

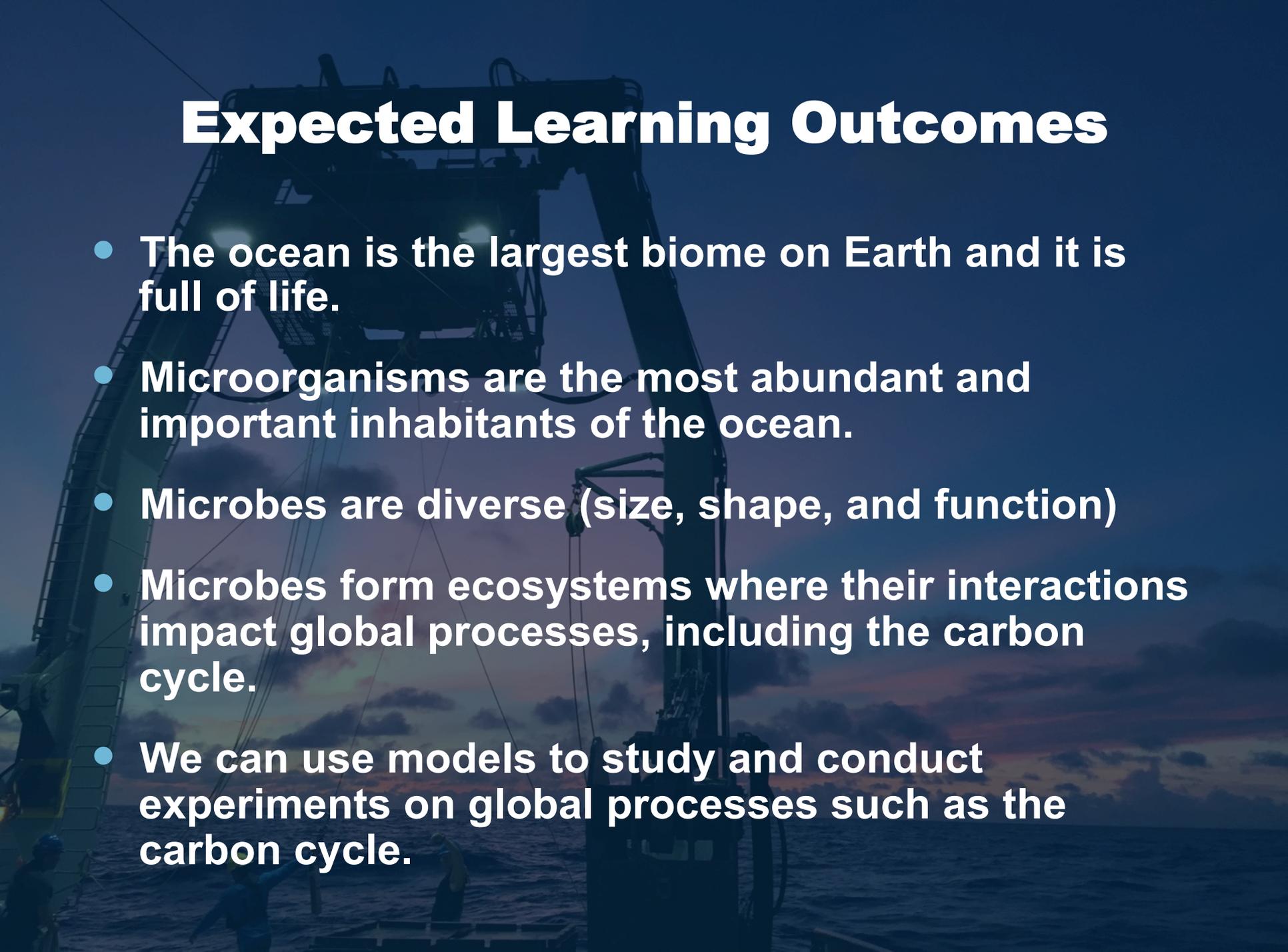
Marine Microbiology in the Oligotrophic Ocean

SMILE High School Teacher Workshop
Giovannoni Lab
August 5th, 2019



Oregon State
University

Expected Learning Outcomes

The background of the slide is a photograph of a research vessel's deck at sunset. The sky is a mix of orange, pink, and blue, with dark clouds. In the foreground, the dark silhouette of a large piece of scientific equipment, possibly a crane or a deck-mounted instrument, dominates the left and center. The ocean is visible in the lower part of the frame, with some crew members' silhouettes and equipment on the deck.

- The ocean is the largest biome on Earth and it is full of life.
- Microorganisms are the most abundant and important inhabitants of the ocean.
- Microbes are diverse (size, shape, and function)
- Microbes form ecosystems where their interactions impact global processes, including the carbon cycle.
- We can use models to study and conduct experiments on global processes such as the carbon cycle.

Outline of Lesson

- Marine Microbiology and Carbon Cycle introduction presentation
- Expert Groups
- Modeling presentation
- Explain *Oligotrophic Simulation*
- *Oligotrophic Simulation 1, 2, and 3*
- Conclusions





Is the Earth **BLUE** or **GREEN**?



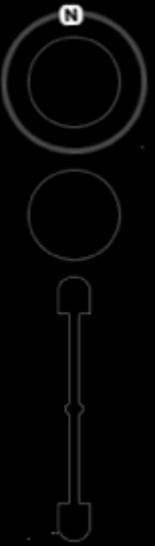
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO
Image © 2011 DigitalGlobe
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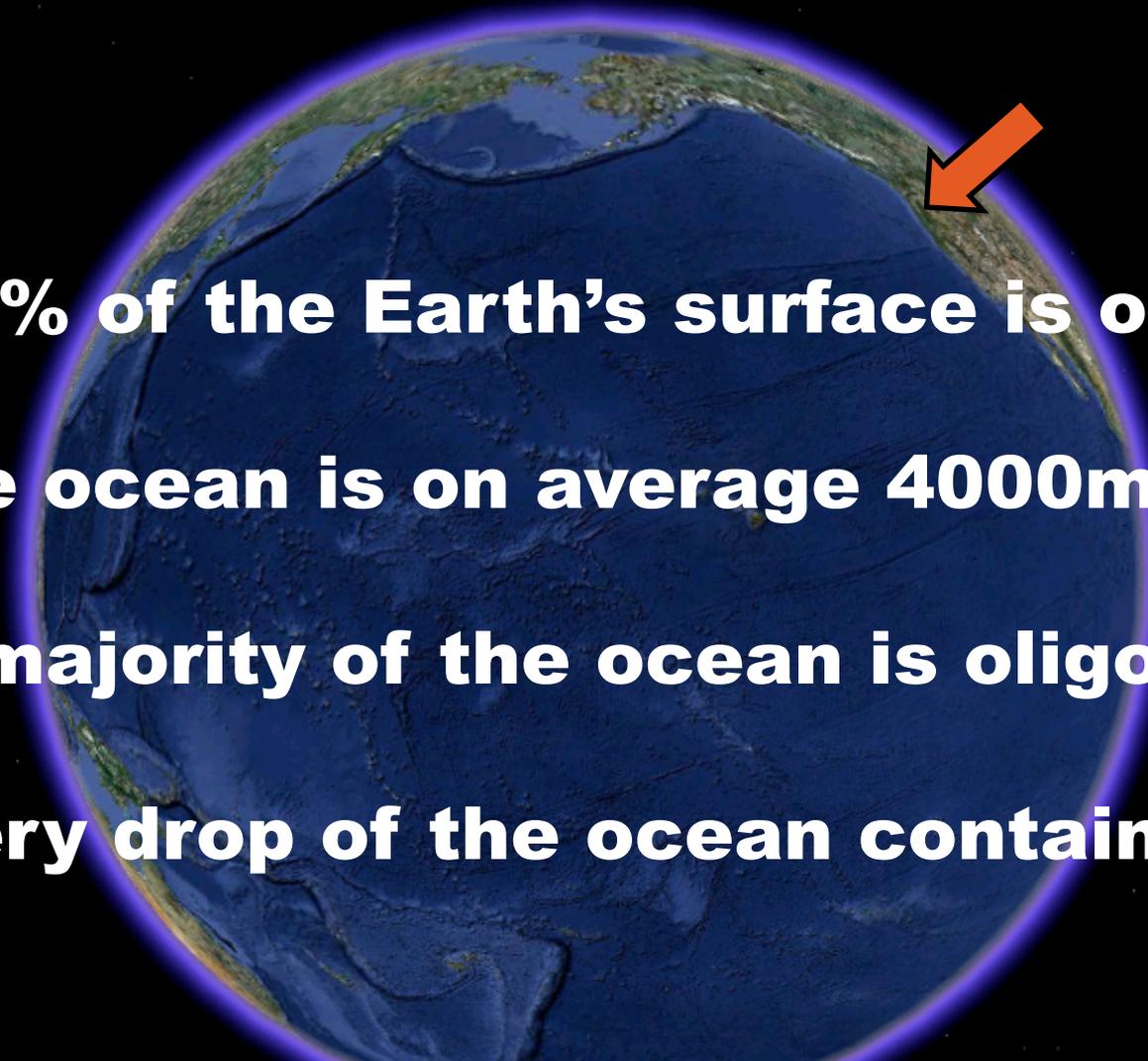
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70% of the Earth's surface is ocean

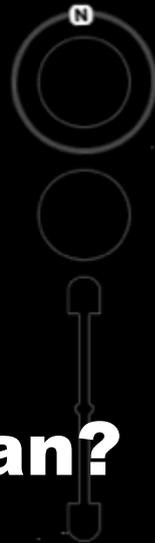
The ocean is on average 4000m deep

The majority of the ocean is oligotrophic

Every drop of the ocean contains life!

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO

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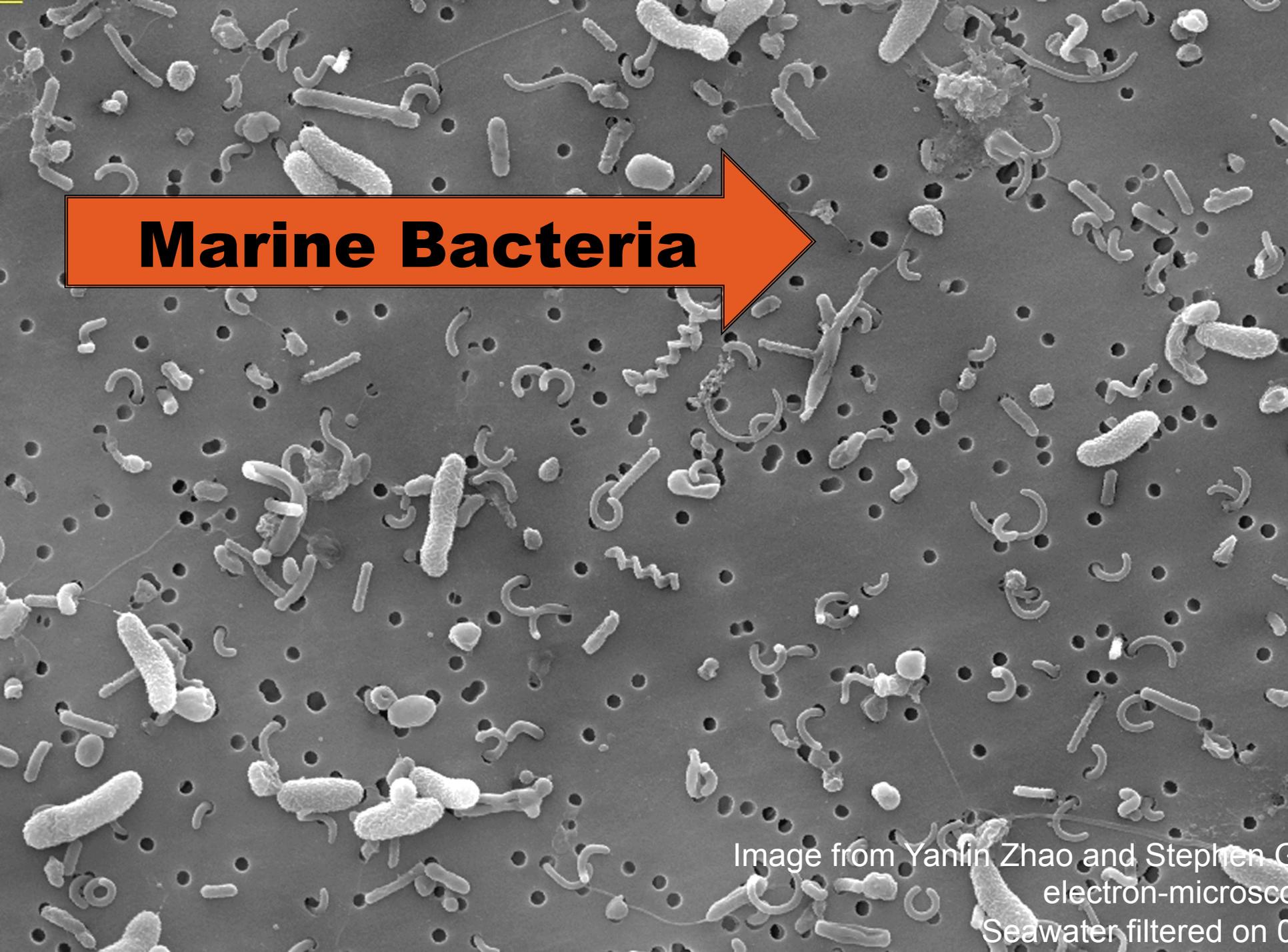
What types of organisms live in the ocean?

**Which types are most important
to our planet?**

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO

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A scanning electron micrograph (SEM) showing a dense population of marine bacteria. The bacteria exhibit a wide variety of shapes, including rod-like, spiral, and curved forms. They are distributed across a dark, textured background that appears to be a filter membrane. An orange arrow points from the text 'Marine Bacteria' towards the right side of the image.

Marine Bacteria

Image from Yanlin Zhao and Stephen C.
electron-microscop
Seawater filtered on C

Fun Fact:
In 1 drop of
seawater there
are
1 million
bacteria!

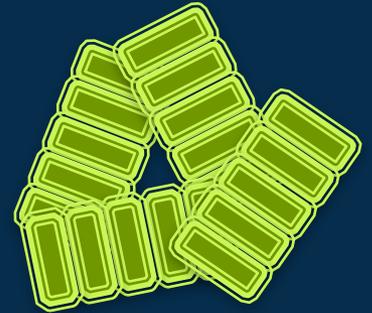
Marine Microbial Vocab!

Oligotrophic: an area of the ocean with low nutrient concentrations

Phytoplankton:

-Create biomass from the sun (like plants)

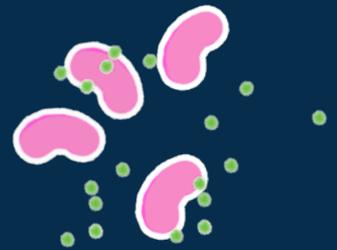
-example: *Prochlorococcus*



Bacterioplankton:

-Use biomass produced by phytoplankton to survive

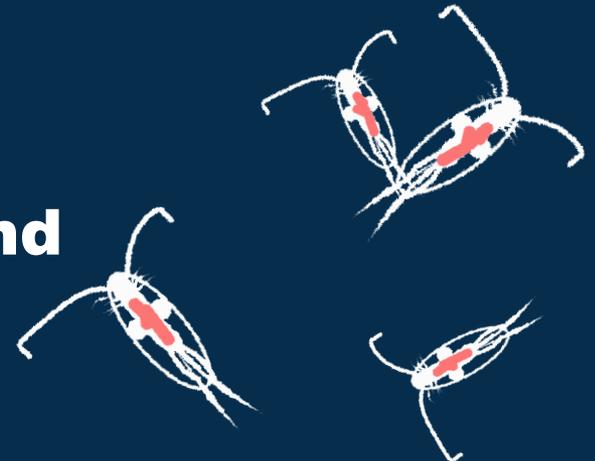
-example: SAR11



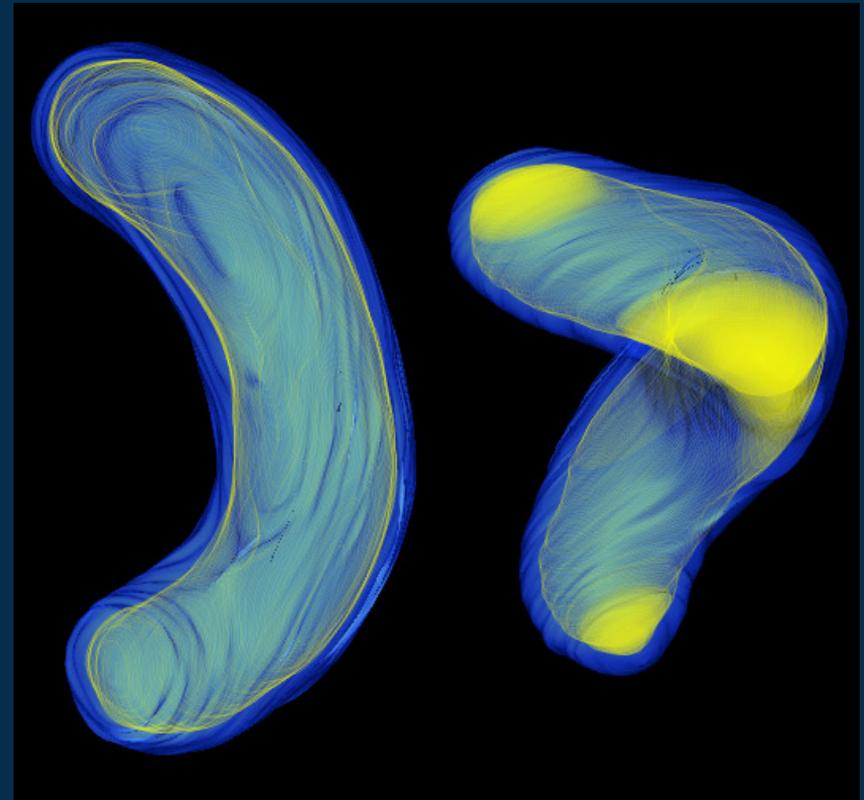
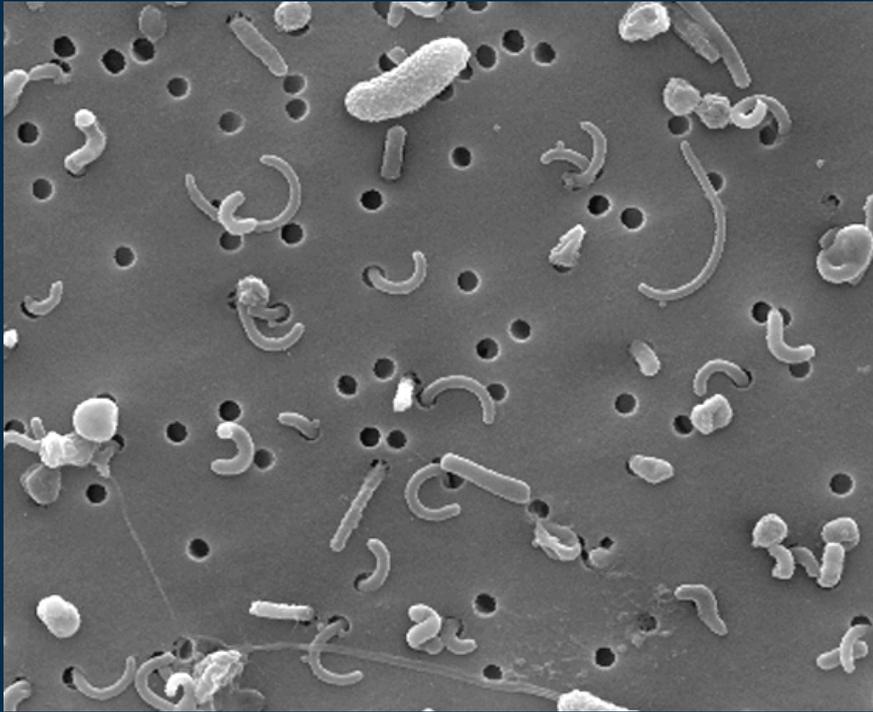
Zooplankton:

-Consume both phytoplankton and bacterioplankton

-example: copepod

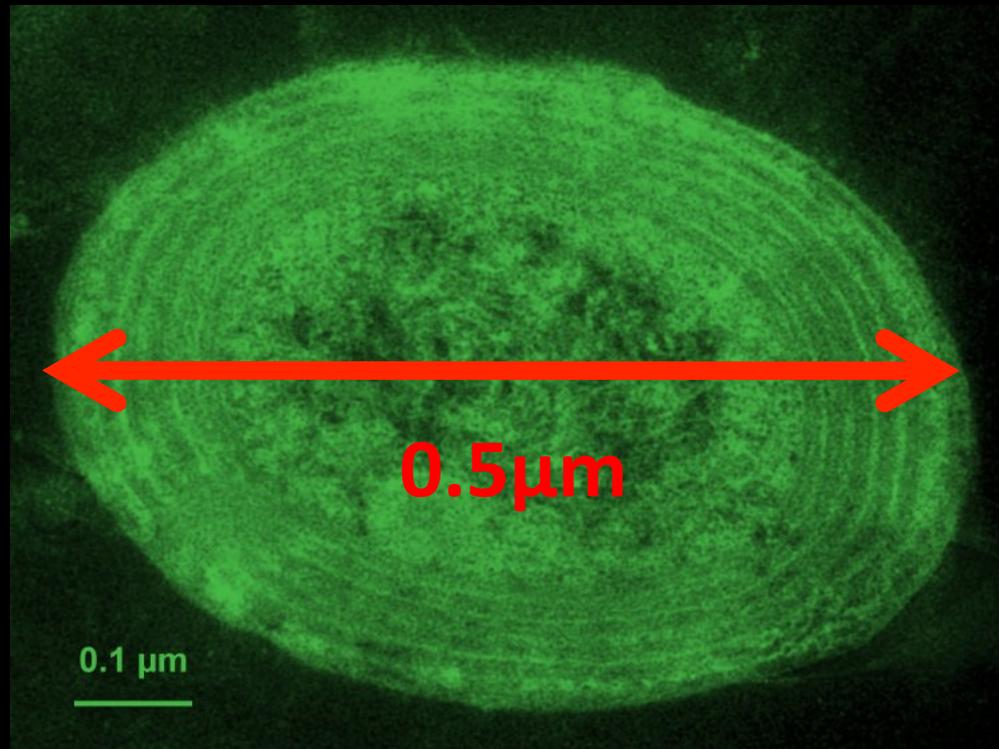


SAR11 is the most abundant bacterioplankton



Discovered in the Giovannoni Lab at OSU

Prochlorococcus is an important phytoplankton



200 in a row = 1 human hair!



Marine microbes are small and diverse

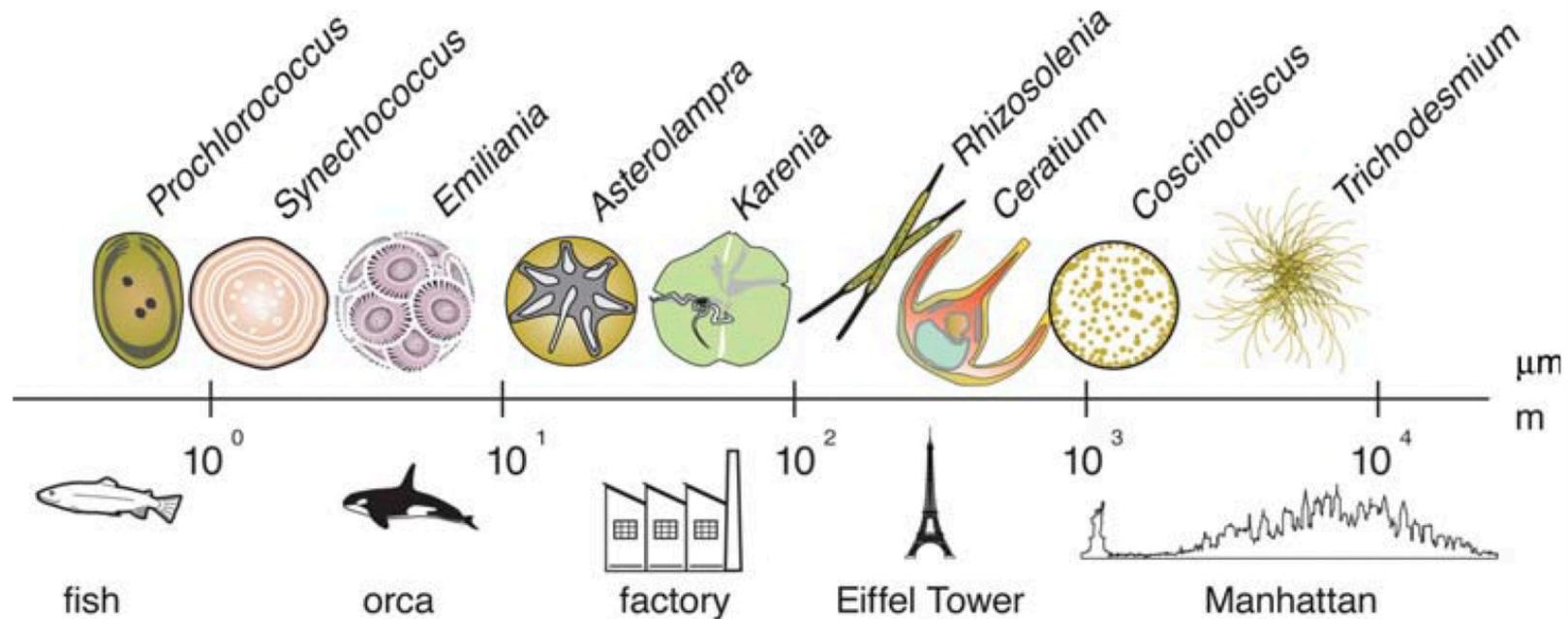
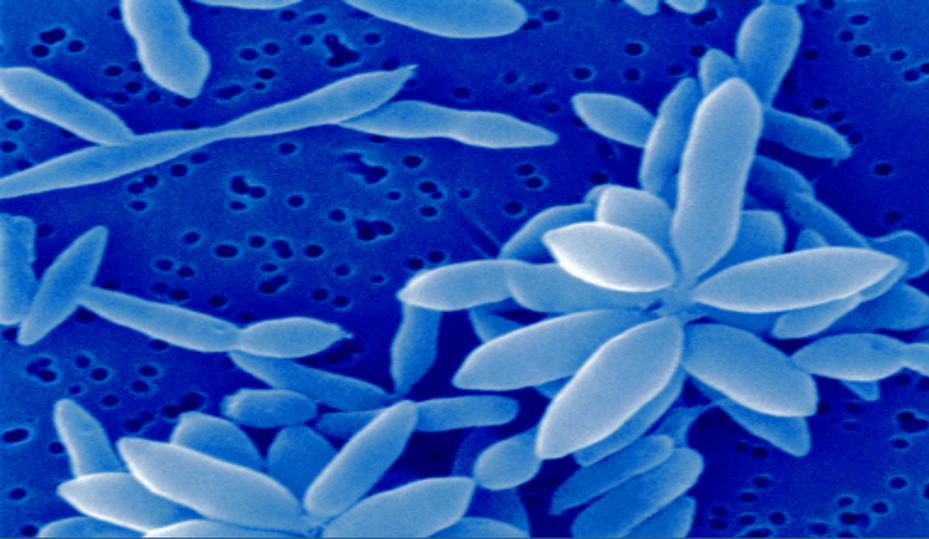
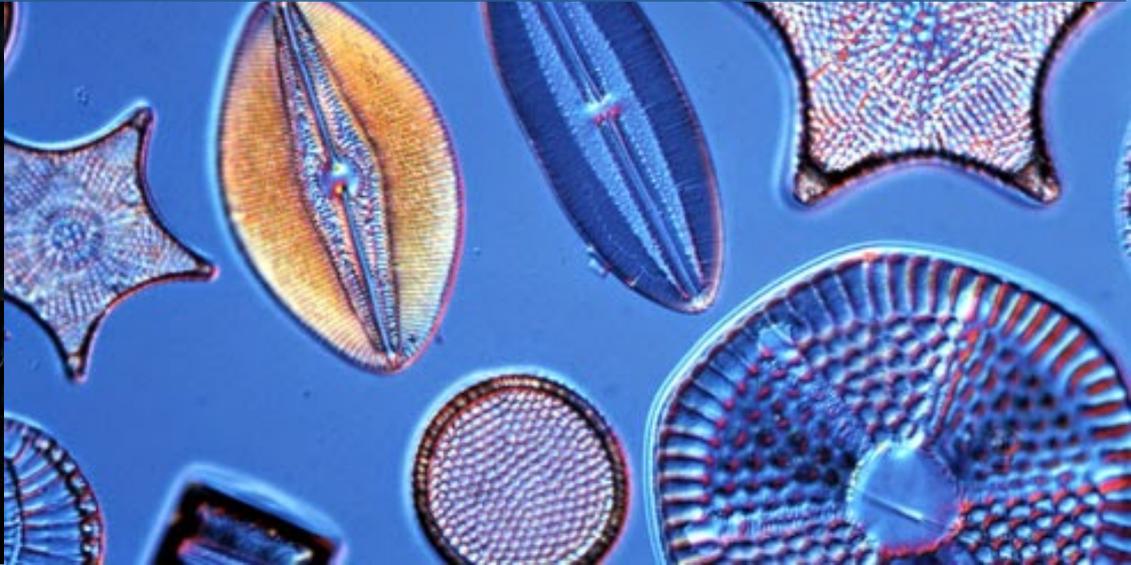


Fig. 2. A comparison of the size range (maximum linear dimension) of phytoplankton relative to macroscopic objects.

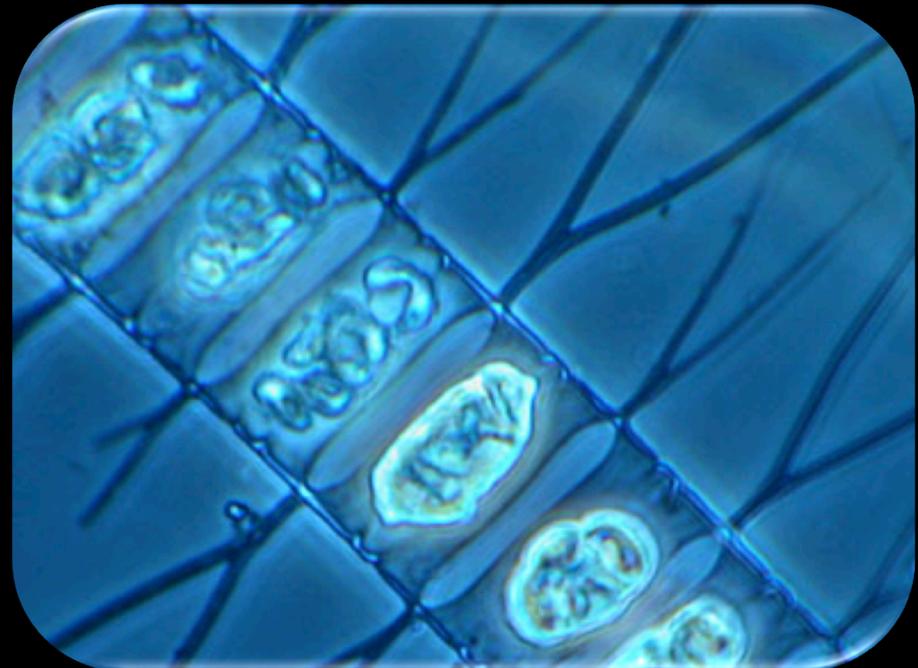
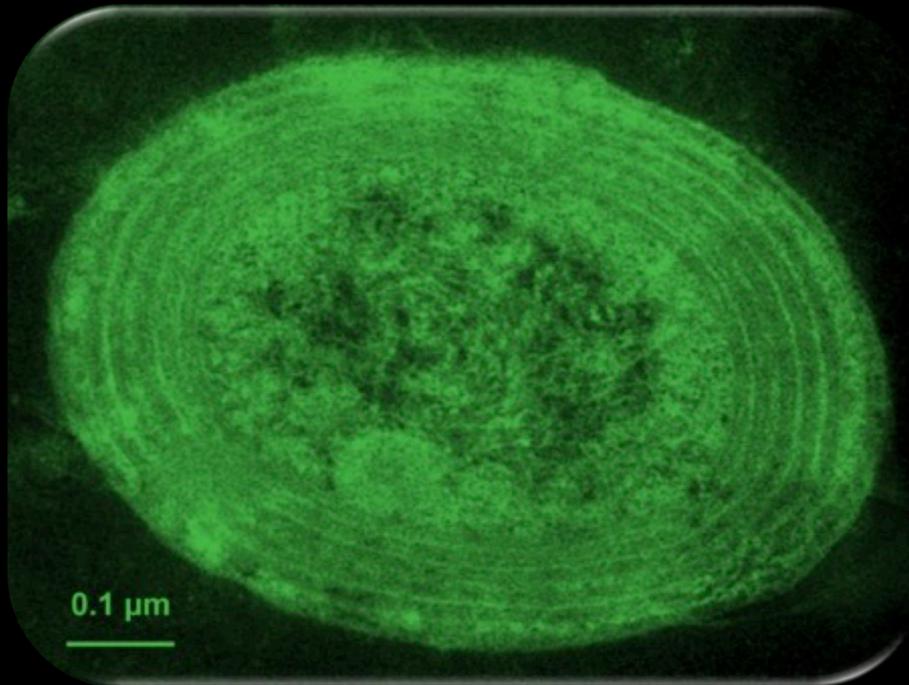


What are these marine microbes doing?

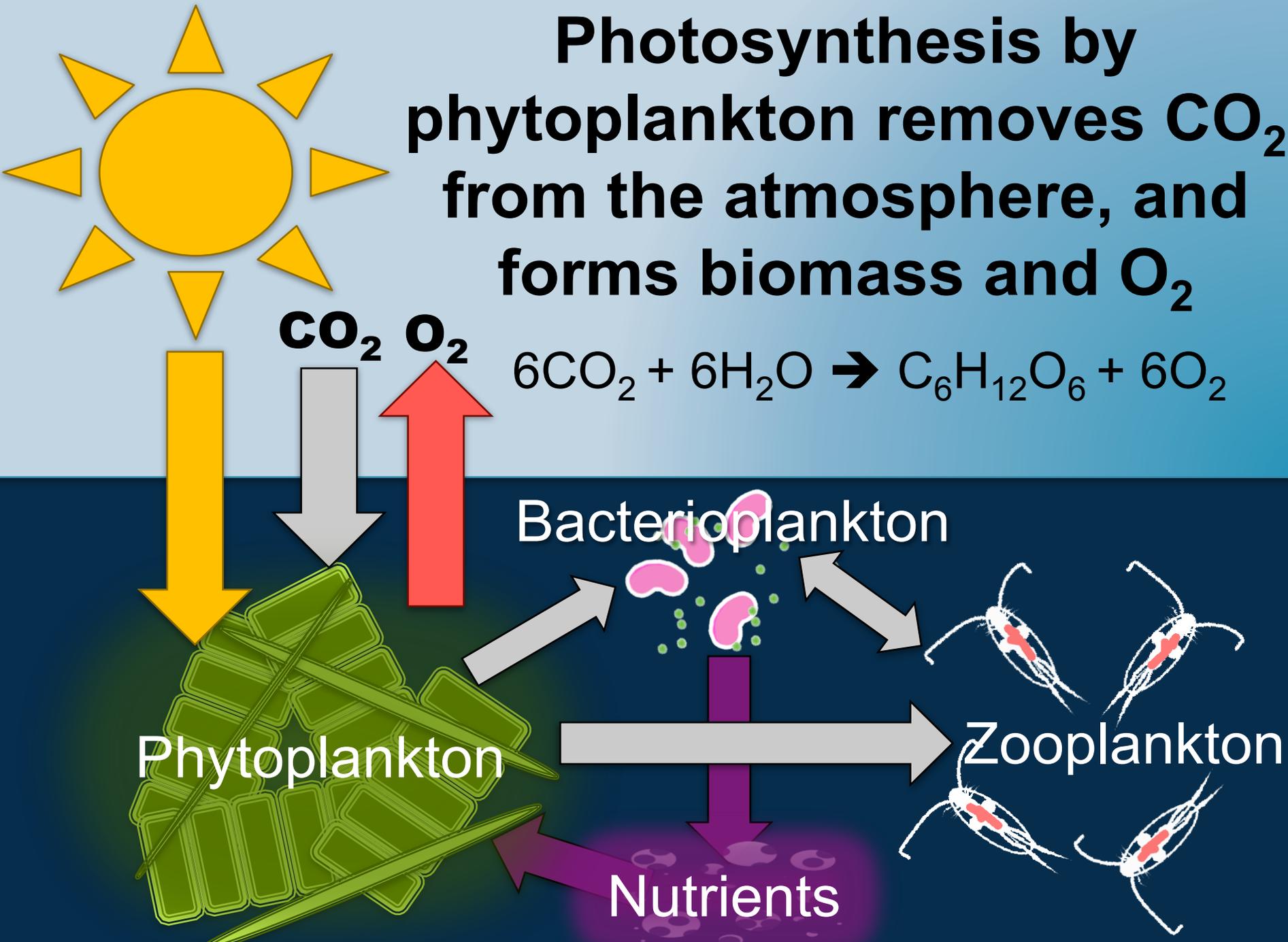
Why should we care about them?



50% of all oxygen we breathe is produced by microbes in the ocean!!



Photosynthesis by phytoplankton removes CO₂ from the atmosphere, and forms biomass and O₂



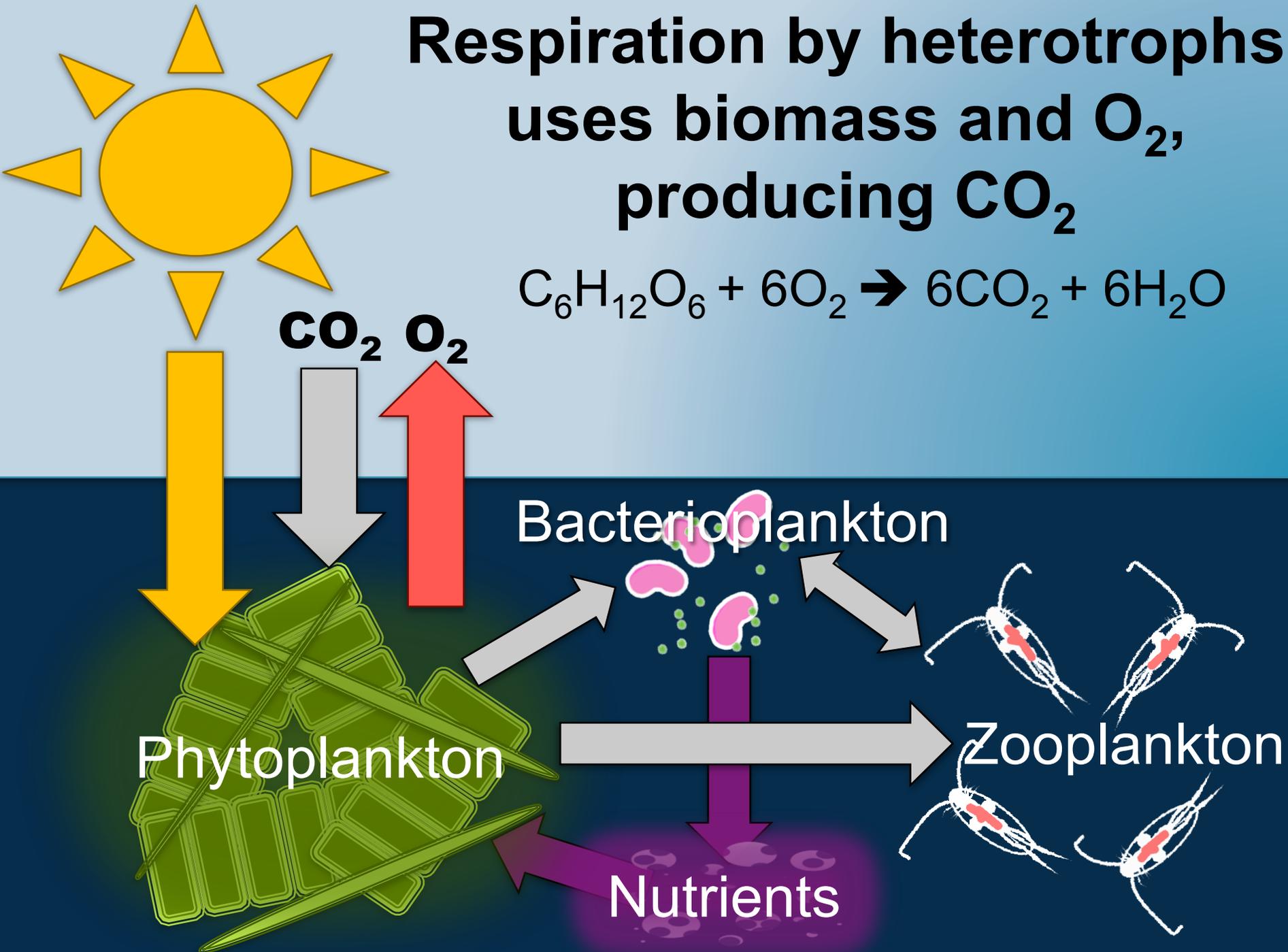
Phytoplankton

Bacterioplankton

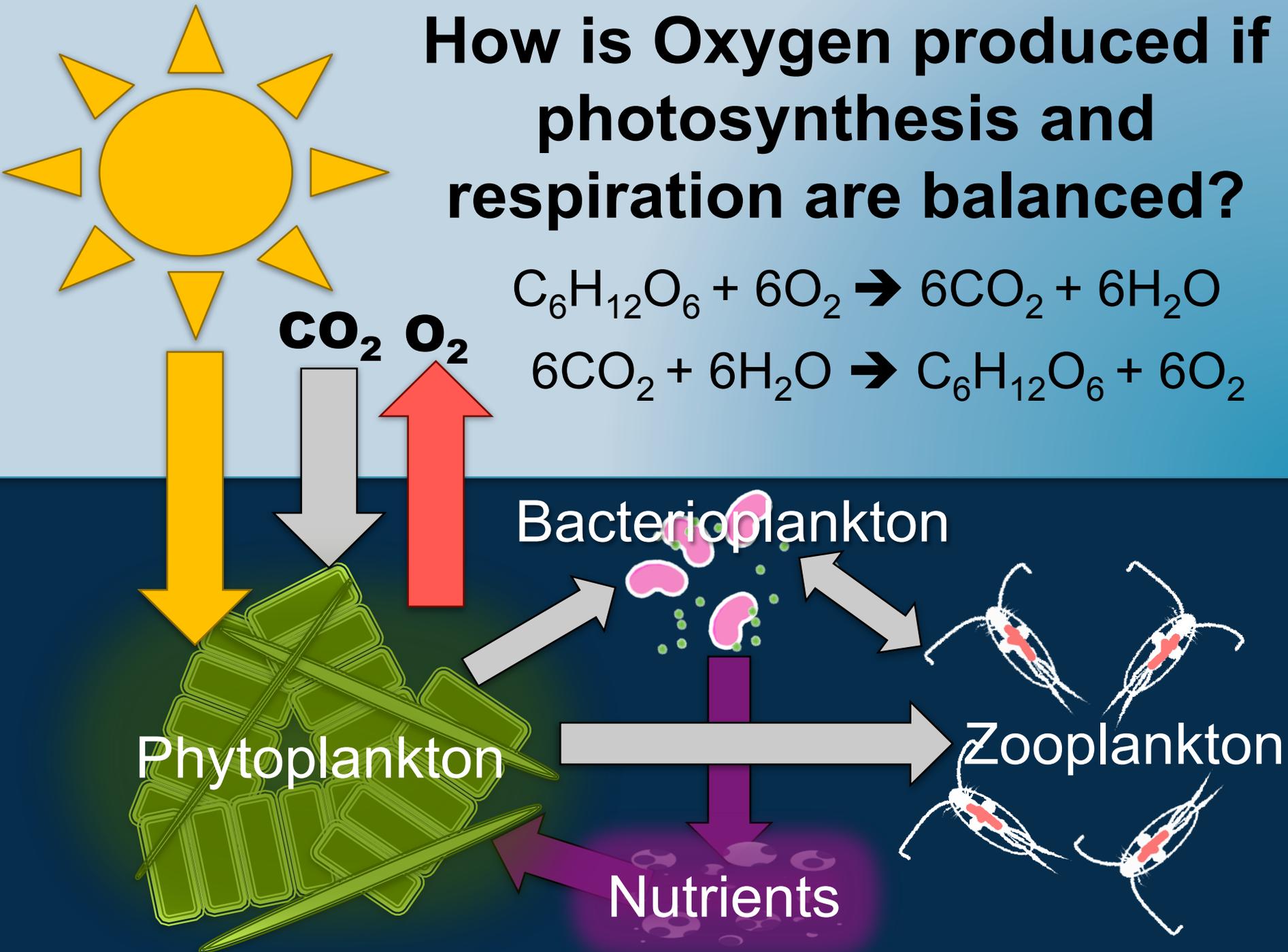
Zooplankton

Nutrients

**Respiration by heterotrophs
uses biomass and O₂,
producing CO₂**



How is Oxygen produced if photosynthesis and respiration are balanced?



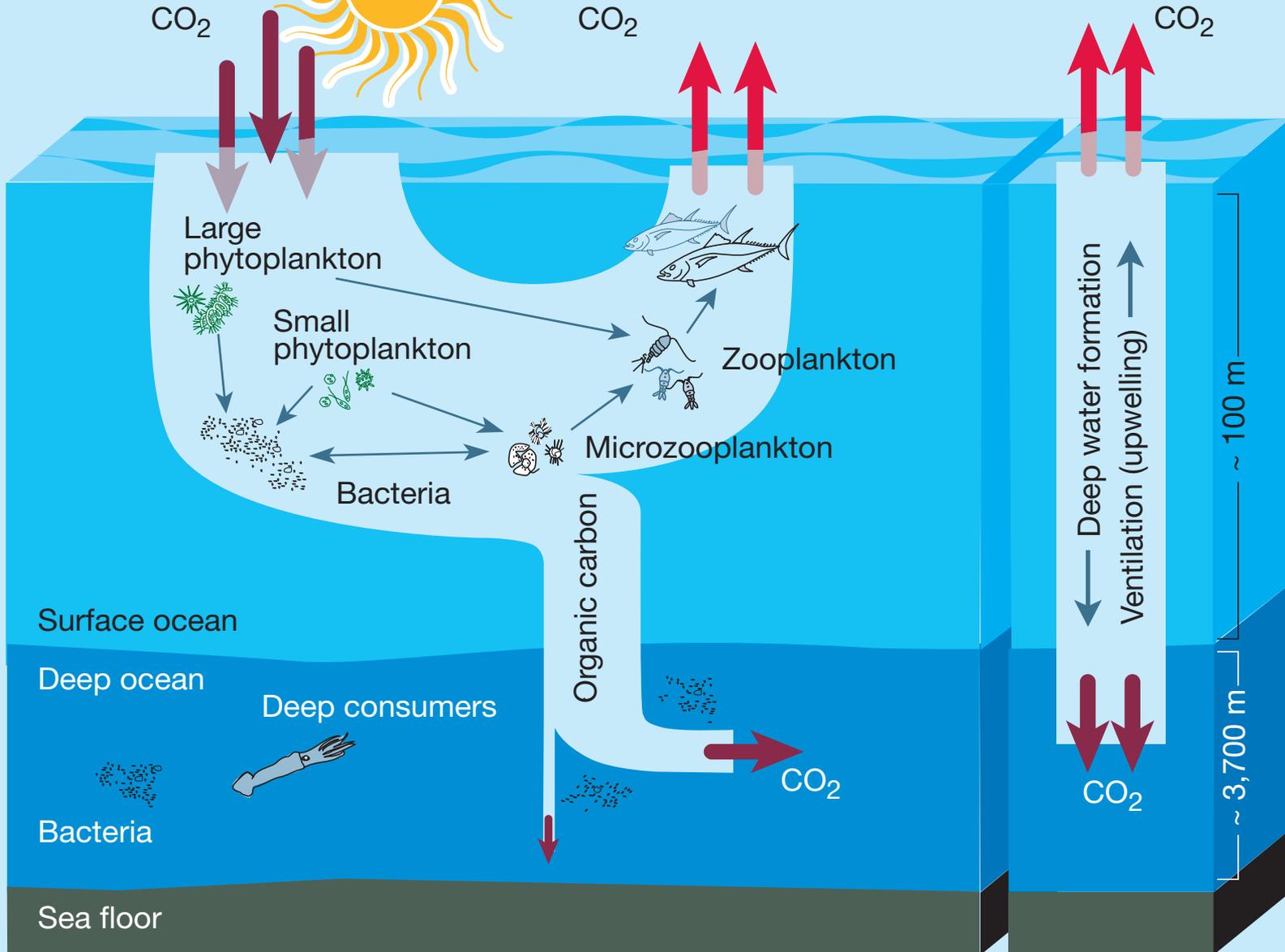
Phytoplankton

Bacterioplankton

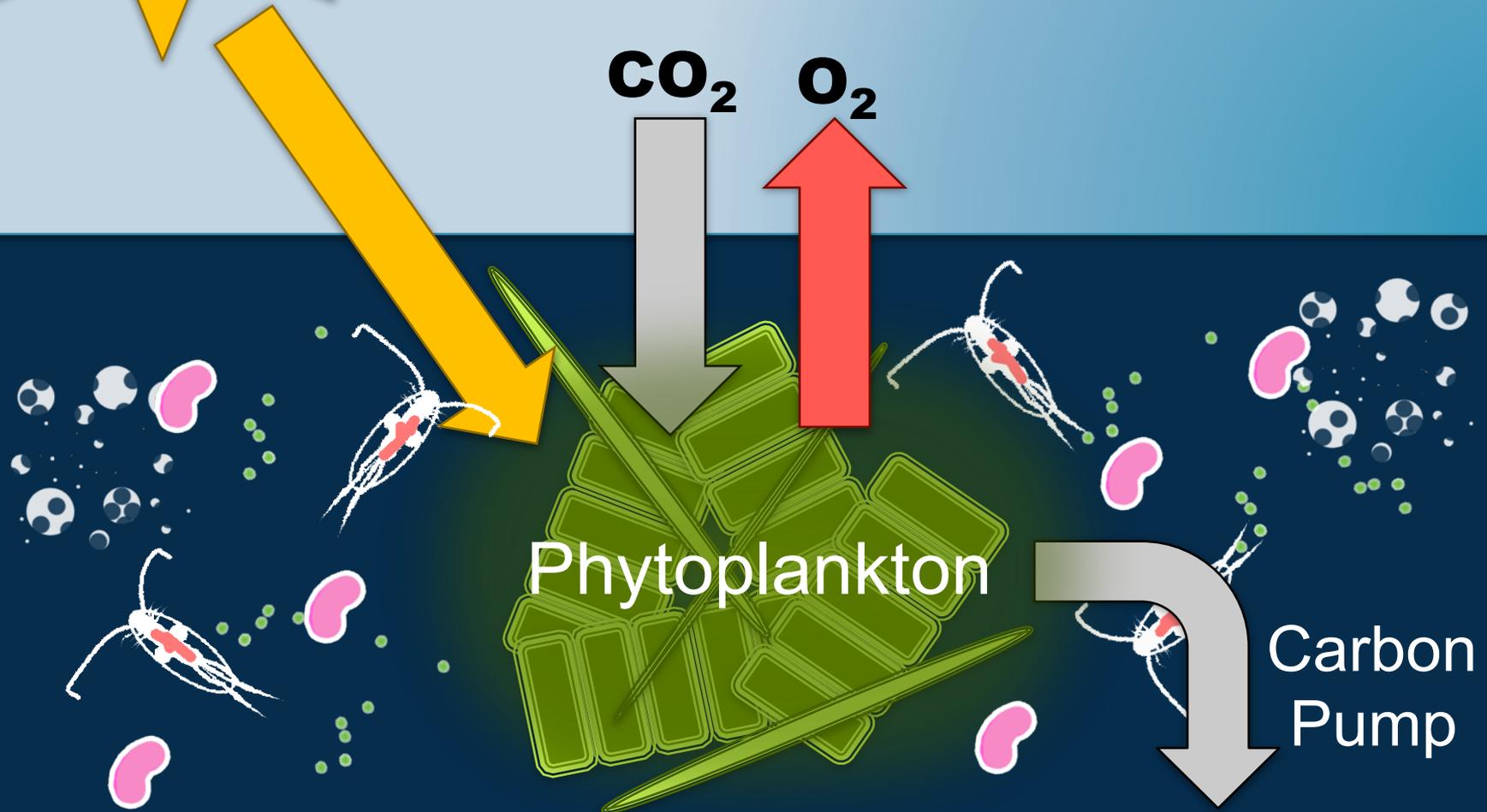
Zooplankton

Nutrients

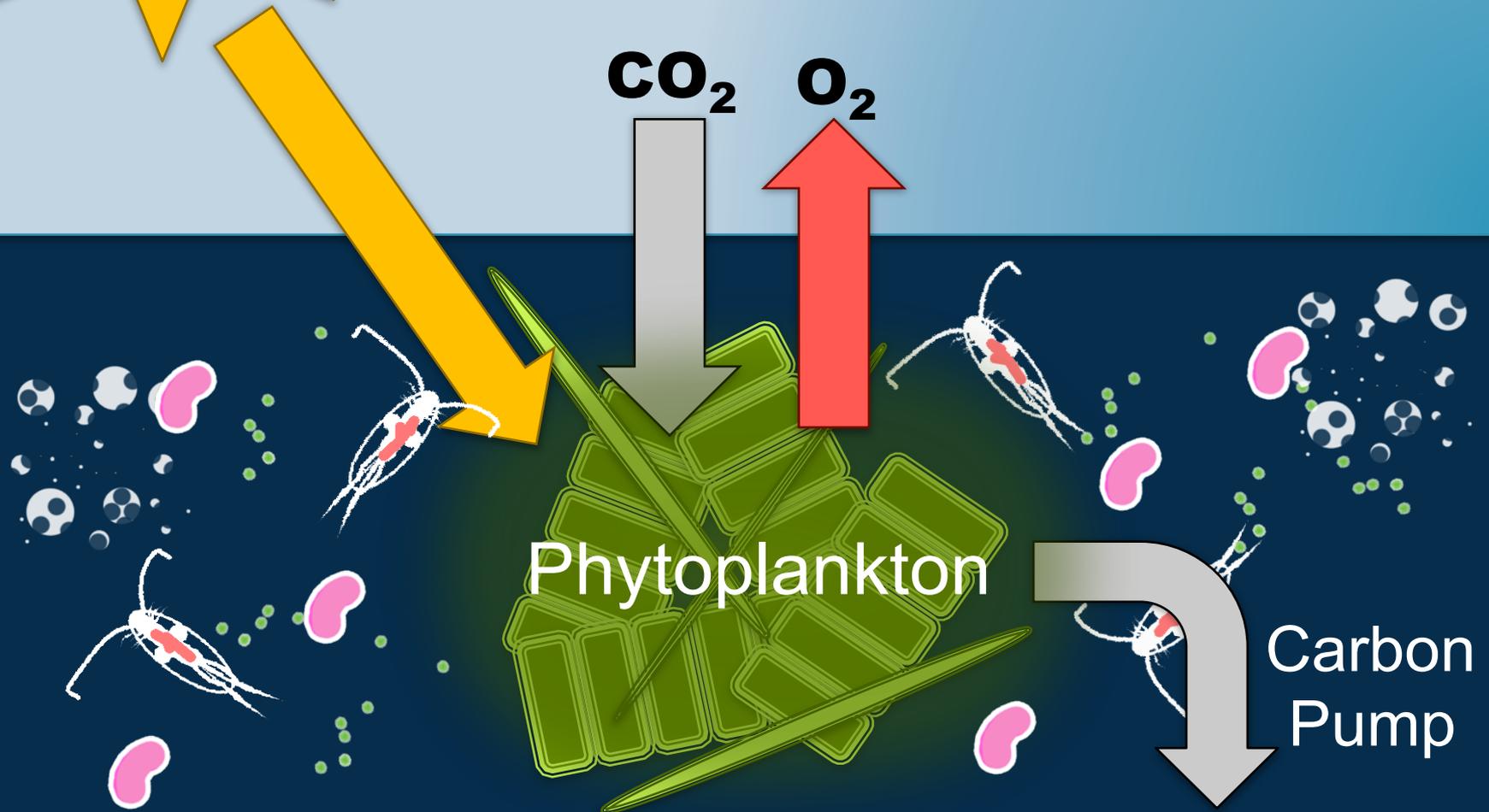
The Carbon Cycle



The Carbon Pump sequesters some fixed carbon, allowing net O_2 production and CO_2 removal



Marine Microbial Interactions control the strength of the Carbon Pump!

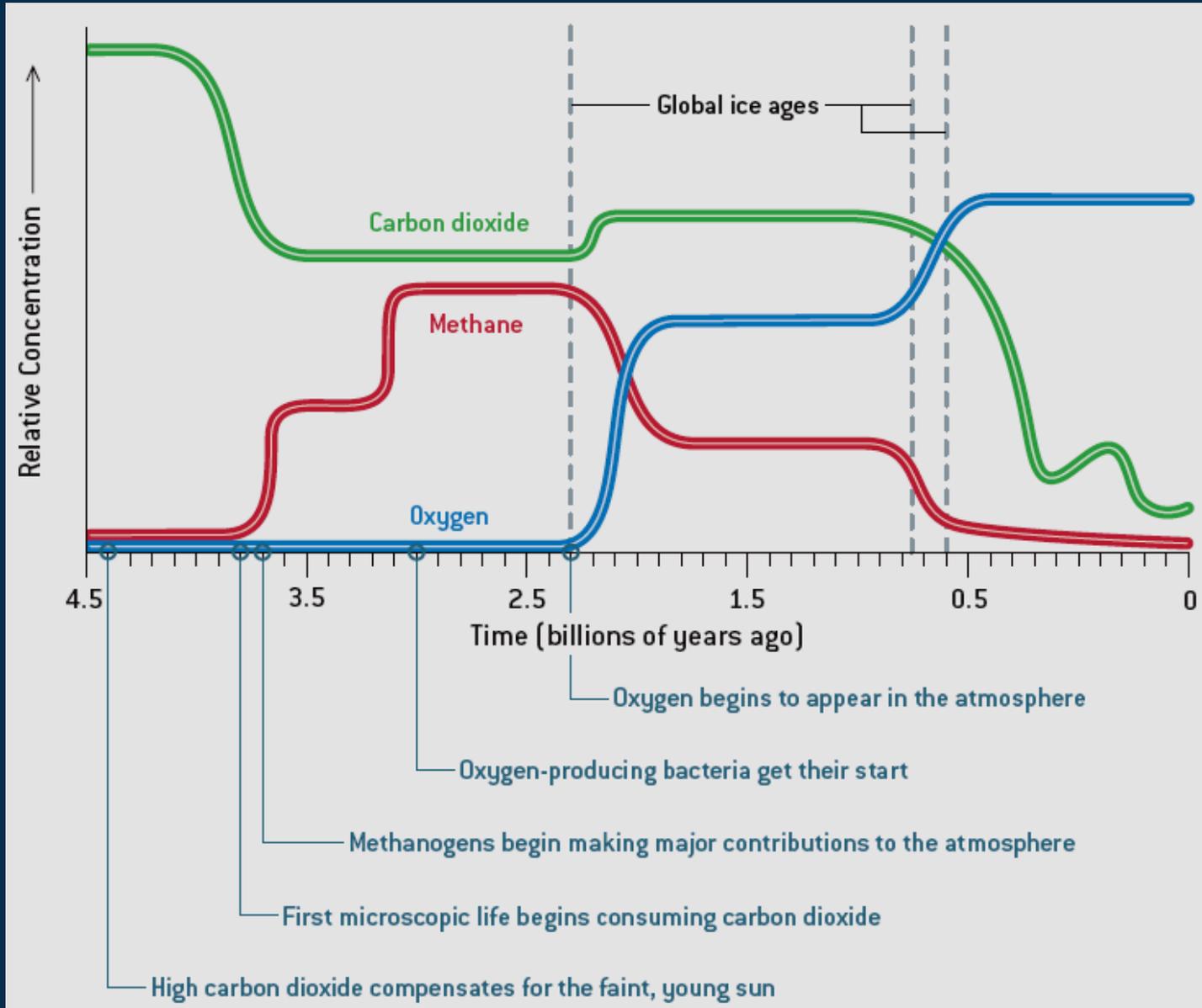


**Why is there so much more
O₂ in the atmosphere than
CO₂?**

**Where do fossil fuels come
from?**

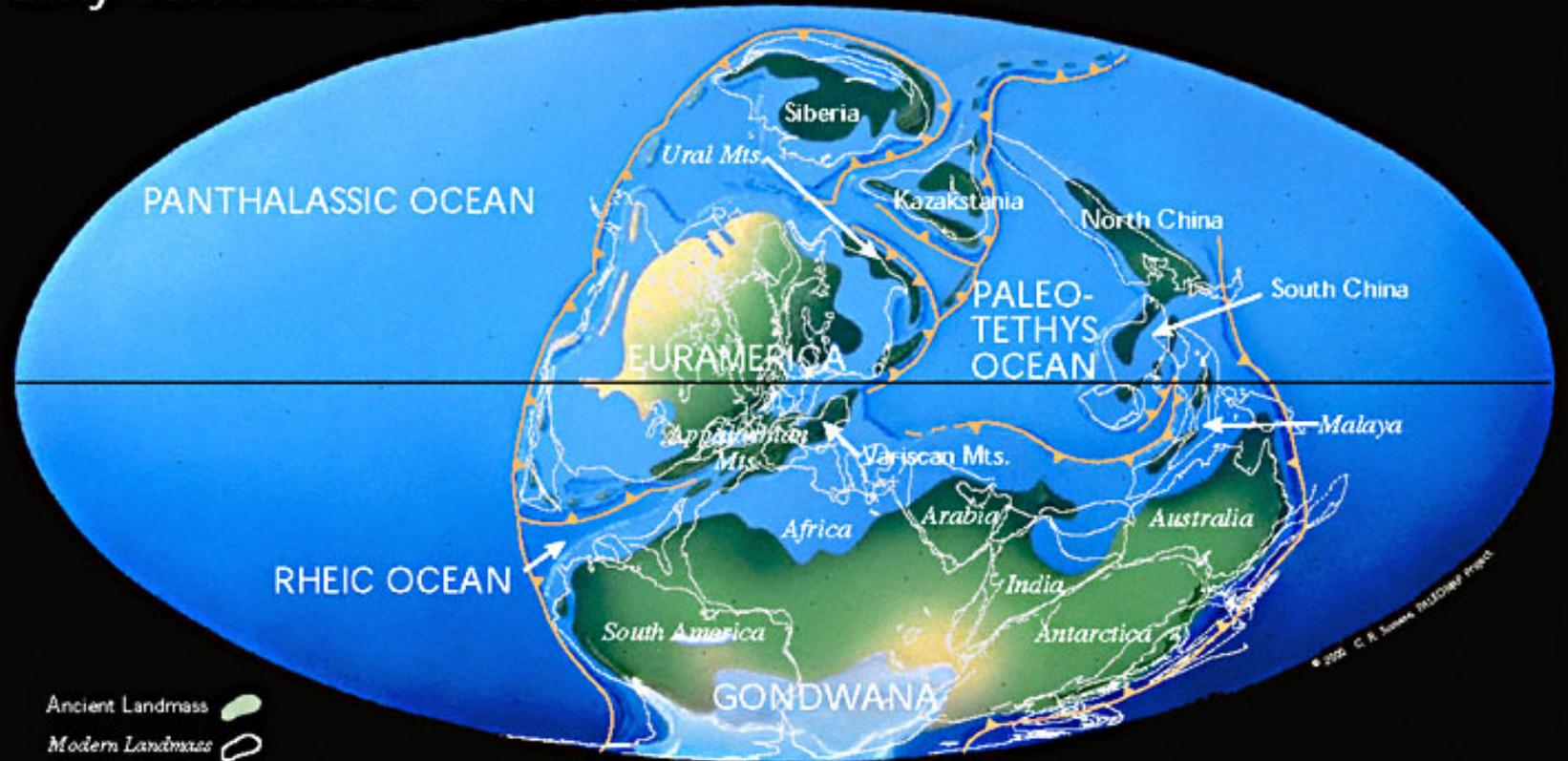
**How is all of this related to
global climate change?**

The Great Oxidation Event



Effect of plate tectonics - productive areas in the tropics and shallow seas

Early Carboniferous 356 Ma



Ancient Landmass

Modern Landmass

Subduction Zone (triangles point in the direction of subduction)

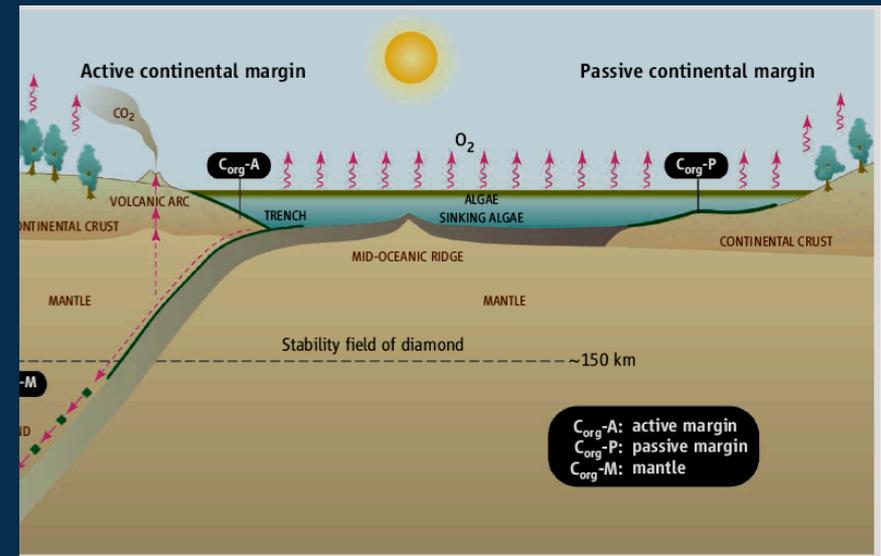
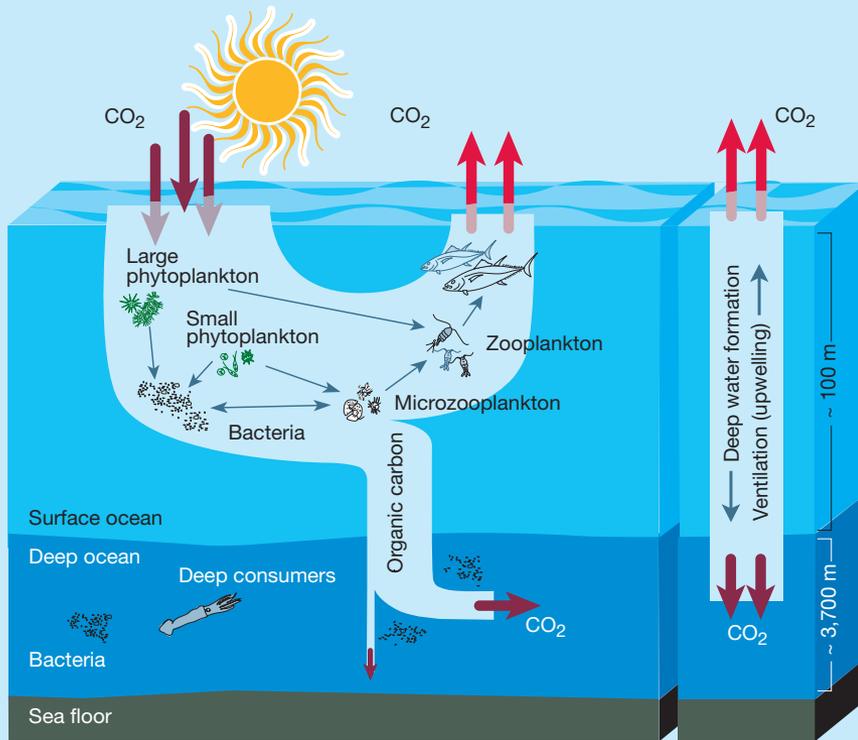
Sea Floor Spreading Ridge

© 2002 C. R. Scotese 20100802 Project

Mass carbon burial hypotheses

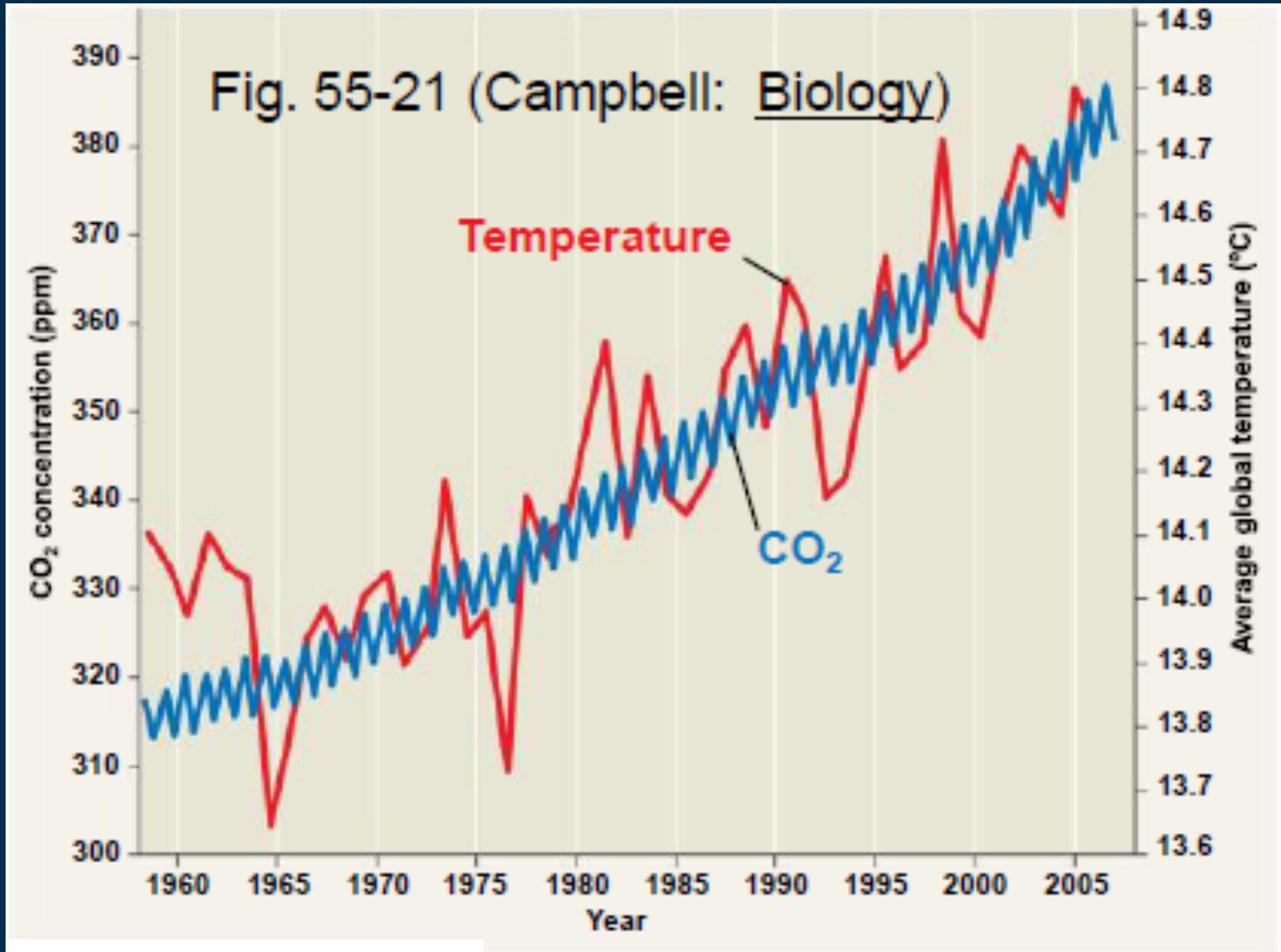
- This hypothesizes the locking up of more organic matter in sediments before they had a chance to decay.
- Prevalence of shallow seas in the Carboniferous Period
- Geological viewpoint – production of clays able to absorb organic matter and preserve it between the seafloor and the assembly of a supercontinent whose weathering could stimulate ocean life by adding nutrients.
- Biological viewpoint - arrival of lichens on land (also increasing weathering and the levels of nutrients in the ocean).

Shallow seas mean sinking carbon is buried faster, so less is respired during the sinking process



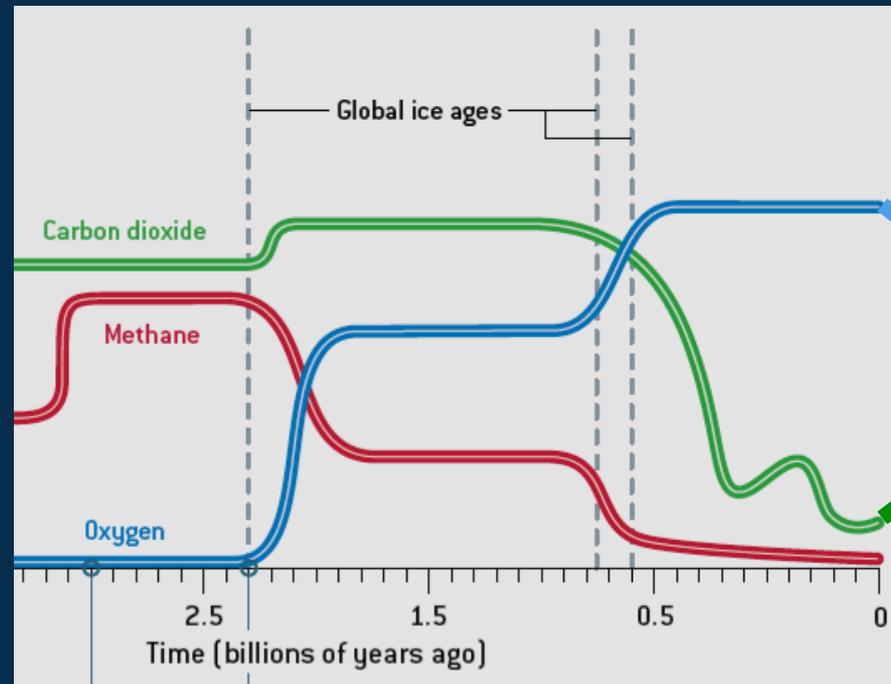
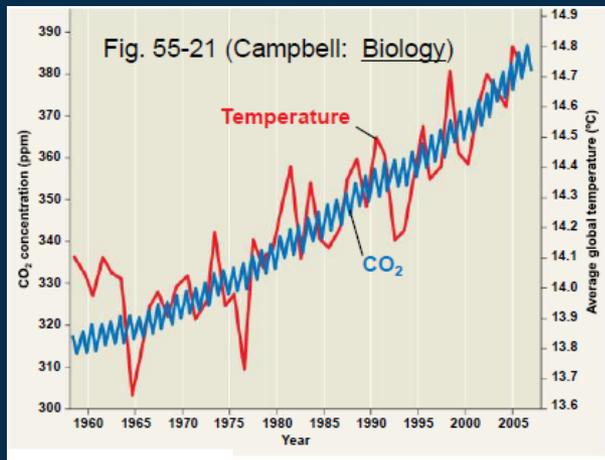
Over 100s of million years, buried carbon becomes fossil fuels!

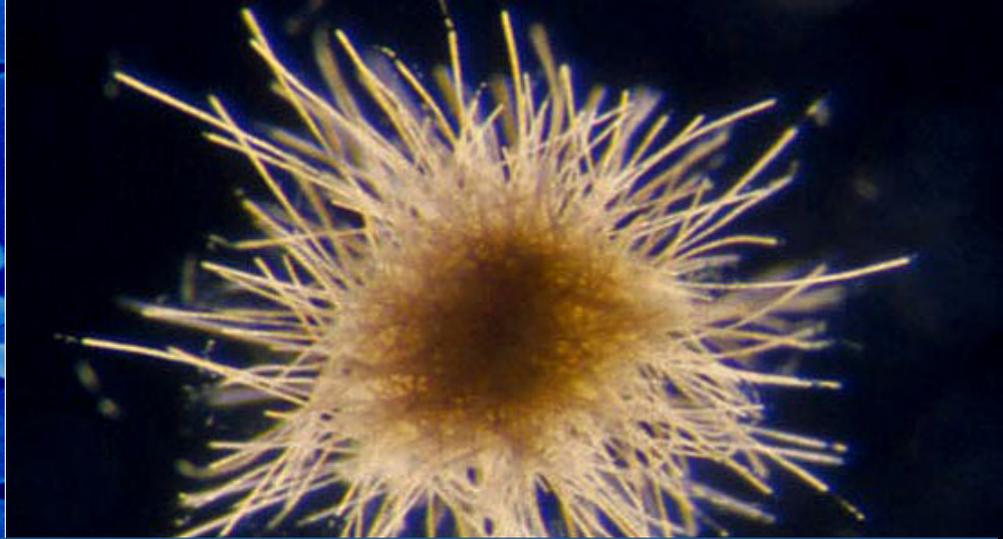
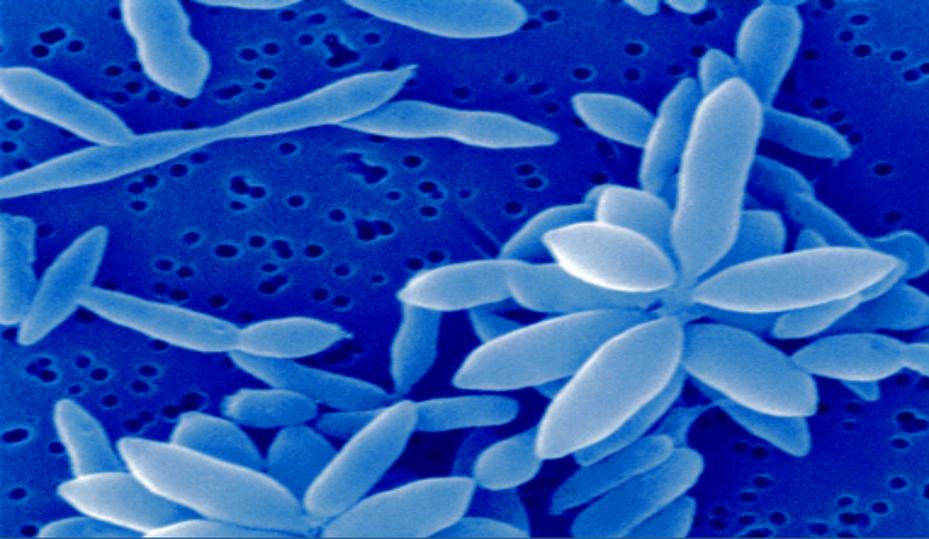
Burning fossil fuels releases CO₂ from buried carbon, causing Atmospheric CO₂ Concentrations to Increase



Burning Buried Sunshine

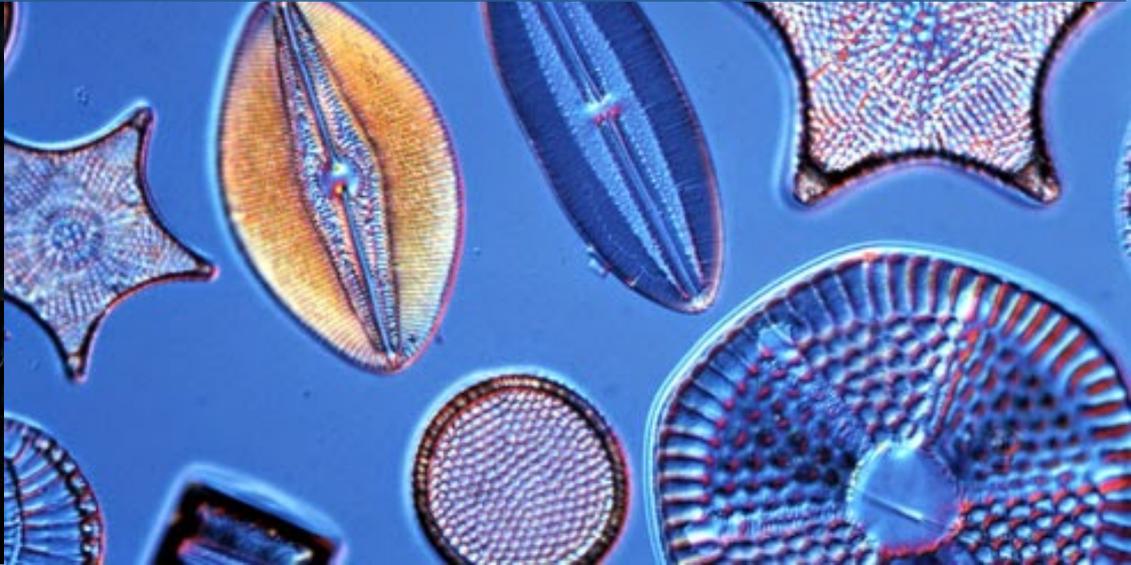
Today's average US gallon of gasoline requires approximately 90 metric tons of ancient plant matter as precursor material



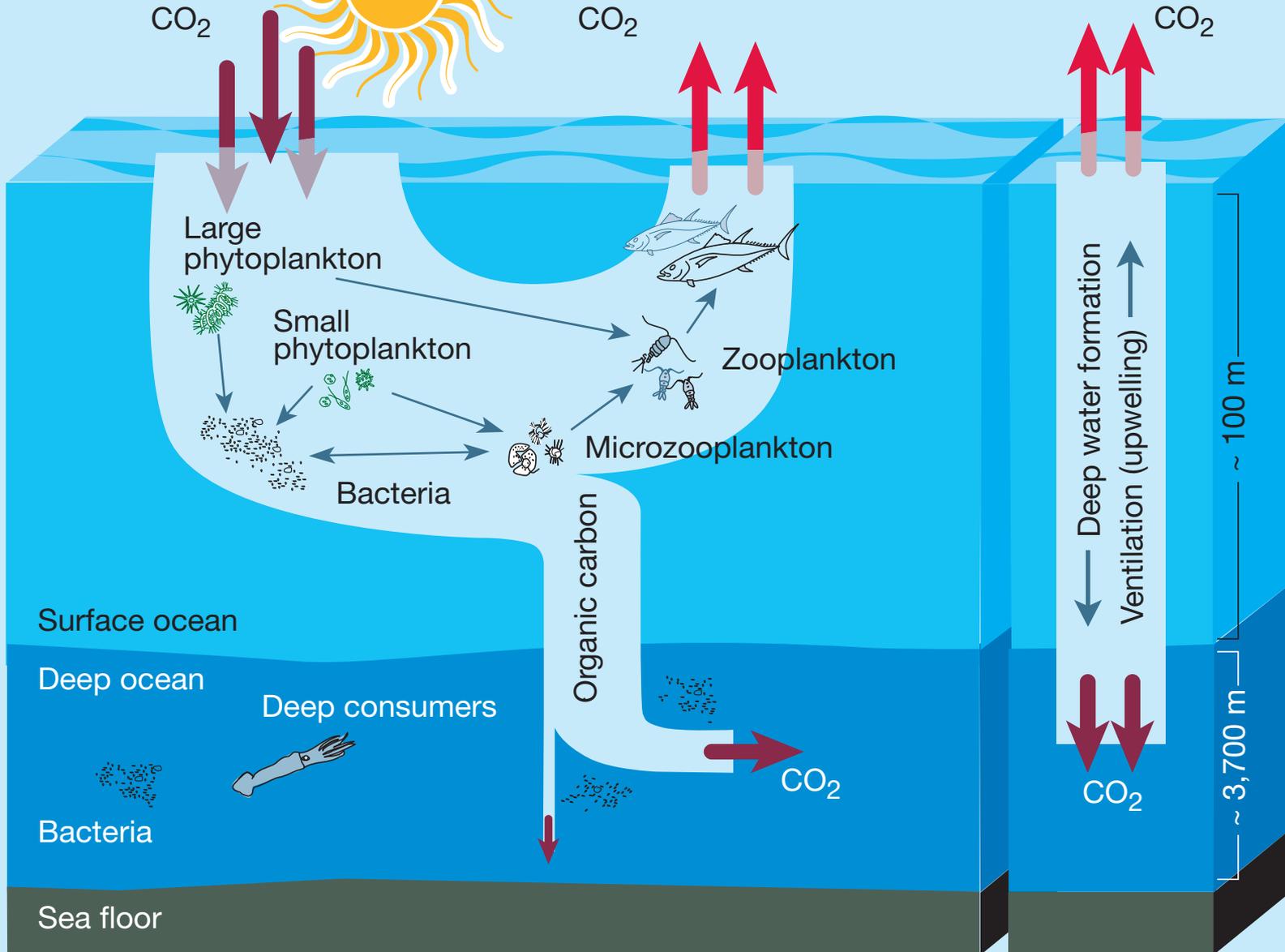


What are these marine microbes doing?

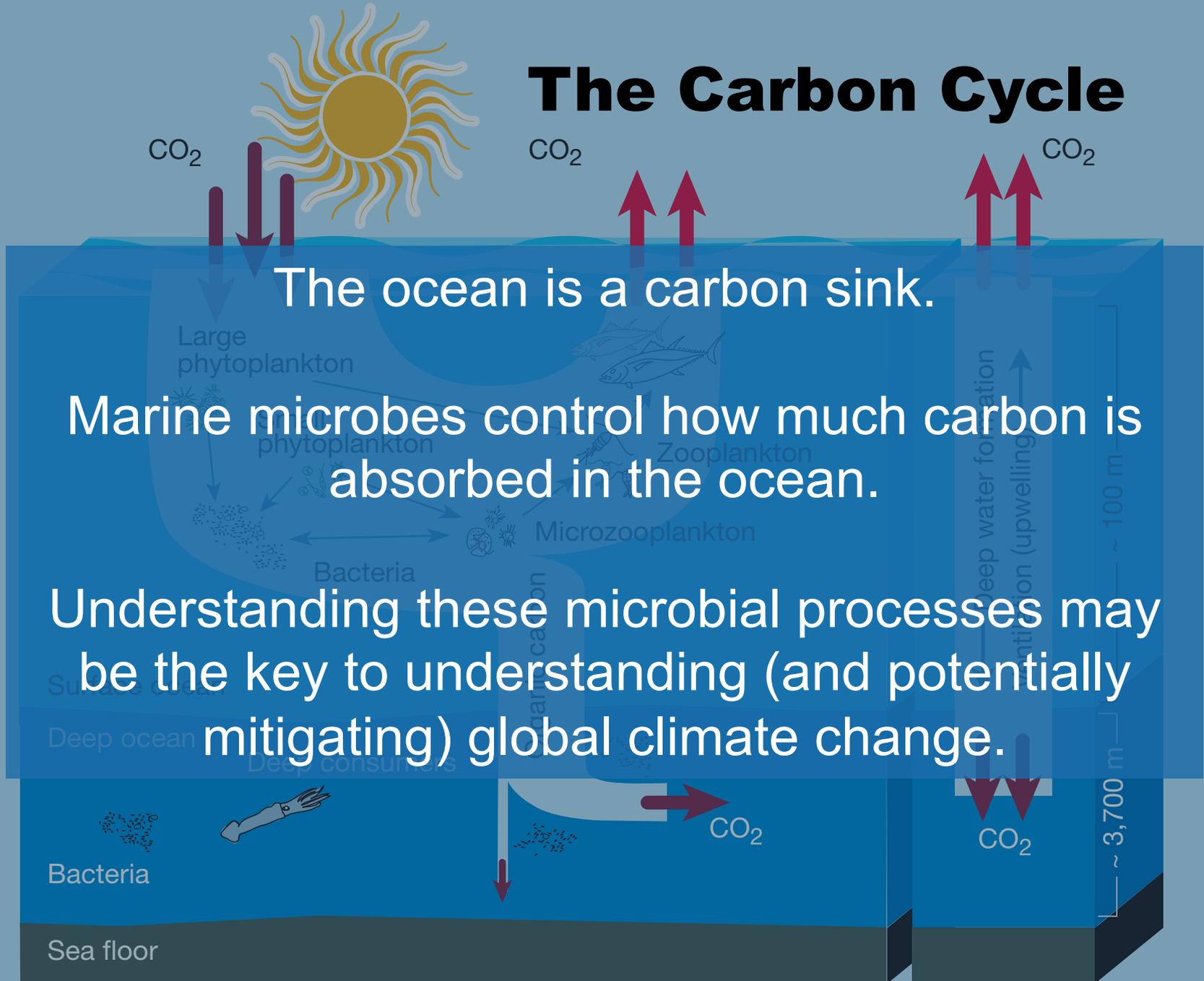
Why should we care about them?



The Carbon Cycle



The Carbon Cycle

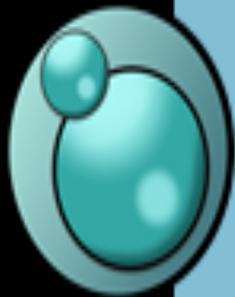


The ocean is a carbon sink.

Marine microbes control how much carbon is absorbed in the ocean.

Understanding these microbial processes may be the key to understanding (and potentially mitigating) global climate change.

Marine Microbe and Carbon Cycle Expert Groups



Abiotic

These are chemicals and processed that can be turned into biomass.



Phototrophs

These are organisms that use photosynthesis to turn atmospheric carbon into their biomass.



Heterotrophs

These are organisms that get energy by consuming biomass, it can be from debris or other organisms.



Viruses

These are non-living entities that use living organisms to make more copies of themselves!

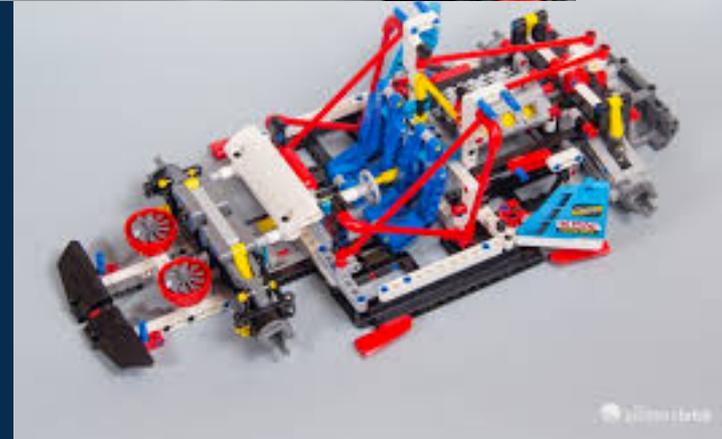
**How can we experiment
with marine microbial
ecology and the carbon
cycle in the classroom?**



How can we study racecars in the classroom?



Models can be used to study systems



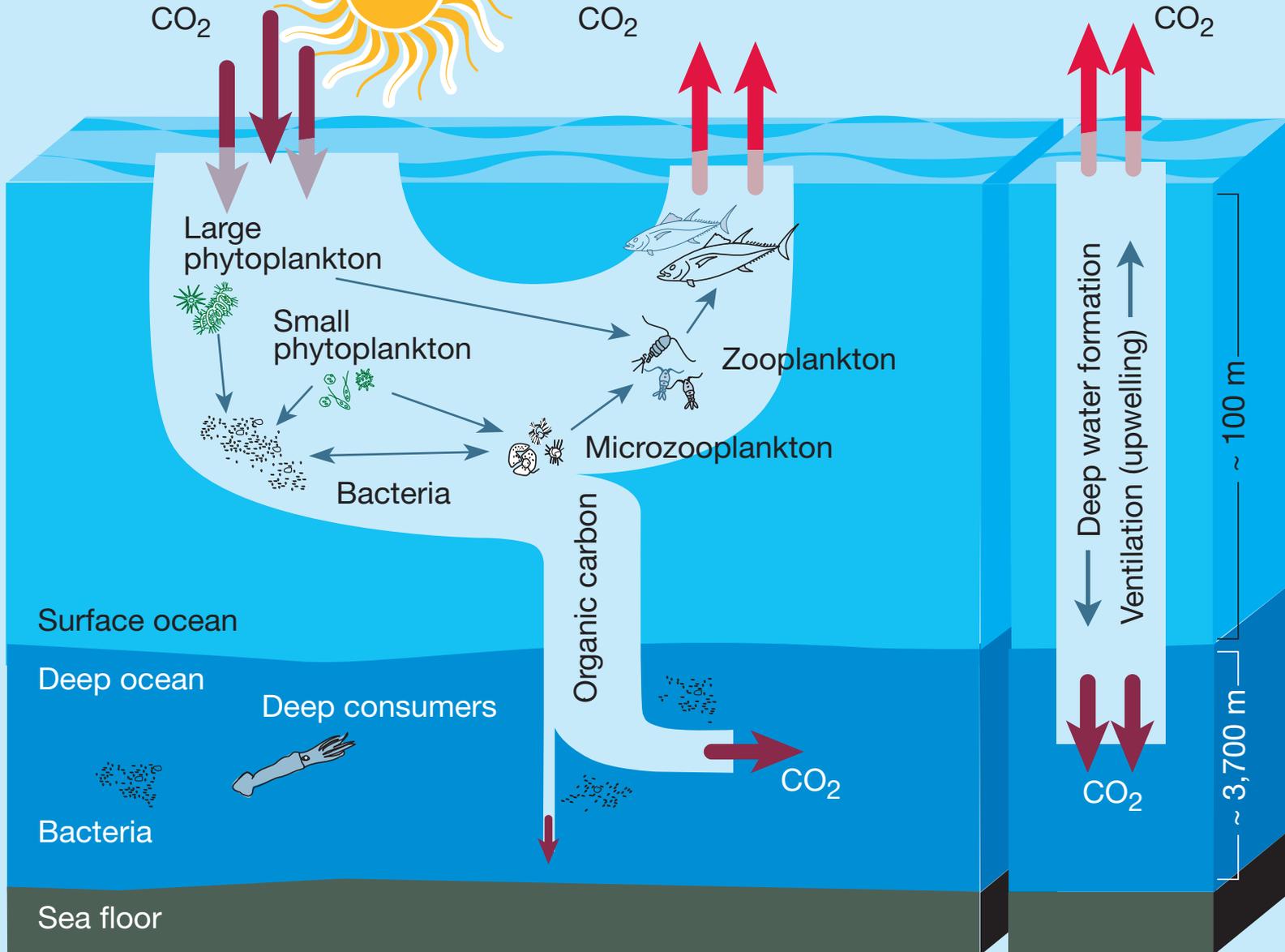
Models use data to recreate actual systems



A large research vessel is shown at sea during sunset. The sky is a mix of orange, pink, and blue, with scattered clouds. The vessel's deck is visible, with several workers in hard hats and safety gear. A large crane structure is prominent, with two bright lights illuminating the area. The text "Models can be used to study the ocean!" is overlaid in white, bold font across the center of the image.

**Models can be used to
study the ocean!**

The Carbon Cycle



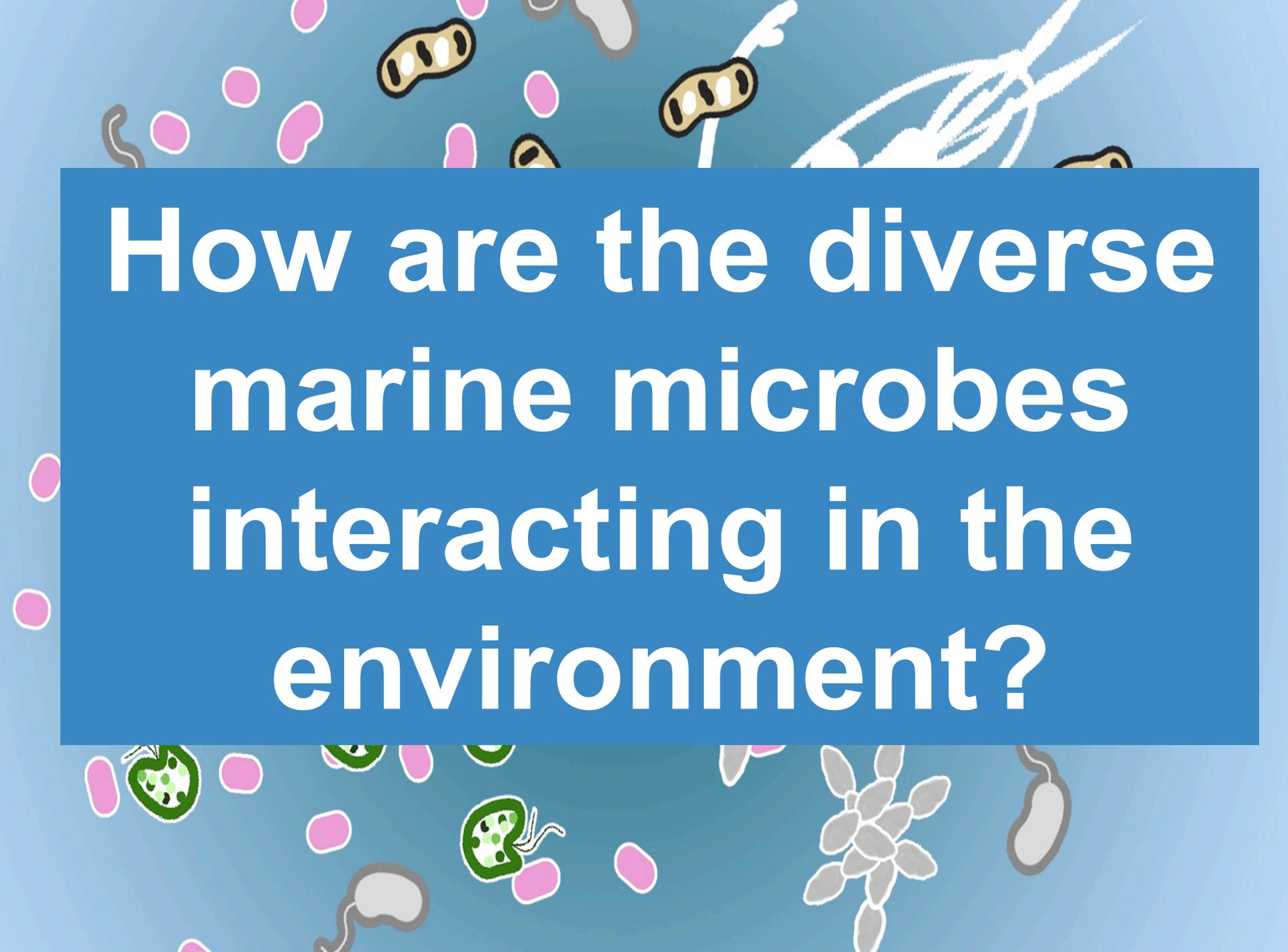
**Scientists
use data to
build models
of marine
ecosystems**



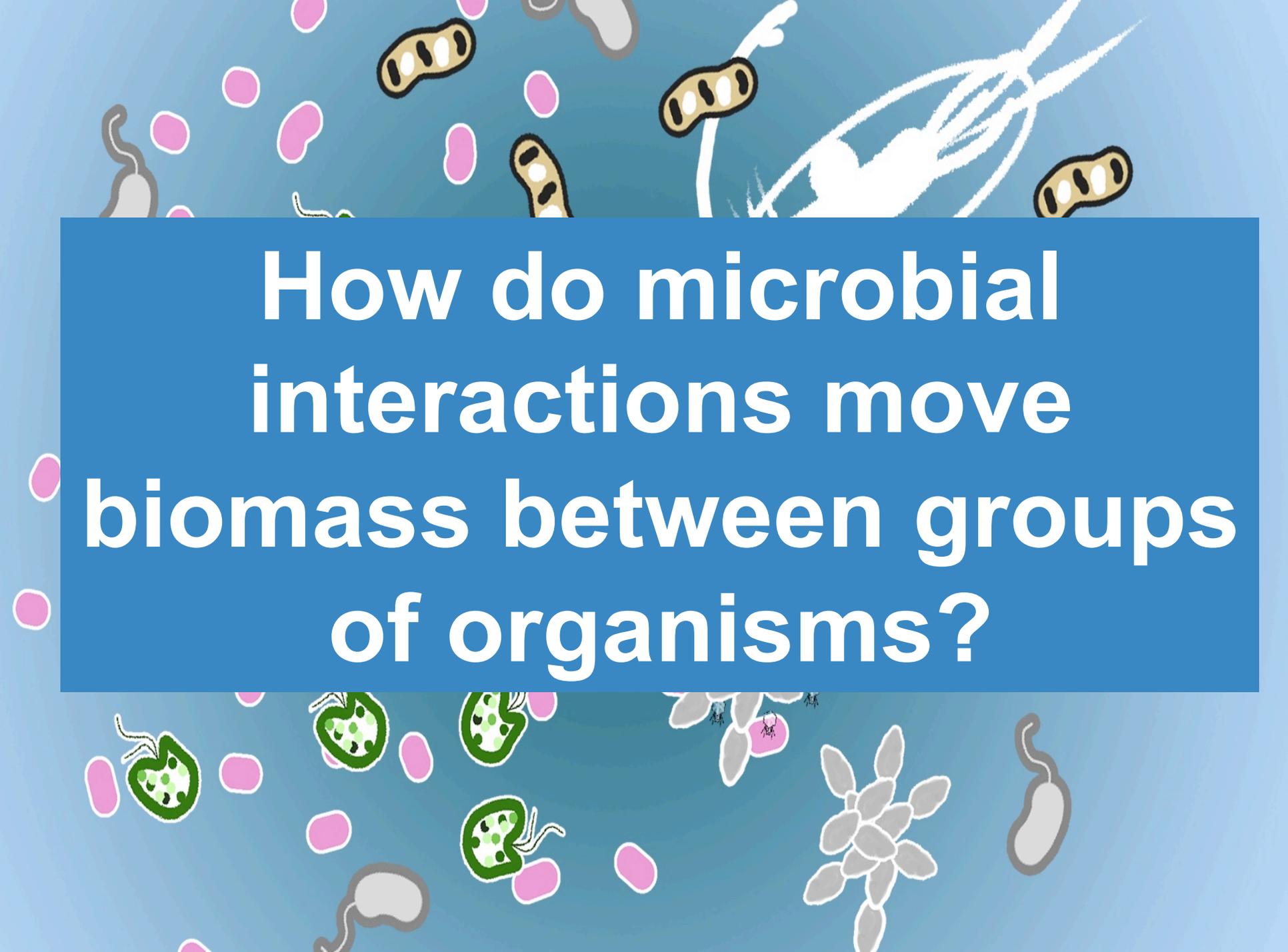
Microbial Ecology Model

The background of the slide is a light blue gradient with a radial pattern emanating from the center. It is populated with various stylized, cartoonish illustrations of microorganisms. These include pink oval shapes, green multi-lobed structures with internal details, greyish elongated forms, and larger greyish structures with multiple leaf-like or petal-like segments. Some of these organisms have small flagella or appendages. The overall aesthetic is clean and educational.

Oligotrophic

The background of the slide is a light blue gradient with various stylized, colorful illustrations of marine microorganisms. These include pink oval shapes, yellow and brown rod-like structures, green circular organisms with internal details, and greyish, multi-lobed structures. The central text is white and set against a solid blue rectangular background.

**How are the diverse
marine microbes
interacting in the
environment?**

The background of the slide is a light blue gradient with various stylized illustrations of microorganisms. At the top, there are several brown, bean-shaped organisms with internal structures, some pink oval shapes, and a white, fibrous structure. At the bottom, there are green, heart-shaped organisms with internal structures, pink oval shapes, a grey, multi-lobed organism, and a grey, bean-shaped organism. The central text is white and set against a dark blue rectangular background.

How do microbial interactions move biomass between groups of organisms?

How to play:

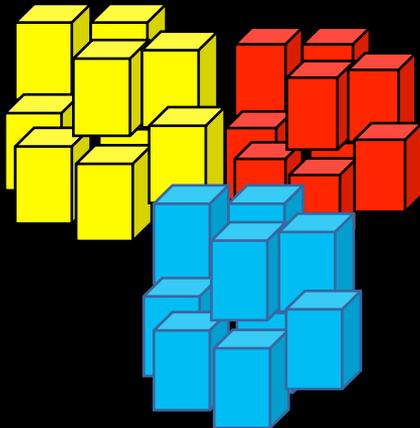
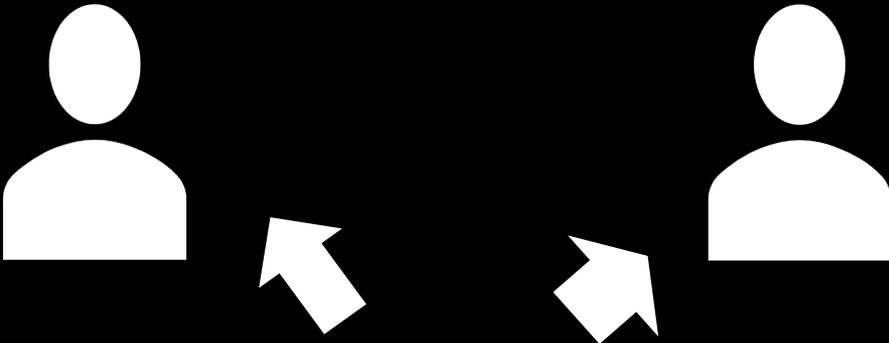
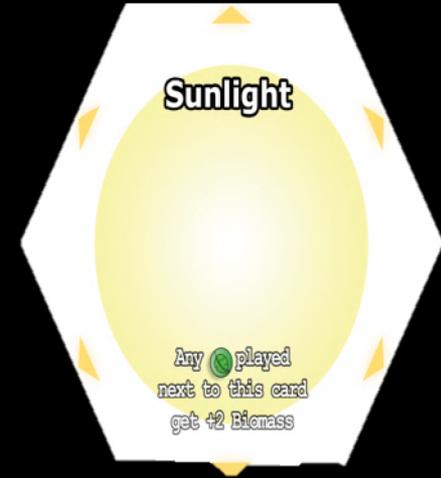
Oligotrophic



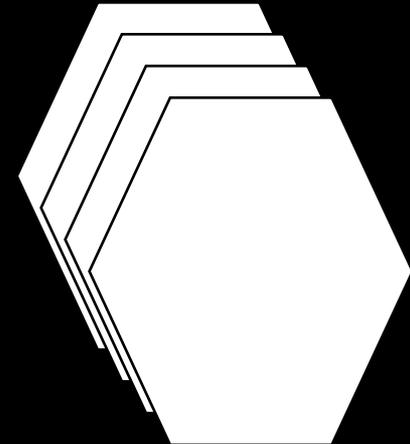
Set up

Give 20 cubes to each player of a single color

Pull out the sunlight

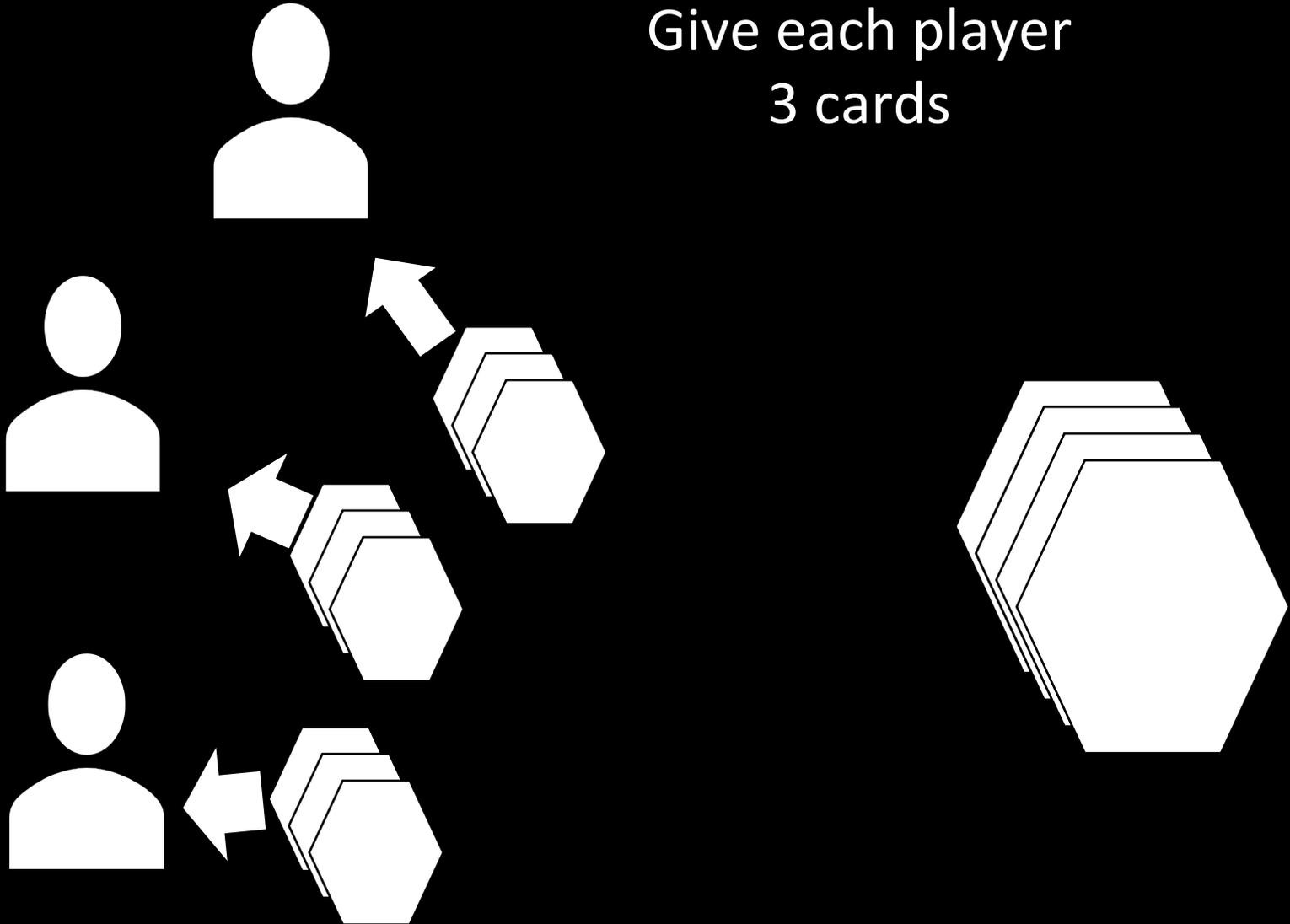


Shuffle all of the other cards together

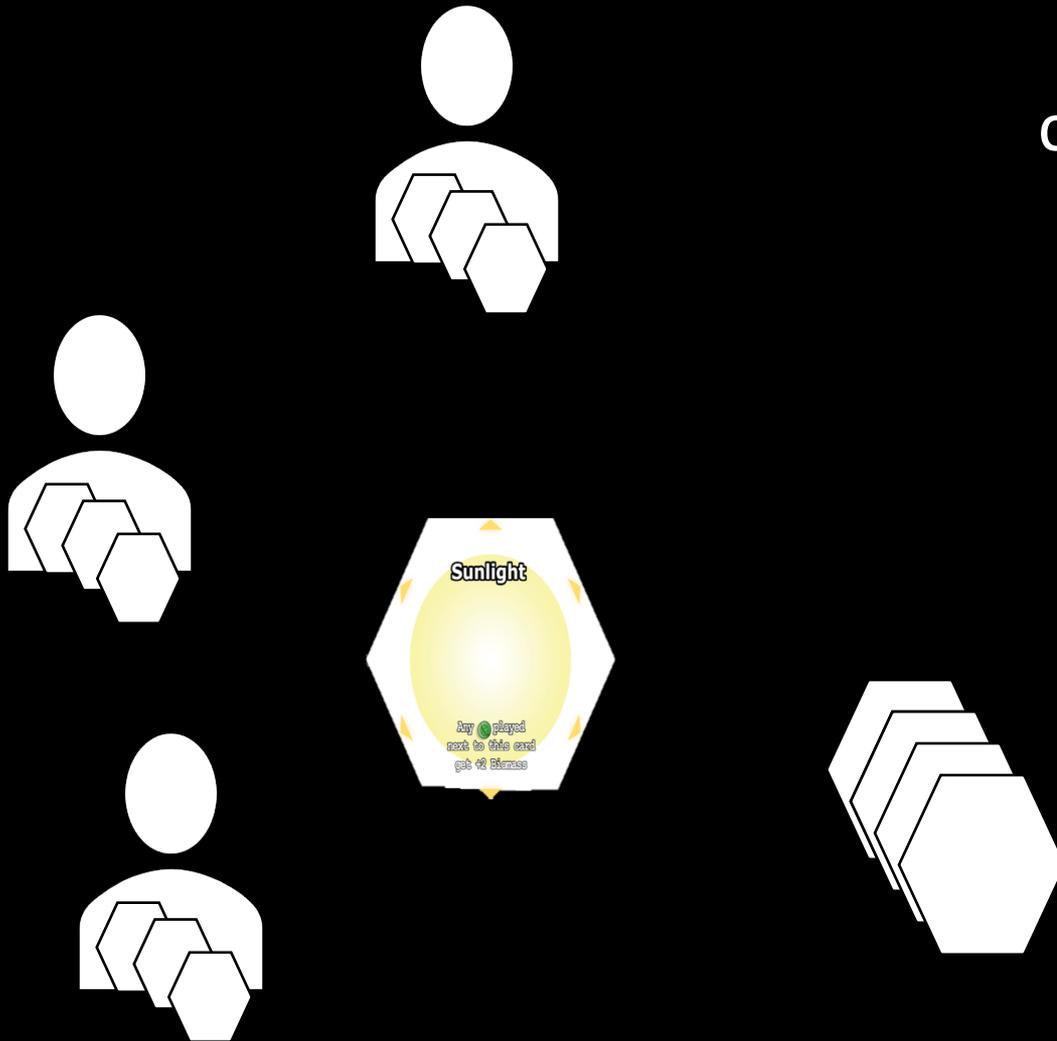


Set up

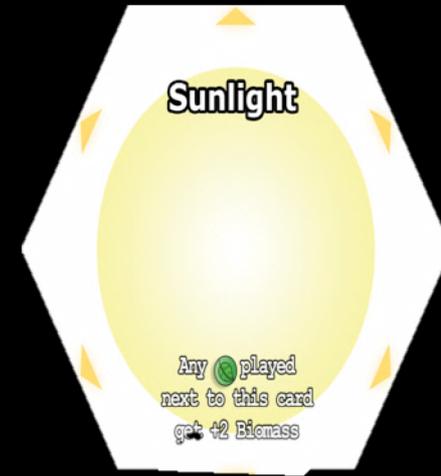
Give each player
3 cards



Set up



Put the sunlight card in the center of the play area

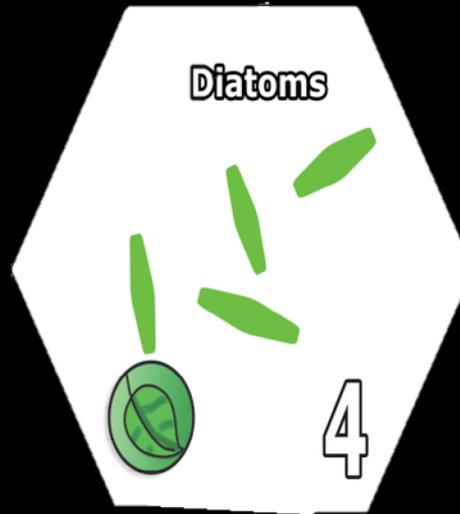
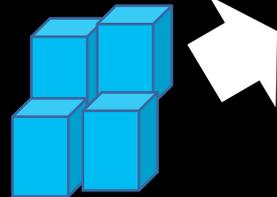


You are now ready to play!

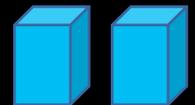
How to play:

Each turn, play 1 card from your hand so it connects to at least one other card.

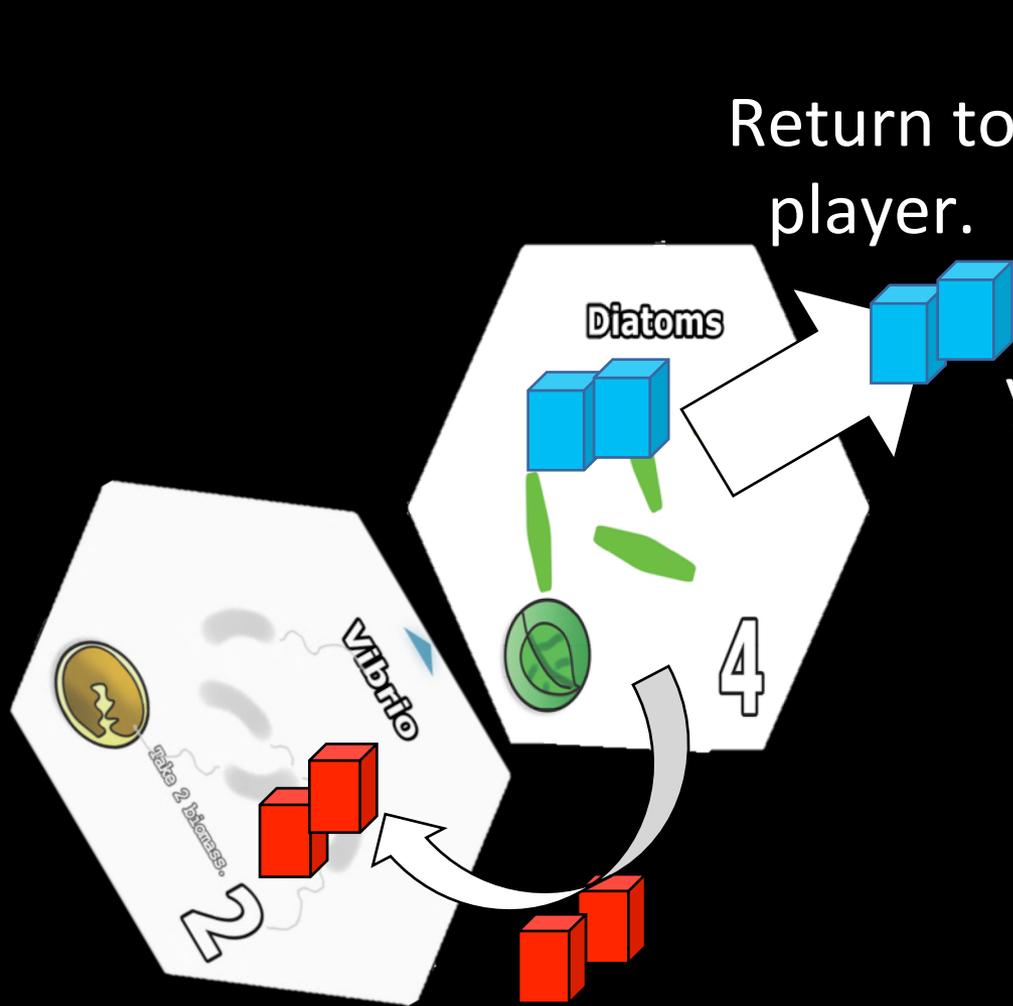
Put cubes of your color equal to the number on the card



If you play a Phototroph by the sun, add 2 more cubes



When you play a card:



Return to
player.

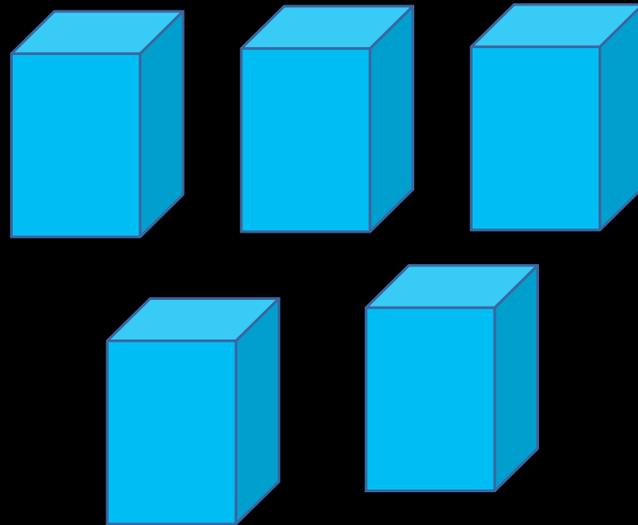
The arrow points to the
cards that it effects.

Take: Switch the cubes to
you color and move it to you
card.

(Remember some can only
take from certain others!)

Return: Give the cubes on
the indicated card back to
their player.

To win, start your
turn with 5 or less
biomass (cubes).



Thank You

Questions?

**Feel free to email your questions to
Chris Suffridge suffridc@oregonstate.edu**



Oregon State
University

Oligotrophic

Available now!

Oligotrophic is a fast-to-learn, strategic tile placement game where players compete to place biomass the fastest. In the game players will select and play hexagonal cards based on actual microorganisms to accumulate biomass, often getting bonuses, hurting, or taking biomass from the other organisms they encounter.

Use it as a fun way to teach about the ecology of globally significant marine microorganism!

Free to download at:

<https://boardgamegeek.com/boardgame/269171/oligotrophic>

Coming to the Game Crafter soon!

<https://www.thegamecrafter.com/>

