Human Energy Systems Instruction Model & Storyline Chart

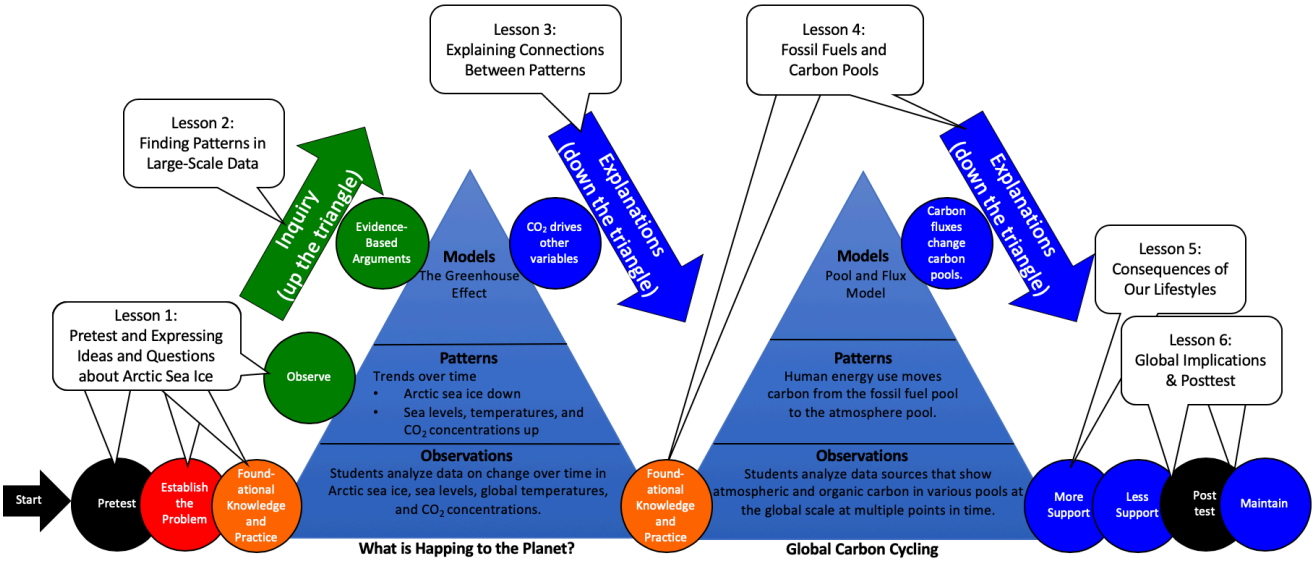
Here, we present two ways to think about how lessons are sequenced in the *Human Energy Systems Unit*. The Instructional Model, immediately below, emphasizes how students take on roles of questioner, investigator, and explainer to learn and apply scientific models in each section of the unit. Further below, the Unit Storyline Chart highlights the central question, activity, and answer that students engage with in each lesson of the *Ecosystems Unit*.

Instructional Model

Like all *Carbon TIME* units, this unit follows an instructional model (IM) designed to support teaching that helps students achieve mastery at answering the driving question through use of disciplinary content, science practices, and crosscutting concepts. To learn more about this design, see the *Carbon TIME* Instructional Model.

The instructional model for the *Human Energy Systems* unit includes two phases, described in the Unit Overview, in which students play the role of questioners, investigators, and explainers. The first phase focuses on helping students to understand, analyze, and explain multiple phenomena associated with climate change (What is happening to the planet?). The second phase focuses on global carbon cycling (What causes changes in CO_2?). Across the unit, classroom discourse is a necessary part of three-dimensional *Carbon TIME* learning. The Carbon TIME Discourse Routine document provides guidance for scaffolding this discourse in lessons.

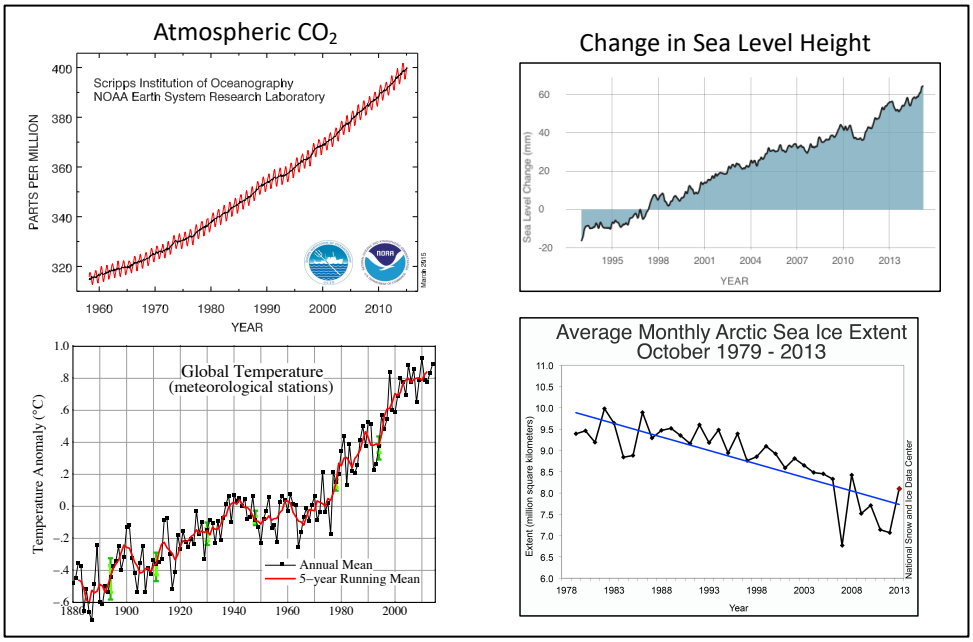
The *Human Energy Systems* Unit



The core of the *Carbon TIME* Instructional Model is the Observation, Patterns, Models (OPM) triangle, which summarizes key aspects to be attended to as the class engages in unit inquiry and explanation. The OPM triangle for the *Human Energy Systems Unit*, shown below, articulates the key observations students make during the unit investigation, the key patterns they identify through analyzing their investigation data, and the central scientific model that can be used to answer the unit's driving question.

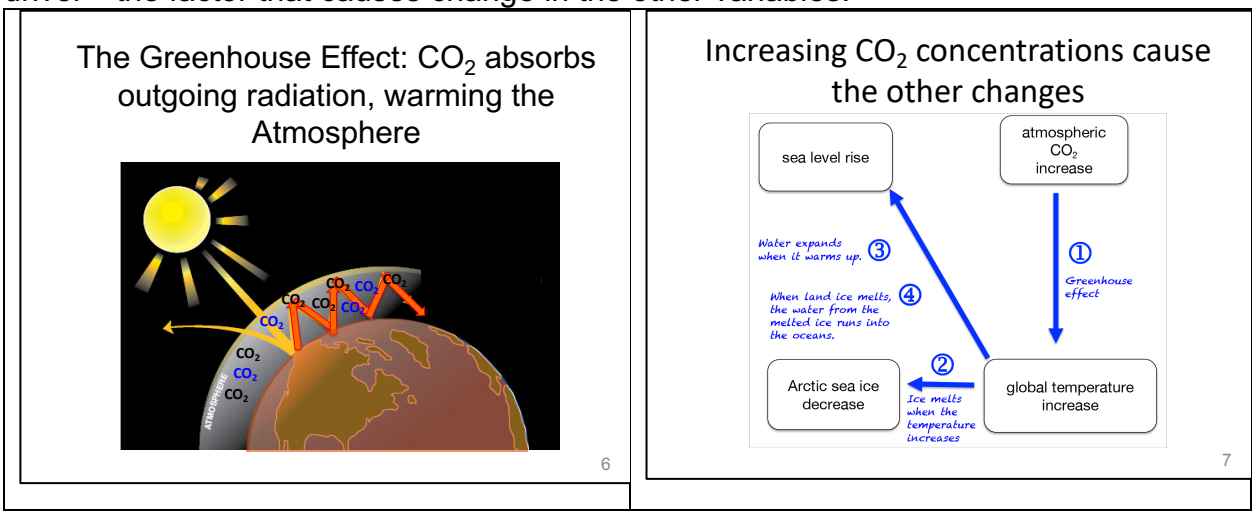
Observations, Patterns, and Models for Phase 1: Climate Change

Observations and patterns: trends in global climate data. Students investigate multiple representations of data about four global phenomena, comparing the representations to look for patterns in the data. They end the Lesson 2 with four clear long-term trends:



- The extent of Arctic sea ice is decreasing
- Sea levels are rising
- Global average temperatures are rising
- Global concentrations of CO_2 are rising

Models: The Greenhouse Effect and CO_2 as the driver. Students learn to use the Greenhouse effect to explain the connections among the long-term trends: Increasing CO_2 levels are causing increases in global temperatures; the increasing temperatures are causing sea level to rise and ice to melt. Thus, atmospheric CO_2 is the driver—the factor that causes change in the other variables.



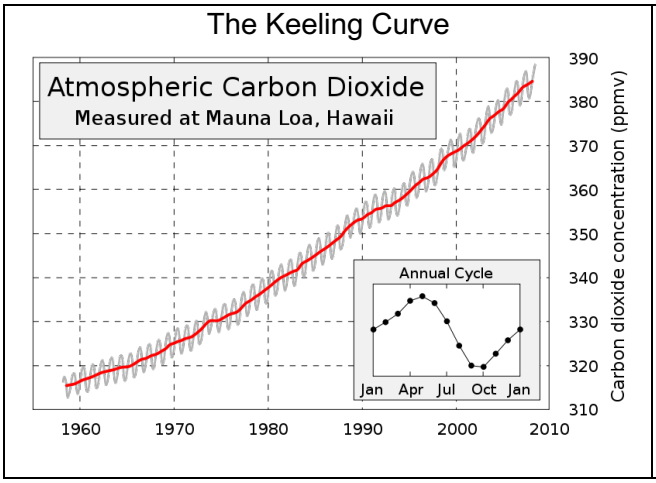
Observations, Patterns, and Models for Phase 2: Global Carbon Cycling

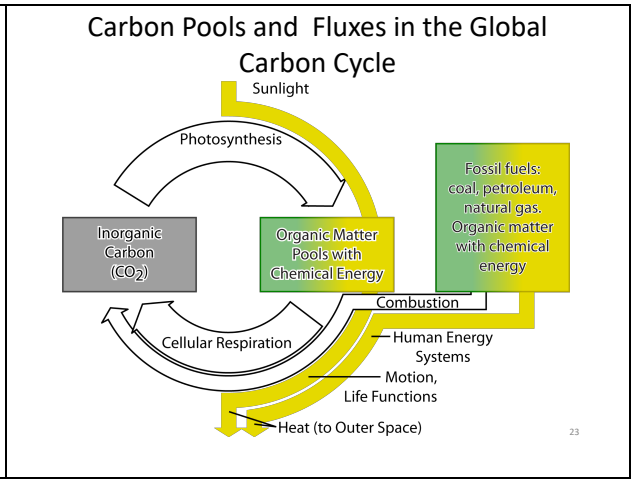
Observations and patterns: Students use visualizations and graphs to investigate changes in atmospheric CO_2 concentrations. Key patterns include:

- The annual cycle: CO_2 concentrations in the northern hemisphere decline every summer and rise every winter.
- The long-term trend: Global CO_2 concentrations have increased from about 310 to 400 ppm since the late 1950s.

Models (and Explanations): Students explain carbon cycling and energy flow between carbon pools by connecting global, macroscopic, and atomic-molecular scales, and answering the Four Questions:

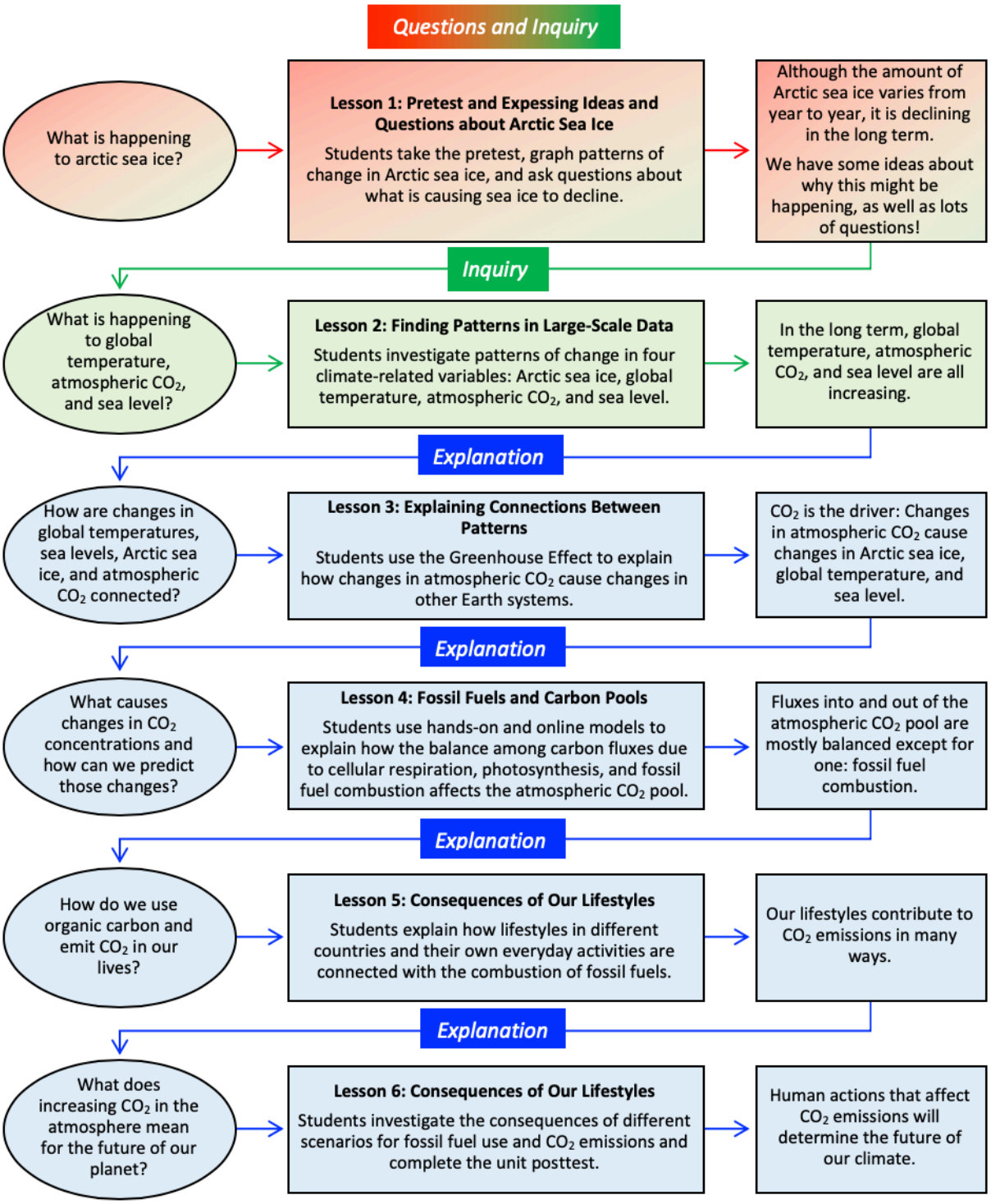
- **Carbon Pools**: carbon atoms are found in CO_2, living organisms, soil organic carbon, oceans, and fossil fuels
- **Carbon Fluxes**: Changes in photosynthesis drive the annual cycle; combustion of fossil fuels drives the long-term trend.
- **Energy Flow**: CO_2 and other greenhouse gases cause climate change.
- **Stability and Change**: The photosynthesis and cellular respiration fluxes are large, but balanced. So, the smaller but unbalanced flux from combustion of fossil fuels is steadily increasing the size of the atmospheric CO_2 pool.





Unit Storyline Chart

Another way to familiarize yourself with the sequence of lessons in the *Ecosystems* Unit is with the Unit Storyline Chart depicted below. The Unit Storyline Chart summarizes a unit phenomenon-based driving question associated with each lesson, what classes will do in each lesson to address the question, what conclusions they will come to, and how they will transition to a subsequent lesson.


Questions and Inquiry
What is happening to arctic sea ice?
Lesson 1: Pretest and Expessing Ideas and Questions about Arctic Sea Ice
Students take the pretest, graph patterns of change in Arctic sea ice, and ask questions about what is causing sea ice to decline.
Although the amount of Arctic sea ice varies from year to year, it is declining in the long term.
We have some ideas about why this might be happening, as well as lots of questions!
Inquiry
What is happening to global temperature, atmospheric CO_2, and sea level?
Lesson 2: Finding Patterns in Large-Scale Data
Students investigate patterns of change in four climate-related variables: Arctic sea ice, global temperature, atmospheric CO_2, and sea level.
In the long term, global temperature, atmospheric CO_2, and sea level are all increasing.
Explanation
How are changes in global temperatures, sea levels, Arctic sea ice, and atmospheric CO_2 connected?
Lesson 3: Explaining Connections Between Patterns
Students use the Greenhouse Effect to explain how changes in atmospheric CO_2 cause changes in other Earth systems.
CO_2 is the driver: Changes in atmospheric CO_2 cause changes in Arctic sea ice, global temperature, and sea level.
Explanation
What causes changes in CO_2 concentrations and how can we predict those changes?
Lesson 4: Fossil Fuels and Carbon Pools
Students use hands-on and online models to explain how the balance among carbon fluxes due to cellular respiration, photosynthesis, and fossil fuel combustion affects the atmospheric CO_2 pool.
Fluxes into and out of the atmospheric CO_2 pool are mostly balanced except for one: fossil fuel combustion.
Explanation
How do we use organic carbon and emit CO_2 in our lives?
Lesson 5: Consequences of Our Lifestyles
Students explain how lifestyles in different countries and their own everyday activities are connected with the combustion of fossil fuels.
Our lifestyles contribute to CO_2 emissions in many ways.
Explanation
What does increasing CO_2 in the atmosphere mean for the future of our planet?
Lesson 6: Consequences of Our Lifestyles
Students investigate the consequences of different scenarios for fossil fuel use and CO_2 emissions and complete the unit posttest.
Human actions that affect CO_2 emissions will determine the future of our climate.