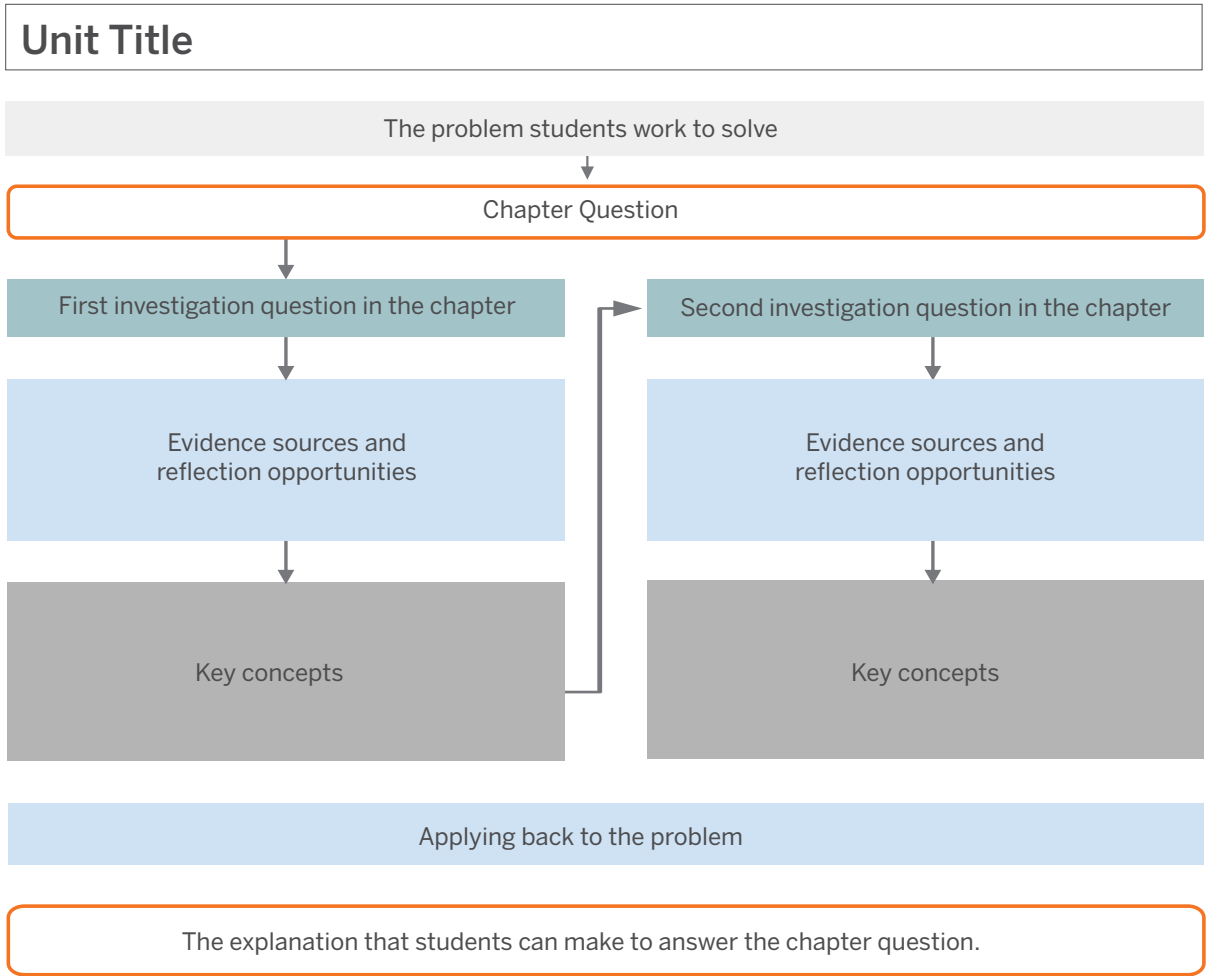
Earth's Changing Climate Coherence Flowchart

The storyline of the unit

In each Amplify Science unit, students figure out a phenomenon by asking questions, gathering evidence, and coming up with an explanation of how the phenomenon works. The Coherence Flowchart visually represents the storyline of the unit, showing the coherent flow of questions, evidence, and ideas that support students as they build complex explanations of the unit's anchor phenomenon. The Coherence Flowchart on the following pages (one chapter per page) can be used to see the connections between the questions that drive students' experiences, the evidence they gather, the ideas they figure out, and the new questions that those ideas generate. The diagram to the right explains the structure of a chapter in the Coherence Flowchart.

Note: The Coherence Flowchart is a tool for teachers and is not meant to be distributed to students.

Typical structure of one chapter in a Coherence Flowchart



Instruction is framed by questions about the unit's anchor phenomenon and the related problem students are solving. Chapter Questions then guide students in figuring out the phenomenon, piece by piece. Within each chapter, Investigation Questions focus students on a manageable piece of content that will help them figure out the Chapter Question. Each question motivates activities, and each activity provides specific evidence related to the Investigation Question. Students synthesize the understanding constructed over multiple activities, and this understanding is formalized through key concepts. Often a key concept leads students to an additional Investigation Question students need to pursue to answer the Chapter Question. At the end of the chapter, students' new understanding is applied back to the unit's anchor phenomenon and leads students to a new Chapter Question or a final explanation.

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Earth's Changing Climate: Vanishing Ice

The problem students work to solve

Why is the ice on Earth's surface melting?

Chapter 1 Question

Why is the ice on Earth's surface melting?

Investigation Questions

What could be causing ice to melt and temperatures to increase on Earth? (1.3)

What kinds of changes to the atmosphere could affect how much energy is absorbed by Earth's surface? (1.4, 1.5)

Evidence sources and reflection opportunities

- Analyze data showing ice decrease and temperature increase over time (1.2)
- Use the Sim to model ice melting and observe energy (1.3)
- Generate claims about why the ice on Earth's surface is melting (1.3)

- Use the Sim to test how increasing or decreasing gases in the atmosphere affects temperature, energy, and ice (1.4)
- Use unit vocabulary to explain the changes that could affect how much energy is absorbed by Earth's surface (1.4)

Key concepts

- Although there are many fluctuations, there is a trend toward increasing temperatures and decreasing ice on Earth since about 1880. (1.2)
- Global average temperature increases when energy absorbed by the surface increases. (1.3)

- When the amount of carbon dioxide or methane in the atmosphere changes, the amount of energy absorbed by the surface also changes. (1.4)
- When the amount of carbon dioxide or methane increases, energy absorbed by the surface increases. (1.4)
- When the amount of carbon dioxide or methane decreases, energy absorbed by the surface decreases. (1.4)

Application of key concepts to the problem

- Analyze data showing an increase in carbon dioxide and methane over time (1.5)
- Use the Modeling Tool to model a claim about what is causing ice to melt and temperature to increase in the Modeling Tool (1.5)

Explanation that students can make to answer the Chapter 1 Question

Ice is melting because more energy is being absorbed by Earth's surface. The data show that carbon dioxide and methane have been increasing in the atmosphere over the past 100 years and when carbon dioxide or methane in the atmosphere increase so does global average temperature and energy absorbed by the surface.

Earth's Changing Climate: Vanishing Ice

The problem students work to solve

Why is the ice on Earth's surface melting?

Chapter 2 Question

Why do temperatures on Earth increase when the amount of carbon dioxide or methane in the Earth system increases?

Investigation Questions

How can the amount of energy absorbed by Earth's surface change? (2.1, 2.2)

How do carbon dioxide and methane affect energy entering or exiting the Earth system? (2.3)

Why does an increase in carbon dioxide or methane result in more energy entering and exiting the Earth system? (2.6)

Evidence sources and reflection opportunities

- Use a token model to track energy entering and exiting a system (2.1)
- Watch a video modeling energy entering and exiting a system (2.1)
- Use the Sim to test the amount of energy that enters and exits the Earth system in various scenarios (2.1)

- Read "Past Climate Changes on Earth" (2.2)
- Revisit "Past Climate Changes on Earth" (2.3)
- Use the Modeling Tool to show what is happening in the Earth System (2.3)

- Use the Sim to investigate how gases redirect outgoing energy back toward Earth's surface (2.6)
- Use a token model to reinforce what students observed in the Sim (2.6)

Key concepts

- A system can be stable, even as something flows into and out of the system. If this balanced flow is disrupted, there may be changes to the system. (2.1)
- A change to either the amount of energy entering or exiting the Earth system affects how much energy is absorbed by the surface. (2.1)
- Temperature increases if more energy enters than exits. (2.1)
- Temperature decreases if less energy enters than exits. (2.1)

- If there is an increase in the amount of carbon dioxide or methane, the amount of energy leaving the Earth system decreases, so more energy enters than exits. (2.3)
- If there is a decrease in the amount of carbon dioxide or methane, the amount of energy leaving the Earth system increases, so less energy enters than exits. (2.3)

- Carbon dioxide and methane stop energy from leaving by redirecting energy that would have exited the system. (2.6)

Application of key concepts to the problem

- Use the Modeling Tool to show how the path of energy is affected by carbon dioxide or methane (2.7)
- Use unit vocabulary to discuss the chapter question and then write an explanation (2.7)

Explanation that students can make to answer the Chapter 2 Question

When carbon dioxide or methane increase, less energy exits than enters Earth's system leading to more energy absorbed by the surface, and therefore an increase in temperature. This is because carbon dioxide and methane stop energy from leaving by redirecting energy that would have exited the system.

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Earth's Changing Climate: Vanishing Ice

The problem students work to solve	Why is the ice on Earth's surface melting?
Chapter 3 Question	What can be done to stop the carbon dioxide and methane in Earth's atmosphere from increasing?
Investigation Question	Why are carbon dioxide and methane increasing in the atmosphere? (3.1)
Evidence sources and reflection opportunities	• Use the Sim to investigate which human activities are connected to the increase in carbon dioxide and methane (3.1) • Observe a video showing how carbon dioxide is released through combustion and how methane is released through livestock (3.1) • Analyze data on human activities (3.1) • Read "Climate Change Solutions" (3.2) • Revisit "Climate Change Solutions" (3.3) • Simulate how to keep the temperature stable (3.3)
Key concepts	• Carbon dioxide and methane in the atmosphere increase as a result of human activities, such as combustion. (3.1) • Some ways to stop the increase of carbon dioxide and methane include decreasing combustion and removing these gases from the atmosphere. (3.3) • Humans can take actions in their daily lives that will reduce the amount of carbon dioxide and methane in the atmosphere. (3.3)
Application of key concepts to the problem	• Model how one solution would affect climate change using the digital Modeling Tool (3.3) • Describe and explain one solution for Climate Change (3.3)
Explanation that students can make to answer the Chapter 3 Question	The increases in carbon dioxide and methane in the atmosphere are due to human activities. Combustion of fossil fuels releases carbon dioxide and livestock release methane. Both combustion of fossil fuels and the amount of livestock have been increasing due to human activities. Reducing these activities can slow the addition of these gases to the atmosphere. The gases can be taken out of the atmosphere by reforestation and by capturing these gases.

The Earth System: Investigating Water Shortages

Problem students work to solve and the Chapter 4 Question

How is Earth's climate affected in the five to ten years after a large volcanic eruption?

Application of key concepts to new problem

- Investigate effects of sulfur dioxide in the Sim (4.1)
- Evaluate quality of evidence (4.1)
- Analyze and sort evidence based on claims (4.2)
- Participate in the Science Seminar (4.3)
- Write an argument to support a claim (4.3)

Explanation that students can make to answer the Chapter 4 Question

One possible explanation students can make:

A large volcanic eruption makes Earth's temperature warmer. Although there will be fluctuations in global temperature, an eruption will add to an overall warming trend. The Pinatubo eruption released 50 million tons of carbon dioxide. In addition, another 1 million tons were released during rebuilding and because the eruption destroyed 155 square kilometers of forest, 3 million tons of carbon dioxide stayed in the atmosphere instead of getting taken in by the trees. The evidence that carbon dioxide increased is important because carbon dioxide stops some energy from leaving the Earth system and instead sends it back toward Earth. Therefore, an increase in carbon dioxide causes an increase in the total amount of energy in the Earth system because more energy enters than exits. Carbon dioxide stays in the atmosphere for up to 100 years, so it would definitely affect the total energy for 5 to 10 years. Because temperature increases when there is more total energy, which means more energy gets absorbed by Earth's surface, the increase in carbon dioxide from volcanic eruptions leads to warmer temperatures on Earth.