FACT SHEET: The Carbon Cycle

(Advanced)

Carbon is everywhere, in the oceans, in rocks and soils, in all forms of life and in our atmosphere. Without carbon, life would not exist as we know it.

The carbon cycle plays a key role in regulating Earth's global temperature and climate by controlling the amount of carbon dioxide in the atmosphere. Carbon dioxide is an important greenhouse gas, because it helps Earth's atmosphere to retain heat generated from the Sun. But too much carbon dioxide going into the atmosphere can lead to a planet that gets unnaturally hot.

THE CARBON CYCLE

The carbon cycle is more easily studied if it is divided into two parts;

- one dealing with rapid carbon exchange among living things, and;
- one dealing with long-term cycling of carbon through geologic processes.

It's important to realize these are closely linked as one large cycle.

The Biological Carbon Cycle

- Carbon exists in the air largely as carbon dioxide - CO_2 gas.
- **Producers** (terrestrial and aquatic **autotrophs** - land plants, phytoplankton, etc.) use **photosynthesis** to convert carbon dioxide and light energy into sugar (**glucose** - a sugar).
- The glucose is used by **consumers** (**heterotrophs** - humans, animals, insects, etc.) as food through digestion and is passed through food chains.
- Living things use **cellular respiration** to convert the glucose into energy and give off carbon dioxide in the process.
- **Decomposers** (also classed as heterotrophs - fungi and some bacteria) also release carbon dioxide when they use aerobic (with oxygen) decomposition to break down dead organisms and waste products.
- Carbon can cycle very quickly through this biological pathway, especially in aquatic ecosystems.

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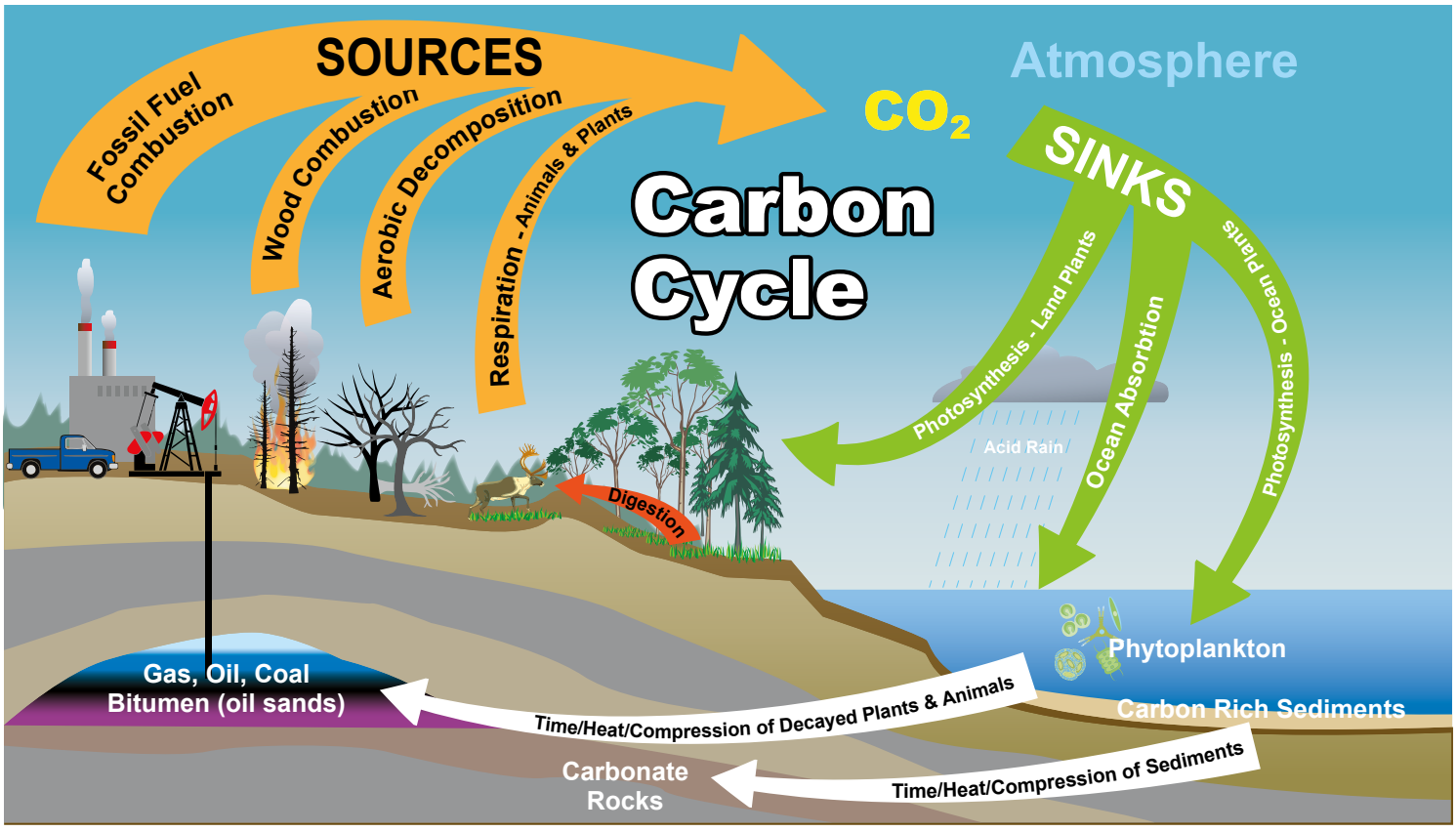


The Geological Carbon Cycle

- Carbon may be stored for long periods of time in the atmosphere, bodies of liquid water—mostly oceans—ocean sediment, soil, rocks, fossil fuels and Earth's interior.
- It usually takes millions of years for carbon to cycle through the geological pathway.

In the air

- Carbon exists in the atmosphere mostly as CO_2 which reacts with water molecules to produce **bicarbonate** HCO^-_3
- The level of CO_2 in the atmosphere is influenced by the reservoir of carbon in the oceans and vice versa.
- Carbon can be dissolved in atmospheric water and deposited on land and oceans by precipitation.

In the oceans

- Atmospheric carbon dissolves in the oceans via precipitation and wave action. There it reacts with calcium in the water to form calcium carbonate ($CaCO_3$), a key component of the shells of marine organisms like plankton.
- When the organisms die, their remains may sink and eventually become part of the sediment on the ocean floor.
- Over geologic time, the sediment turns into limestone, which is the largest carbon reservoir on Earth.

On land

- Carbon is stored in soil as organic carbon from the decomposition of living organisms
- Carbon is stored as inorganic carbon from weathering of terrestrial rock and minerals which can be washed to the oceans by streams and rivers.
- Deeper under the ground are fossil fuels such as oil, coal, and natural gas, which were formed from the remains of ancient decomposed plants under great pressure over thousands of years.

Return to the air

- Carbon can be cycled back to the atmosphere from the geological cycle naturally by the eruption of volcanoes, hydrothermal vents or hot springs.

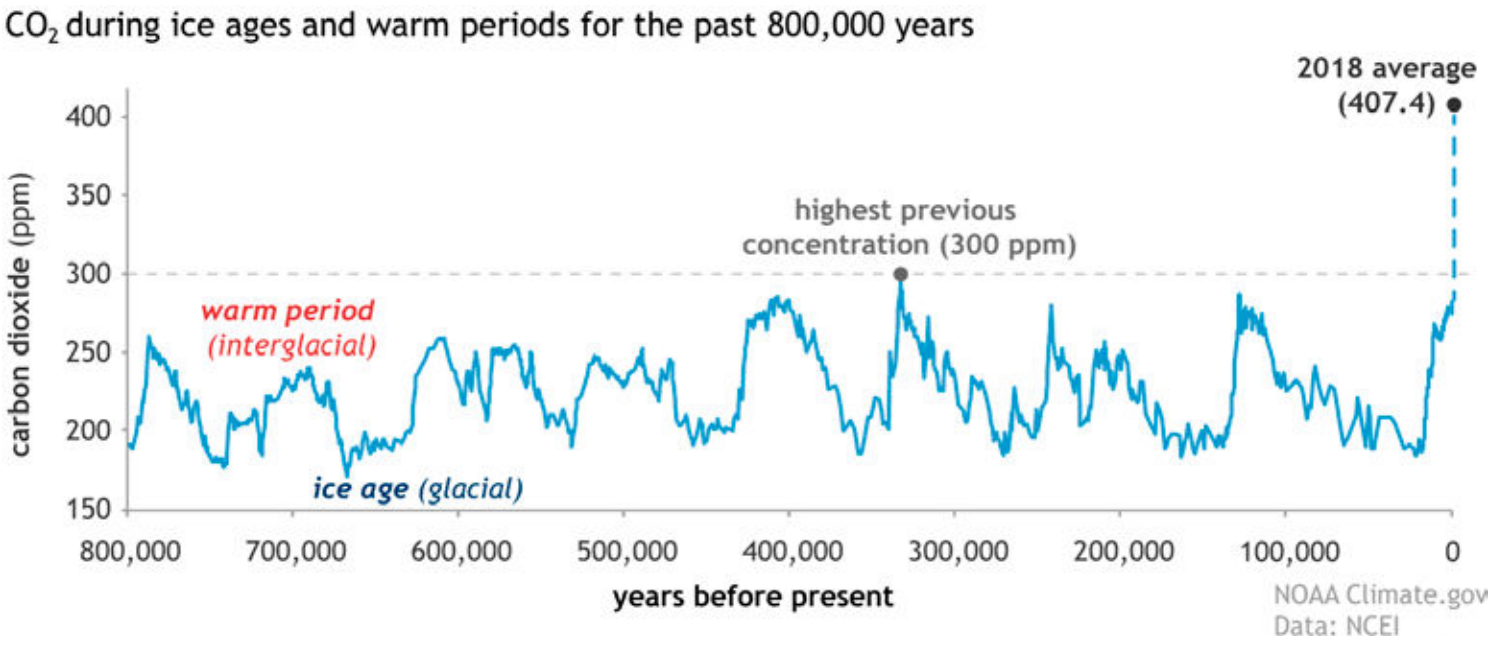
Carbon Sequestration

(For more details, see Fact Sheets on Carbon Sinks & Sources)

Carbon sequestration is the process of removing carbon from the atmosphere and storing it.

Sources and Sinks

- A **source** is any process that releases CO_2 into the atmosphere.
  - Natural sources of CO_2 include volcanoes, fires, decomposition, respiration, digestion and, under certain conditions, oceans and fresh water bodies.
  - A source emits more CO_2 than it absorbs.
- A **sink** is any process that absorbs a greenhouse gas and acts like a reservoir.
  - Forests, soil, oceans, the atmosphere, oceans and freshwater bodies, fossil fuels and carbonate rock are important sinks of carbon.
  - A sink absorbs more carbon than it gives off.
- Carbon is constantly moving between these different stores, that act as either "sinks" or "sources." Human activity has been altering the balance between these sources and sinks.



This chart shows carbon dioxide concentrations (vertical axis) over time (horizontal axis) - NOAA 2018

Human Impacts On The Carbon Cycle

Before the Industrial Revolution, the amount of carbon moving between trees, soil, oceans and the atmosphere was relatively equal - the sources and sinks were balanced. Research has shown that there has been a dramatic shift eroding the sinks and increasing the sources due to human activity. CO_2 levels naturally rise and fall in cycles over long periods of time, but they are higher now than they have been in the past 400,000 years.

Nabeel Syed / Unsplash

Fossil Fuels

- Fossil fuels take millions of years to form. When humans burn them, carbon is released into the atmosphere as CO_2 at a very rapid rate. What was once a major carbon sink has been turning into a carbon source.
- They are considered a nonrenewable resource because they are being used up much faster than they can be produced by geological processes.

Roya-ann Miller / Unsplash

Deforestation / Agricultural Clearing / Wetland Destruction

- Rapid destruction of forests, wetlands and other plant based sinks is also a major contributor to increasing CO_2 levels.
- Photosynthesis accounts for about half of the carbon extracted from the atmosphere - less plants = less photosynthesis = less carbon sequestration.
- Plants also release CO_2 when they are burned or left to decompose, again increasing the CO_2 levels.

Kouji Tsuru / Unsplash

Industry

- Many industries release additional CO_2, for example, cement manufacturing produces large amounts of carbon dioxide when calcium carbonate that has been stored in limestone is heated. Remember, limestone is the largest carbon sink on Earth and it now is becoming more of a source.

Caitlin Seaview Survey / Wikimedia

Ocean Acidification

- The excess carbon dioxide which is dissolving in the oceans is causing the water to become more acidic which, in turn, harms sea life. This can reduce the amount of photosynthesis as well.
- This also reduces the oceans ability to absorb more CO_2.

Why Does Increasing Carbon Dioxide Matter?

- CO_2 is a major greenhouse gas. In the atmosphere, it traps heat and keeps it from radiating into space.
- Based on extensive evidence, scientists think that elevated levels of CO_2 and other greenhouse gases are causing pronounced changes in Earth's climate.
  (See Fact Sheet on Climate Change)

Other Resources

The Carbon Cycle - Earth Observatory - NASA
https://earthobservatory.nasa.gov/features/CarbonCycle

Video - Human Influence – CO_2 Cycle & Balance - PICS Canada
https://www.youtube.com/watch?v=-X-AcS5bvDc

"... due to human activity, CO_2 levels ... are higher now than they have been in the past 400,000 years."