

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_2 . 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 CO₂ 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 (CO₂ 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?