The Earth System Coherence Flowchart

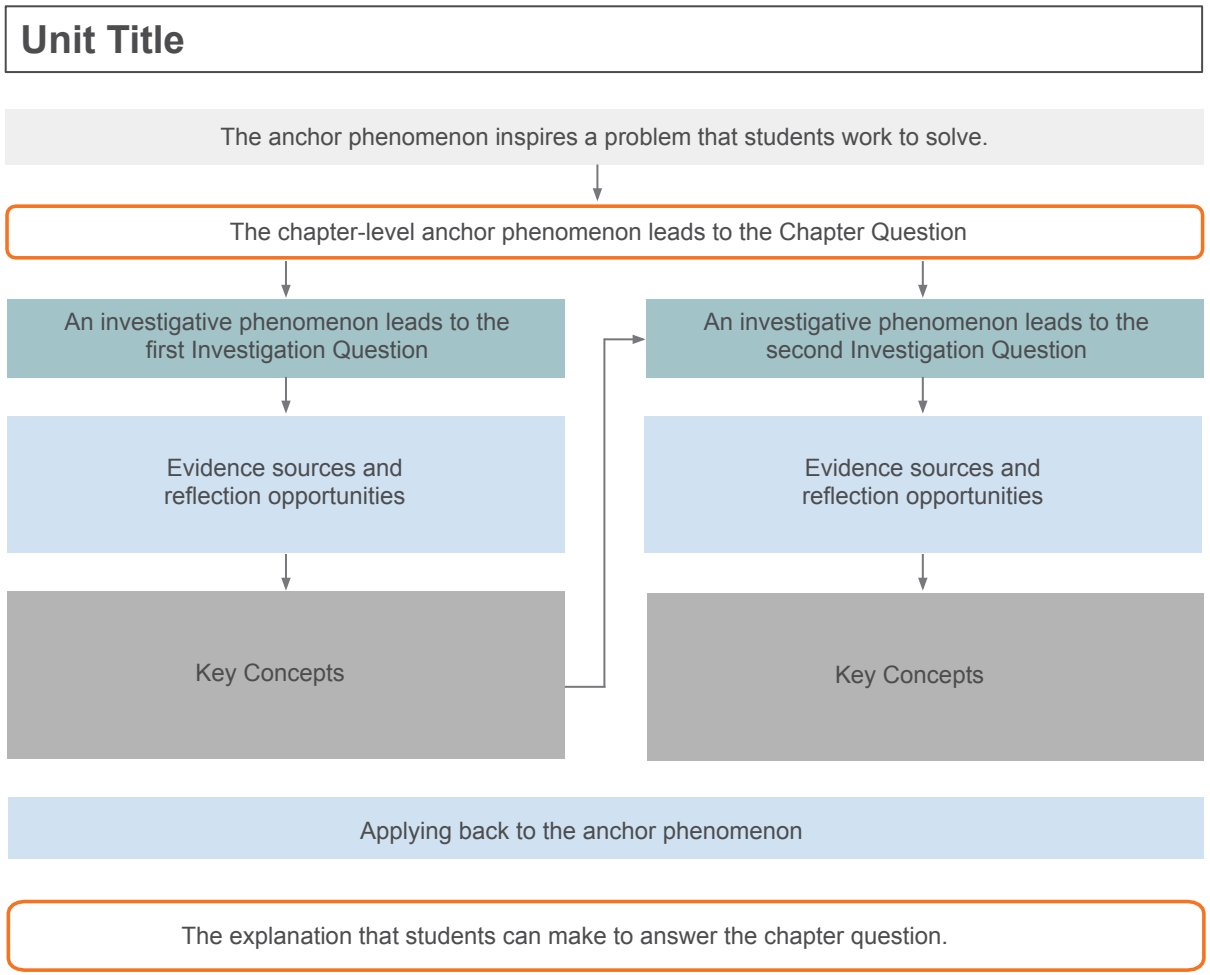
The storyline of the unit

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 based on phenomena, 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 phenomena and 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.

In some units a design problem drives the investigations of the unit or of specific lessons. In these cases the design problem will be noted in place of the phenomenon.

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, investigative phenomena lead to Investigation Questions that focus students on a manageable piece of content that will help them figure out the Chapter Question. Each phenomenon leads to a question which 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 investigative phenomenon and 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.

AmplifyScience

The Earth System: Investigating Water Shortages

Unit Anchor Phenomenon
Problem students work to solve

West Ferris has more freshwater than East Ferris.
Why does West Ferris have more freshwater than East Ferris?

Chapter-level Anchor Phenomenon
Chapter 1 Question

East Ferris doesn't have enough water.
Why is East Ferris running out of water while West Ferris is not?

Investigative Phenomena
Investigation Questions

Water is some places on Earth but not others.
Where is water on Earth? (1.1)

There is less freshwater in some places than others.
How can people affect how much freshwater is available? (1.2-1.3)

Evidence sources and reflection opportunities

- Investigate how much water there is on Earth through a globe tossing activity (1.1)
- Analyze graphs of global water distribution in Water Encyclopedia (1.1)

- Discuss how people use fresh water in their daily lives (1.2)
- Read *Water Shortages, Water Solutions* (1.2)
- Observe videos of of water flowing in and out of a reservoir at different rates (1.3)

Key concepts

- Almost all of Earth's water is salt water in the ocean. The limited amount of freshwater is mostly in glaciers and groundwater. (1.1)

- The amount of available freshwater decreases when people use more than the amount that flows into their area. (1.3)

Application of key concepts to the problem

- Analyze data about precipitation and population in East Ferris (1.3)
- In pairs, create diagrams showing why East Ferris is running out of water while West Ferris is not (1.3)
- Write a scientific explanation to answer the Chapter 1 Question (1.3)

Explanation that students can make to answer the Chapter 1 Question

Ferris Island is surrounded by ocean, but salt water is unusable for most human purposes. East Ferris's growing population is using up their only freshwater source, a groundwater reservoir, whereas West Ferris has an additional source of freshwater—rain.

The Earth System: Investigating Water Shortages

Unit Anchor Phenomenon
Problem students work to solve

West Ferris has more freshwater than East Ferris.
Why does West Ferris have more freshwater than East Ferris?

Chapter-level Anchor Phenomenon
Chapter 2 Question

West Ferris gets more rain than East Ferris.
Why does more rain form over West Ferris than East Ferris?

Investigative Phenomena
Investigation Questions

Rain falls in drops. *How do drops of water form?* (2.1- 2.2)	Rain falls from the sky in drops. *How do raindrops form?* (2.3)	Rain falls from the sky in drops. *Where does water vapor in the air come from?* (2.4-2.6)
Evidence sources and reflection opportunities		
• Observe drops of water forming on a cup of ice water (2.1) • Observe drops of water forming on an empty cup that was in the freezer (2.1) • Observe a cup of ice water sealed in a bag with no air in it (2.2) • Discuss the gases that make up air (2.2)	• Read about phases of water in *Water Encyclopedia* (2.3) • Use the Sim to investigate condensation at the nanoscale (2.3) • Use the Modeling Tool to create digital nanoscale models of how raindrops form (2.3)	• Use the Sim to investigate where water vapor comes from (2.4) • Observe a water vapor demonstration (2.4) • Investigate what happens when drops of saltwater and freshwater are exposed to air (2.4-2.5) • Read *Drinking Cleopatra's Tears* (2.5) • Engage in a Roundtable Discussion about how raindrops form (2.6)
Key concepts		
• Drops of water can form when enough water vapor gets cold and condenses into liquid water. (2.2)	• Raindrops can form when enough water vapor gets cold and condenses into liquid water. (2.3) • Water molecules are spread apart in water vapor. Water molecules are • close together in liquid water. (2.3)	• Water vapor in the air comes from liquid water that has evaporated. (2.5) • When water changes from gas to liquid or liquid to gas, water molecules are not created or destroyed. (2.6)

Application of key concepts to the problem

- Write a scientific explanation to answer the Chapter 2 Question (2.6)
- Plan, design, and test freshwater collection systems (2.7)
- Read *Engineering Clean Water* (2.8)
- Reflect on how engineers iterate upon their designs (2.8)

Explanation that students can make to answer the Chapter 2 Question

More rain forms over West Ferris because more water vapor condenses there. During condensation, water vapor gets colder and turns into liquid water. There is a lot of water getting cold in West Ferris, so a lot of rain forms. There is not a lot of rain forming over East Ferris, so there is not a lot of water vapor getting colder and condensing into liquid water there.

The Earth System: Investigating Water Shortages

Unit Anchor Phenomenon
Problem students work to solve

West Ferris has more freshwater than East Ferris.
Why does West Ferris have more freshwater than East Ferris?

Chapter-level Anchor Phenomenon
Chapter 3 Question

West Ferris gets more rain than East Ferris even though the cities have similar temperatures.
Why is more water vapor getting cold over West Ferris than East Ferris?

Investigative Phenomena
Investigation Questions

In the part of the atmosphere where weather happens, it is colder higher up.
Where in the atmosphere does water vapor condense? (3.1-3.3)

Evidence sources and reflection opportunities

- Read about the atmosphere in *Water Encyclopedia* (3.1)
- Use Condensation in the Atmosphere Models to investigate condensation at different heights (3.1)
- Revisit *Drinking Cleopatra's Tears* to gather evidence about where and why water vapor condenses (3.1)
- Use the Sim to gather data about where and at what temperature liquid water forms in the atmosphere (3.2)
- Use the Data Tool to make and analyze graphs of data collected in the Sim (3.2)
- Use the Modeling Tool to develop models of where in the atmosphere raindrops form, and why (3.3)

Key concepts

- Water vapor condenses as it moves higher, to where the atmosphere is colder. (3.2)

Application of key concepts to the problem

- Write a scientific explanation to answer the Chapter 3 Question (3.3)
- Gather data from and evaluate Chapter 2 freshwater collection systems (3.4)
- Use the Engineers' Jigsaw routine to share and plan to iterate upon freshwater collection system designs (3.4)
- Build new freshwater collection systems (3.4)

Explanation that students can make to answer the Chapter 3 Question

There is more water vapor getting cold over West Ferris because on that side of the island more water vapor moves upward in the atmosphere where it is colder. This means that more water vapor can condense and fall as rain

The Earth System: Investigating Water Shortages

Unit Anchor Phenomenon
Problem students work to solve

West Ferris has more freshwater than East Ferris.
Why does West Ferris have more freshwater than East Ferris?

Chapter-level Anchor Phenomenon
Chapter 4 Question

The side of the island West Ferris is on gets more rain than the side of the island East Ferris is on.
Why is there more water vapor high up over West Ferris than East Ferris?

Investigative Phenomena
Investigation Questions

In some places, one side of a mountain gets more rain than the other side of the same mountain.
How does water vapor move to different areas in the atmosphere? (4.1-4.3)

Evidence sources and reflection opportunities

- Use the Sim to investigate what factors affect the movement of water vapor in the atmosphere (4.1)
- Use a physical model to investigate how wind and a mountain can affect the movement of water vapor (4.1)
- Discuss how mountains and the wind can affect where rain will fall (4.1)
- Use the Sim to investigate the rain shadow effect (4.2)
- Use the Modeling Tool in pairs to develop digital models that explain the rain shadow effect (4.2)
- Use the Modeling Tool as a full class to label satellite images of real locations with uneven rainfall patterns (4.2)
- Engage in a Roundtable Discussion about rain formation and the rain shadow effect (4.3)

Key concepts

- When wind blows toward a mountain, the mountain can direct the wind upward. This moves water vapor higher in the atmosphere. (4.2)
- Iterating allows engineers to improve their solutions to problems. (4.5)

Application of key concepts to the problem

- Write a scientific explanation about the rain shadow on Ferris Island (4.3)
- Discuss ideas for solutions to East Ferris's water shortage problem (4.3)
- Read *How the Earth System Explains Dinosaur Extinction* (4.4)
- Discuss and diagram Earth System interactions on Ferris Island (4.4)
- Gather data from and evaluate Chapter 3 freshwater collection systems (4.5)
- Use the Engineers' Jigsaw routine to share and plan to iterate upon freshwater collection system designs (4.5)
- Write and draw final freshwater collection system designs (4.5)

Explanation that students can make to answer the Chapter 4 Question

There is more water vapor getting cold over West Ferris because on that side of the island more water vapor moves upward in the atmosphere where it is colder. This means that more water vapor can condense and fall as rain over East Ferris.

The Earth System: Investigating Water Shortages

Unit Anchor Phenomenon

Another problem students work to solve

West Ferris has more freshwater than East Ferris.
Why does West Ferris have more freshwater than East Ferris?

Chapter-level Anchor Phenomenon

Chapter 5 Question

Wastewater can be turned into freshwater.
How can East Ferris turn wastewater into clean freshwater?

Investigative Phenomena

Investigation Questions

Substances can change.
How do new substances form? (5.1-5.3)

Engineers select reactants to produce particular chemical reactions.
How can engineers control the results of a chemical reaction? (5.4)

Evidence sources and reflection opportunities

- Analyze a wastewater treatment diagram (5.1)
- Compare the properties of substances before they are mixed to the properties of the mixture in the Mixing Substances Investigation (5.1)
- Read *Chemical Reactions Everywhere* (5.2)
- Discuss whether a chemical reaction occurred during the Mixing Substances Investigation (now renamed the Hot Yellow Gas Reaction) (5.2)
- Analyze images for evidence of chemical reactions (5.2)
- Analyze nanoscale diagrams of chemical reactions (5.3)
- Use the Modeling Tool to create digital models of chemical reactions at the nanoscale (5.3)

- Manipulate substances in the Hot Yellow Gas Reaction to determine which combination of substances caused the different observable results (5.4)
- Discuss the effect of changing the reactants in a chemical reaction (5.4)

Key concepts

- In a chemical reaction, substances are mixed and at least one new substance with different properties is formed. (5.2)
- In chemical reactions, matter is not created or destroyed. (5.3)

- By choosing which substances to combine, engineers can control the results of a chemical reaction. (5.4)
- People can design solutions to protect Earth's resources. (5.6)

Application of key concepts to the problem

- Read about wastewater treatment in *Water Encyclopedia* (5.5)
- Write a scientific explanation to answer the Chapter 5 Question (5.5)
- Engage in a Town Hall Meeting discourse routine to discuss the causes for the East Ferris water shortage, and possible solutions (5.6)

Explanation that students can make to answer the Chapter 5 Question

East Ferris can add substances to wastewater that react with harmful substances in the water. The reaction creates new substances that are easier to remove from the water, so East Ferris can get clean freshwater.