Nature's CO_2 Pumps - Fast and Slow

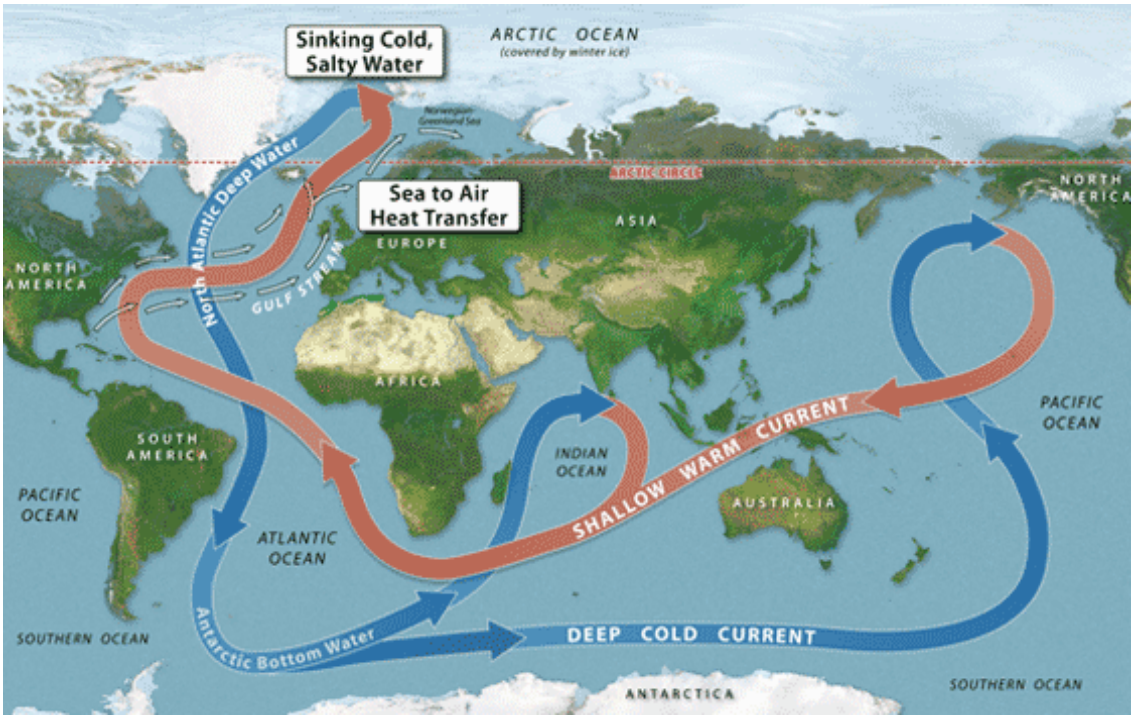
Sources and Resources for this Study

The Global Conveyor Belt | EARTH 103
The Carbon Cycle
Global Carbon Cycle - an overview | ScienceDirect Topics
How dead stuff at the bottom of the ocean helps slow the pace of climate change
Annual CO_2 emissions from oil - Our World in Data
Plankton - Wikipedia
https://en.wikipedia.org/wiki/Marine_microorganisms

Carbon Cycle | A Level Geography
Understanding the long-term carbon-cycle: weathering of rocks - a vitally important carbon-sink
Particulate organic matter - Wikipedia
Carbon cycle | Definition, Steps, Importance, Diagram, & Facts | Britannica
Carbon cycle | National Oceanic and Atmospheric Administration
Carbon sequestration | Definition, Methods, & Climate Change | Britannica
Crude Oil | MME
The Natural Carbon Cycle
Formation & Contents of Crude Oil (GCSE Chemistry) - Study Mind
How does coal form? | Live Science

Several months ago, we tackled ***"The Great Conveyor Belt"*** - the global ocean current which distributes **ENERGY** around the planet. For fun, you might look back over:

- CSSG-2.5 The Great Conveyor Part 1 - The Closing of the Isthmus of Panama
- CSSG-2.6 The Great Conveyor Part 2 - The Amazing CO2 Suckers
- CSSG-2.7 The Great Conveyor Part 3 - The Global Ocean Current



ENERGY is not the only thing that gets pumped around. **CARBON** itself has quite a story to tell, particularly regarding climate and climate change.

The Carbon Cycle

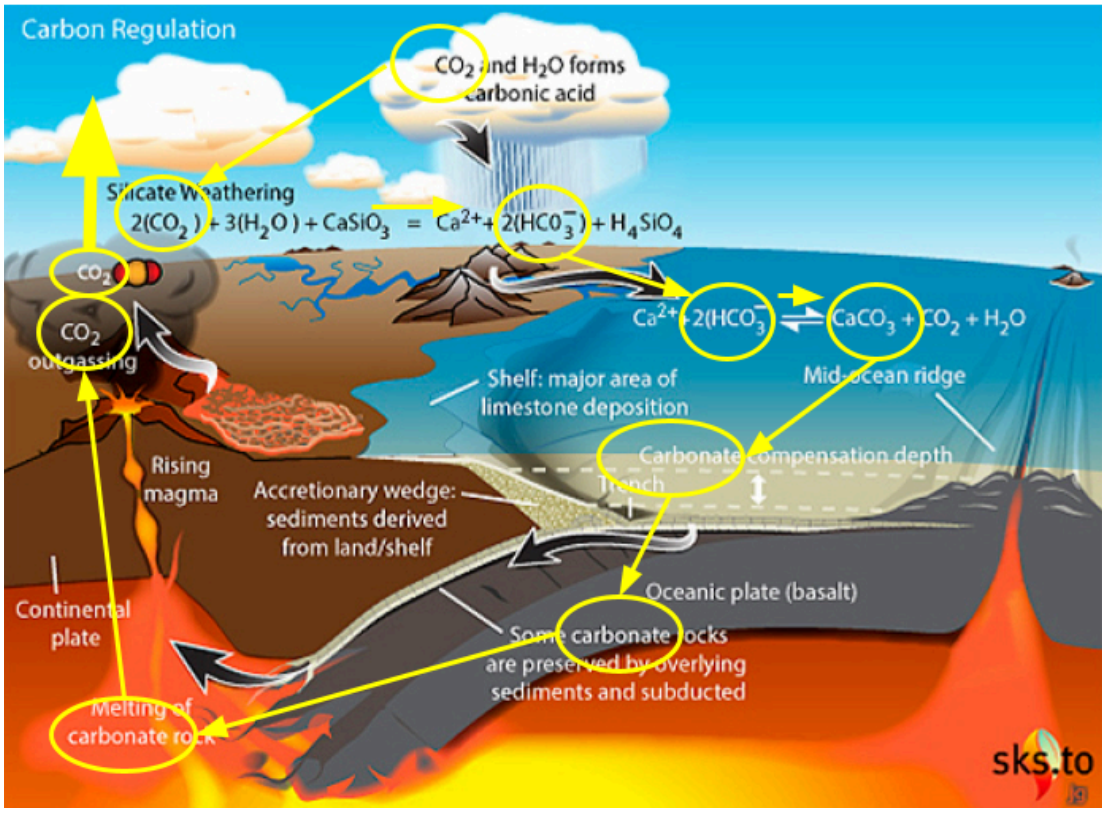
Forged in the heart of aging stars, carbon is the **fourth most abundant element** in the Universe. Most of Earth's carbon—about 65,500 billion metric tons—is stored in rocks. The rest is in the ocean, atmosphere, plants, soil, and fossil fuels.

Carbon is the backbone of life on Earth. We are made of carbon, we eat carbon, it keeps our atmosphere comfortable, and our civilizations—our economies, our homes, our means of transport—are built on carbon. **We need carbon**, but that need is also entwined with one of the most serious problems facing us today: global climate change.

As wonderful as carbon is, we have evolved to enjoy a certain equilibrium. We are disrupting that balance by taking carbon out of its long term reservoirs (coal and oil) and burning it into the atmosphere.

Carbon flows between each reservoir in an exchange called the carbon cycle, which has **slow** and **fast** components. Any change in the cycle that shifts carbon out of one reservoir puts more carbon in the other reservoirs. Changes that put carbon gasses into the atmosphere result in warmer temperatures on Earth. [Particular thanks to: The Carbon Cycle]

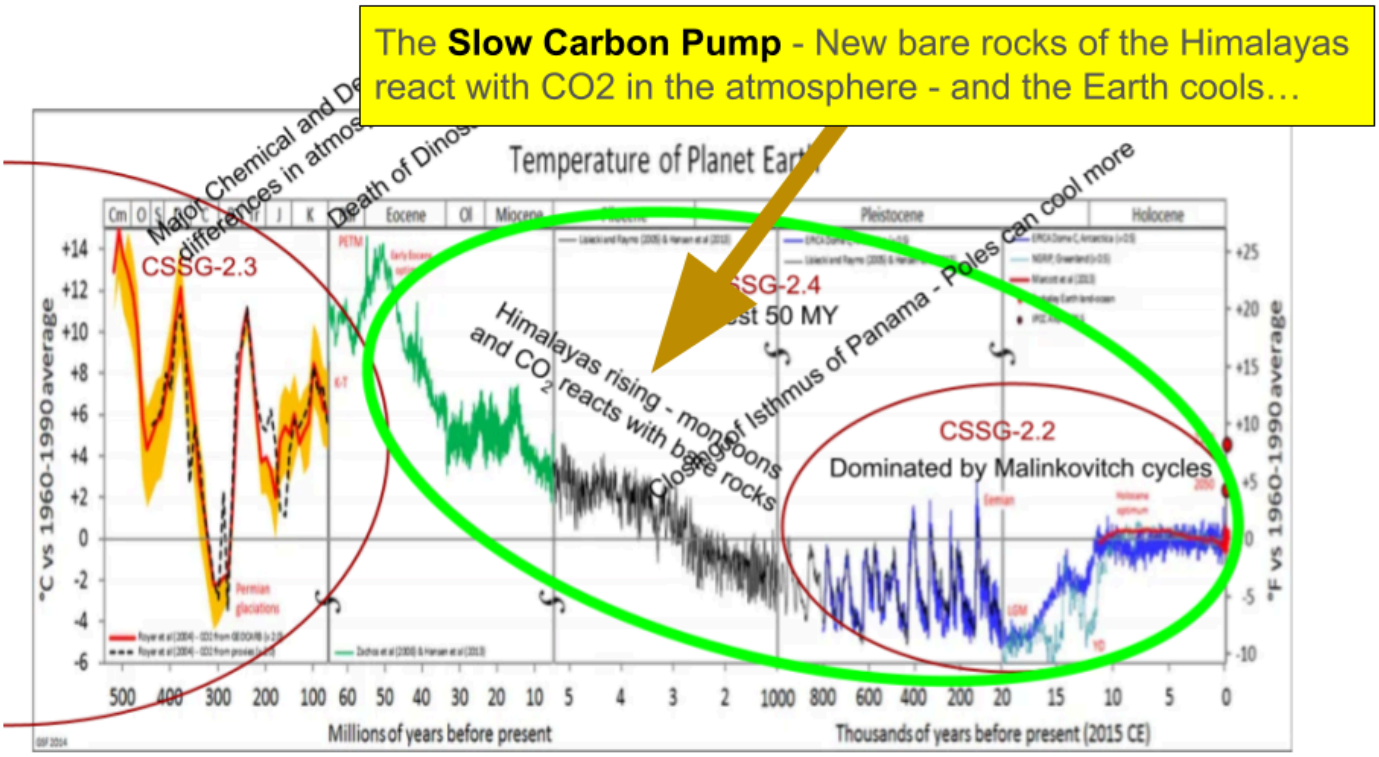
The Slow Carbon Cycle - Geologic Timing



Through a series of chemical reactions and volcanic and tectonic activity, carbon takes between 100-200 million years to move between rocks, soil, ocean, and atmosphere in the slow carbon cycle.

Remember the Himalayas taking out CO_2 in

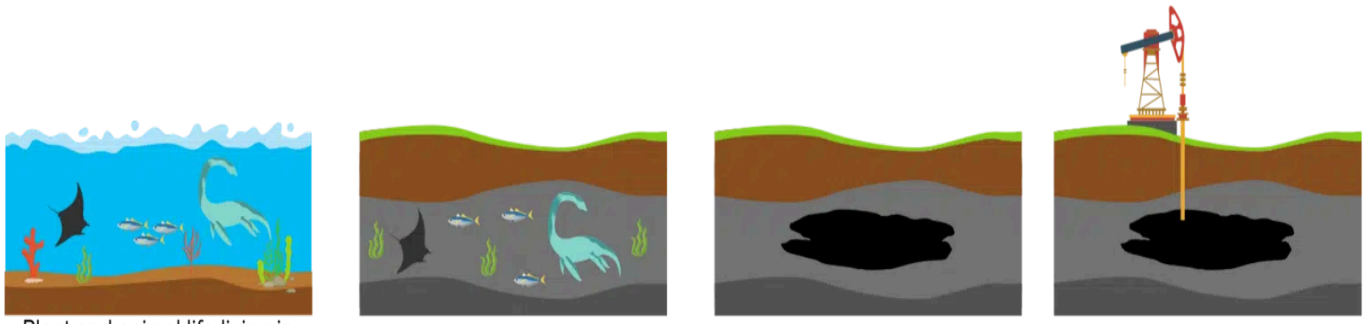
CSSG-2.4 Paleo Part 3 - the latest 50 million years - the Big Cooldown



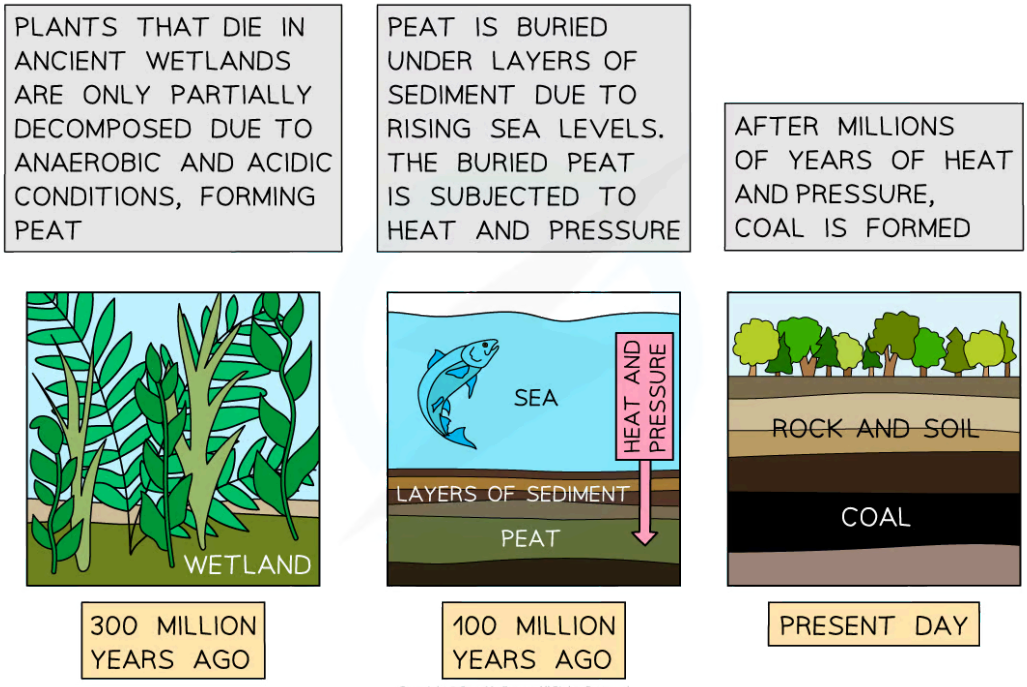
The Slow Carbon Cycle - Removal of CO2 into Coal and Oil

Tacked onto the Slow Carbon Cycle have been a couple of separate CO2 pumps - locking up plant and plankton carbon into coal and oil reservoirs.

OIL

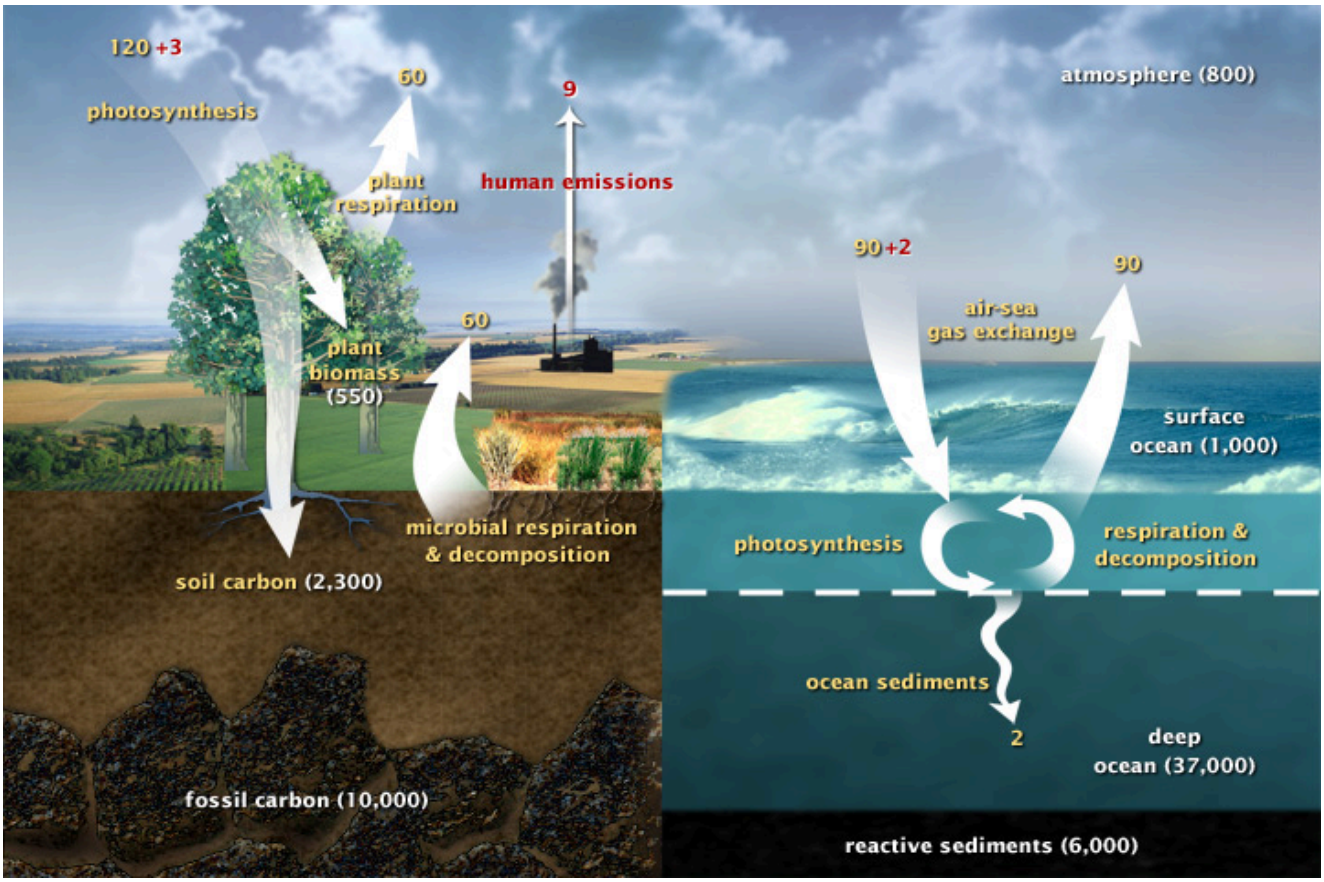


COAL



The Fast Carbon Cycle plus Human Emissions

The fast carbon cycle takes less than 100 years largely through **life forms** in the biosphere. Here, notice that of the 9 units of "human emissions" only 3 (into land photosynthesis increase) and 2 (into ocean photosynthesis) are taken out of the atmosphere.



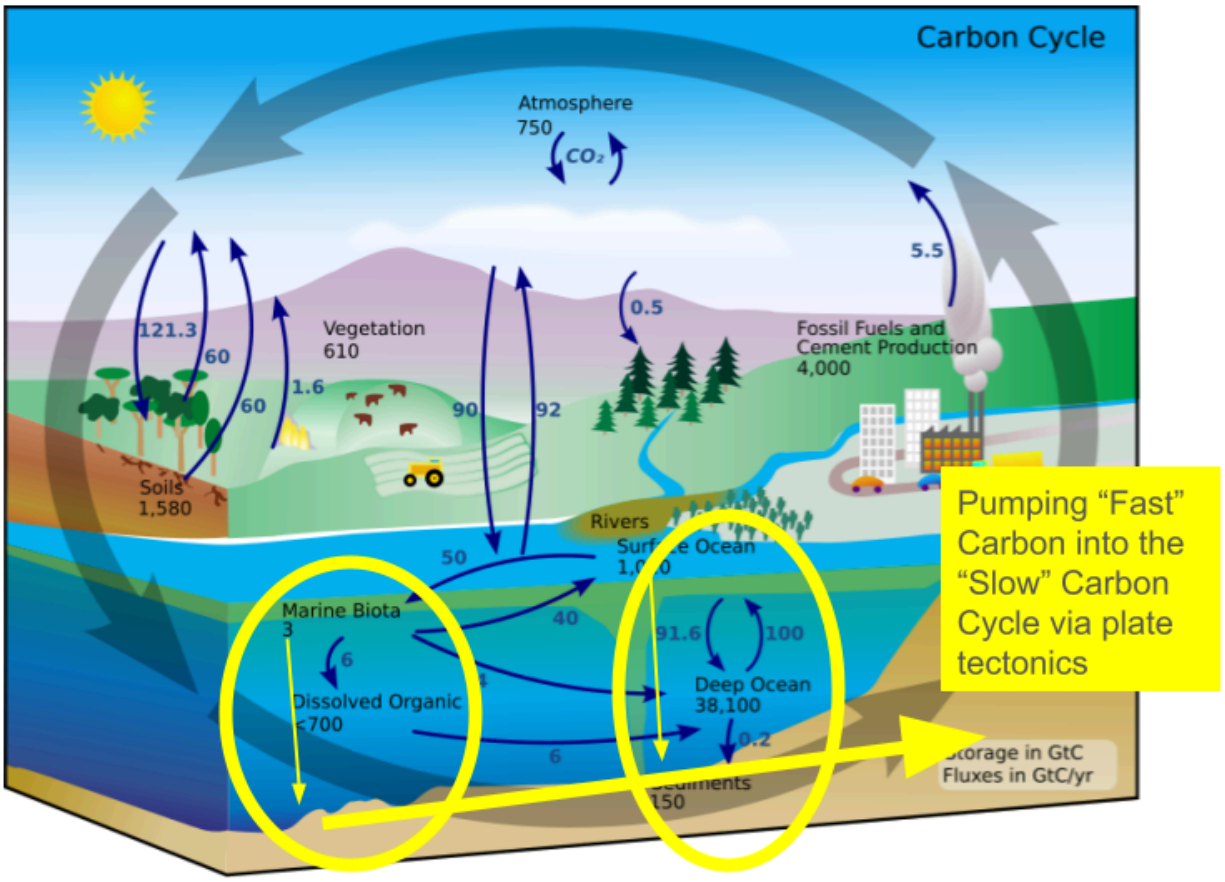
Pumping here, i.e., removing CO2 so the atmosphere can cool, is in two forms:

- SHORT RETENTION: Into the soils and trees, etc. where it can be held for decades
- LONG RETENTION: Ultimately into the ocean → to become shell/ bio components in dissolved carbon and plankton → debris deposited into sediments and rock → subsumed by tectonic action.

The Ocean's Biological Pump

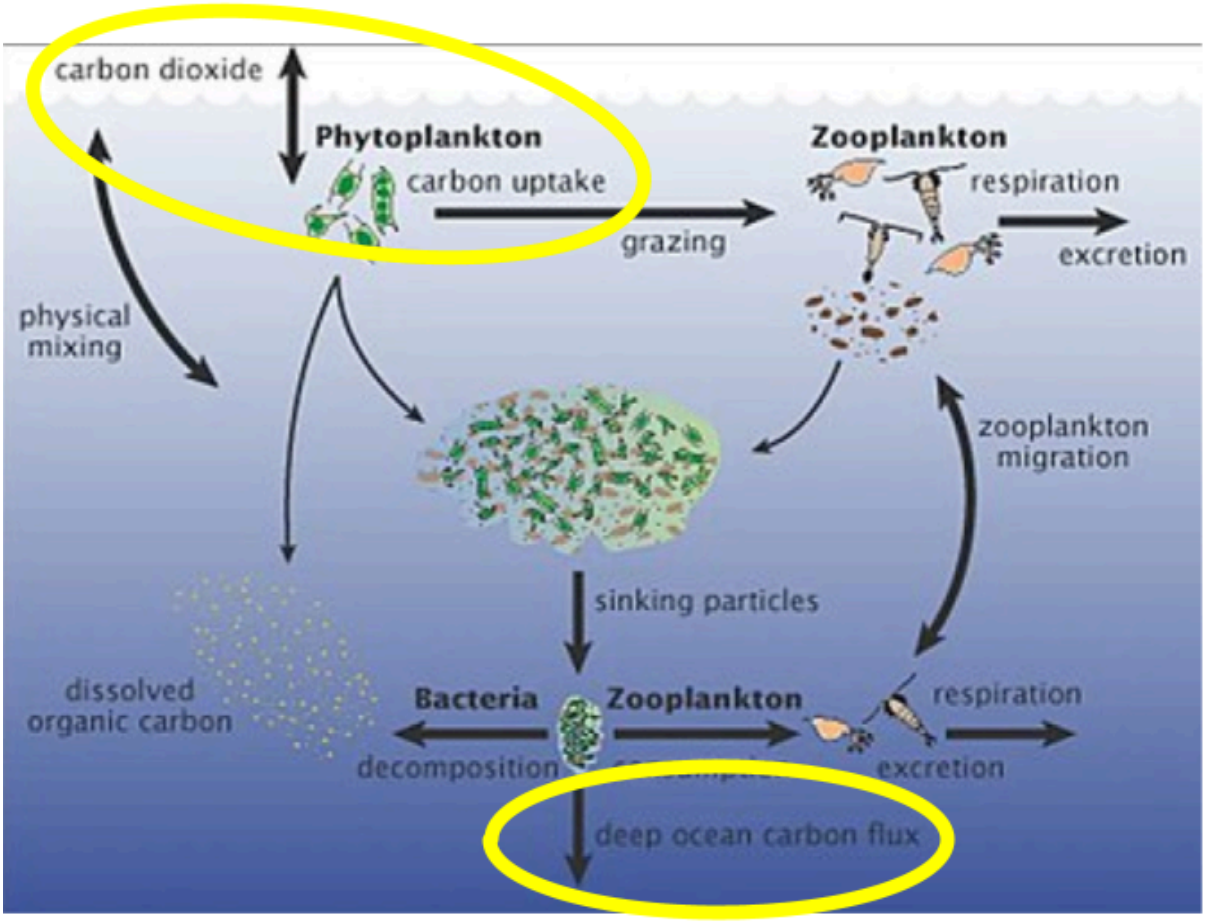
- Transferring Human Emissions (taken <u>from</u> the SLOW cycle) <u>back</u> to the SLOW Carbon Cycle

[Special thanks to: How dead stuff at the bottom of the ocean helps slow the pace of climate change]



Plankton* - *from Greek planktos 'wandering'
Phyto- from Greek "plant"

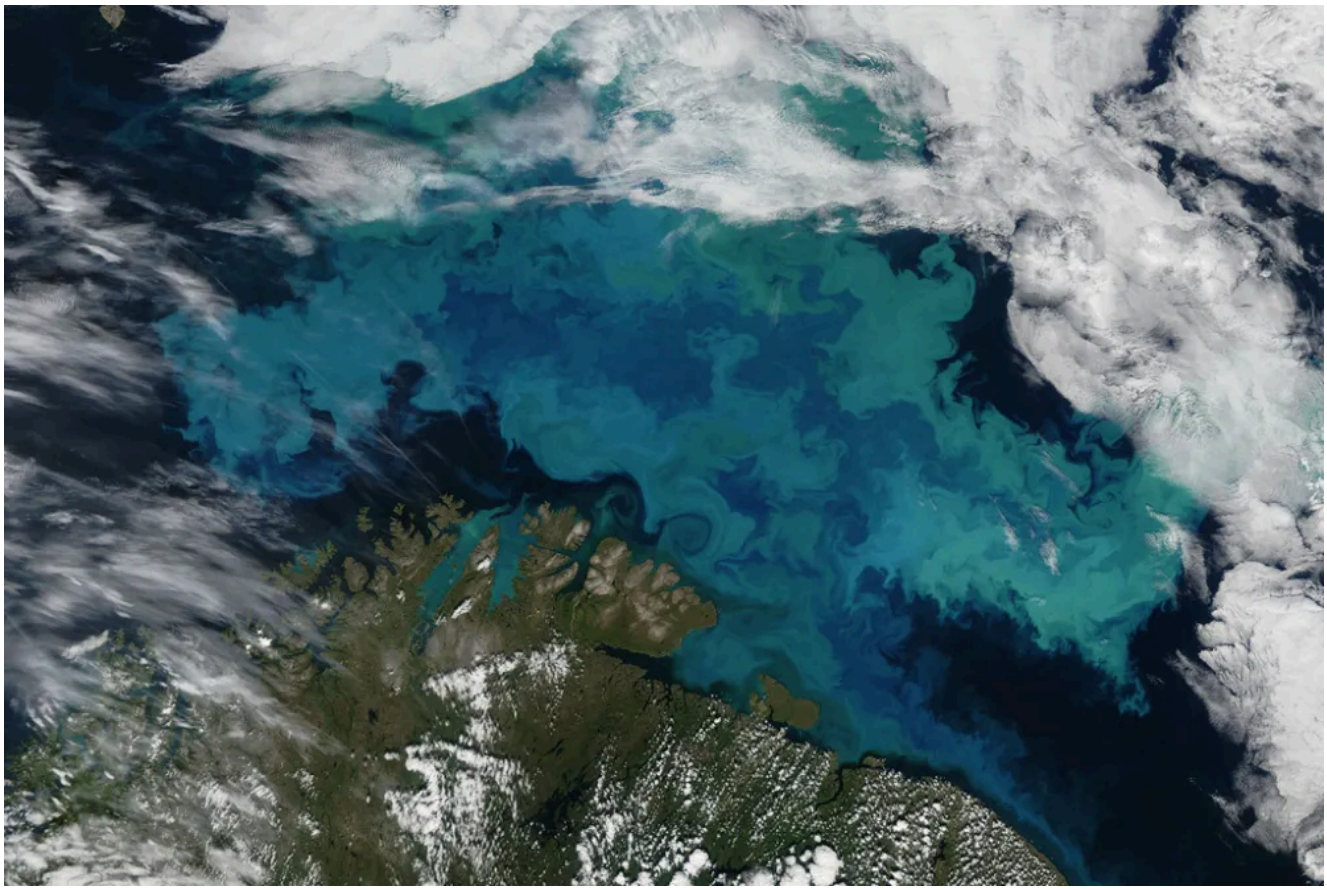
are the diverse collection of organisms that drift in water (or air) but are unable to actively propel themselves against currents (or wind).



Role of the microbial community in the marine carbon cycle

Marine microorganisms have been variously estimated to make up about 70%,[4] or about 90%, of the biomass in the ocean.

Geoengineering Phytoplankton Blooms



(NASA Goddard Space Flight Center)

The bright, brilliant swirls of blue and green seen from space are a phytoplankton bloom in the Barents Sea. Phytoplankton can bloom like this, rapidly growing and reproducing, because of a sudden increase in nutrients and sunlight. In the process, the phytoplankton absorb carbon dioxide from the atmosphere and, when they die, they sink to the seafloor, trapping the carbon in sediment.

Because of this, some researchers want to add nutrients like iron to the ocean to cause phytoplankton blooms, hoping that they will remove carbon dioxide and slow global warming. However, because it's hard to know what the full effects will be, most scientists are hesitant to try this large-scale geoengineering experiment.

Slow and Fast Flows

Yearly Movement of Carbon around the Planet		
"Slow" Carbon Cycle	*"Fast" Carbon Cycle*	*Human emissions of carbon to the atmosphere*
100-200 million years to move	*Measured in a lifespan.*	*Daily - no equilibrium cycle*
SLOW: 10-100 million metric tonnes per year	*FAST: 10-100 billion metric tonnes per year*	*Really FAST one way: 1-50 billion metric tonnes per year*

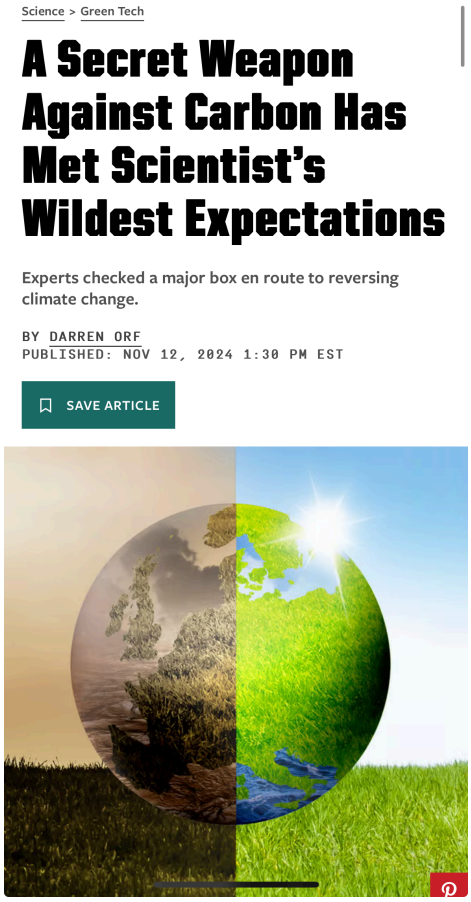
PUNCHLINES

- *Carbon Dioxide comes and goes via the Fast and Slow Carbon Cycles*
- *Human Carbon Emissions were taken from SLOW reservoirs*
- *In the FAST reservoirs, CO2 warms the planet, increases vegetation growth, and acidifies the ocean.*
- *Some Emitted CO2 is returned to the SLOW reservoirs via Plankton and dissolved organic carbon*
- *Geoengineering via increased plankton could accelerate carbon removal, but is insufficiently understood.*

GOOD NEWS CORNER

A Secret Weapon Against Carbon Has Met Scientist's Wildest Expectations

Because of CSAR's simple and efficient design, the tech could be retrofitted to existing flues that are currently exacerbating the climate crisis.



Science > Green Tech

A Secret Weapon Against Carbon Has Met Scientist's Wildest Expectations

Experts checked a major box en route to reversing climate change.

BY DARREN ORF
PUBLISHED: NOV 12, 2024 1:30 PM EST

SAVE ARTICLE

"The CSAR technology utilizes two reactors in the capture process," Jan Hendrik Cloete, SINTEF research scientist, said in a press statement. "The CO_2 is initially captured in the first reactor by a sorbent, which binds the gas to its surface. This binding process occurs at low temperature and generates heat. The heat is then transferred to the other reactor, where it is used to release the CO_2 from the sorbent, this time at a higher temperature. The heat pump is used to transfer the heat between the reactors, while the vacuum pump assists in releasing the CO_2."

Our Natural World

Portfolio Award Winner, Shane Gross

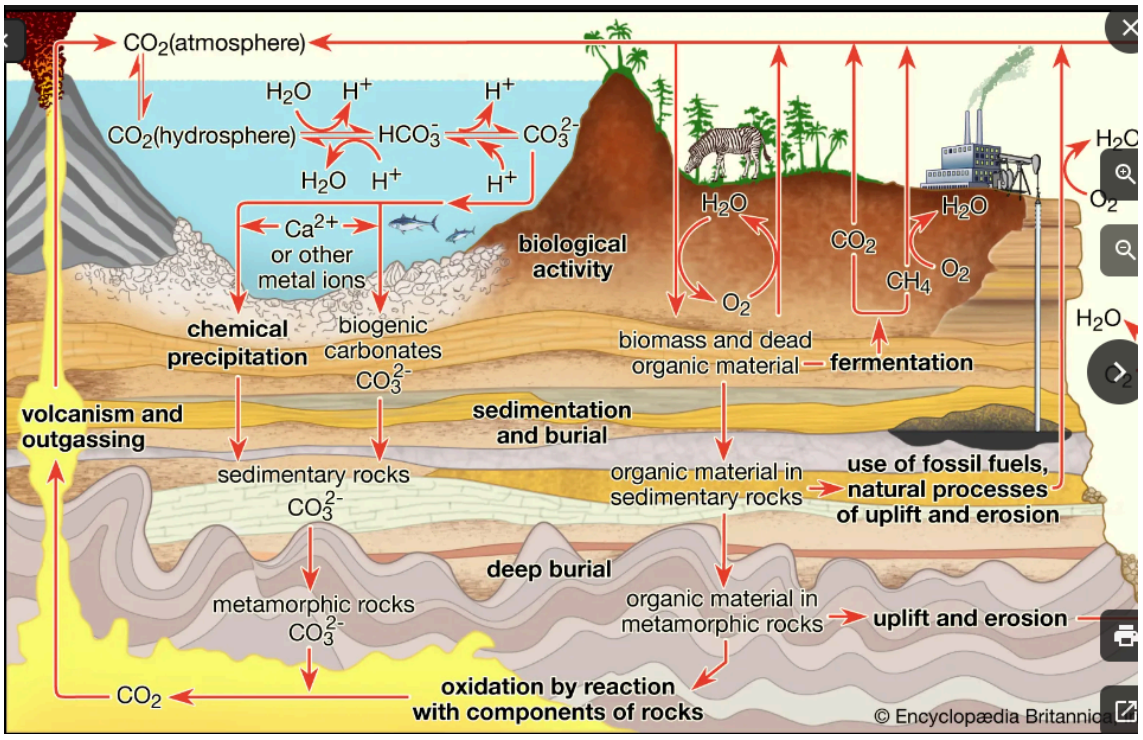
Baby plainfin midshipman fish, still attached to their yolk sacs. Shane Gross

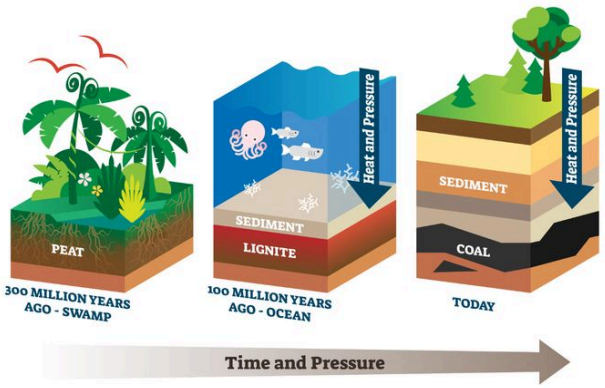
https://www.smithsonianmag.com/smart-news/see-15-stunning-images-from-the-ocean-photographer-of-the-year-awards-180985064/

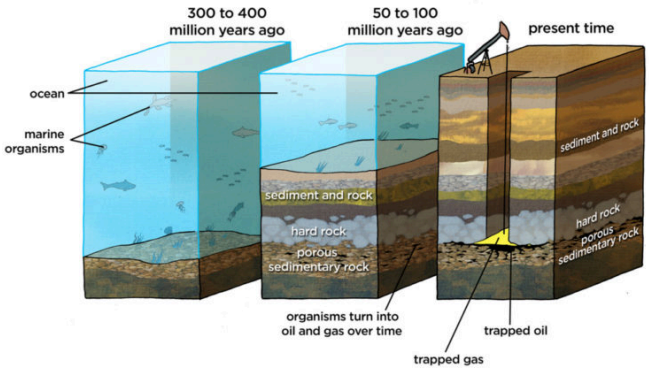
Supplemental Materials

Approximate "Cheat Sheet":

1 meter → 3 feet **1 degree Celsius (°C)** → 2 degree Fahrenheit (°F)
ppm = parts per million **CO_2** = Carbon Dioxide
1 tonne = 1000 kilograms = 2205 pounds **1 gigatonne (1 Gt)** = 1 billion tonnes
1 trillion tonnes (1Tt) = 1000 gigatons







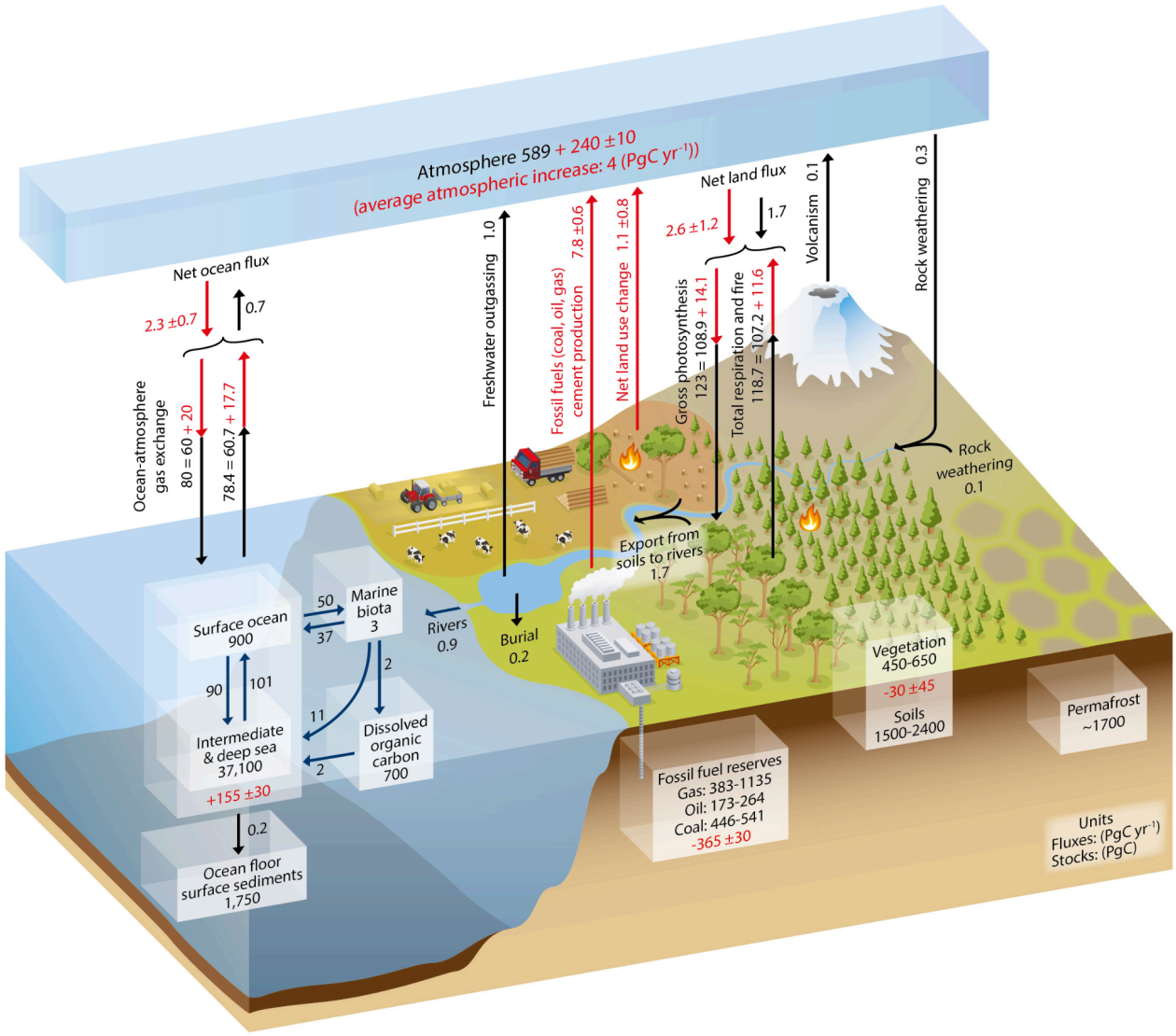


Figure 1.2: The boxed numbers represent reservoir mass or carbon stocks in petagrams of carbon (Pg C). Arrows represent annual exchange (fluxes) in Pg C per year. Black numbers and arrows represent preindustrial reservoir masses and fluxes, while red arrows and numbers show average annual anthropogenic fluxes for 2000 to 2009. The red numbers in the reservoirs denote cumulative changes of anthropogenic carbon for the industrial period. Uncertainties are reported as 90% confidence intervals. [Figure source: Reprinted from Ciais et al., 2013, Figure 6.1. Copyright IPCC, used with permission.]