

The Carbon Cycle

Credit: Degleex on Unsplash

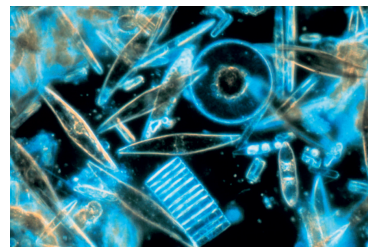
What is the carbon cycle?

Carbon is an essential element and makes up all life on this Earth. It is in you and me, in the trees around us, in the soil beneath your feet, and in the deep ocean. It moves constantly from state to state and compound to compound, creating a cycle within the Earth's system. You can picture carbon's movement among the Earth's systems as a flow in and out of reservoirs. A source is a reservoir that releases carbon and a sink is a reservoir that absorbs carbon. Carbon reservoirs store carbon for varying amounts of time - it can be as short as days or as long as hundreds of millions of years, such as carbon in coal deposits.

Carbon Ebbs and Flows

The ocean both takes in and releases carbon. Phytoplankton—photosynthesizing, one-celled organisms in the ocean—consume vast quantities of carbon dioxide (CO₂), on par with the amount taken in by land plants. It's largely through phytoplankton that the oceans act as a sink of carbon, when they die, drift to the bottom, and get covered with sediment.

Carbon release occurs where deep ocean water rich in CO₂ from respiring organisms wells up to the surface. This same water is rich in nutrients and may become a site for a phytoplankton bloom. The cycle of carbon sinking to the bottom of the ocean and rising up again in currents can take hundreds or thousands of years.



Diatoms, a type of phytoplankton, as seen through a microscope.

Photo: Gordon T. Taylor (public domain) via Wikimedia Commons

How much carbon can the ocean absorb?

There has been an approximate balance between the amount of carbon the oceans take from the atmosphere and the amount they release back. Over geologic time, very small imbalances may have led to some of the climate changes we see over the course of millions of years.

Recently, however, the oceans have been taking in more than they release. Ultimately, we don't know how much carbon the oceans can absorb. If the oceans reach their upper limit, we'll end up with a lot more CO₂ in the atmosphere and a much warmer Earth.

The Biological Pump

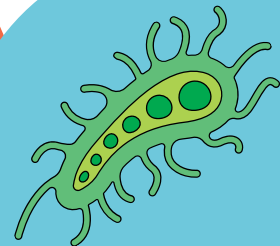
The process of transferring carbon from the atmosphere to the ocean through the actions of marine organisms is sometimes called the biological pump.

Phytoplankton play a key role by absorbing carbon through photosynthesis, and using it to create organic compounds for their growth and reproduction. Tiny marine animals called zooplankton further contribute to the pump as they consume phytoplankton, and larger animals eat zooplankton. Marine animals respire, releasing carbon into seawater, and they also release wastes containing carbon that sink to the ocean floor.

The cycle continues when both large and small organisms die, and their bodies sink to deeper ocean layers. Once at depth, microbial decomposition occurs, releasing carbon dioxide back into the water while a tiny bit of carbon eventually becomes part of sedimentary rocks at the ocean bottom.

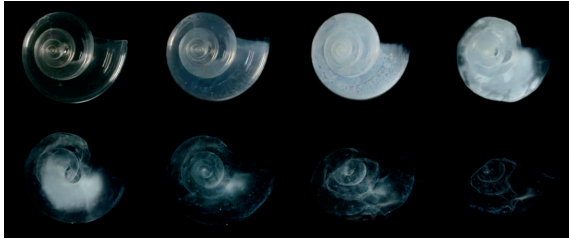
The biological pump is a crucial mechanism in maintaining the balance of atmospheric carbon dioxide levels, helping to regulate the Earth's climate. By sequestering carbon in the deep ocean for extended periods, it aids in the long-term storage of carbon and contributes to mitigating the impact of human-induced climate change.

Did you know?
At least half of the oxygen we breathe comes from photosynthesis by phytoplankton and other marine plants.



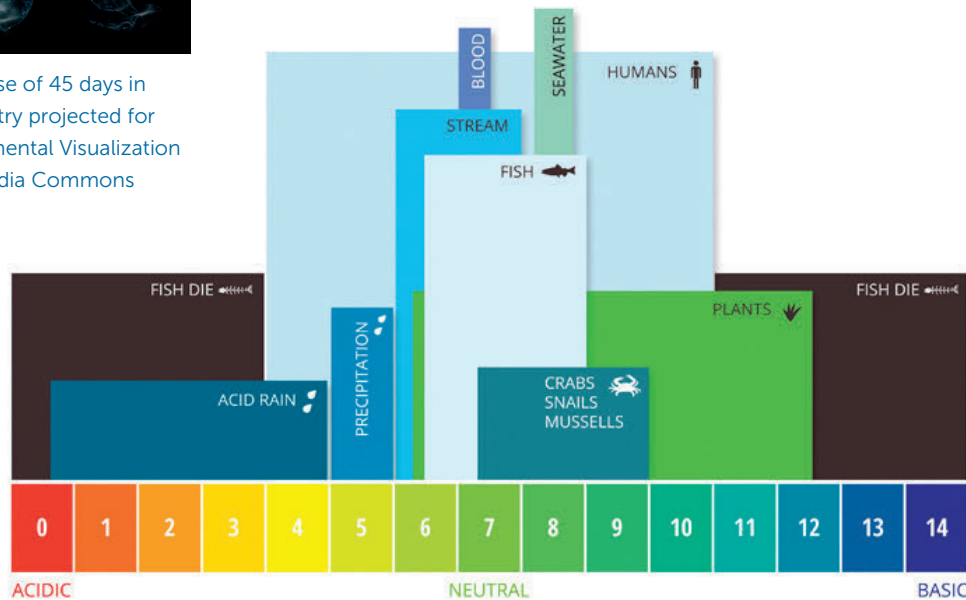
Ocean acidification

As carbon dioxide (CO₂) from the atmosphere dissolves in seawater, a chemical reaction begins that results in the water becoming more acidic. You may have learned that acidity is expressed as a pH level—the lower the pH of a substance, the more acidic it is. Ocean pH has dropped from 8.2 to 8.1 since the Industrial Revolution and is projected to reach 7.8 or 7.7 by this century's end. The situation is worsened by a reinforcement mechanism in place. Elevated CO₂ levels increase seawater acidity, which in turn causes carbonate minerals in ocean sediments to dissolve more easily. This leads to the release of stored carbon from sediments, further increasing CO₂ concentration in the water.



Pteropod shell dissolved over the course of 45 days in seawater adjusted to an ocean chemistry projected for the year 2100. Image: NOAA Environmental Visualization Laboratory (public domain) via Wikimedia Commons

Aquatic pH levels and optimum ranges for different organisms.
Source: Fondriest Environmental, Inc. "pH of Water." Fundamentals of Environmental Measurements. 19 Nov. 2013. <https://www.fondriest.com/environmentalmeasurements/parameters/water-quality/ph/>

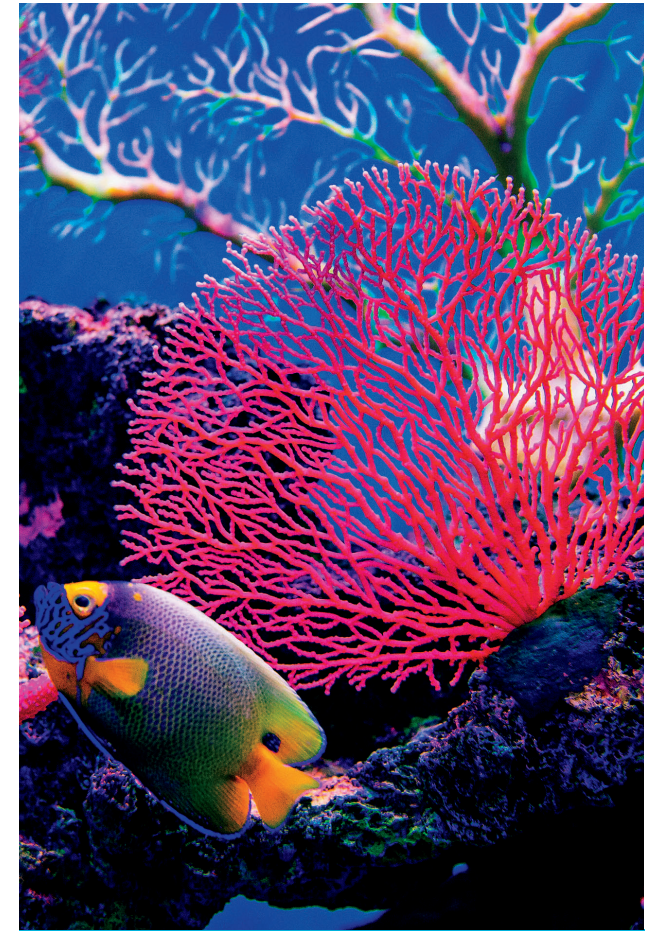


Why does ocean acidification matter?

It's a complex process with far-reaching consequences for marine ecosystems. As carbon dioxide levels increase, the ocean becomes more acidic, disrupting the delicate balance of marine life. This acidity impedes the ability of shell-forming organisms like shellfish and corals to thrive, leading to coral bleaching and reef degradation, which in turn diminishes biodiversity. Furthermore, it alters fish behavior, growth, and prey availability, perturbing the intricate structure of the marine food web. Even phytoplankton, fundamental to marine ecosystems, experience inhibited growth and productivity. In essence, ocean acidification induces widespread disruption in marine ecosystems, affecting the abundance, distribution, and functioning of marine organisms, and compromising their ability to sustain vital habitats.

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Oceans in the Carbon Cycle



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