NO PREP

Plankton and the Global Carbon Cycle

Includes: Student reading, case study, differentiated questions, teacher key

Name: Period: Date:

Plankton and the Global Carbon Cycle

The Earth's climate system is powered by the constant exchange of carbon between the atmosphere, oceans, land, and living organisms. One of the most important players in this cycle is also one of the smallest: plankton. These microscopic organisms are responsible for capturing vast amounts of carbon dioxide from the atmosphere and transferring it into the ocean. Without plankton, Earth's climate would look very different, and life as we know it might not even exist. Phytoplankton, the photosynthetic plankton, play a central role in the carbon cycle. By absorbing carbon dioxide during photosynthesis, they remove greenhouse gases from the atmosphere and produce oxygen. When these organisms die or are consumed, some of the carbon they contain sinks into the deep ocean, where it can be stored for centuries. This process, known as the biological pump, is one of Earth's most effective carbon regulators.

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Carbon Fixation by Phytoplankton

Like plants on land, phytoplankton capture carbon dioxide and convert it into organic molecules. This process, called carbon fixation, occurs throughout the sunlit photic zone of the ocean. Because plankton are so abundant and widespread, their combined activity accounts for at least half of the photosynthesis on Earth. This means that every second breath you take may be owed to the oxygen produced by marine plankton. Carbon fixation is not evenly distributed. Areas of high productivity, such as coastal upwelling zones and polar waters, absorb much more carbon than nutrient-poor gyres. Seasonal blooms also have an outsized effect, temporarily drawing down atmospheric carbon on massive scales. These patterns highlight the importance of regional and seasonal variations in the ocean's carbon cycle.

Sinking Carbon and the Biological Pump

When plankton die or are eaten, their remains sink into the deep ocean. Some of this material is decomposed and recycled, but a significant fraction reaches depths

where it can remain stored for hundreds to thousands of years. This downward transfer of carbon is known as the biological pump. It essentially locks away carbon, preventing it from quickly returning to the atmosphere as carbon dioxide. Zooplankton play an important role by packaging phytoplankton into fecal pellets that sink faster, enhancing the pump's efficiency. Larger plankton species, such as diatoms with silica shells, also contribute significantly because their heavy remains sink more readily. This process explains why the ocean acts as such a powerful buffer against climate change.

Plankton and Climate Regulation

Plankton are not only part of the carbon cycle but also central to climate regulation. By absorbing carbon dioxide, they reduce the amount of greenhouse gas in the atmosphere, slowing the pace of global warming. Without their activity, carbon dioxide levels would be significantly higher, and Earth's average temperature would rise. At the same time, climate change affects plankton productivity. Warming oceans, acidification, and altered circulation patterns threaten the stability of the biological pump. Scientists are studying how these changes might reduce the ocean's ability to store carbon, potentially creating a feedback loop that accelerates warming. Protecting plankton productivity is therefore vital for maintaining climate balance.

Plankton Shells and Long-Term Carbon Storage

Some plankton species, such as coccolithophores, build shells made of calcium carbonate. When these organisms die, their shells sink to the seafloor, becoming part of marine sediments and eventually forming limestone deposits. This process sequesters carbon on geological timescales, locking it away for millions of years. The White Cliffs of Dover in England, composed largely of coccolithophore remains, are a striking reminder of how plankton shape Earth's history. Such deposits show that even the tiniest organisms can leave behind massive geological legacies, transforming the atmosphere and climate over time.

Key Information: Table: Pathways of Carbon in the Ocean

Pathway	Role in Carbon Cycle
Photosynthesis by phytoplankton	Fixes carbon dioxide into organic matter
Grazing by zooplankton	Transfers carbon up the food web and aids sinking
Biological pump	Moves carbon to the deep ocean for long-term storage
Coccolithophore shells	Stores carbon as calcium carbonate in sediments
Respiration and decomposition	Returns carbon to the water and eventually the atmosphere

Case Study: Iron Fertilization Experiments

In the 1990s and early 2000s, scientists conducted experiments in which they deliberately added iron to certain regions of the ocean. The idea was based on the observation that iron is a limiting nutrient in many open ocean areas. By adding small amounts of iron, researchers triggered massive phytoplankton blooms, which absorbed large amounts of carbon dioxide. Satellite images showed clear increases in productivity in the fertilized regions. The experiments suggested that adding iron could enhance the biological pump and help mitigate climate change by removing CO_2 from the atmosphere. However, the approach raised serious ethical and ecological concerns. Artificial blooms could alter food webs, deplete oxygen, or increase harmful algal blooms. While the experiments provided valuable scientific insights, they also highlighted the risks of interfering with natural cycles on a global scale.

1. What did the iron fertilization experiments reveal about the role of nutrients in phytoplankton growth?

2. Why is artificial manipulation of the carbon cycle considered risky?

Multiple Choice

1. What is the biological pump?

    a) A machine designed to measure plankton productivity

    b) A process that circulates water in the photic zone

    c) The downward transfer of carbon into the deep ocean

    d) The recycling of oxygen in marine sediments

2. Which plankton group produces calcium carbonate shells that store carbon long-term?

    a) Armored dinoflagellates

    b) Cyanobacteria

    c) Diatoms

    d) Coccolithophores

3. What was the main finding of iron fertilization experiments?

    a) Iron kills zooplankton

    b) Iron triggers massive phytoplankton blooms

    c) Iron increases ocean acidity

    d) Iron reduces total carbon storage in the deep ocean

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ Phytoplankton	A) Transfer carbon through grazing and fecal pellets
2. ___ Zooplankton	B) Absorb CO_2 through photosynthesis
3. ___ Biological pump	C) Store carbon in shells as calcium carbonate
4. ___ Coccolithophores	D) Return carbon to atmosphere or surface waters
5. ___ Respiration	E) Move carbon to deep ocean for long-term storage

Fill-in-the-Blank

1. The process that locks away carbon in the deep ocean is called the _____ pump.

2. Iron is considered a _____ nutrient in many parts of the ocean.

3. Coccolithophores contribute to long-term carbon storage by producing _____ shells.

Short Answer

Answer each question in 2-4 complete sentences.

1. Why are plankton so important for Earth's climate stability?

_____

_____

_____

2. How does zooplankton activity enhance the efficiency of the biological pump?

3. What risks are associated with human attempts to manipulate plankton productivity?