

# The Four Questions

## Carbon Pools

### Question

Where are the carbon pools in our environment?

### Rules to Follow

**Atoms last forever!** Atoms cannot be created or destroyed, but atoms can be rearranged to make new molecules.

Carbon atoms stay in pools unless a process moves them in or out.

### Evidence We Can Observe

The air has carbon atoms in CO<sub>2</sub>. Organic materials are made of molecules with carbon atoms:

- Living and dead plants, animals, and decomposers
- Fossil fuels

## Carbon Cycling

### Question

How are carbon atoms cycling among pools?

### Rules to Follow

**Carbon cycles!** Carbon atoms cycle and recycle within Earth systems. Carbon-transforming processes move carbon atoms among pools.

If carbon atoms leave one pool, they must enter another pool. Atoms never disappear.

### Evidence We Can Observe

Evidence of carbon movement or carbon-transforming processes:

- Organisms eating, breathing, growing, moving, dying, or decaying
- Burning

## Energy Flow

### Question

How does energy flow through environmental systems?

### Rules to Follow

**Energy flows!**

Energy flows through Earth systems. Carbon-transforming processes change energy from:

- Sunlight to
- Chemical energy to
- Work or motion energy and eventually to
- Heat radiated into space.

### Evidence We Can Observe

We can observe indicators of different forms of energy:

- Chemical energy stored in organic materials
- Light energy
- Heat energy
- Work or motion energy

## Stability and Change

### Question

How do carbon fluxes change the size of carbon pools?

### Rules to Follow

**Fluxes change pools!** A pool size only changes when fluxes into and out of that pool are unbalanced. The photosynthesis limit is an upper limit to the photosynthesis flux in every ecosystem.

### Evidence We Can Observe

Disturbances such as fires, floods, droughts, or human management can change pools and fluxes.

Some disturbances change the photosynthesis limit of ecosystems or the Earth's biosphere.

# Four Questions Explanation Checklist

Scientists explain many processes in nature by connecting the things we can observe and measure (such as CO<sub>2</sub> concentrations in the atmosphere) with things that are more difficult to observe and measure (such as carbon pools and fluxes). You can use the Large-Scale Four Questions as a guide for using pools and fluxes to explain Earth systems and processes. The checklist below will help you make sure you include important information.

## Setting the stage

- a. Did you name and describe the observations or patterns in data that you are explaining?
- b. Did you explain how the system is changing (or how you predict it will change)?

## 1. Carbon Pools: Where are the carbon pools in our environment?

- a. Did you name and describe all the pools that are involved in the process?
- b. Did you say what kinds of carbon molecules are in the pool (CO<sub>2</sub> or organic carbon)?

## 2. Carbon Cycling: How are carbon atoms cycling among pools?

- a. Did you name all the fluxes that move carbon atoms from one pool to another?
- b. Did you explain the chemical changes that go with those carbon fluxes?

## 3. Energy Flow: How does energy flow through environmental systems?

- a. Did you identify the carbon pools with stored chemical energy?
- b. Did you explain where the chemical energy in those pools comes from?
- c. Did you explain how energy is transformed in carbon fluxes?

## 4. Stability and Change: How do carbon fluxes change the size of carbon pools?

- a. Did you explain whether the fluxes going into or out of each pool are balanced or unbalanced?
- b. Did you explain or predict how unbalanced fluxes will change the size of pools?

## Other Elements to Consider

- a. Did you use scientific vocabulary correctly?
- b. Did you organize your explanation logically to tell a story that flows?