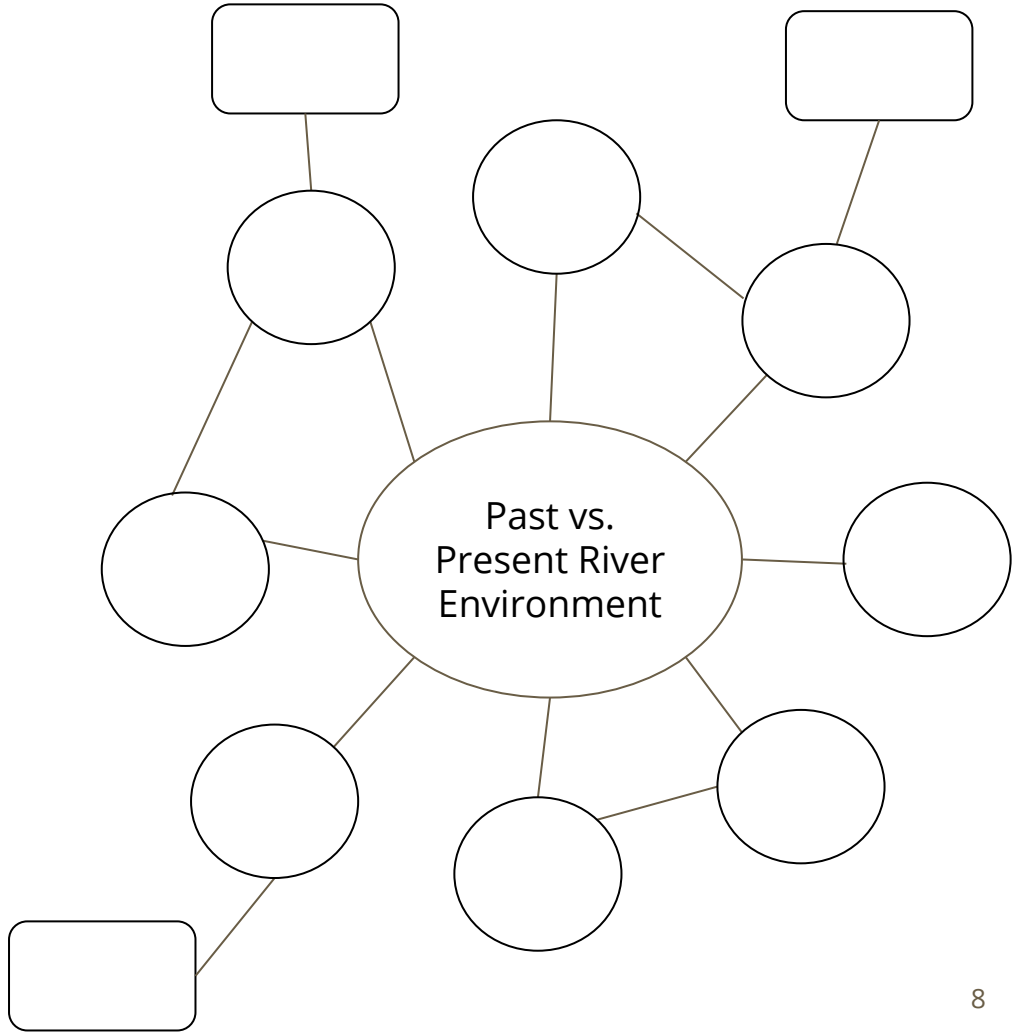
If you wanted to know more about what happened to this river environment over time, what questions would you ask?



Group Concept Map

As a group, create a concept map that shows:

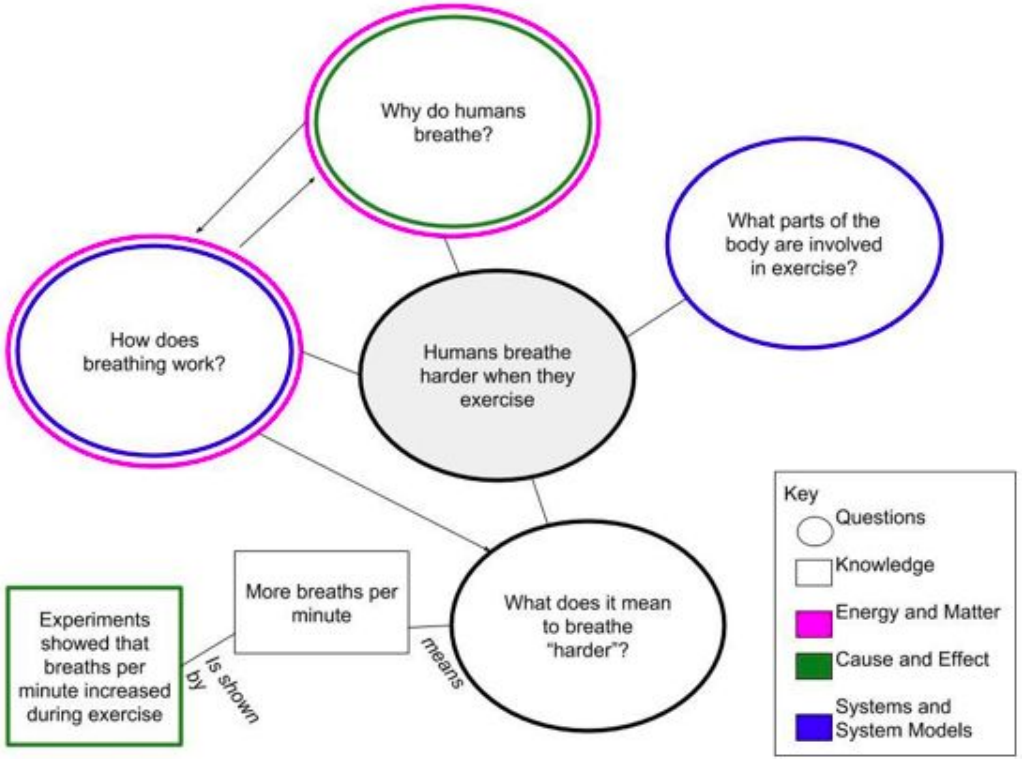
- Questions your group members had in common (circles)
- Possible answers to some questions (squares)
- Connections between related questions (lines)



Class Concept Map

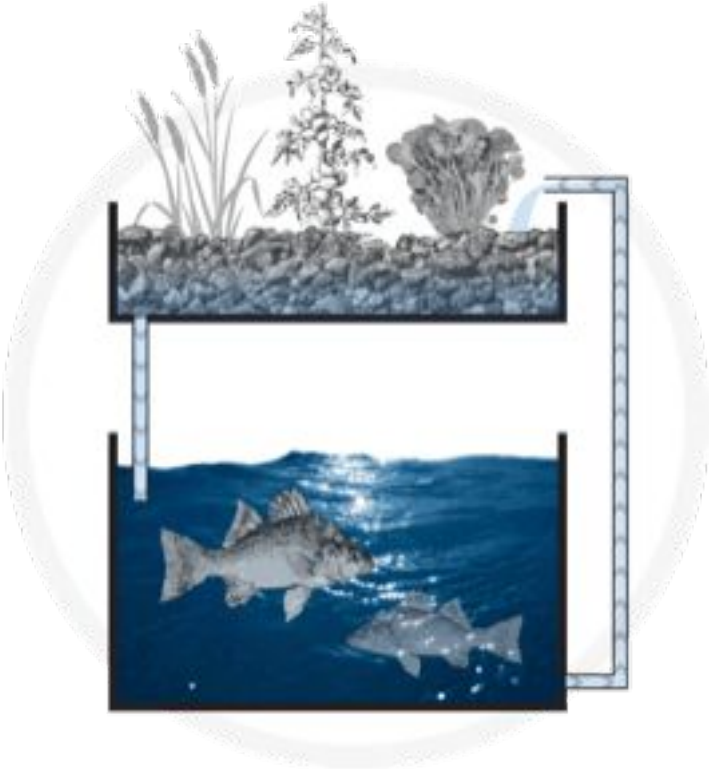
As a class, create a concept map that shows:

- Key questions (circles)
- Possible answers to some questions (squares)
- Connections between related questions (lines)
- Crosscutting concepts used (trace in color)



Introduction to the Culminating Project

Design and Build an Aquaponics System!



Group Project - Create an aquaponics system that mimics a natural ecosystem

Individual Project - Write an instruction manual for your aquaponics system that explains the science behind how it functions

What is an Aquaponics System?

https://www.youtube.com/watch?v=n-SXRtNoEkI

Examples of Aquaponics Systems

Examples of Aquaponics Systems

Examples of Aquaponics Systems

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 of the river environment that you might also want to include in your aquaponics system (garden and tank)?

Complete this **individually** in your Project Organizer.

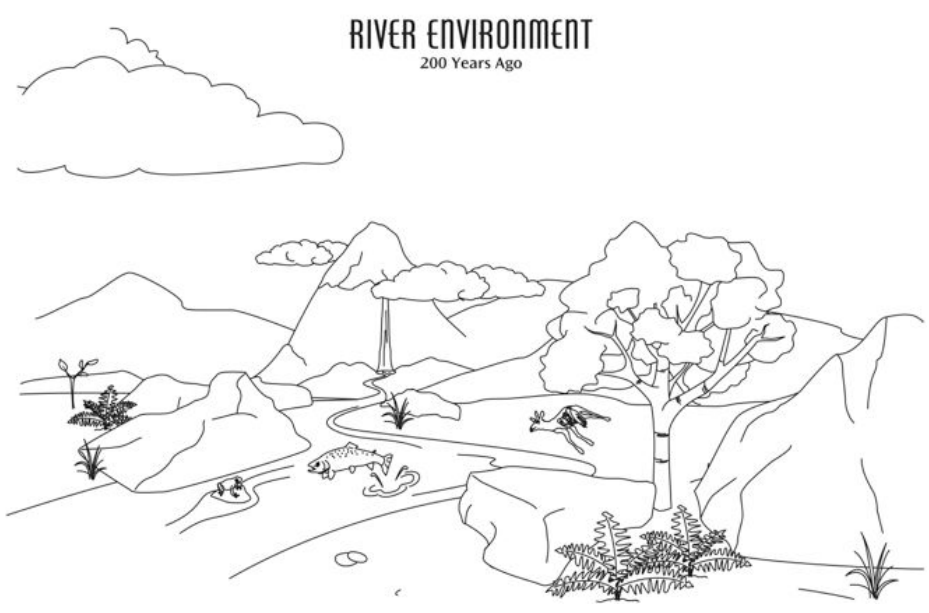
Reflection

Complete the questions at the end of your student guide to reflect on what you have learned in the Lift-Off Task.

Types of Changes

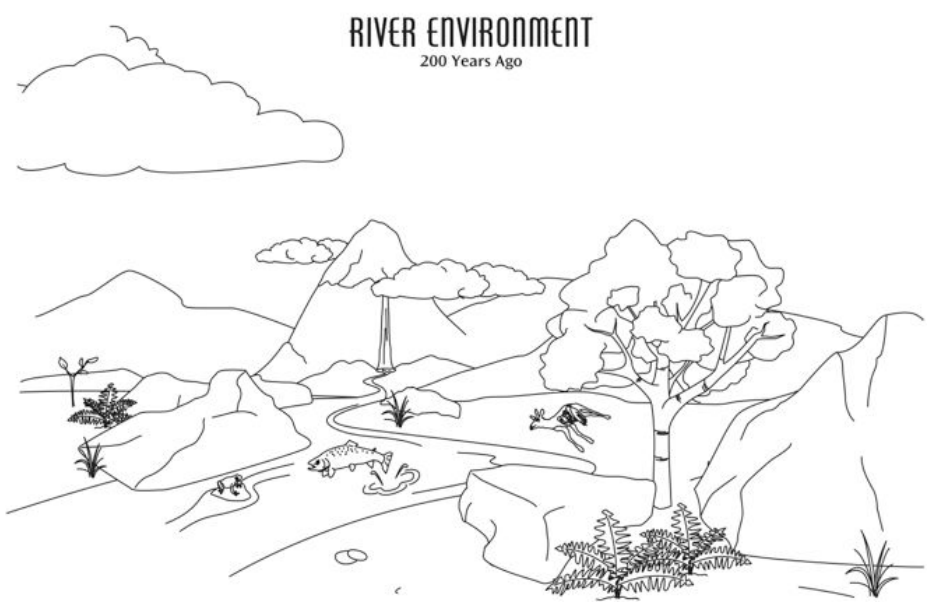
Task 1

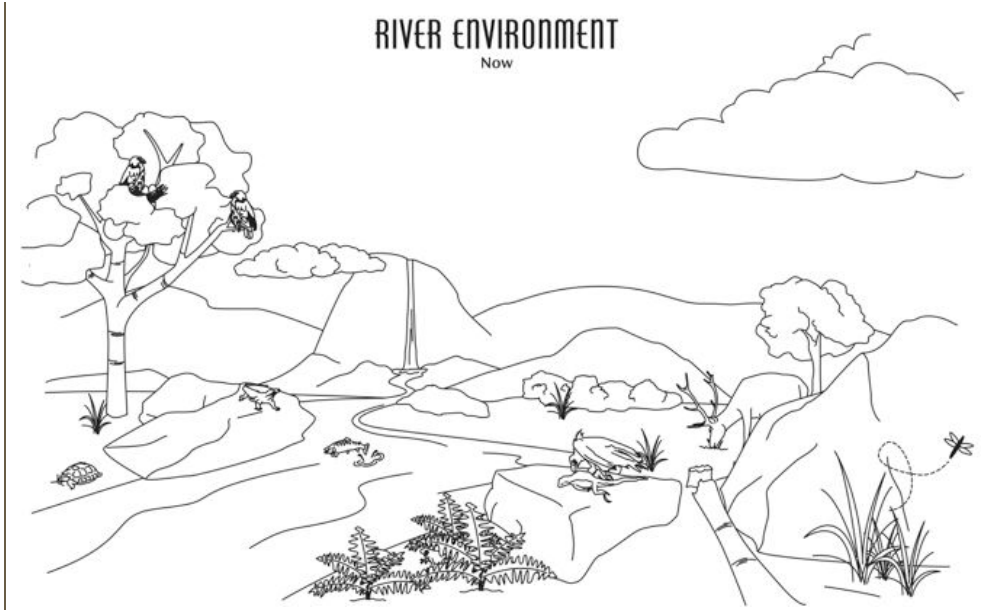
What questions do you still have?



Engage

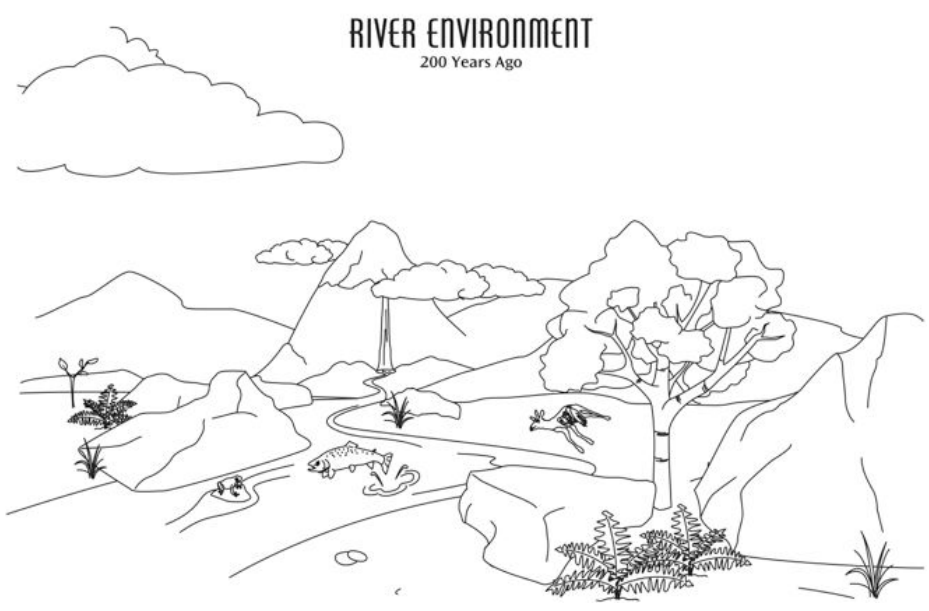
How has the river environment changed in the last 200 years?

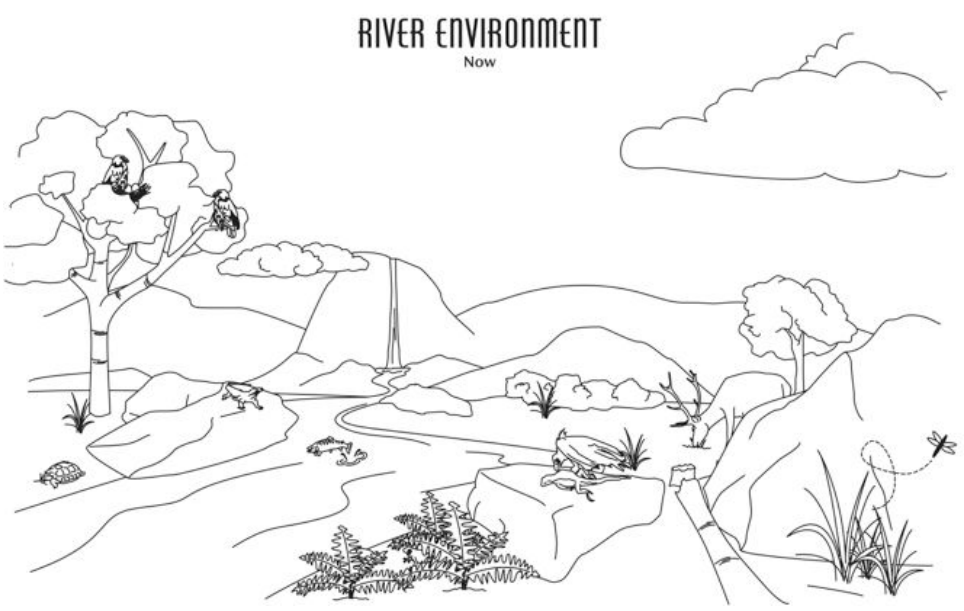




With a partner, generate a list of changes you see.

How would you group the changes you identified?





Explore

Analyzing and Interpreting Data About Two Common Changes in Environments

Data Set 1 - Plant Growth

Data Set 2 - Fog Rising Off Water

As a group, analyze the data tables and respond to the questions in your student guide.

How does fog rising off water compare to plant growth?

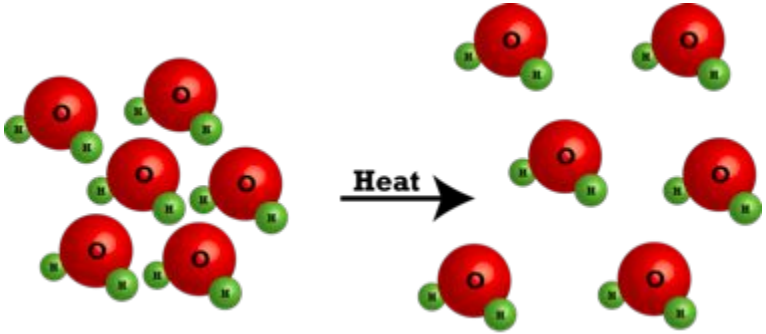
Data Set 1 - Plant Growth

Data Set 2 - Fog Rising Off Water

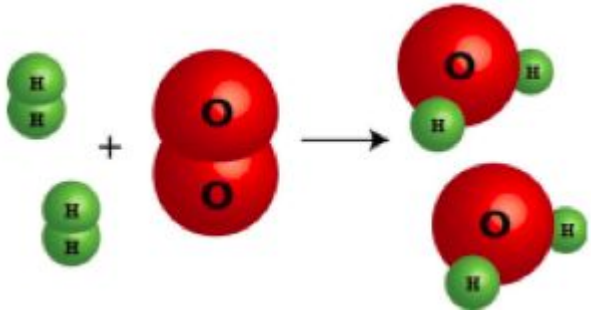
Explain

Types of Changes

Physical Change



Chemical Change



With a partner, compare the two models above and come up with definitions for physical changes and chemical changes.

Which was a physical change and which was a chemical change?

Data Set 1 - Plant Growth

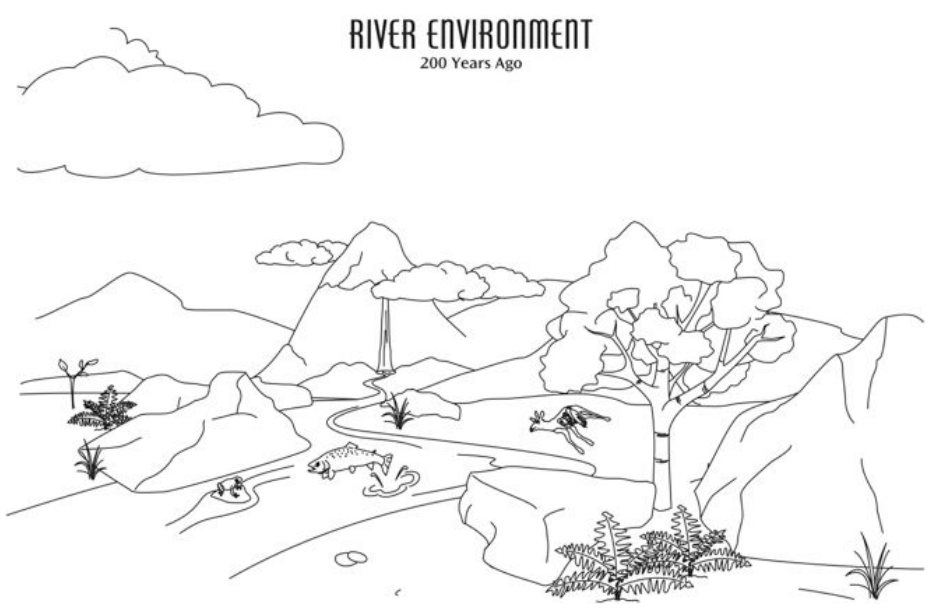
Data Set 2 - Fog Rising Off Water

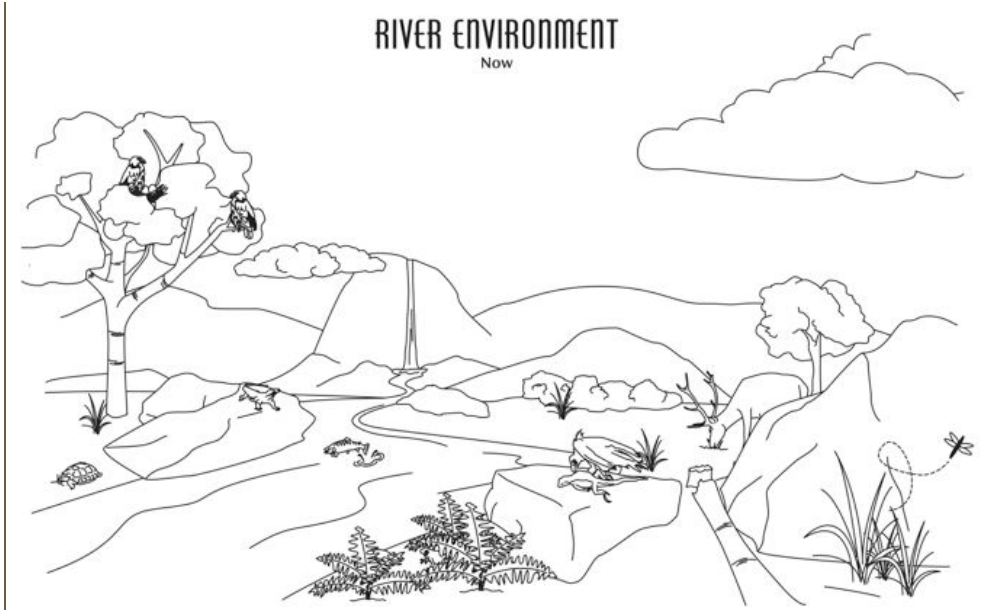
Which changes do you think are physical? Chemical?

With a partner, answer the questions in your student guide.

Elaborate

Did you notice the deer in the first image that is no longer present in the second image?





Is it a physical change or a chemical change?

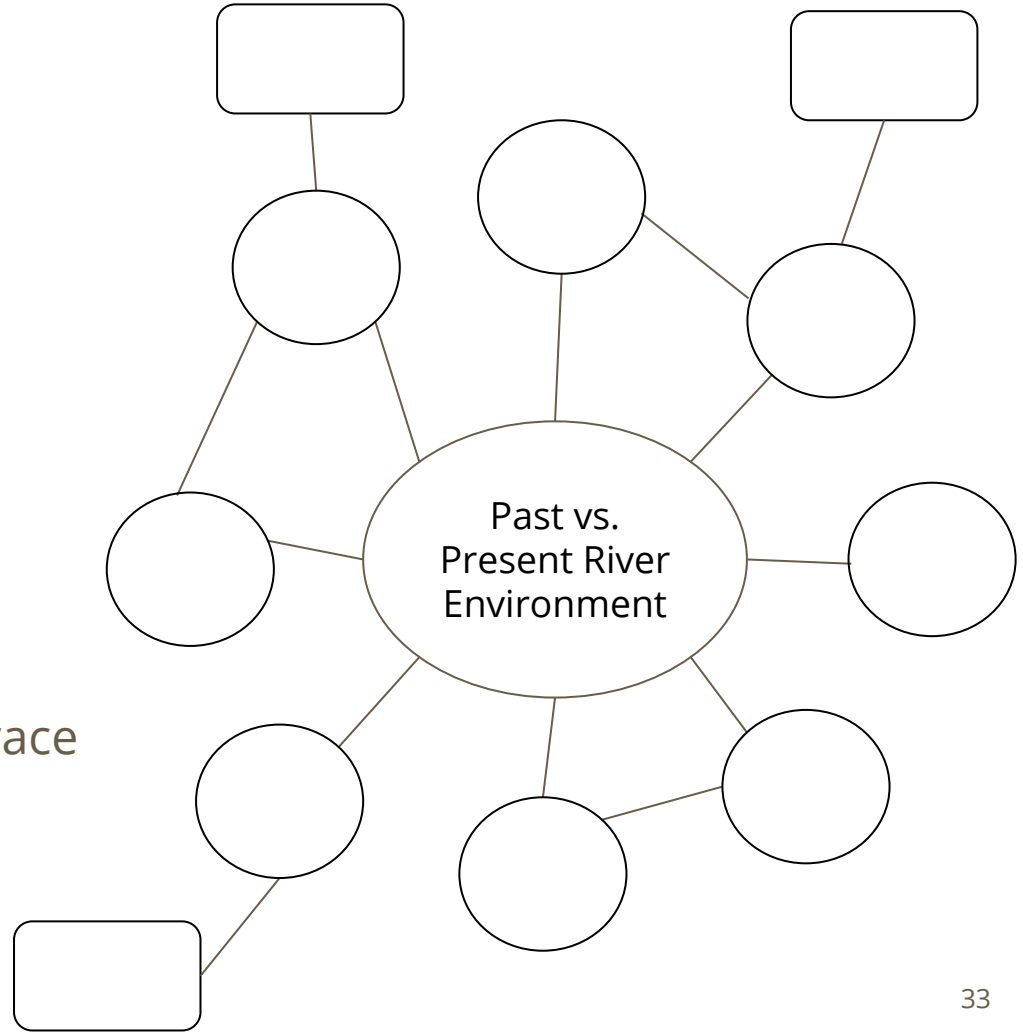
Reactants substances at beginning of reaction		Products substances at end of the reaction	
Ammonia (NH_3)	Oxygen (O_2)	Hydroxylamine (NH_2OH)	Water (liquid) (H_2O)
Properties density: 1.98 kg/m3 melting point: -56.6 C boiling point: -78.5 C	Properties density: 1.43 g/L melting point: -218.8 C boiling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

Individually, explain your choice in your student guide.

Class Concept Map

Add to your class concept map:

- New questions (circles)
- New ideas learned (squares)
- New connections (lines and connector words)
- Crosscutting concepts used (trace in color)
    - Patterns



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 labeled 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.

Complete this **individually** in your Project Organizer.

Reflection

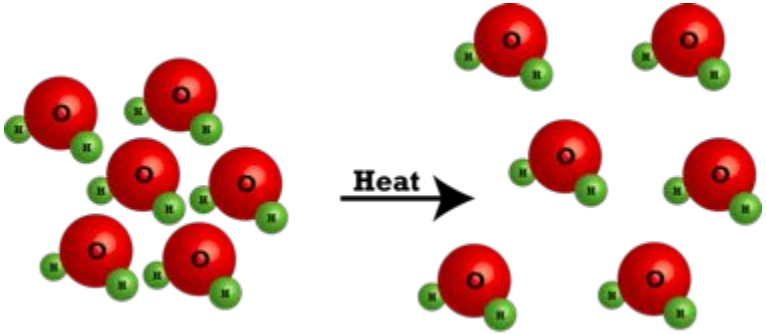
Complete the questions at the end of your student guide to reflect on what you have learned in Task 1.

Matter Moves You

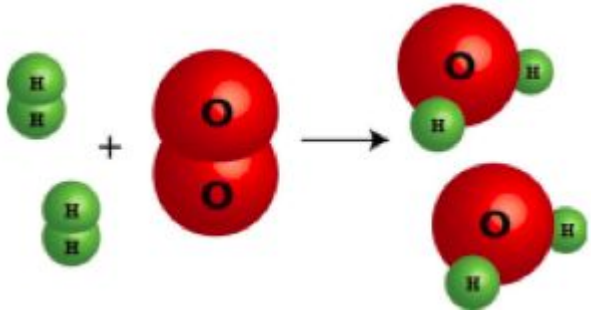
Task 2

What questions do you still have?

Physical Change

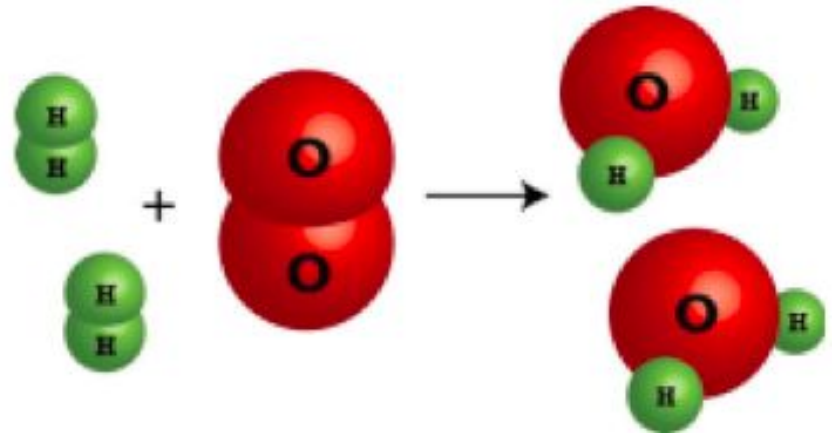


Chemical Change



Engage

Analyze the Chemical Reaction Model from Task 1



With a partner, answer the questions in your student guide.

Explore

Let's Investigate a Familiar Chemical Reaction

Watch as your teacher covers a burning candle with a jar.

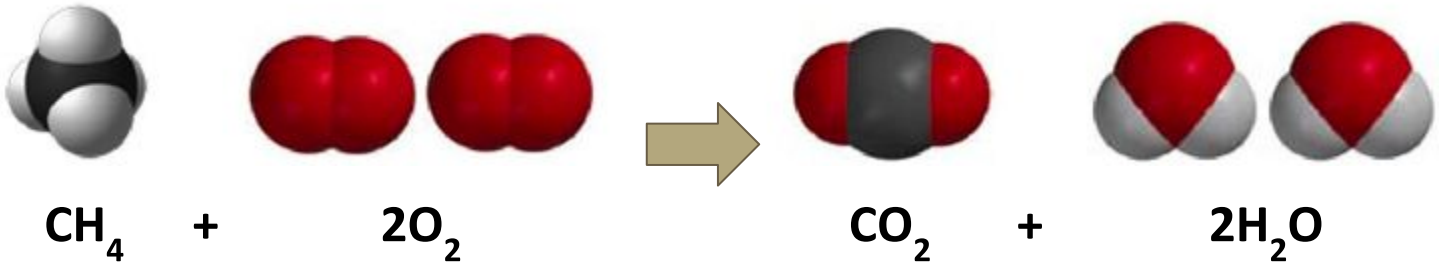
Record your observations in your Student Guide.

Chemical Reaction for a Burning Candle

CH_4 + $2O_2$ → CO_2 + $2H_2O$

Methane (from Melted Candle Wax) + Oxygen → Carbon Dioxide + Water

Developing and Using Models



As a group, count the atoms on each side of the arrow and record in the table in your Student Guide.

Think-Pair-Share: The Mystery of the Extinguished Candle!

Why do you think the flame went out when the jar was put over the candle?

Use your model to help you explain.

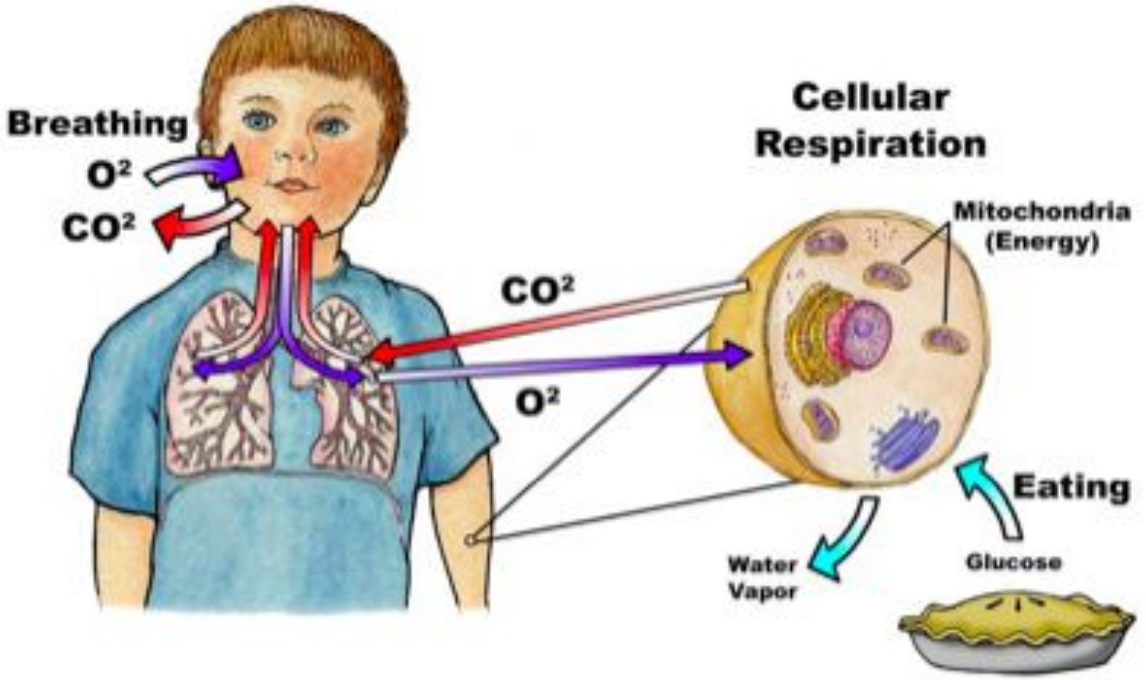
Explain

Think-Pair-Share

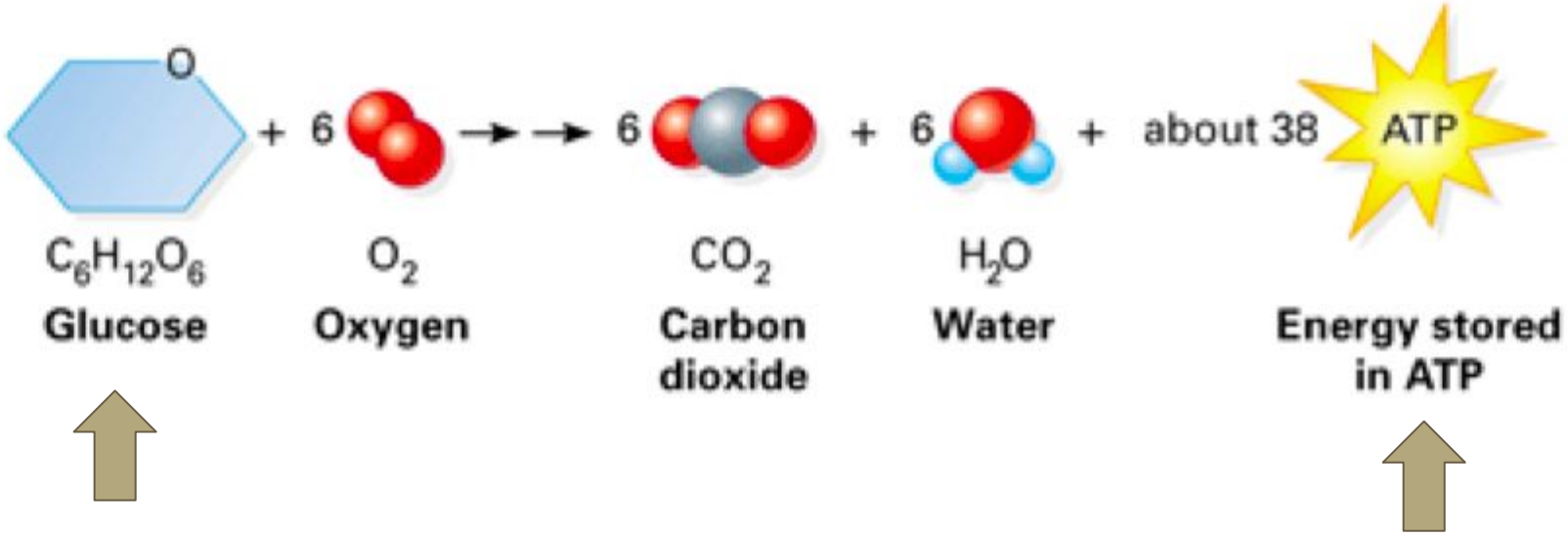
What do all animals, like the deer in this photo, need in order to grow and do their daily activities?

How do animals get the energy they need?

Cellular Respiration!



Chemical Reaction for Cellular Respiration



The Sugar in the Food Animals Eat

The Type of Energy Animals Need

Developing and Using Models - Cellular Respiration

With your group,

1. Use the “Atom Pieces” and scale to make a physical model of the cellular respiration chemical reaction.

Individually,

2. Make a drawing of the model you just built (using pictures, arrows, and labels).
3. Write a paragraph to explain your model.

Elaborate

Stronger Clearer

1. **Individual Think Time:** How will you explain your model to your partner without looking at your explanation?

2. **Partner Discussions:**
   a. **Student A:** Explain your model.
   b. **Student B:** Listen and ask clarifying questions.
   c. **Student A and Student B:** Write down any notes to make your model and explanation stronger and clearer.

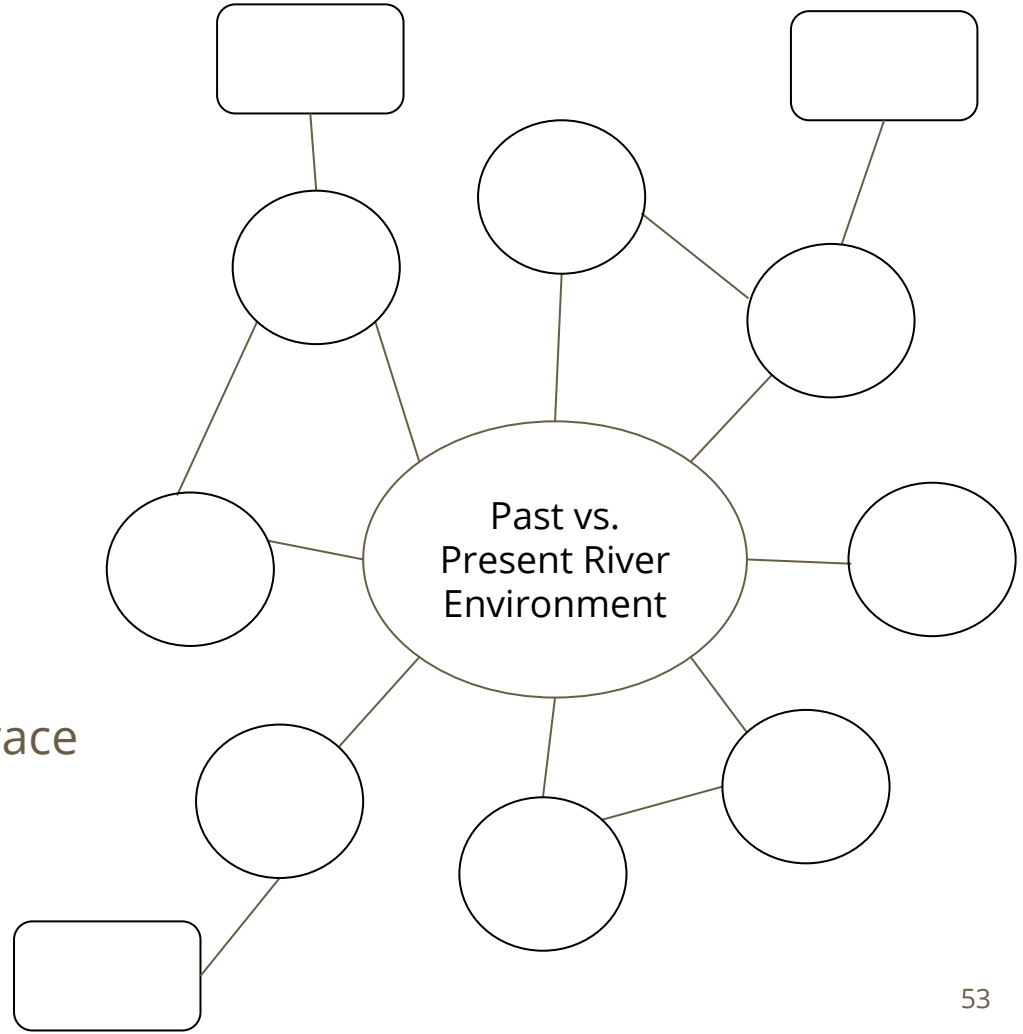
3. **Repeat with 2 more partners!**

4. **Revise both your model and explanation.**

Class Concept Map

Add to your class concept map:

- New questions (circles)
- New ideas learned (squares)
- New connections (lines and connector words)
- Crosscutting concepts used (trace in color)
    - Energy and Matter



Evaluate

Connecting to the Culminating Project

You will be creating 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.

Complete this **individually** in your Project Organizer.

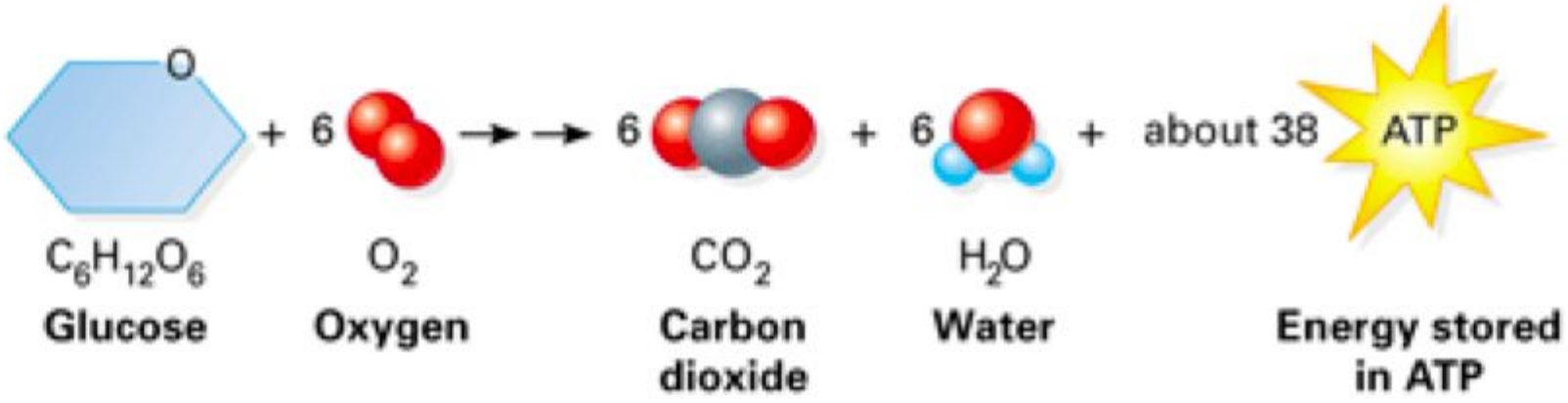
Reflection

Complete the questions at the end of your student guide to reflect on what you have learned in Task 2.

Cycling Matter Through Living Things

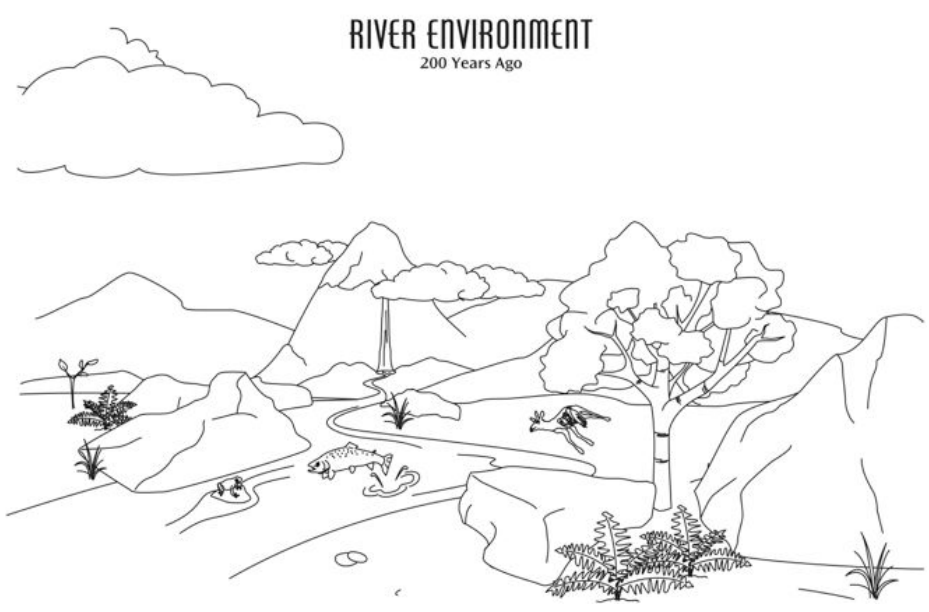
Task 3

What questions do you still have?



Engage

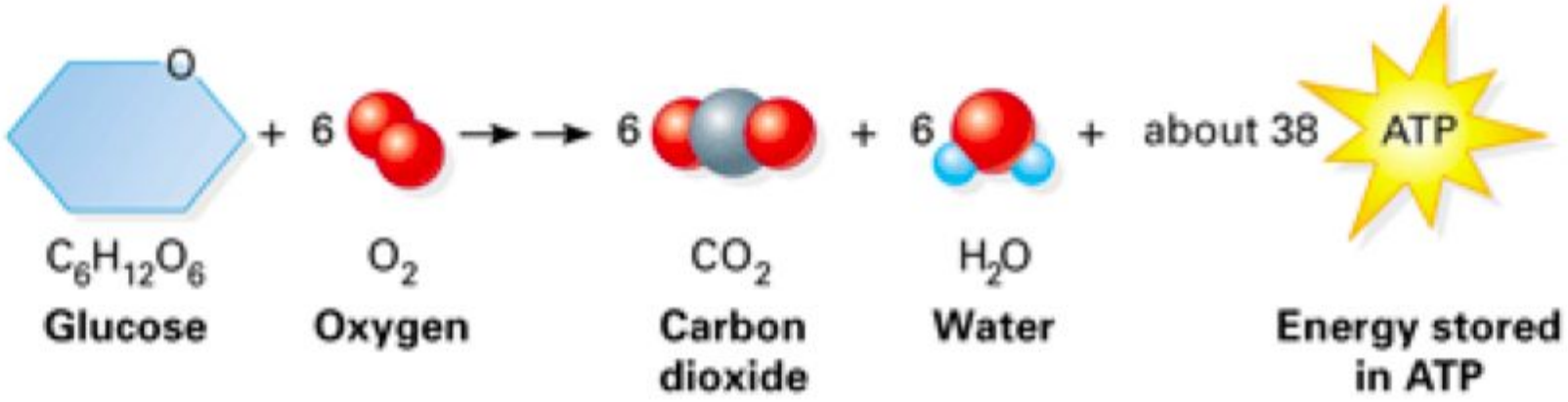
What do you think causes plants and animals to grow and make energy?



With a partner, answer the questions in your Student Guide.

Explore

Remember the chemical equation for cellular respiration?



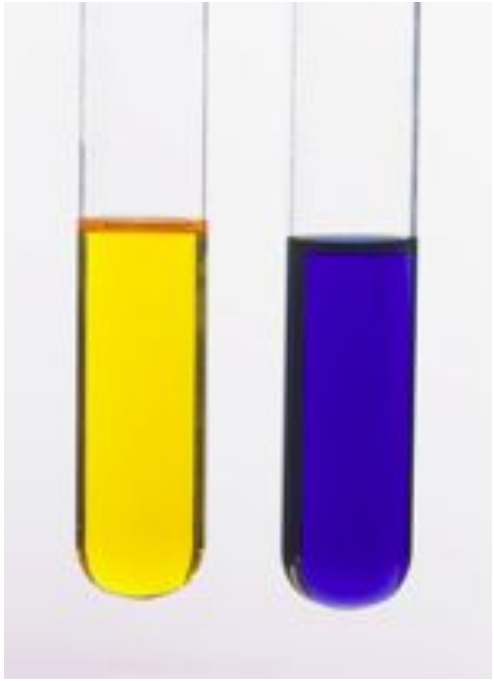
Investigation 1: How do we know that cellular respiration is happening?

With your group,

1. Review the chemical equation for cellular respiration.
2. Follow the procedure in your Student Guide to conduct the investigation.
3. Discuss and answer the data analysis question.

Bromothymol Blue (BTB) is an indicator for carbon dioxide!

Carbon Dioxide Present



Carbon Dioxide Absent

Investigation 2: What other chemical reaction happens in plants?

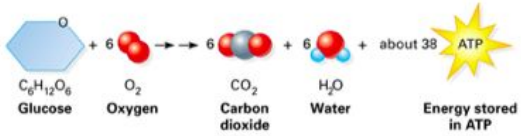
With your group,

1. Follow the procedure in the Investigation Card to set up the investigation.
2. Record observations and make predictions.
3. After 24 hours, record new observations.

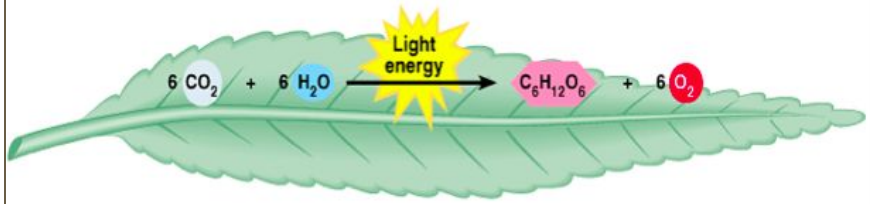
Explain

What happened in Investigation 2?

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.

Individually,

1. Read and annotate the article to learn more about photosynthesis.

In pairs,

2. Complete the lab conclusion questions, using what you learned in the article.

Cellular Respiration and Photosynthesis

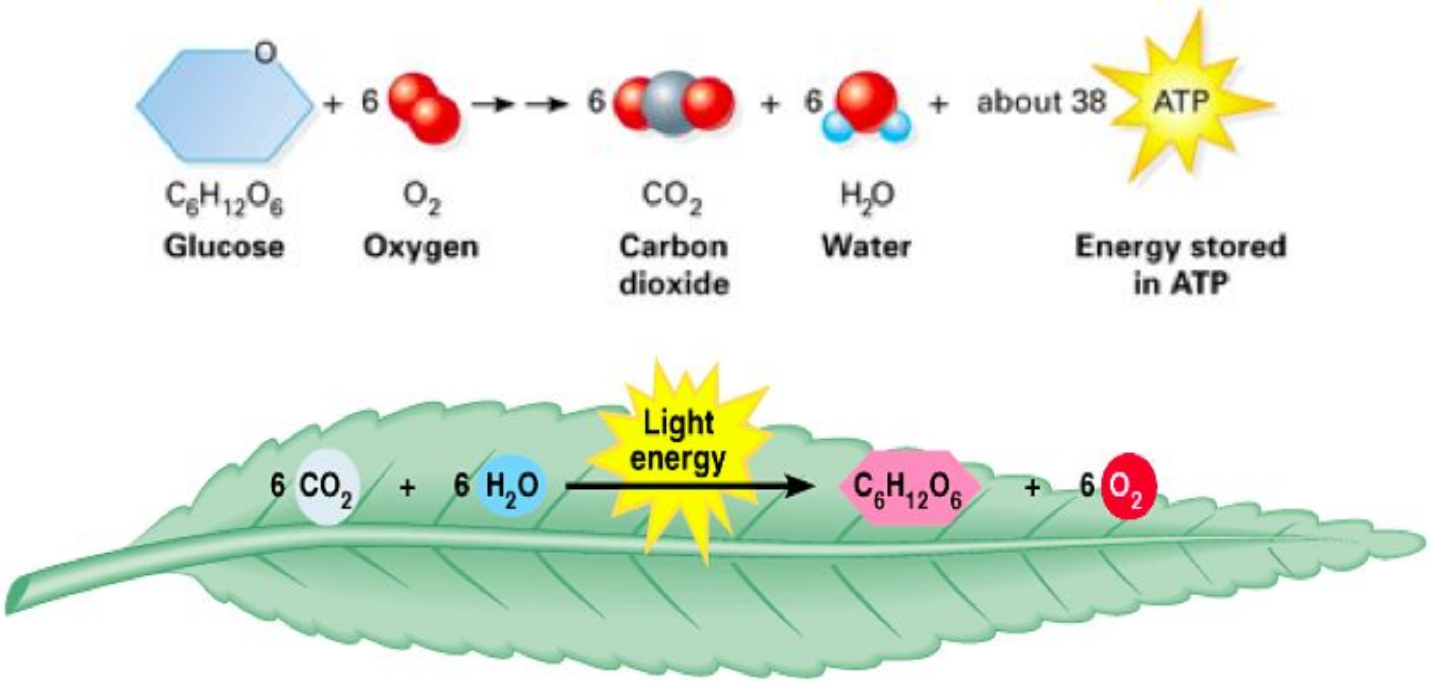
https://ed.ted.com/lessons/the-simple-but-fascinating-story-of-photosynthesis-and-food-amanda-ooten#review

Class Debrief: What happened in Investigation 2?

Light Dark

Elaborate

How do photosynthesis and cellular respiration work together to make ecosystems function?



What if you added a fish to your Experimental Set-Up?

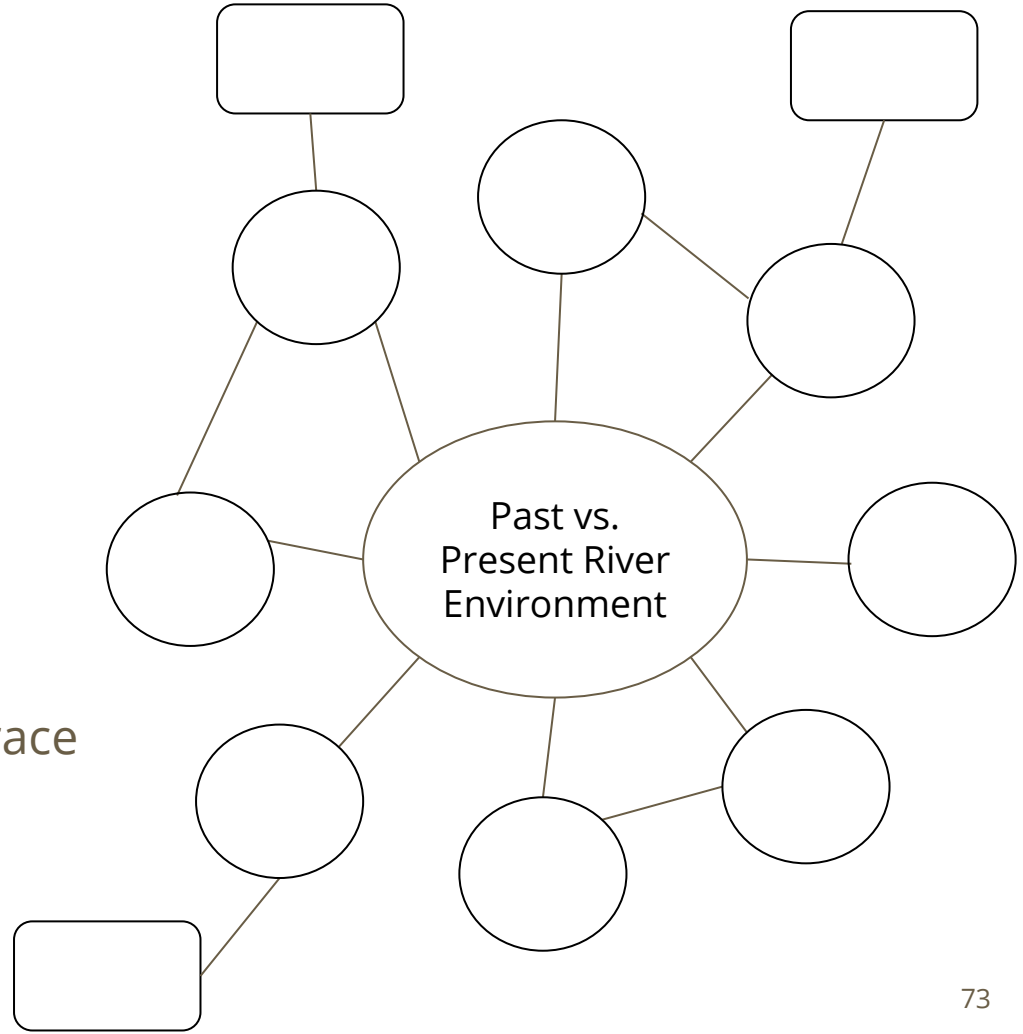
Individually,

1. Predict what color you think the solution would be after 24 hours.
2. Draw a new model showing the fish and Elodea in BTB solution, placed in light.
3. Explain how the model shows cellular respiration and photosynthesis working together.

Class Concept Map

Add to your class concept map:

- New questions (circles)
- New ideas learned (squares)
- New connections (lines and connector words)
- Crosscutting concepts used (trace in color)
    - Energy and Matter



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 the organism requires for photosynthesis. How will your system provide these molecules?
- 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. Use arrows to show which 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?

Complete this **individually** in your Project Organizer.

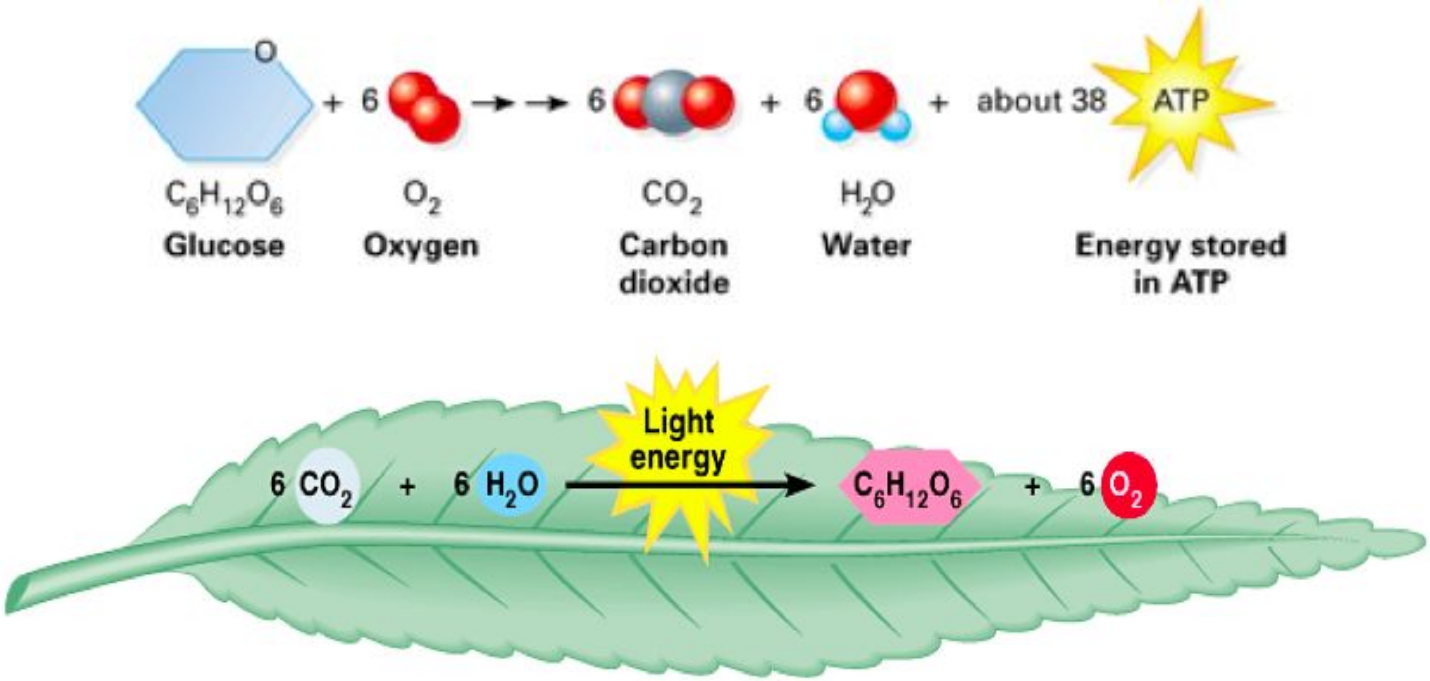
Reflection

Complete the questions at the end of your student guide to reflect on what you have learned in Task 3.

Cycling Matter Through Rocks

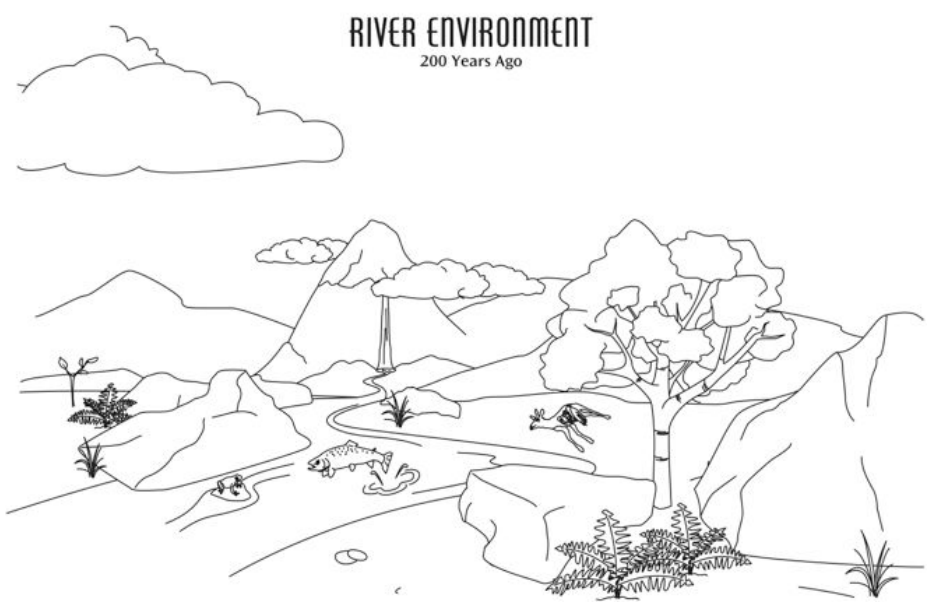
Task 4

What questions do you still have?



Engage

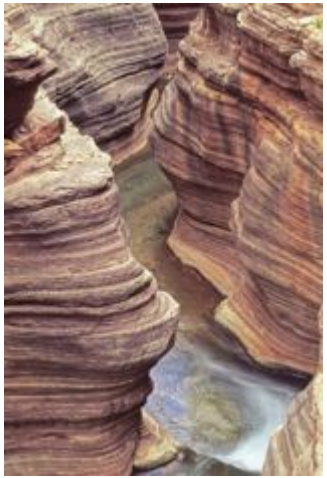
Find at least two changes in rock formations that occurred over 200 years



With a partner, answer the questions in your Student Guide.

Explore

Model The Rock Cycle with Crayons

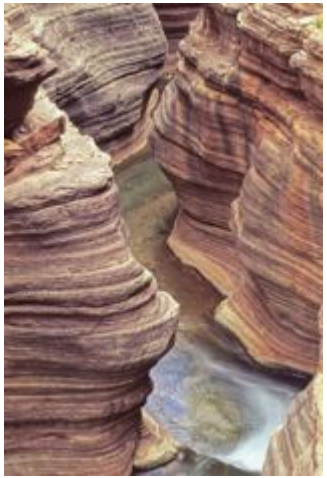


As a group,

1. Use the materials provided and the directions on the Resource Card to model how Earth's materials cycle through environments.
2. Record observations in the table on your Student Guide.

Class Debrief

Weathering



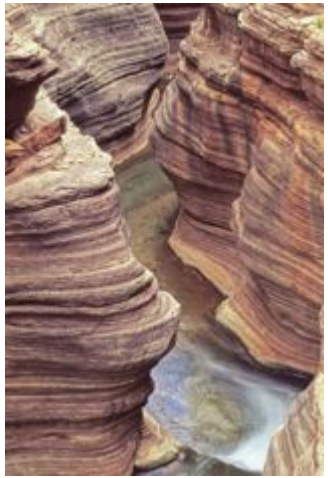
Sedimentation

Deformation

Crystallization

Explain

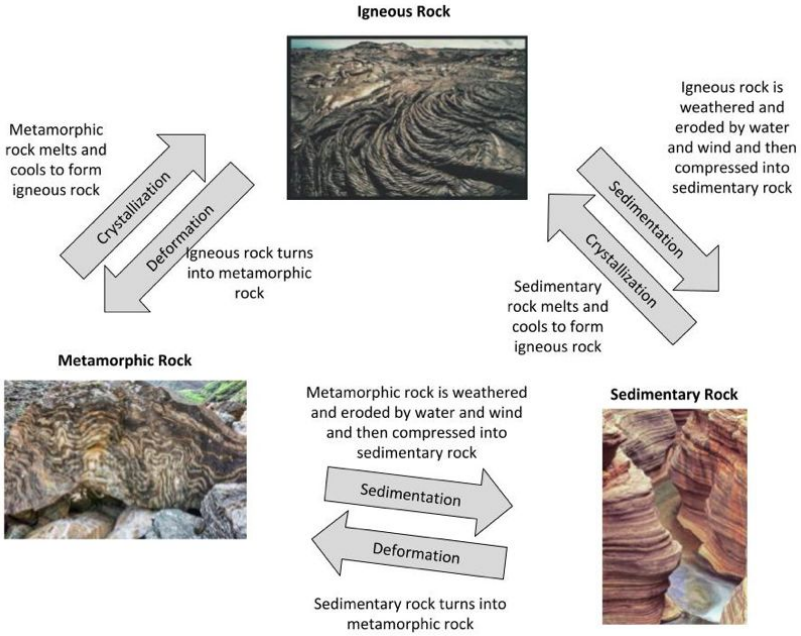
Developing and Using Models: The Rock Cycle



Individually, make a flowchart that shows how Earth's matter cycles throughout the environment and how the flow of energy drives all these processes.

Elaborate

Critique, Correct, and Clarify



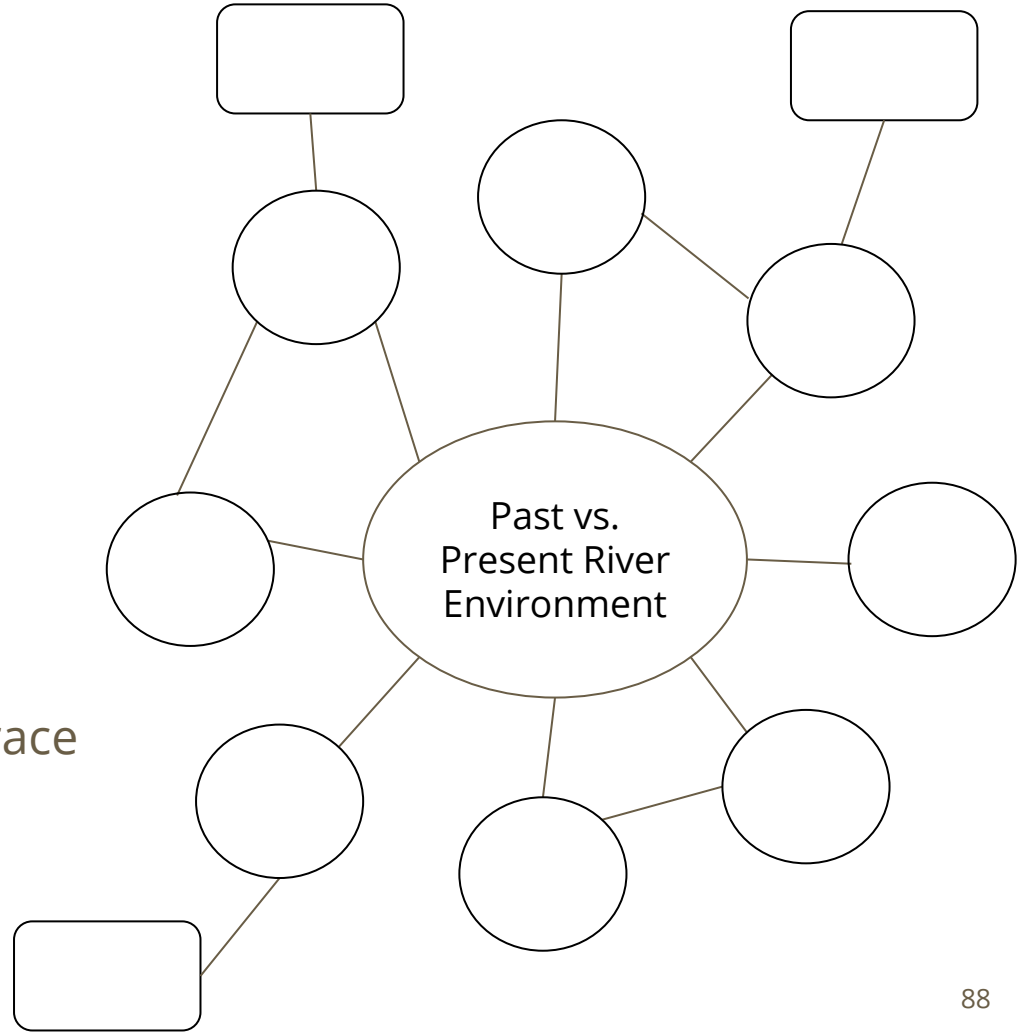
1. Critique: Analyze the rock cycle model provided by your teacher. Identify and discuss error(s), parts that aren't clear, or ideas that are missing.
2. Correct: Write on the model to make it clearer and more accurate.
3. Clarify: Describe how and why you corrected the model.

Then return to your own model and make any revisions needed!

Class Concept Map

Add to your class concept map:

- New questions (circles)
- New ideas learned (squares)
- New connections (lines and connector words)
- Crosscutting concepts used (trace in color)
    - Stability and Change



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 be the effects on your system?

Complete this **individually** in your Project Organizer.

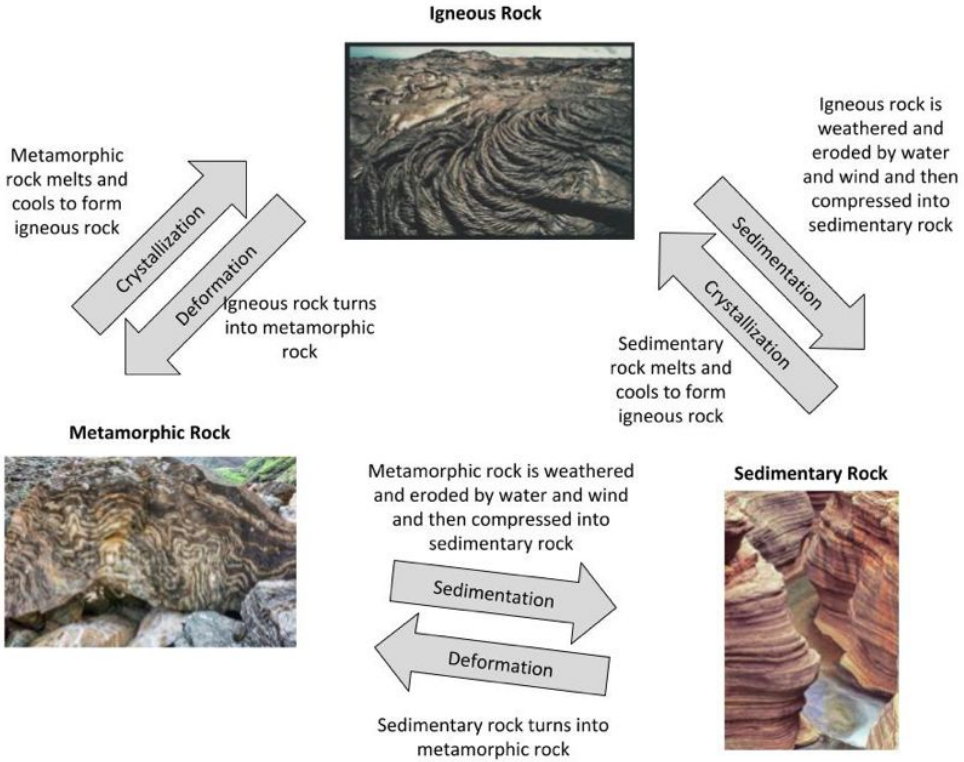
Reflection

Complete the questions at the end of your student guide to reflect on what you have learned in Task 4.

Design a Thermal Device

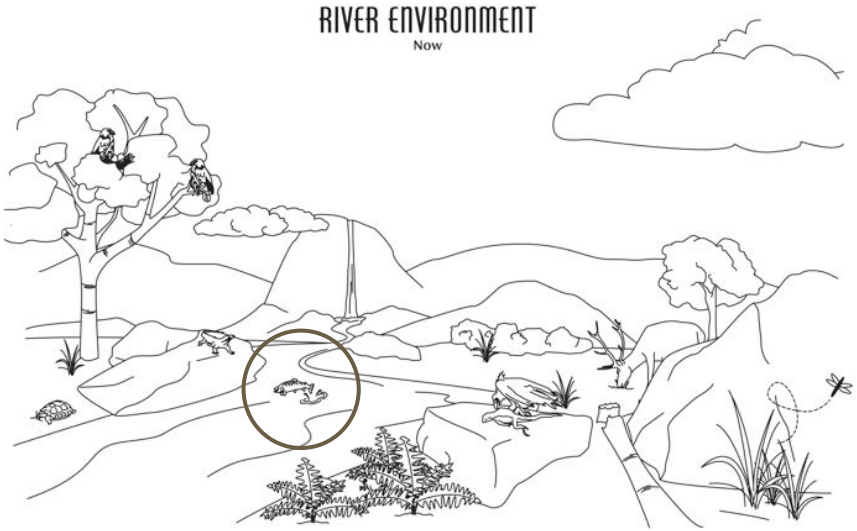
Task 5

What questions do you still have?



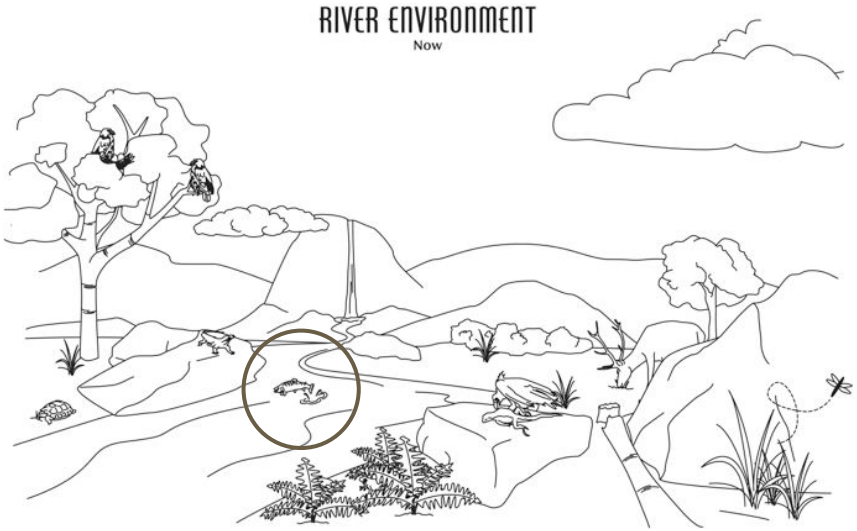
Engage

The Problem



The river environment has experienced a climate change, leaving the water a few degrees colder than normal. This interferes with fish spawning, which only happens at a certain temperature.

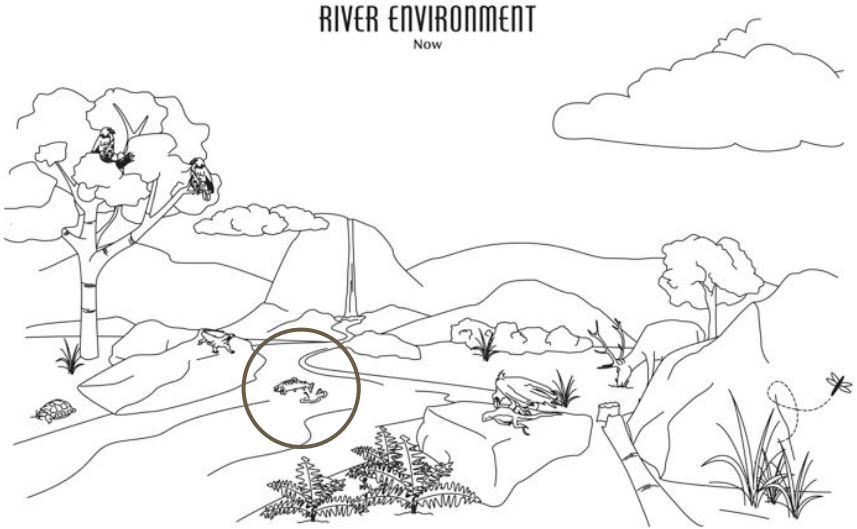
Think-Pair-Share



What happens if fish can’t spawn? What other “domino” effects might this have on the river environment?

Explore

Your job is to design devices that keep the river warm enough for fish spawning!



Our Inspiration

Many instant hot packs and cold packs work by using chemical reactions that either absorb or release heat

Investigating Thermal Chemical Reactions

In groups,

1. Use the materials and Resource Card provided at your table.
2. Test each of the substances provided.
3. Record observations and decide which ones create chemical reactions that release heat and which ones create chemical reactions that absorb heat.

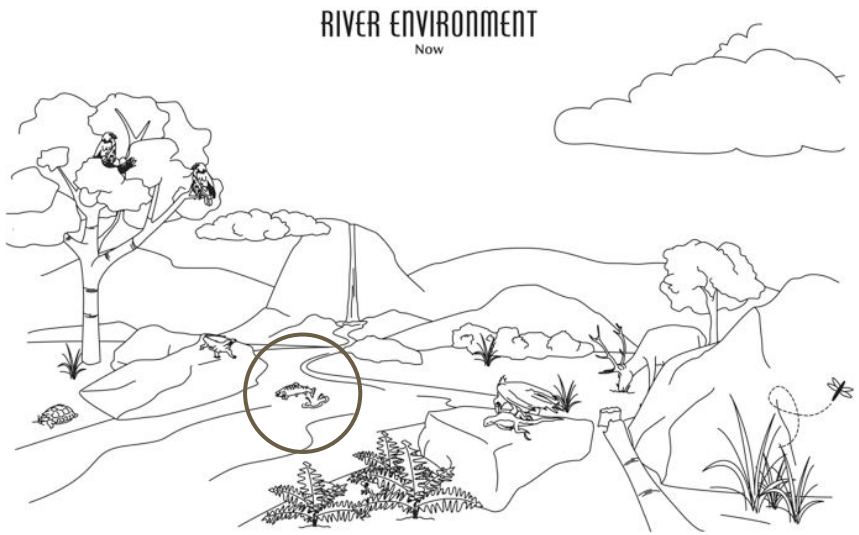
Class Debrief

Substances Combined	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	

Explain

Design a Heat-Regulation Device

Blue Catfish spawns in river water at 70-75 degrees, but the pool is currently at a temperature of 68 degrees

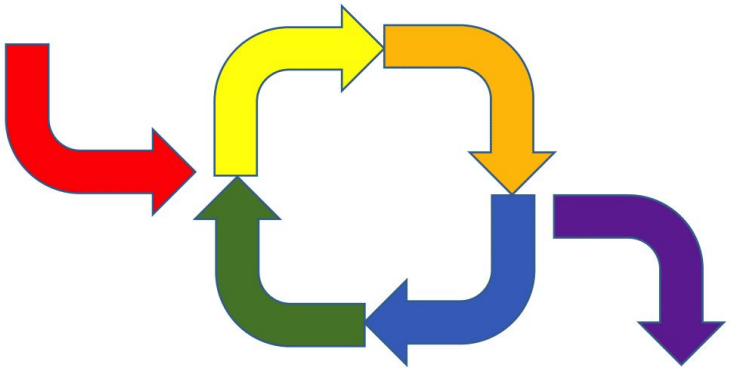


In groups, begin the design process by:

1. Identifying the criteria and constraints of the problem
2. Deciding which substances will be best for your device
3. Designing and drawing models of two potential devices

Elaborate

Test and Revise a Heat-Regulation Device



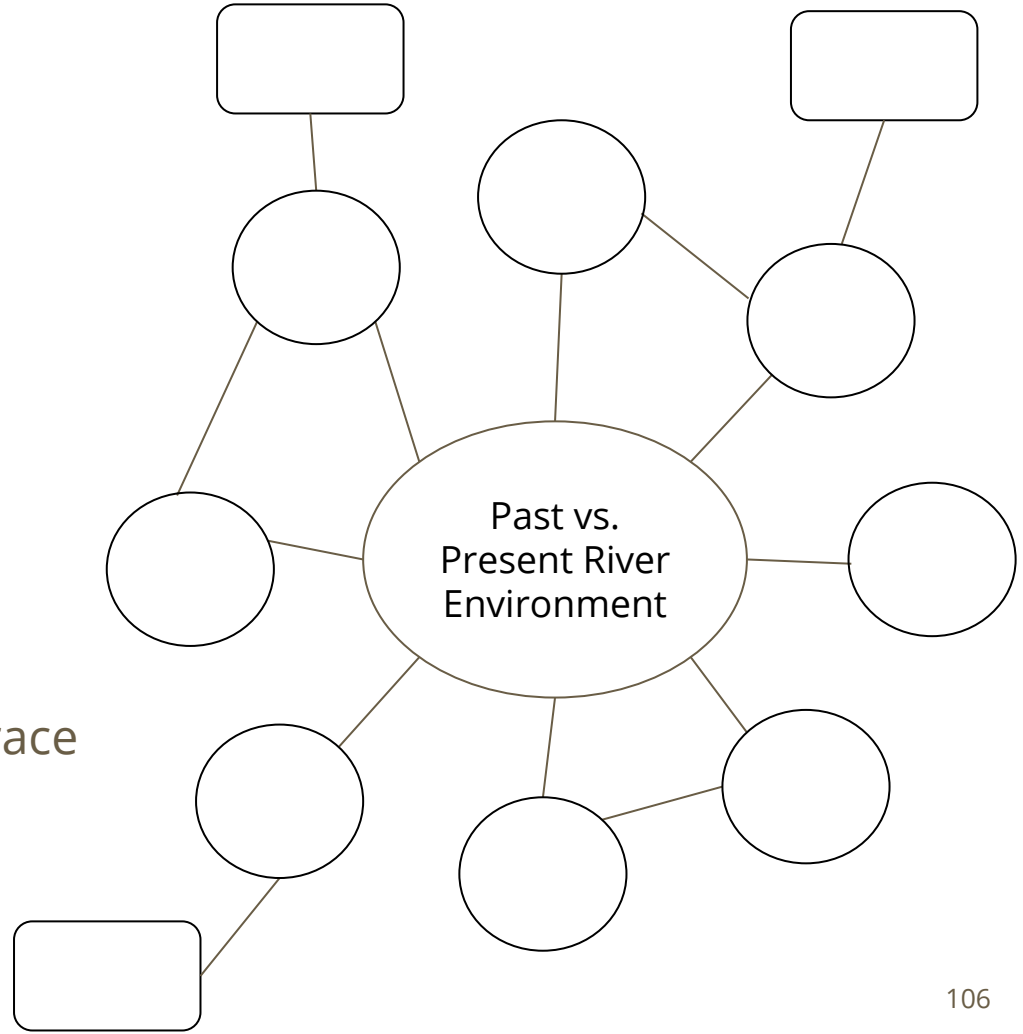
In groups, continue the design process by:

1. Testing your devices and analyzing the data.
2. Sharing designs and test data with other groups.
3. Revising your device to combine best characteristics of multiple designs.
4. Retesting the final device.

Class Concept Map

Add to your class concept map:

- New questions (circles)
- New ideas learned (squares)
- New connections (lines and connector words)
- Crosscutting concepts used (trace in color)
    - Energy and Matter



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 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.

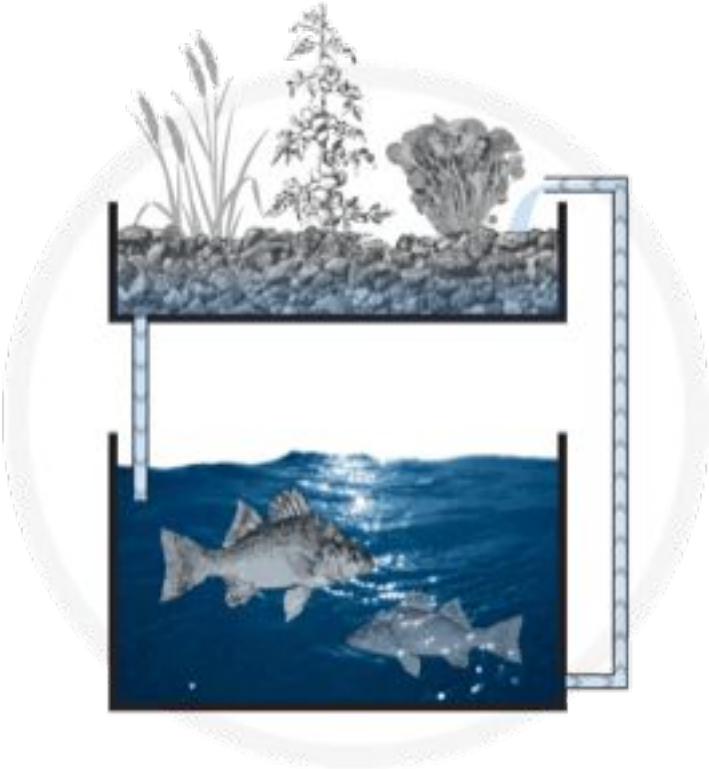
Complete this **individually** in your Project Organizer.

Reflection

Complete the questions at the end of your student guide to reflect on what you have learned in Task 5.

Culminating Project

Design and Build an Aquaponics System!



Group Project - Create an aquaponics system that mimics a natural ecosystem

Individual Project - Write an instruction manual for your aquaponics system that explains the science behind how it functions

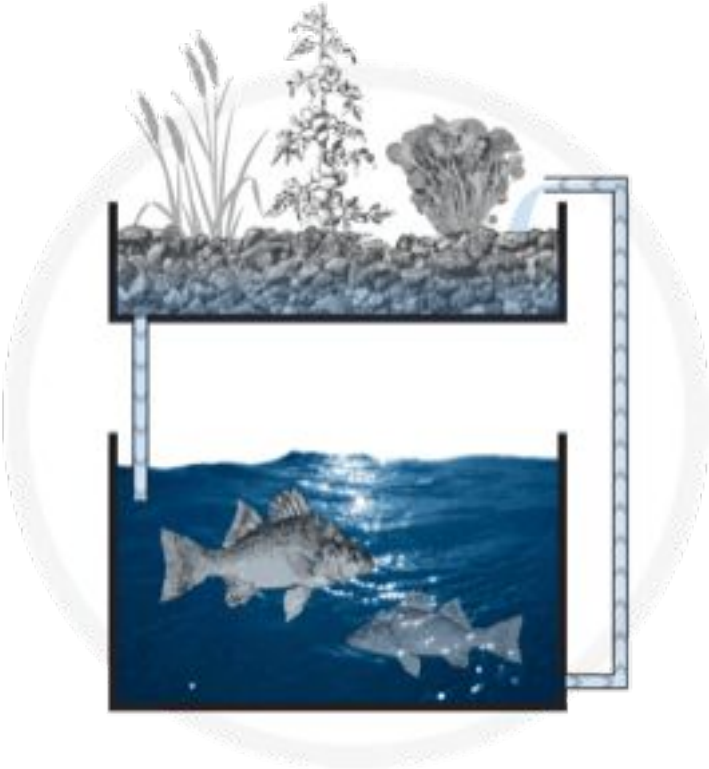
Don’t forget to use your checklist of criteria!

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

Design and Build an Aquaponics System!



Group Project - Create an aquaponics system that mimics a natural ecosystem

Individual Project - Write an instruction manual for your aquaponics system that explains the science behind how it functions

Optional Template

Aquaponics System Instruction Manual Template

Title
Introduction to Manual

Diagram of Aquaponics System

How Aquaponics Systems Sustain Themselves	
Cellular Respiration	Photosynthesis

Possible Changes to Your Aquaponics System Over Time	
Rock Cycle	Physical and Chemical Changes

How to Regulate Temperature in Your Aquaponics System

Benefits and Limitations of an Aquaponics System

Don’t forget to use your checklist of criteria!

Individual Project Criteria for Success

The instruction manual for your aquaponics system should include:

- ❑ A diagram of your aquaponics system
  - o Label all living and non-living parts in your system
- ❑ Identify at least one organism that does cellular respiration in your aquaponics system
  - o Model and describe the process of cellular respiration (using pictures, labels, arrows and captions)
  - o 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
  - o Model and explain the process of photosynthesis (using pictures, labels, arrows and captions)
  - o In your model, make sure to show all forms of energy and matter involved
  - o 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
  - o Identify the flow of energy that drives the processes you identify
  - o 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
  - o 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
  - o 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
  - o 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?

Peer Review

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:
- ❑ 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)
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