POLAR TREC
Learning Resources

Details

Completion Time: Less than 1 period
Permission: Download and Share

Pumping Carbon

Overview
This activity allows students to participate in a physically interactive dramatization of the oceanic biological pump.

Objective
The purpose of this activity is to develop a conceptual understanding of how the biological pump moves carbon through the oceans.

Preparation
Background Information:
The Carbon cycle is a biochemical cycle that transfers carbon between short and long-lived reservoirs in the biosphere, atmosphere, oceans, and geosphere. Short-term reservoirs are found in terrestrial, oceanic and atmospheric systems, with turnovers in ~1000- 10,000 yrs. The largest short term reservoir is the deep ocean. The largest long-term carbon reservoirs are sedimentary rocks with residence times in 100 millions of years. We increase short-term reservoirs by "mining" the long-lived reservoirs. If we do this faster than nature intended (e.g. human activity, land use, fossil fuels), the short-term reservoirs increase in size. Scientists construct carbon budgets from measurements of productivity, food webs, and nutrient cycling to understand the global carbon cycle. The atmosphere is the link between the reservoirs and the oceans play a major role in determining atmospheric levels of CO_2 through physical, chemical and biological means. CO_2 levels have increased from 280 ppm to 385 ppm (about 38%) since the beginning of the Industrial Revolution, and the rate of increase is increasing from 1ppm (pre-2000) to 2ppm per year. Most of the concentrations of CO_2 come from changes in land use and fossil fuels. But the atmosphere sees only about half the increase it would, were it not for the "sinks" in the ocean and terrestrial biosphere. So how does that work?

Materials

- 2 cans or bottles of coke for demonstration
- Blue crepe paper or material to represent ocean (cheap bed sheets or blue shower liners work well)
- Props for the warmer equatorial /surface waters (straw hat, sunglasses)
- Props for the polar ocean (gloves, hat, scarf, etc)
- 1 set of identification cards (plankton, photosynthesis, etc. examples attached)
- String or yarn for ID cards (they will be worn around the neck)
- Copies of CO_2 cards- about 100
- 15-20 Envelopes marked "Organic Matter"
- 1 image of the Sun
- Bubble mixture and wands (represent outgassing)

Description
A. Begin with a demonstration:
In front of the students, open 2 cans of coca cola, one warm (room temp), one cold. Tell them you will let them sit for awhile and come back to them later!

B. Activity:
1. The first time around, tell the students that they will act out the narration you will read. Do not give them too much prior information other than an overview of the intent: to act out the processes of the carbon cycle in the ocean.
2. Assign roles and give them the props they will need. One person for each different component will be needed, although you can have lots of plankton and bacteria!
3. As you narrate, stop the action from time to time to explain what is happening.
4. After the activity, go back to the cokes. Which one tastes better? Why? (The warmer coke is flat (less carbonation; the colder one retains more taste. How is this like the ocean?)
5. After several runs, my students wanted to "say their own lines". This is a great way to assess understanding! Later, they were able to recall their actions and make connections as we spoke about the oceanic carbon cycle!

SCRIPT
Using props and movements, participants will act out the sequence of events that demonstrate the processes that drive the oceanic carbon pumps. Remember that as with all models, these are simplifications to capture the essence of the process. Use the attached script as a guide.

Resources
N/A

Credits
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The Solubility Pump -moving the carbon between the atmosphere and the oceans.

Narrative- the science	Associated action
First, we need an ocean and an atmosphere!	Create the ocean by laying blue crepe paper or material on the floor and positioning someone at either end to represent warm low latitudes and cold higher latitudes. The atmosphere will be represented by one person who moves in between.
Gas exchange between the oceans and atmosphere moves CO_2 through diffusion	Blow bubbles from two directions constantly and atmosphere blows bubbles as well.
Wind and waves enhance the rate of gas exchange	Wave crepe paper or sheet in oscillating motion across the ocean
Time to turn on the sun. Solar input is not equal across the globe.	Sun moves into the scene. Person in the tropics puts on sunglasses. Person at the poles puts on a stocking cap.
Colder ocean surface waters hold a lot of carbon	Polar Person holds lots of carbon cards
Tropical surface waters warmed by the sun hold less carbon.	Tropics Person holds a few carbon cards up
Cold salty water sinks and deep ocean circulation acts like a conveyor belt, moving the carbon from polar surface waters to deeper cold waters and then up again to warmer surface layers. Outgassing occurs because warmer waters hold less carbon dioxide. The atmosphere takes in the CO_2 and it moves around the atmosphere. In a steady state scenario, the amount of CO_2 taken in balances the amount outgassed. In terms of time, this takes thousands of years.	Deep Ocean Person takes 3 carbon cards from the cold water and crawls to the warmer water slowly where it hands the carbon over. The tropics person takes the card and then blows bubbles up into the air (outgassing) and the atmosphere takes the cards from the tropical surface ocean. The atmosphere person dances around the area to simulate mixing the air in and eventually gives those all back to the Polar Ocean Person who then gives them to the deep ocean person. The cycle repeats again.

As we warm up the world, the capacity of the ocean to hold the carbon decreases.	Both areas blow more bubbles as the atmosphere collects more cards from the cold and warm oceans.

Consider this: As the whole world warms up, what will happen to the ocean's capacity to take up extra CO_2?

But this cycle doesn't act alone! Biological and geological systems interact with the atmosphere and oceans to drive the global carbon cycle

The Biological Pump – the plankton moves in!

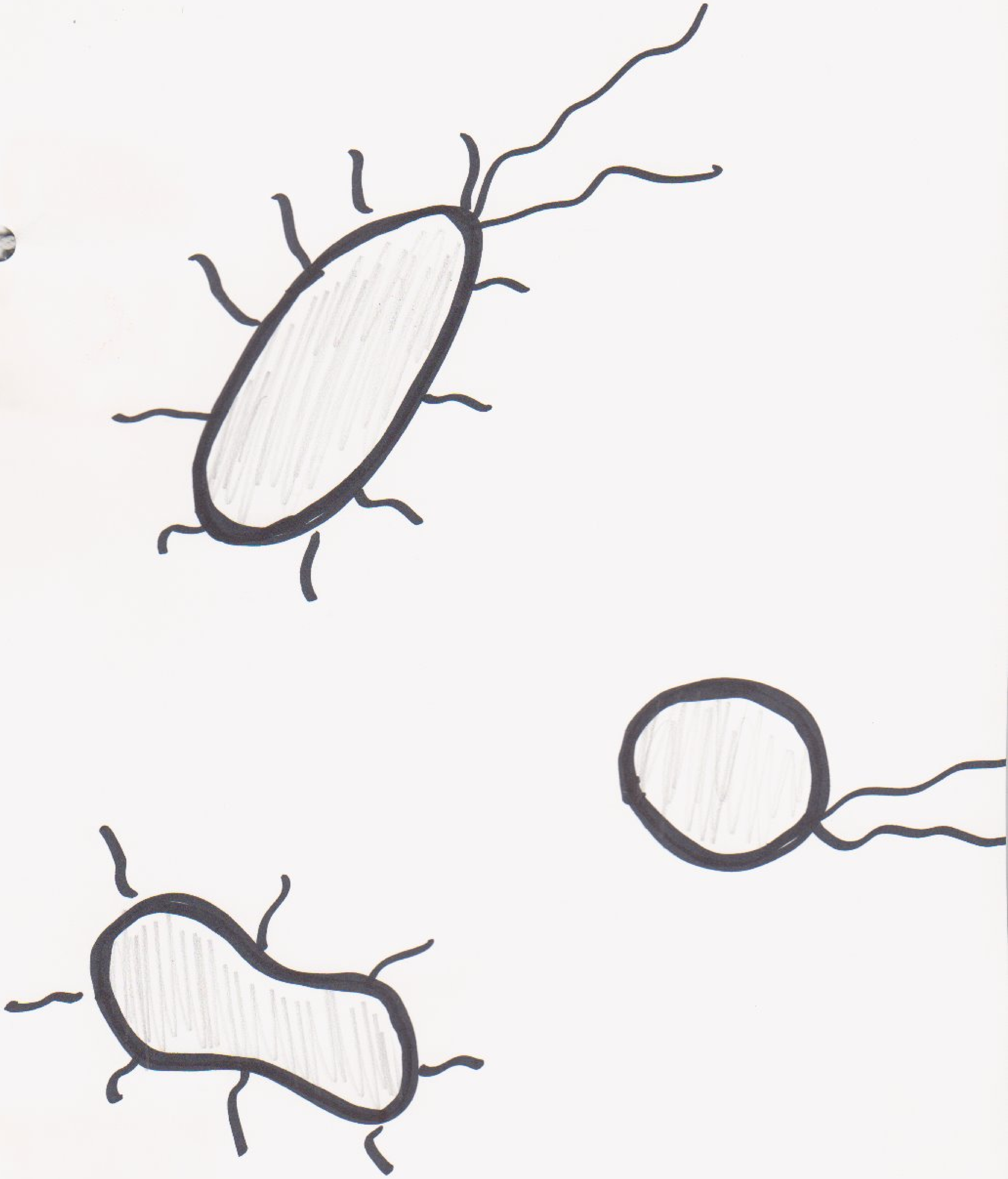
Providing sunlight to the upper level of the ocean allows green algae to grow	Phytoplankton moves in
Using energy from the sun, phytoplankton uses CO_2 during photosynthesis, Photosynthesis is the process of converting light energy and CO_2 into sugars.	Show photosynthesis formula card and take carbon cards from both sides. Algae take CO_2 card and put it in an envelope labeled Organic Matter.
As CO_2 is taken up by the phytoplankton, the atmosphere can add more CO_2 to the ocean	As the surface ocean gives cards to the phytoplankton, the atmosphere gives an equal number of cards to the surface ocean.
Respiration is the reverse process of burning sugar for energy and producing CO_2.	Show respiration formula. Algae give one of the CO_2 cards back to the surface ocean.
Other organisms eat the phytoplankton, and then respire. All of this happens in the warm surface lit water layer of the ocean	Zooplankton move in and takes the envelope from the phytoplankton. Zooplanktons pull out a CO_2 card and give it back to the surface ocean.
When phytoplankton and zooplankton die, they decompose. Just like the compost pile in your backyard, bacterial respiration converts the organic matter to CO_2 and nutrients. Some of the decomposition occurs in the surface ocean and the CO_2 is returned there.	One of the phytoplankton dies and then hands over their envelope of organic matter to the bacteria that appear in the surface ocean. Bacteria slowly remove CO_2 cards from the envelope and give it to each of the surface ocean persons, who might give a card or two back to the atmosphere.
Not all the plankton decomposes before they sink. Once on the floor, there are deep bacteria who continue to take the organic matter cards.	Some plankton falls to the floor. Bacteria move along the floor and slowly remove one card at a time from the Organic Matter envelope and hand it to the Deep Ocean Person

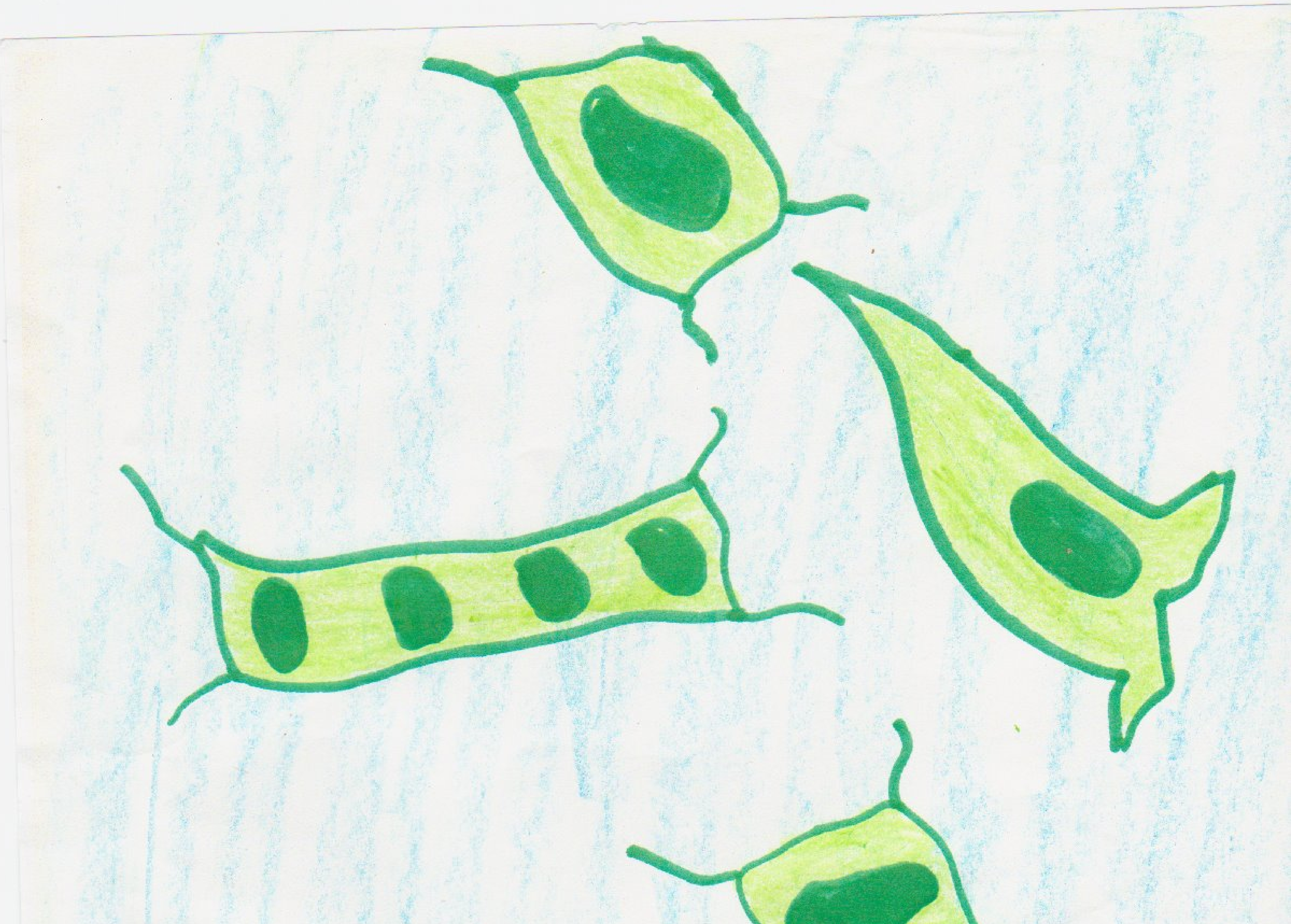
	as it crawls along the floor.
The only loss from this system is less than 1% that is buried in sediments and eventually becomes rock and/or fossil fuel	The bacteria leave 1 CO_2 card in the Organic Matter envelopes and bury it. (It can simply be laid on the floor)
Since the Industrial Revolution we have removed Organic Matter from these ancient reservoirs at a much faster rate than the ocean can replace it!	Industrial Revolution moves in and scoops up buried envelopes of Organic Matter quickly, takes out the CO_2 and hands them to the atmosphere who struggles to hold all of them while trying to hand over 1 or 2 to the ocean!!

Consider this: What controls the fate of primary production in the Southern Ocean?

What might happen to change the efficiency of this pump?

What happens when you shut off the pumps?





Industrial Revolution