

965SV

You belong here

★ **Inclusivity statement:**

My laboratory and my philosophy aim to create an inclusive environment in which students of all backgrounds, cultures and orientations can feel safe learning, growing, and participating within their community.

From my experience and working with many people in my field, I have found this to be an important topic to bring up and present myself as a resource for those who find they might need it.

BEFORE

Microbes not
important

Microbes=Disease

AFTER

**Microbes are
everywhere and will
always be...**

**Microbes as ecosystem
engineers**

**Microbes keep the
ecosystem functioning**

**Humans and biota as
microbial ecosystems**

**Holistic managing of
marine ecosystems**

TOPICS

- 1. Microbes in the Marine Environment**
- 2. Metabolic Diversity and Ecophysiology of Marine Microbes**
- 3. Diversity of Marine Bacteria, Archaea and Viruses**
- 4. Microbes in Ocean Processes: Carbon, Nitrogen, Sulfur, Iron, Phosphorus, and Silicon Cycles**
- 5. Marine Microbial Symbioses and Marine Microbial Diseases**
- 6. Marine Microbes, Climate and Society**

Testing the knowledge

Equal to 50% of the final grade: individual presentation on a specific topic related to the course, in English

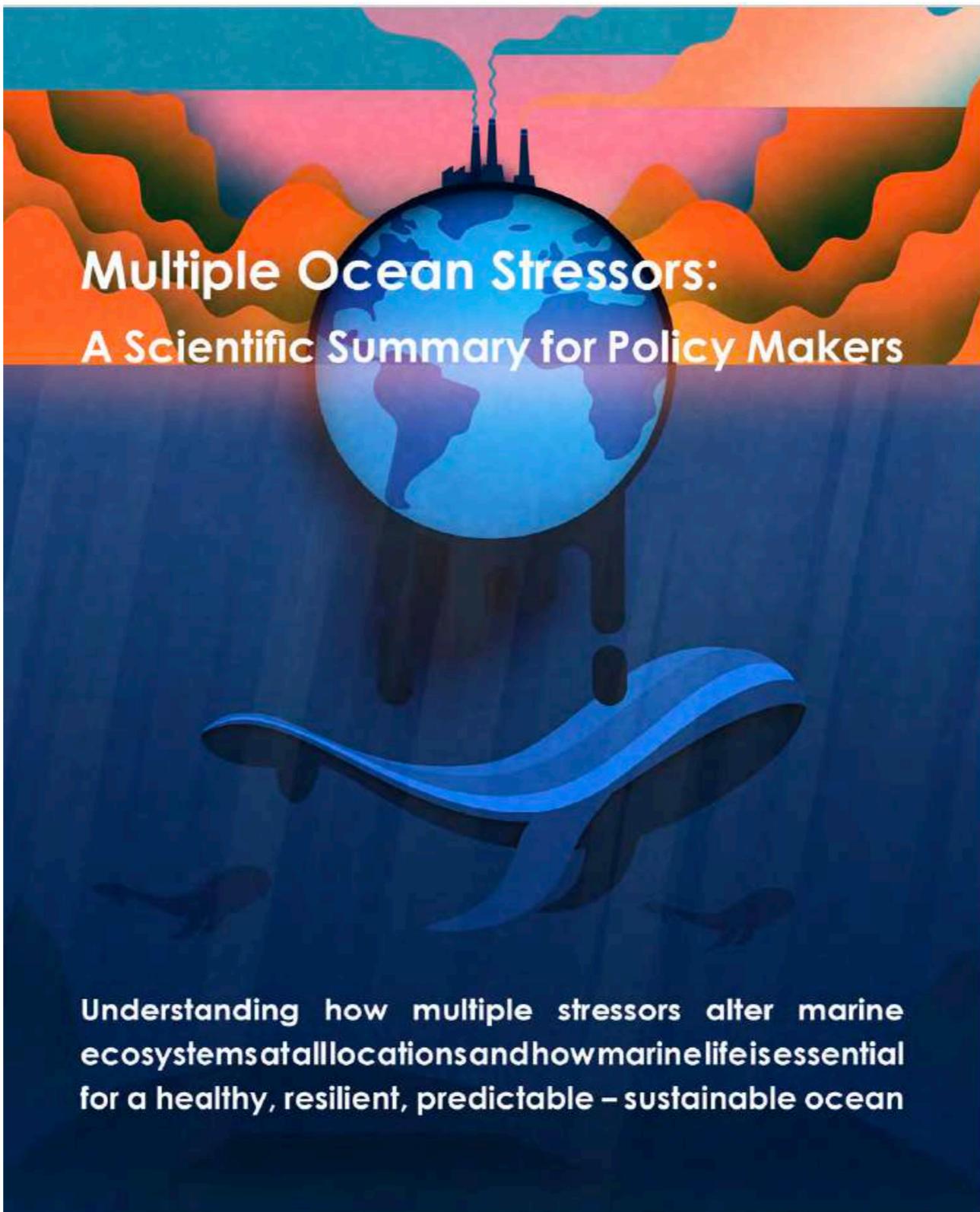
Equal to 50% of the final grade: 1 hr paper-critique written test on 3 open questions, in English

Evaluation criteria: correctness, completeness, organization, clarity and use of specific terms

Testing the knowledge: presentation

Equal to 50% of the final grade: individual presentation on a specific topic related to the course, in English

Topic: “Multiple Ocean Stressors: A Scientific Summary for Policy Makers” and marine microbes (Bacteria and Archaea only)



Multiple Ocean Stressors: A Scientific Summary for Policy Makers

Understanding how multiple stressors alter marine ecosystems at all locations and how marine life is essential for a healthy, resilient, predictable – sustainable ocean





Cataloguing stressors exposure

- Identification of key stressors at all locations
- Identification of temporal variability and their sources



Understanding biological responses

- Taking into account local specific combinations of stressors over time and space



Adaptation and mitigation strategies to combat the impact of multiple stressors

- Consider local specific human capacity

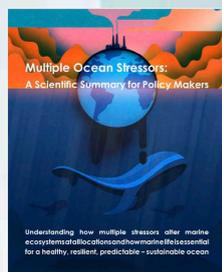


Policy actions

- Implementation of adaptation and mitigation strategies addressing the effects of multiple ocean stressors



Healthy, resilient, productive, diverse sustainably managed, ocean, whose future we can predict

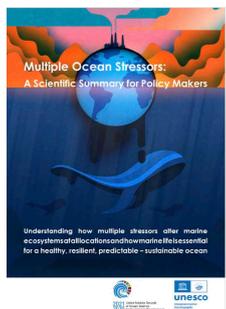


Box 1. Definitions to remember

Drivers: Environmental properties (e.g. temperature) and ecological processes (e.g. grazing pressure) that influence marine life and its productivity and diversity. Drivers can be natural or anthropogenic forces that cause beneficial or detrimental effects. For example, temperature determines growth rates but excessive temperature causes stress and eventually mortality.

Healthy ocean: The ocean is healthy if and only if it is resilient, productive, and diverse.

Stressors: Environmental properties or ecological processes, which at a certain threshold (e.g. excess nutrient supply or over-harvesting) results in detrimental effects to marine life. Stressors, individually or collectively, are directly responsible for a range of significant harmful changes to the biological components, patterns, and relationships in natural systems.



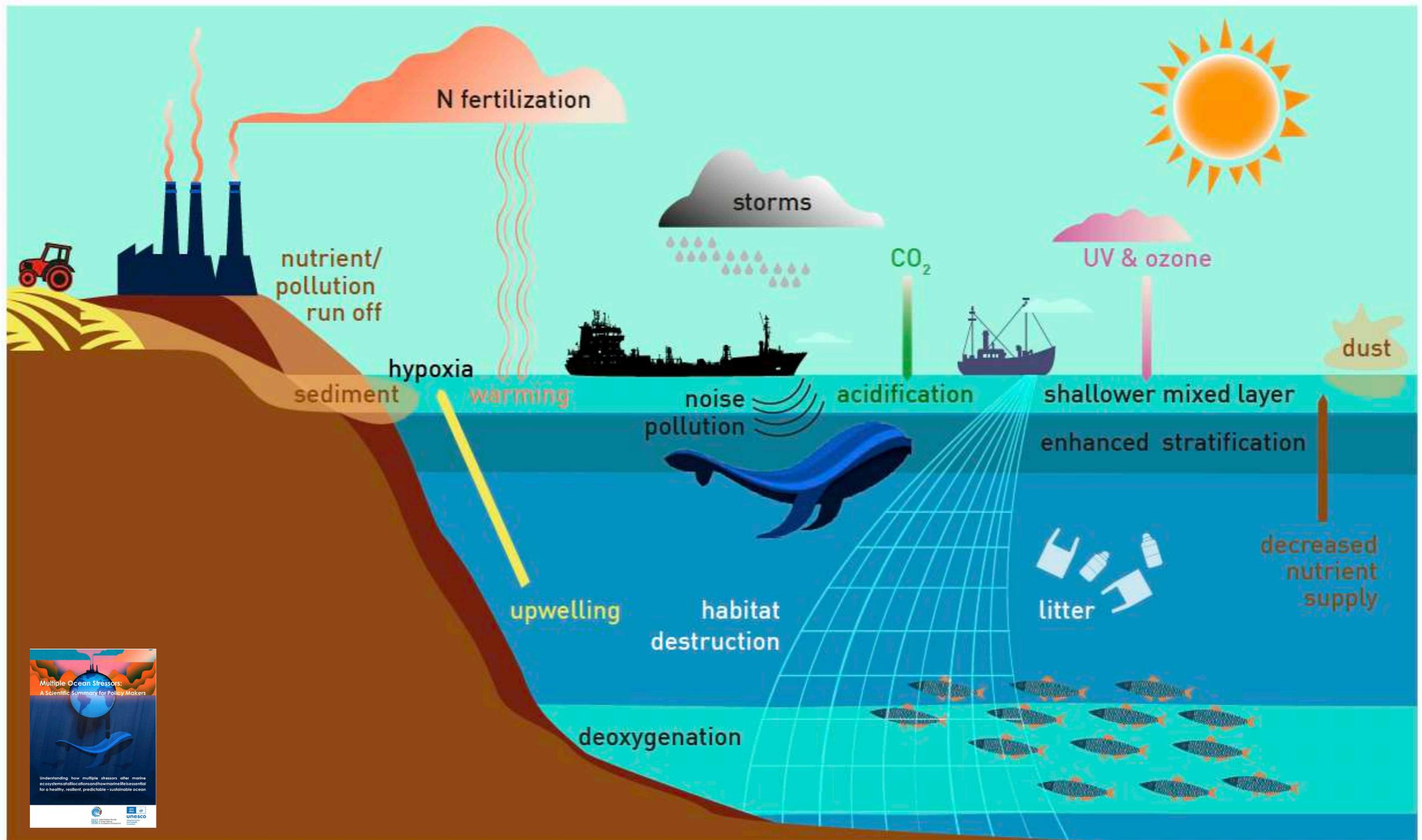


Figure 2. Illustrative examples of global (warming, acidification), regional (ozone, litter, atmospheric pollutants) and local (sedimentation, pollution and nutrient runoff) stressors that can affect marine life (adapted from Boyd et al., 2018). Illustrative examples are used here since insertion of icons for all stressors would cover the ocean in this figure. Marine life at each location, from coastal areas to offshore waters, will encounter a unique combination of stressors, and ecosystems may be exposed to concurrent changes to multiple stressors simultaneously.

Marine Microbiology

Ecology & Applications Third Edition

By Colin B. Munn

Edition 3rd Edition

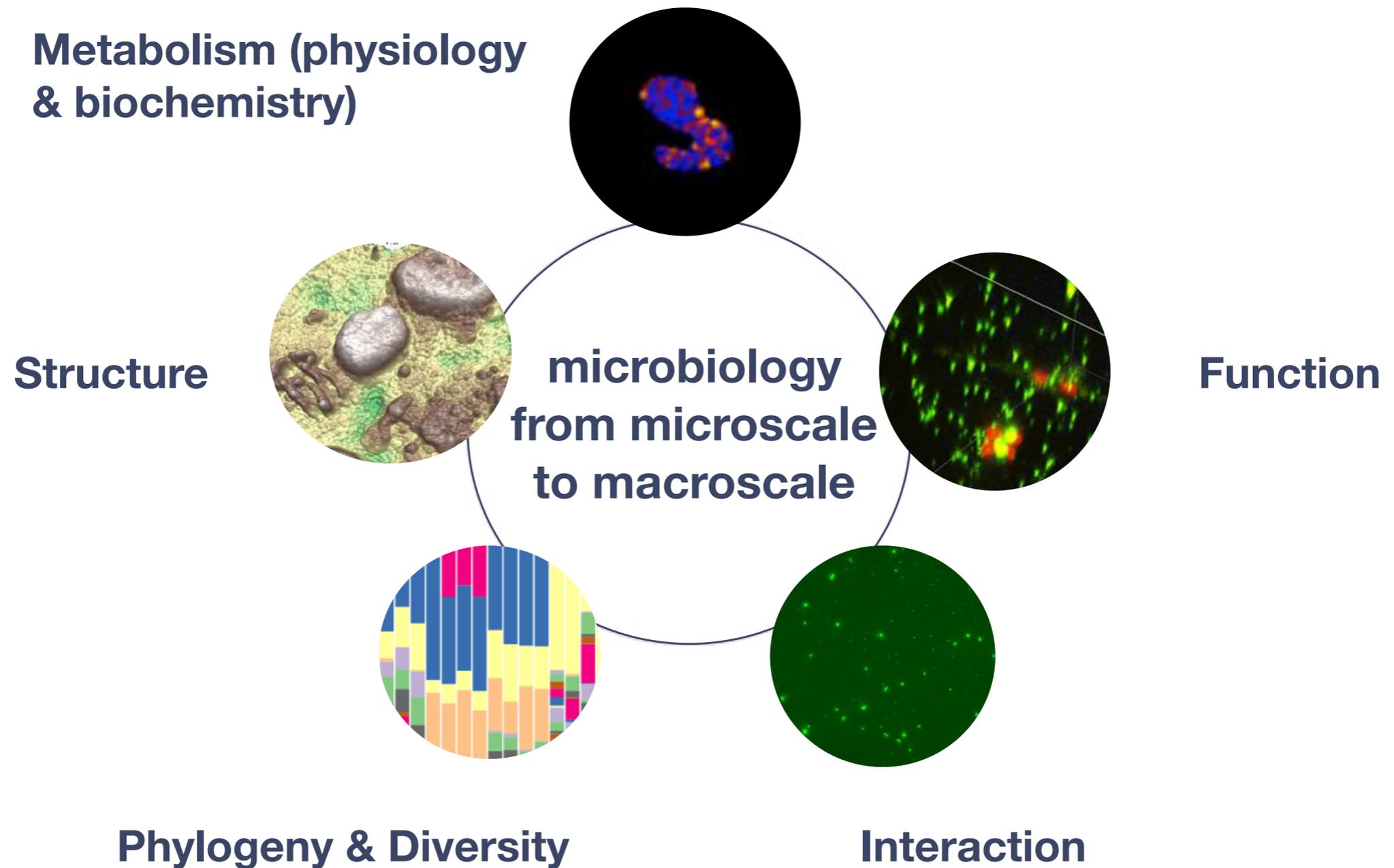
Imprint CRC Press

DOI <https://doi.org/10.1201/9780429061042>

***Tell me and I will forget,
show me and I may remember,
involve me and I will understand.***

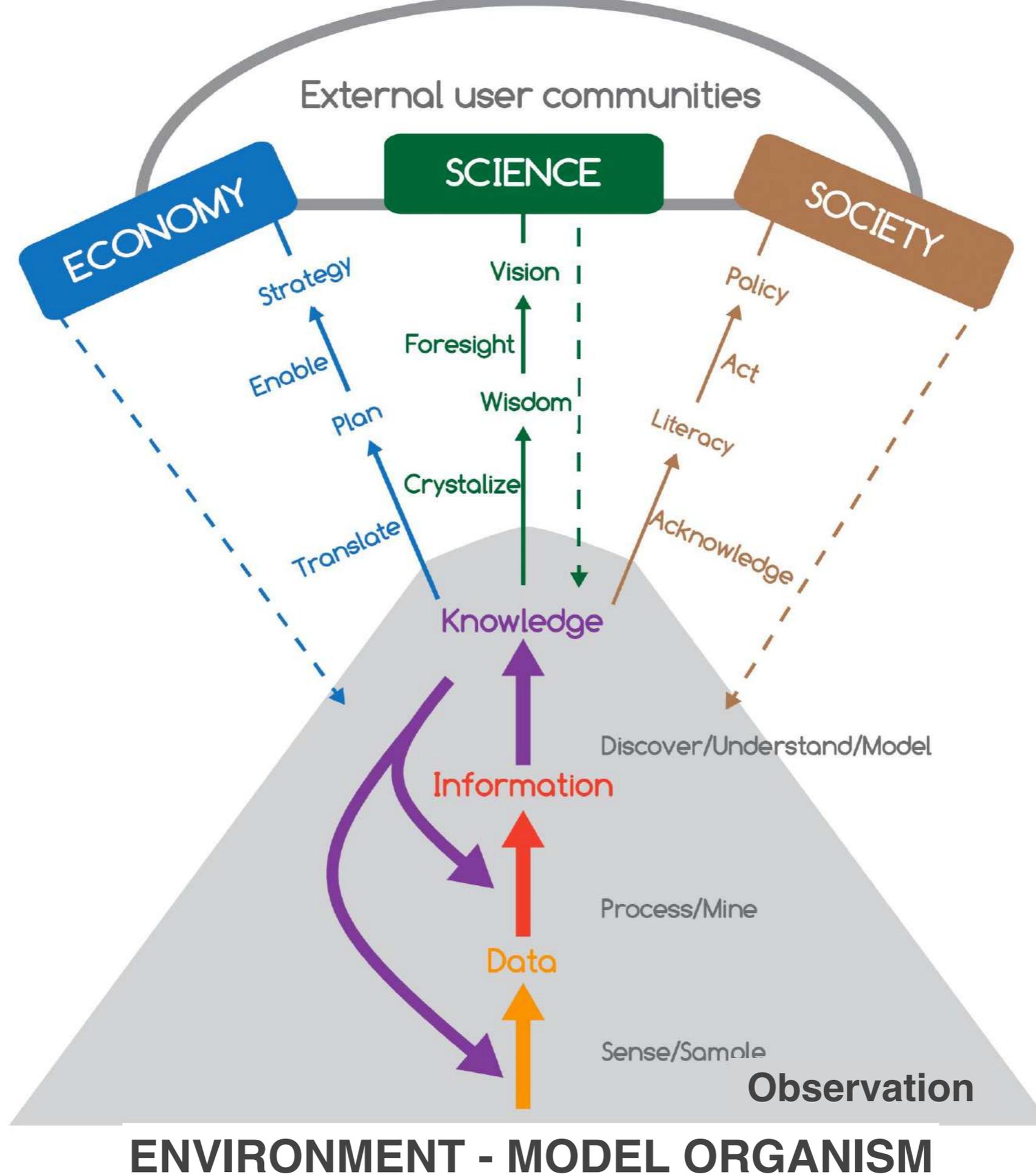
Brief self-introduction and future career

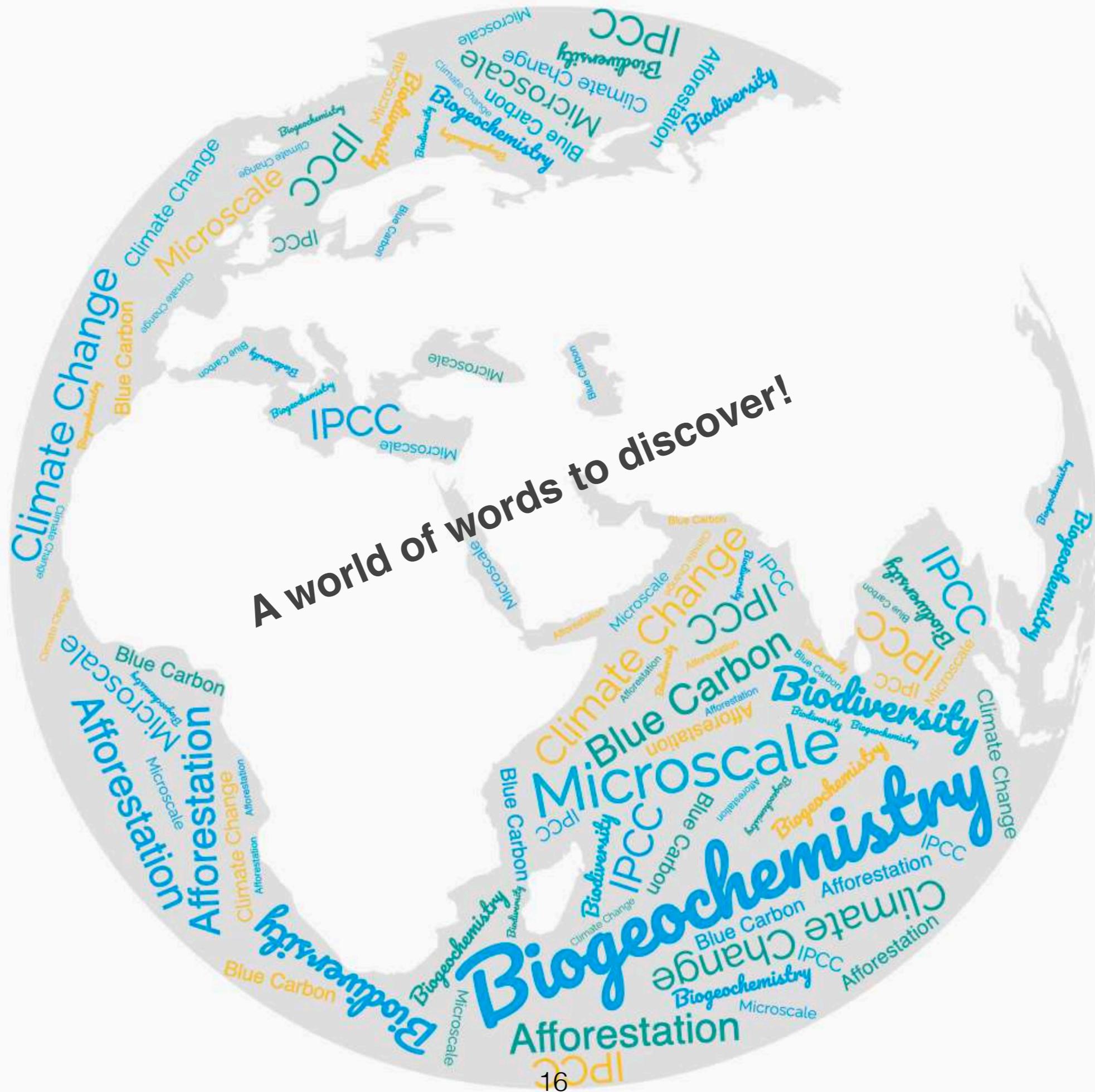
Mechanistic integrative approach



Crise A, Ribera d'Alcalà M, Mariani P, Petihakis G, Robidart J, Iudicone D, Bachmayer R and Malfatti F

(2018) A Conceptual Framework for Developing the Next Generation of Marine Observatories (MOBs) for Science and Society. *Front. Mar. Sci.* 5:318. doi: 10.3389/fmars.2018.00318





A world of words to discover!

Intro: Where do we stand?.....anatomy of the Ocean



<https://scripps.ucsd.edu/>

**Expect the
unexpected!**



<https://scripps.ucsd.edu/>

**What do you know
about the ocean?**

**How do you describe
the oceanby its
features?**



The Essential Principles of Ocean Sciences

- 1 The Earth has one big ocean with many features.**
- 2 The ocean and life in the ocean shape the features of Earth.**
- 3 The ocean is a major influence on weather and climate.**

4 The ocean makes Earth habitable.

5 The ocean supports a great diversity of life and ecosystems.

6 The ocean and humans are inextricably interconnected.

7 The ocean is largely unexplored.

JUVENILE WALRUS. Photo: NOAA Ocean Exploration and Research

OUR WORLD OCEAN provides

THE AIR WE BREATHE



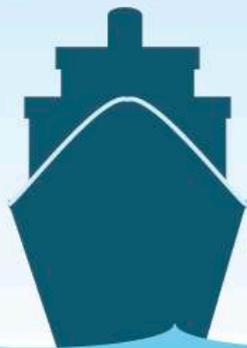
>50% The ocean produces over half of the world's oxygen and stores 50 times more carbon dioxide than our atmosphere.

CLIMATE REGULATION

70% Covering 70% of the Earth's surface, the ocean transports heat from the equator to the poles, regulating our climate and weather patterns.



TRANSPORTATION



76% Percent of all U.S. trade involving some form of marine transportation.

RECREATION



From fishing to boating to kayaking and whale watching, the ocean provides us with so many unique activities.

ECONOMY



\$282 billion Amount the U.S. ocean economy produces in goods and services. Ocean-dependent businesses employ almost 3 million people.

FOOD

The ocean provides much more than just seafood. Ingredients from the sea are found in surprising foods such as peanut butter and soymilk.

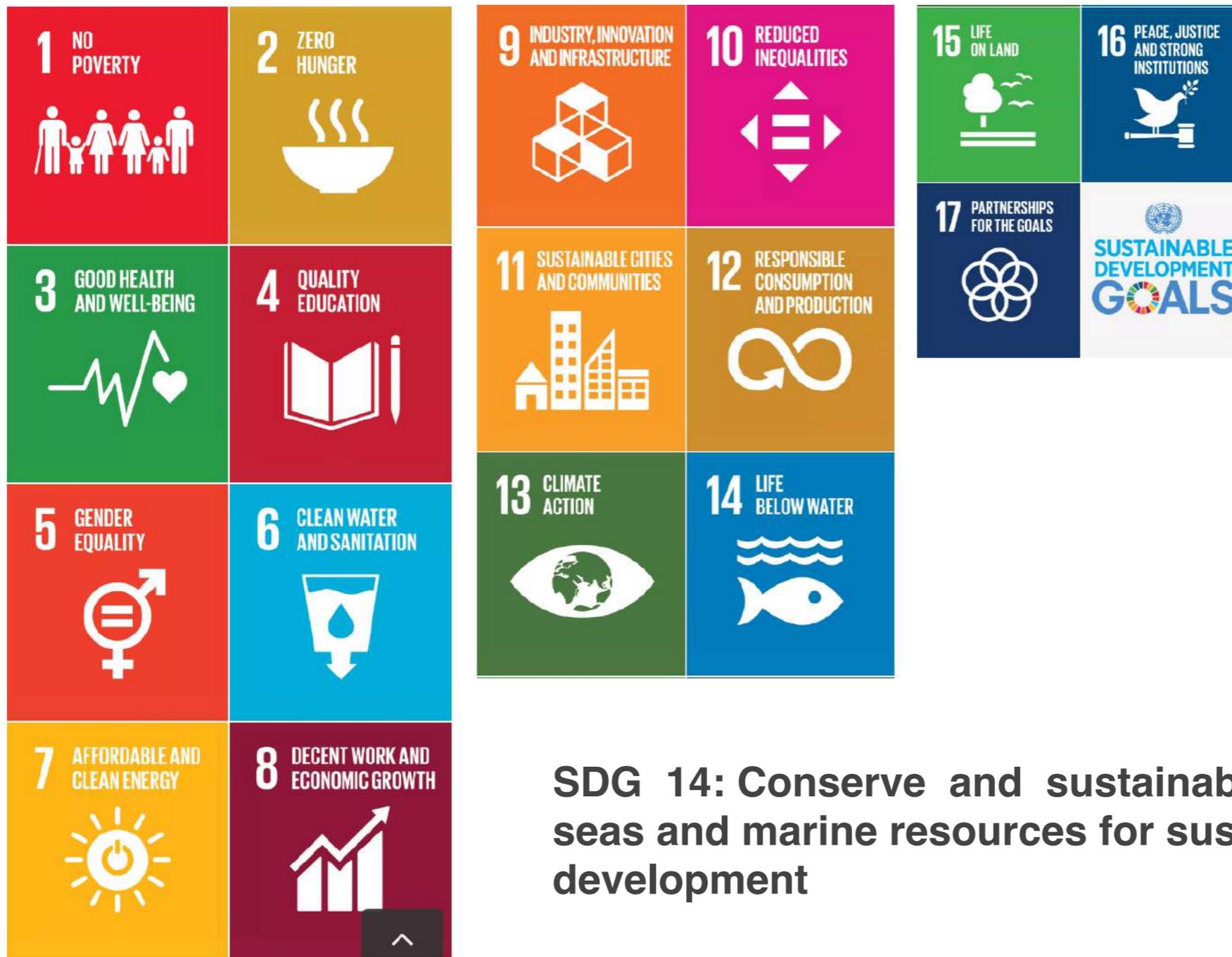


MEDICINE

Many medicinal products come from the ocean, including ingredients that help fight cancer, arthritis, Alzheimer's disease, and heart disease.



The 17 UN Sustainable Development Goals are a call for action by all to promote prosperity while protecting the planet



SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

OUR WORLD OCEAN provides

THE AIR WE BREATHE



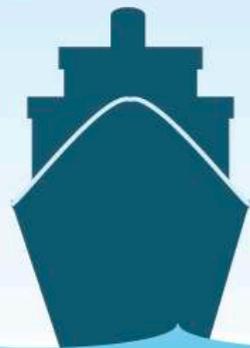
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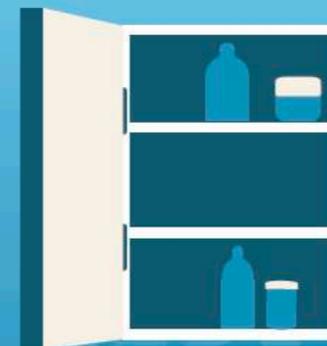


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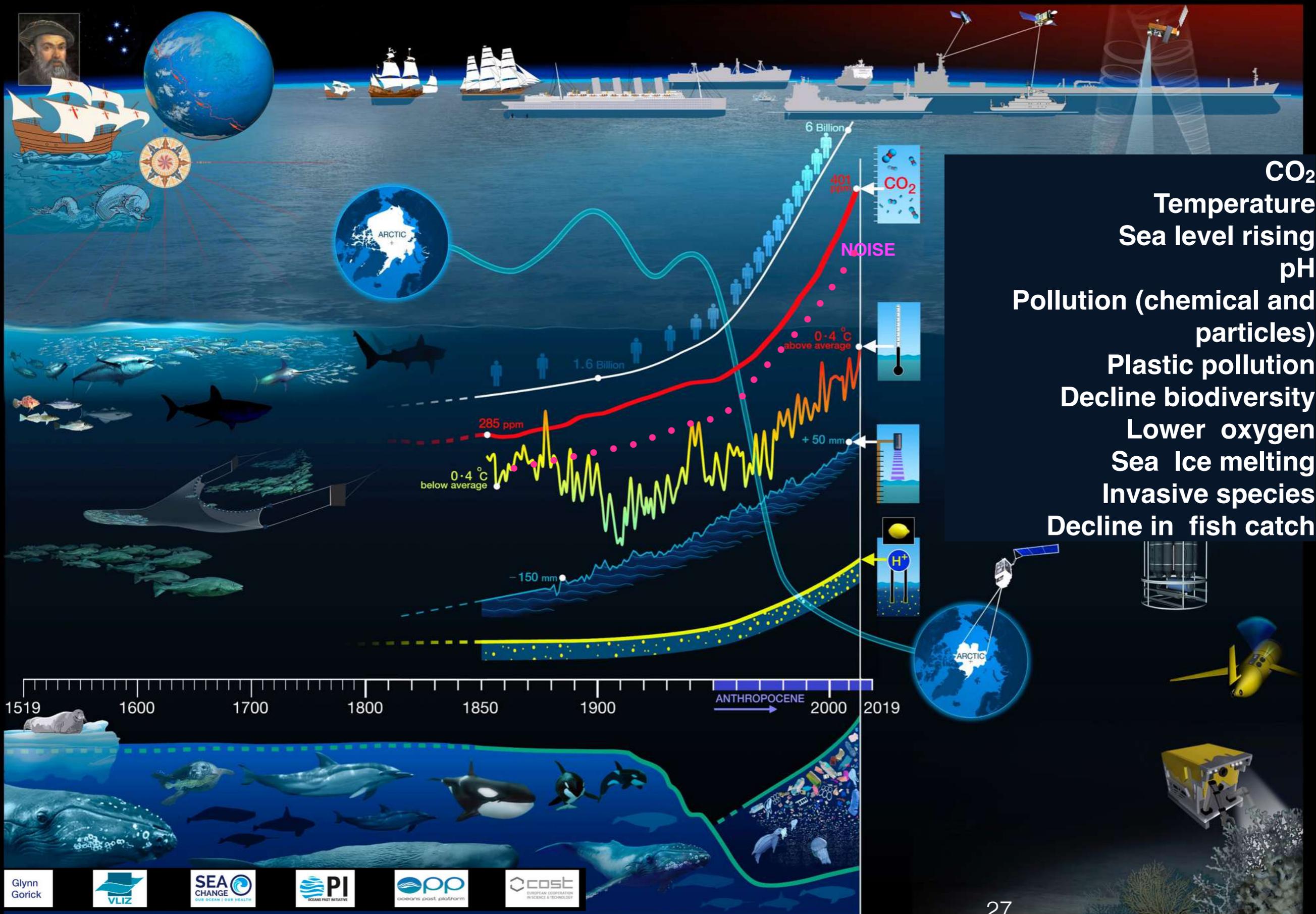


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500 years of a changing ocean...and still changing





Long-term changes in the Ocean

**500
Years
of
Ocean
Change**



- 1 Carbon Dioxide in the Atmosphere - NOAA
- 2 Sea Surface Temperature anomaly - ERSST4 . NOAA
- 3 Global Mean Sea Level - Church & White 2011
- 4 Ocean Acidity - adapted from Mackenzie *et al* 2011
- 5 Arctic Summer Sea Ice Cover - Kinnard *et al* 2011
- 6 Global Human Population - Kremer 1993 & US Census Bureau
- 7 The changing designs of ships
- 8 Stocks of large predatory fish
- 9 Plastic debris in the ocean - Barnes 2009
- 10 Populations of larger sea mammals - Christensen 2006
- 11 Ocean Observation - methods of taking measurements

**Are Monitoring, Experimenting and Observing the Ocean
good approaches for a global sustainable society?**

**How do I/You think
about the microbes?**

**Where are the
microbes in the ocean?**

**A few challenges to
overcome...**

I see microbes

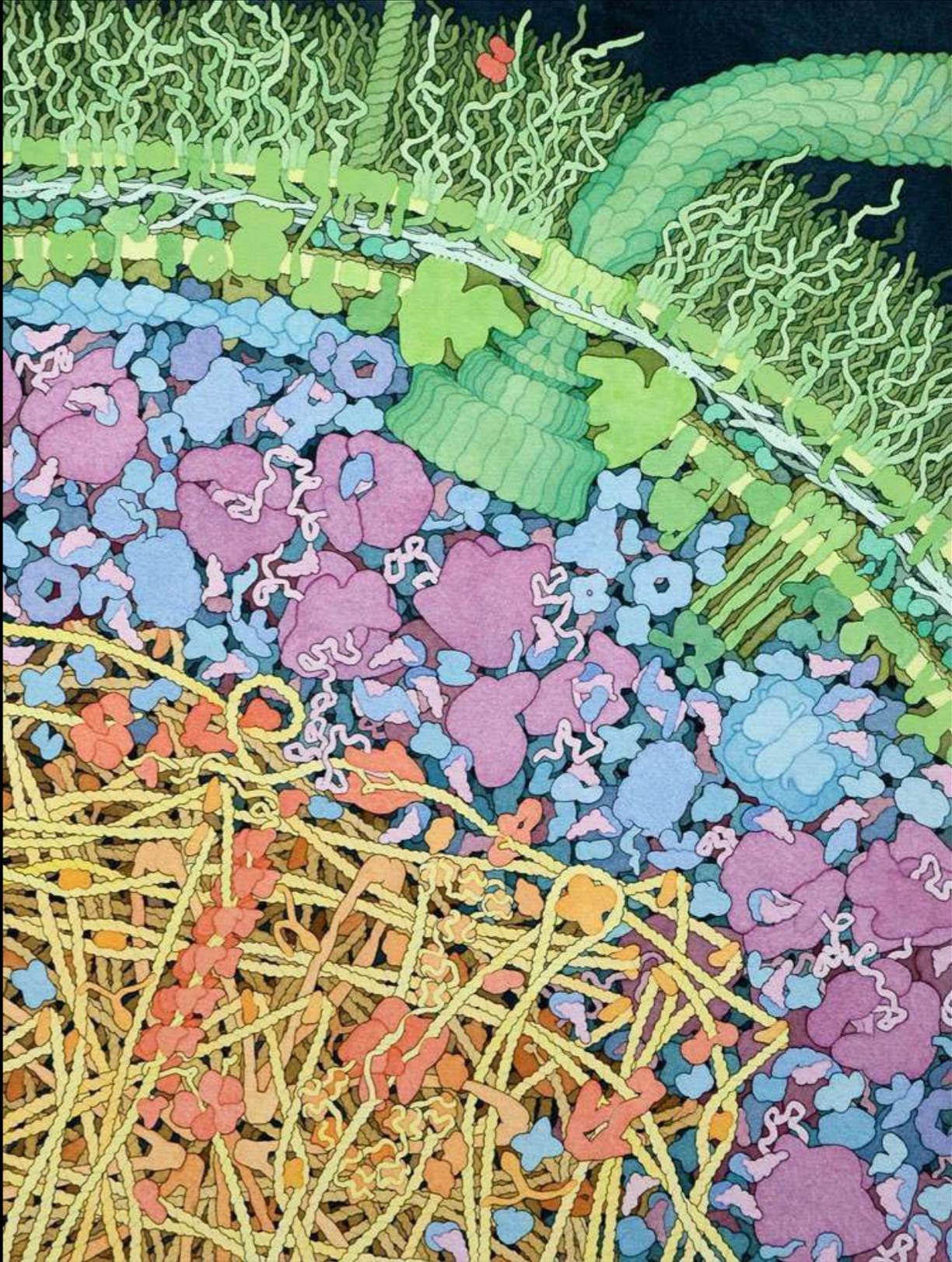
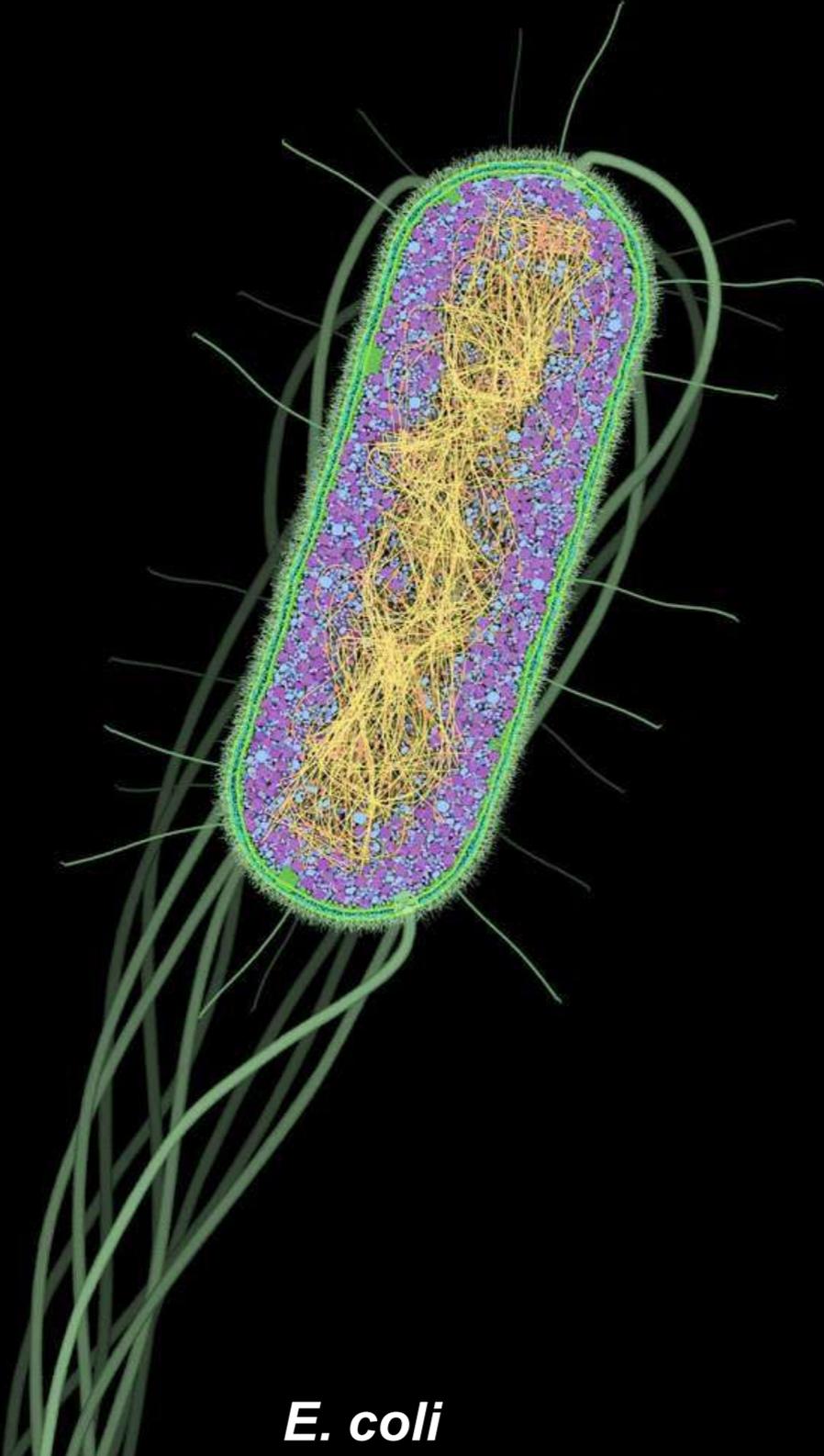


88 μm

118 μm

From micro to nanoscale...at their scale

David S. Goodsell



A few challenges to overcome...

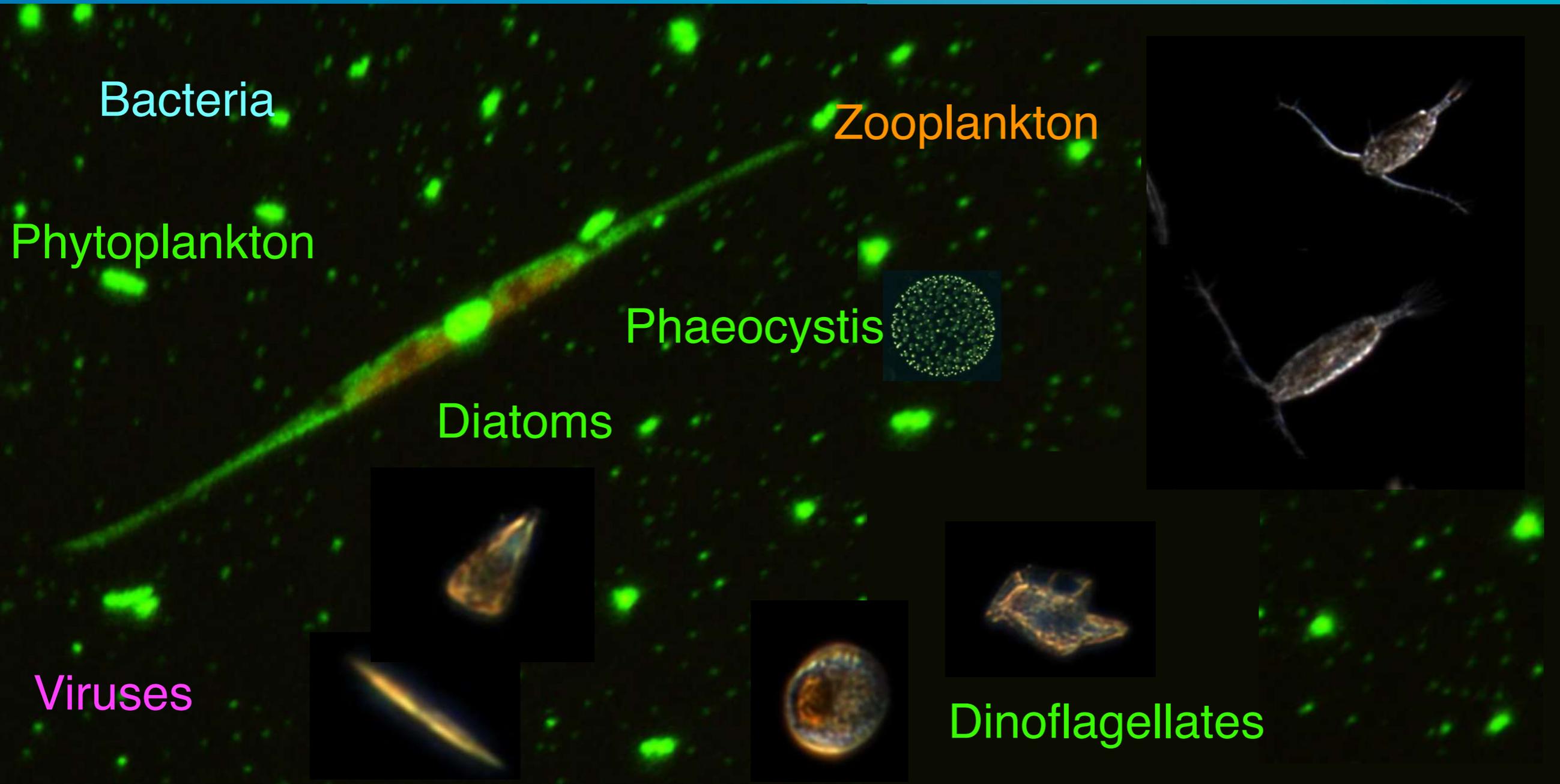
We need to:

- 1 See/count them**
- 2 Identify them**
- 3 Measure their metabolic rates**

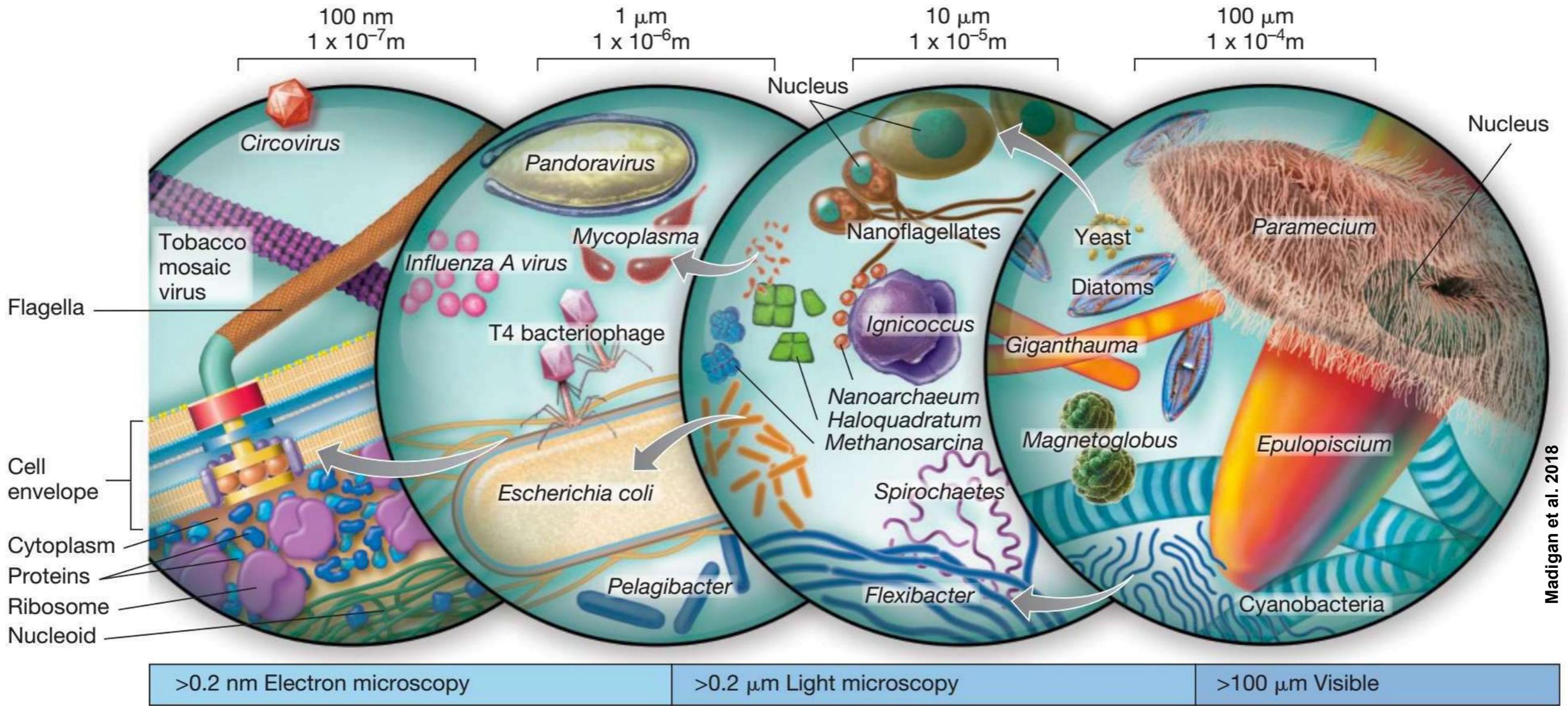
L01: Microbes in the Marine Environment

**Ocean as a microbial
habitat**

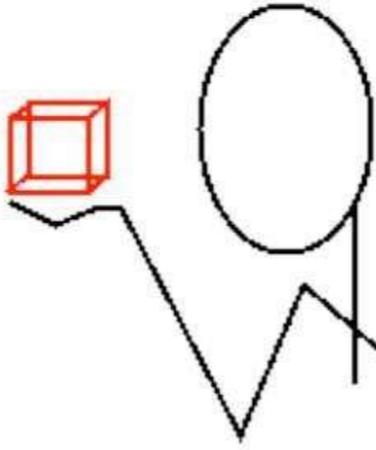
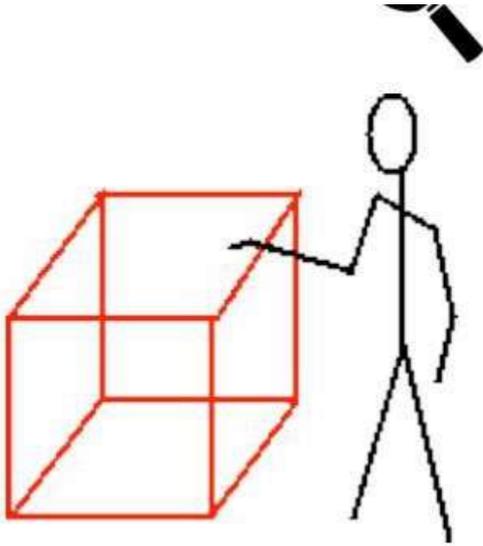
..scale matters

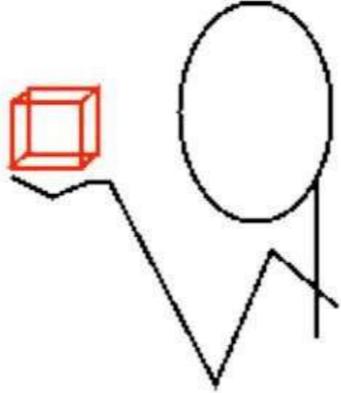
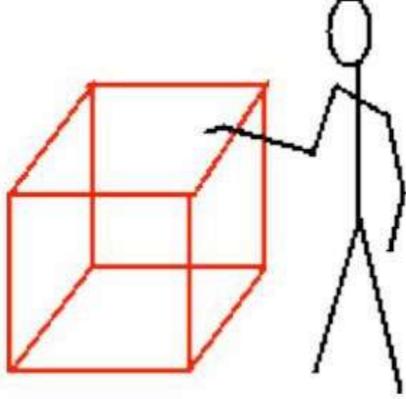
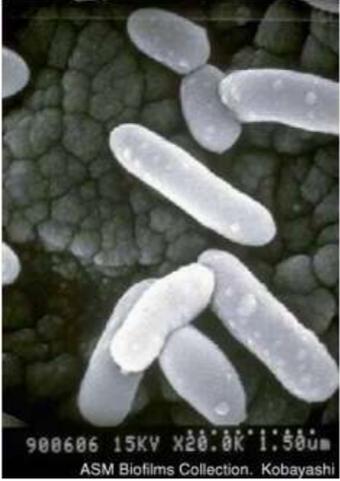
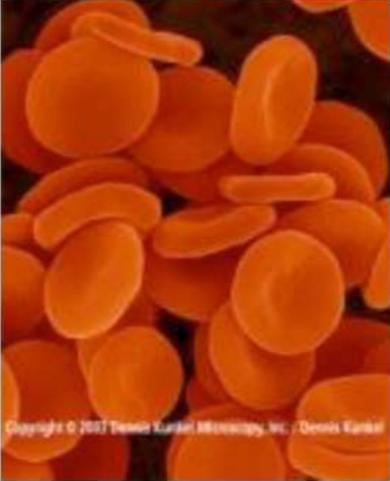


Microbial size range

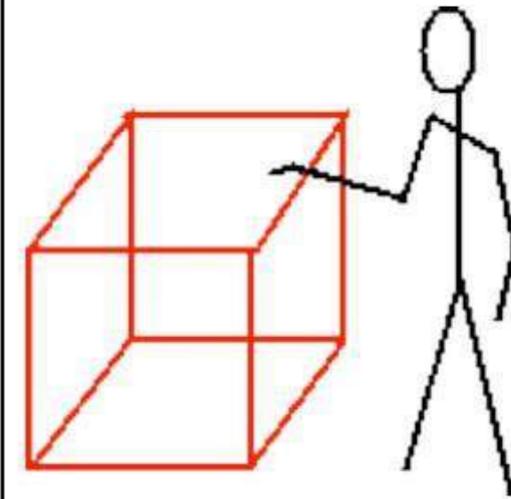
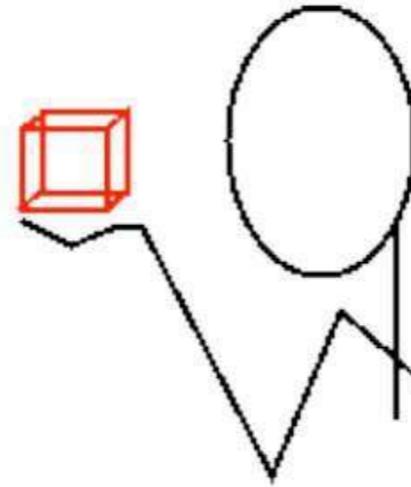


Macroscale

			
10^{-3} m (1 mm)	10^{-2} m (1 cm)	10^{-1} m (10 cm)	1 m
a grain of salt 	a marble 	a baseball 	A box 

			
10^{-6} m (1 micron)	10^{-5} m (10 microns)	10^{-4} m (100 microns)	10^{-3} m (1 mm)
bacteria	red blood cells	your hair	a grain of salt
		 	

Microscale



10^{-9} m

(1 nanometer)

10^{-8} m

(10 nanometers)

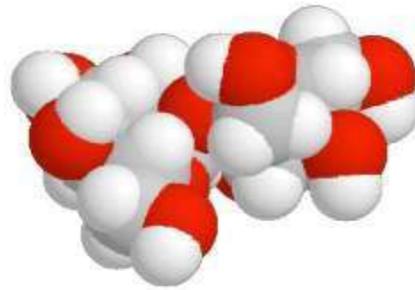
10^{-7} m

(100 nanometers)

10^{-6} m

(1 micron)

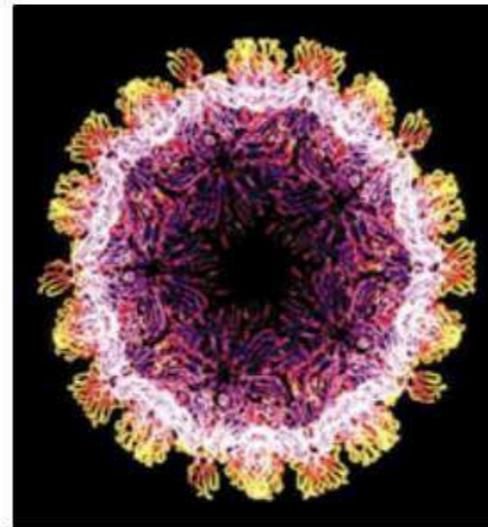
atoms and small molecules



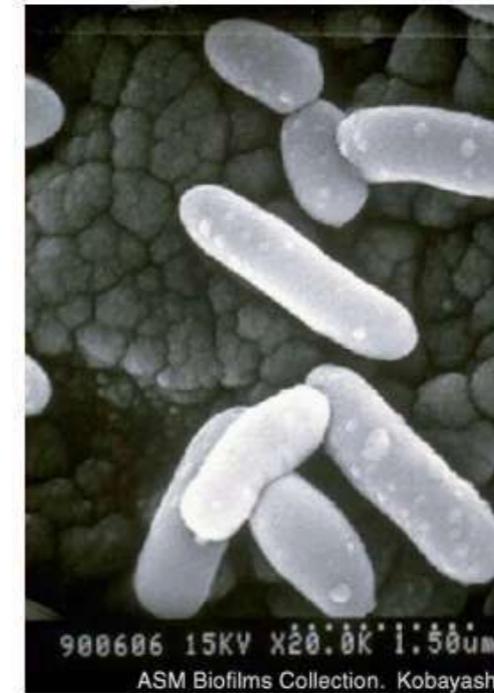
Proteins and large molecules



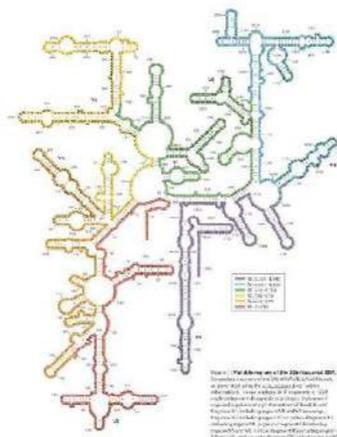
a virus



bacteria



900606 15KV X20.0K 1.50um
ASM Biofilms Collection. Kobayashi



Nanoscale



Definition of *ocean*:

the whole body of salt water that covers nearly three fourths of the surface of the earth

The *ocean* covers most of our planet, regulates our weather and climate, absorbs vast amounts of carbon dioxide, provides most of our oxygen, and feeds much of the human population.

— *National Oceanic and Atmospheric Administration, NOAA*

<https://www.merriam-webster.com/>



Merriam-
Webster

SINCE 1828

Definition of *sea*

**: a great body of salt water
that covers much of the earth**

broadly : the waters of the earth
as distinguished from the land
and air

: a body of salt water of second
rank more or less landlocked
the Mediterranean *sea*

Definition of *coast*

: the land near a
shore : SEASHORE

<https://www.merriam-webster.com/>

Ocean

More than 80% unexplored

Most of the ocean is unseen by human eyes — more than 80% of our ocean is unmapped, unobserved and unexplored.

Coastal habitat is about 7% of ocean area

The Great Barrier Reef in Australia is the largest living organism on Earth and can be seen from the moon.

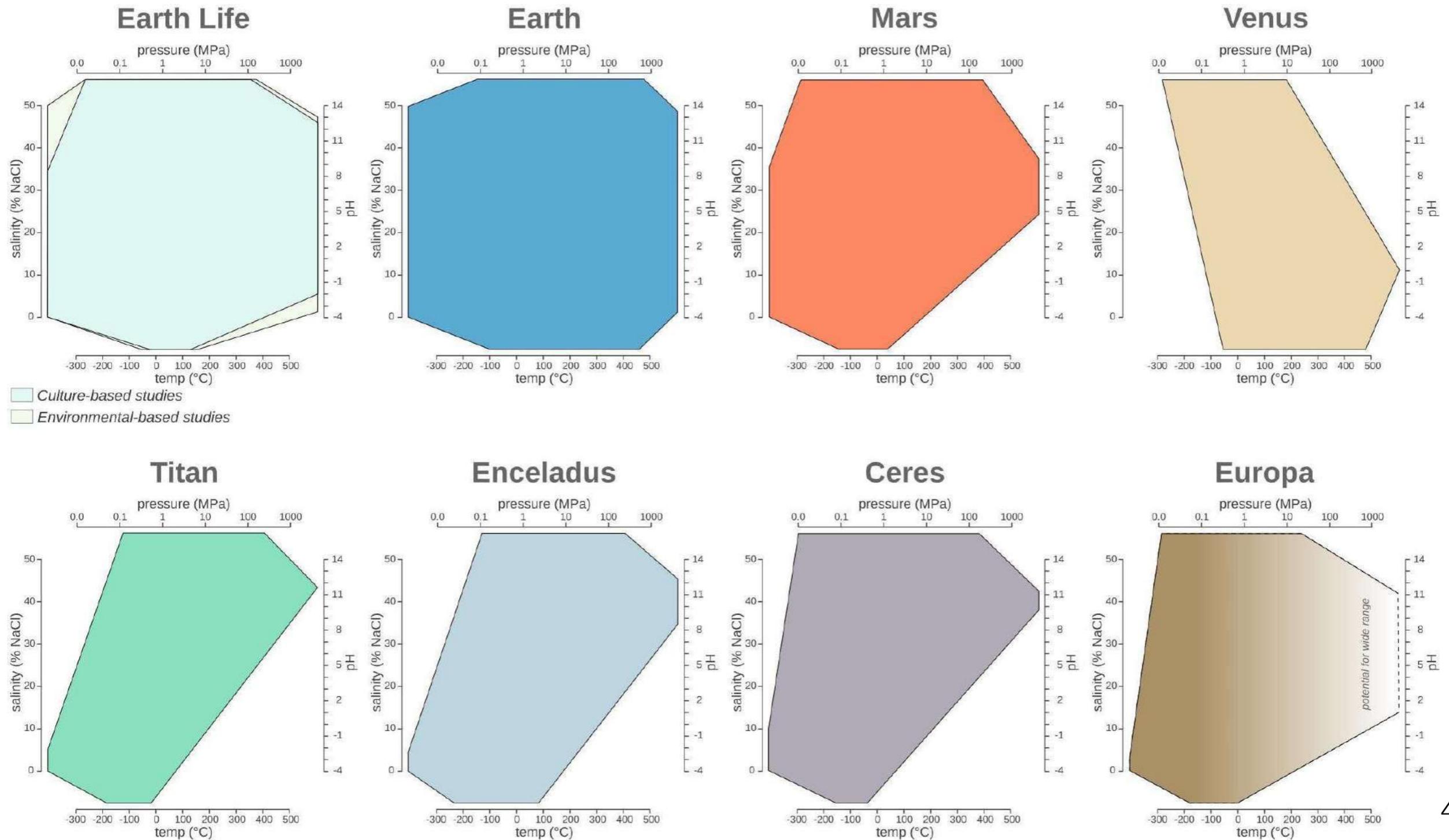
99% of the Earth's water

The ocean contains more than 96 percent of the Earth's water.

Upper layer is well lit, warm, and highly oxygenated with low salinity, density and nutrients

Bottom layer with relatively high salinity, density, and nutrients and low temperature and salinity, low constant oxygen and dark

Life T, pH, Pressure, S ranges on Earth-Ocean



Ocean environment, I

Temperature

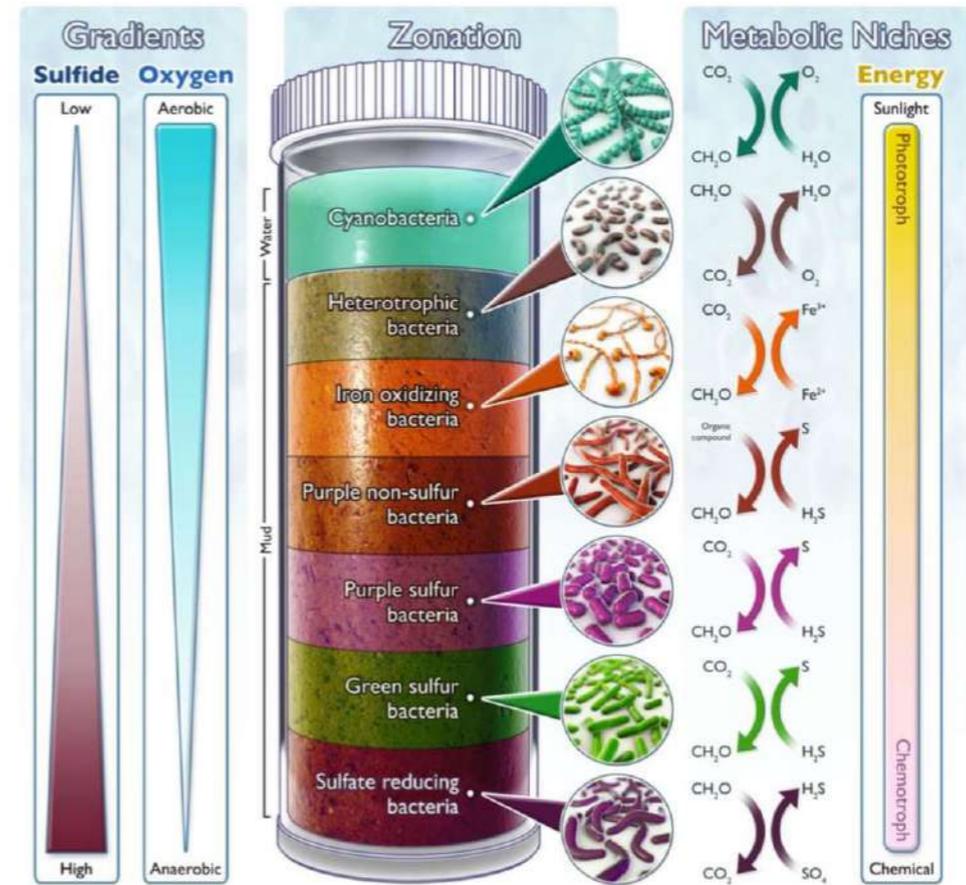
Salinity/ Ionic strength

Pressure

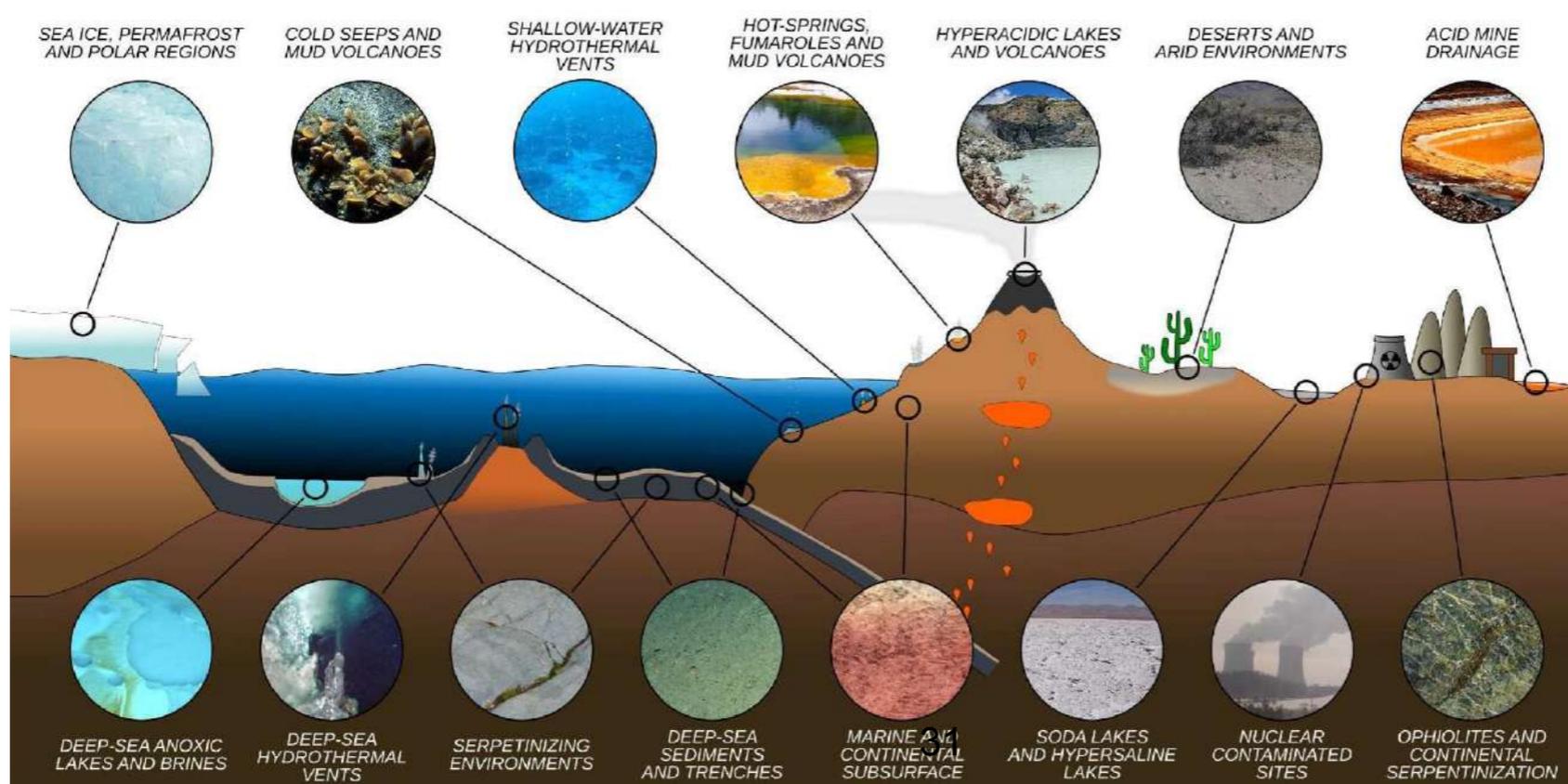
pH

Solar radiations

Light/Dark



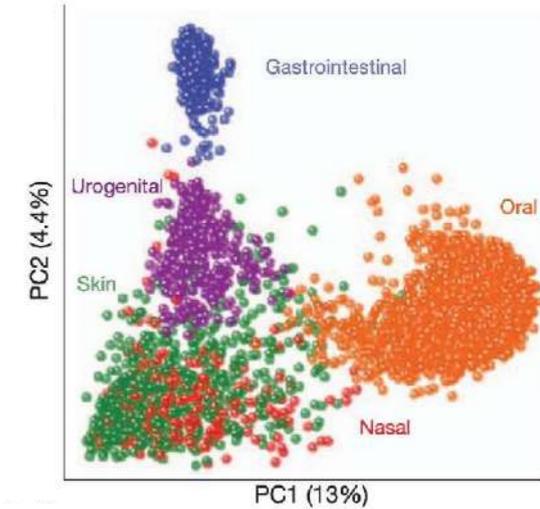
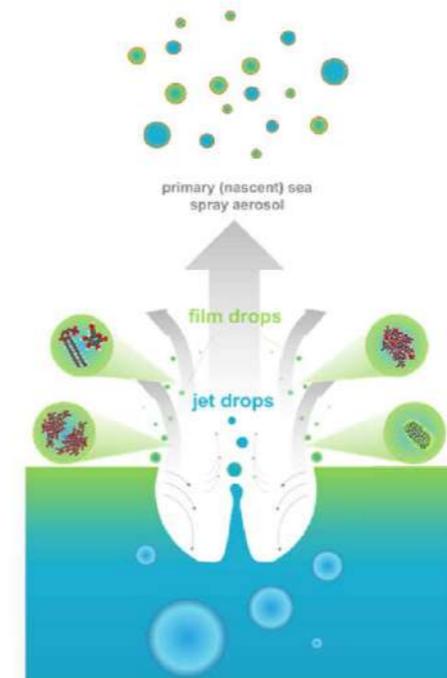
HHMI Biointeractive poster Winogradsky Column—
Microbial Evolution in a Bottle



Merino et al. 2019

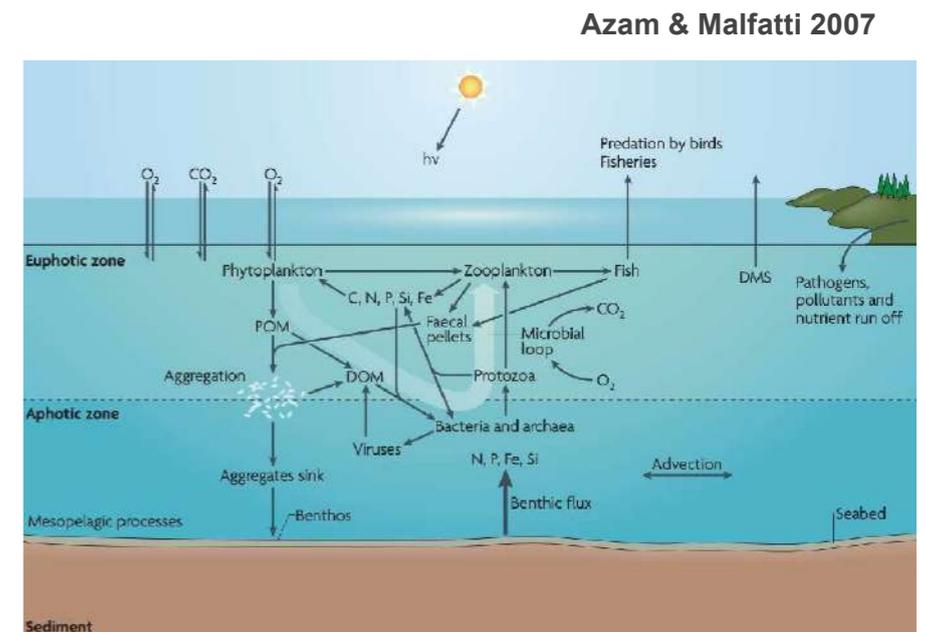
Ocean environment, II

Oxygen
Organic matter
3D organic matter structure in space and time
Nutrients
State of water
Other micro/macro-organisms (gut, skin, etc...)



2020 CENTER FOR AEROSOL IMPACTS ON CHEMISTRY OF THE ENVIRONMENT

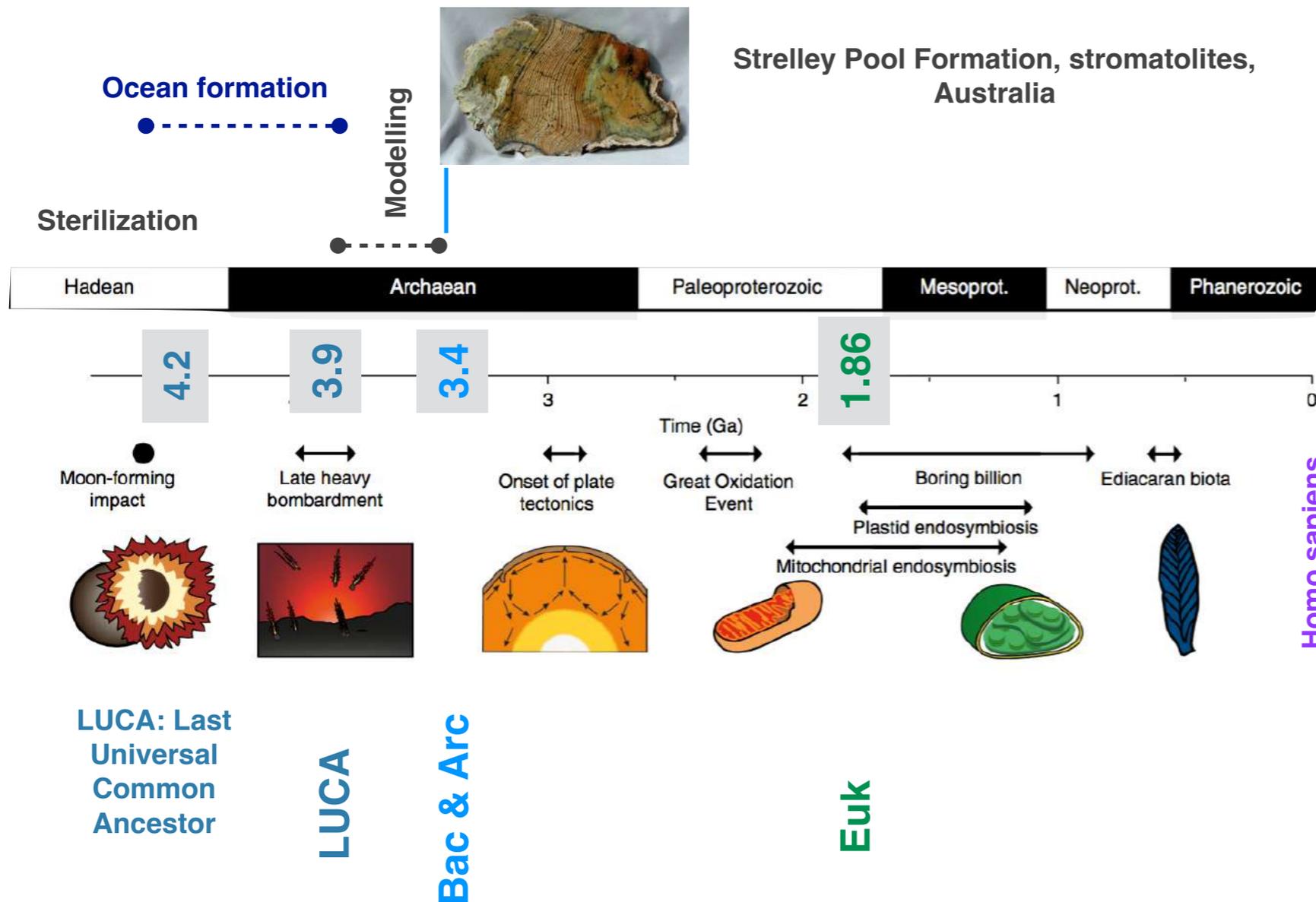
Specific microbial adaptations to grow in the microenvironment



Origin of the OCEAN

About 4-4.2 to 3.9 billion years ago, the water condensed into rain which filled the basins that we now know as our world ocean

Atmosphere and the ocean accumulated gradually over millions and millions of years with the continual 'degassing' of the Earth's interior (water coming from meteorites)



Betts et al., 2018
Moody et al., 2024

Open vs Coastal ocean

Ocean habitats can be divided into two: coastal and open ocean habitats

Ocean and coastal habitats can be created by species living in them

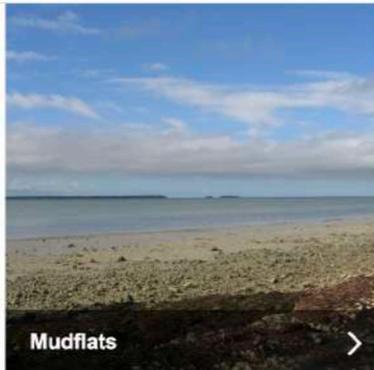
Marine natural habitats

<https://www.nps.gov/subjects/oceans/ocean-habitats.htm>



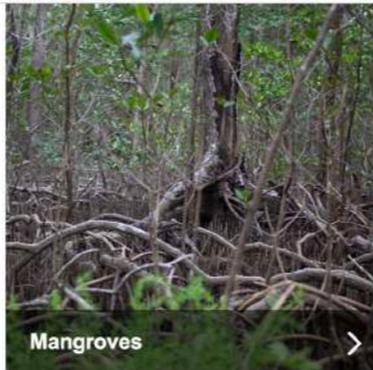
Intertidal >

A habitat between low and high tide.



Mudflats >

A muddy habitat near the ocean.



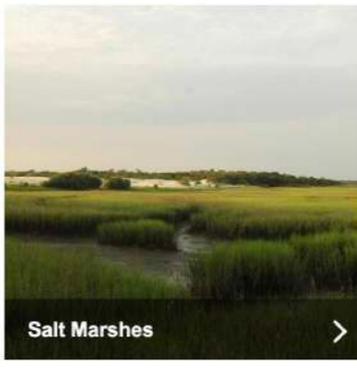
Mangroves >

A nursing ground habitat.



Tidewater Glaciers >

An ice-cold giant habitat that makes a splash.



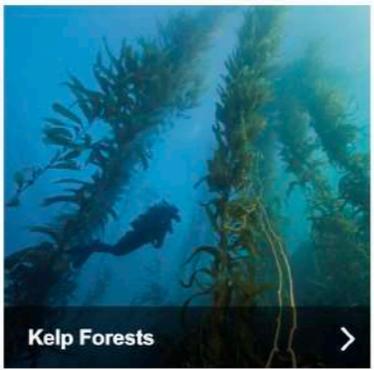
Salt Marshes >

A crucial habitat that is suffering a lot of losses.



Estuaries >

A habitat with a mixture of salt and fresh water.



Kelp Forests >

A forest under the sea, comparable to the rainforest.



Seagrass Meadows >

A habitat for grazers.



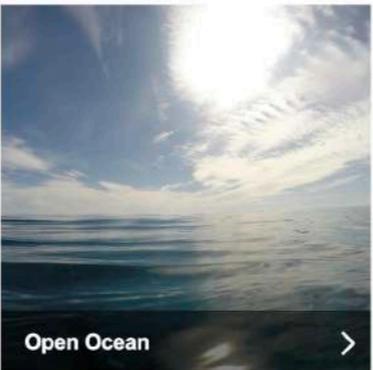
Coral Reefs >

A vibrant habitat in peril.



Oyster Reefs >

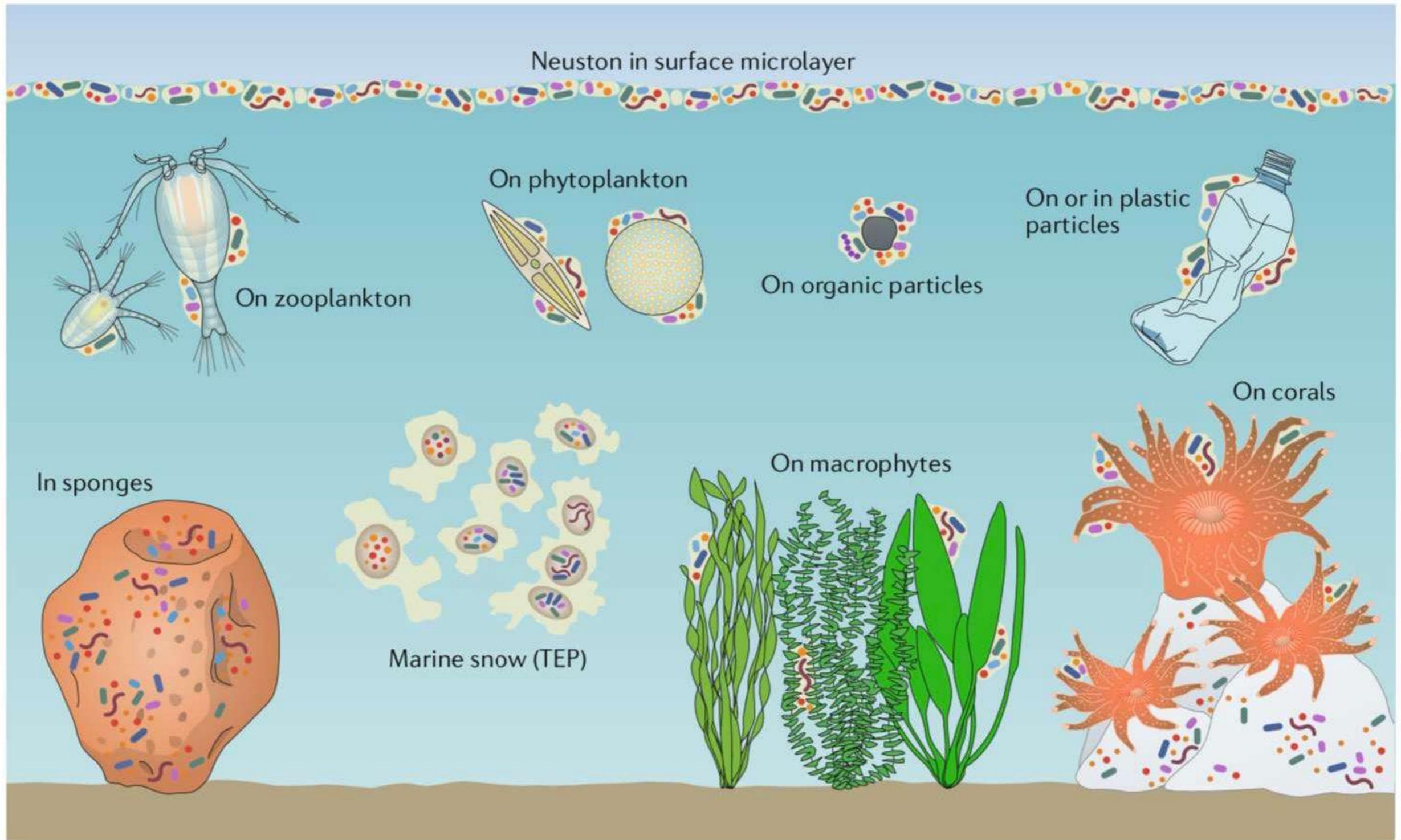
Not just a tasty treat, but a protector of the shore.



Open Ocean >

A vast and open habitat away from the shore.

Open Ocean in the Anthropocene



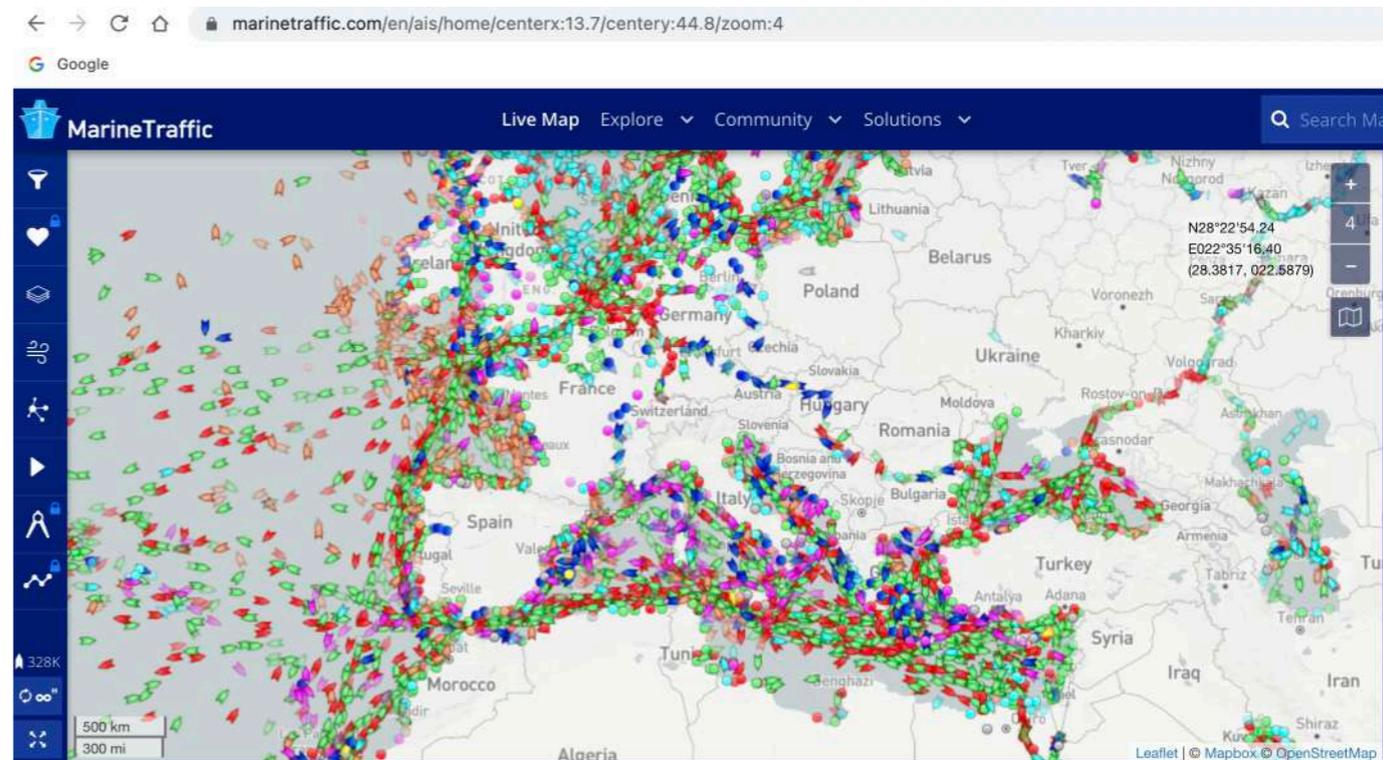
Marine habitats

<https://www.cruisemapper.com/ports/trieste-port-280>



- Human infrastructures
- Harbours
- Boats
- Ballast water tank
- Ships
- Oil rig

<https://www.barcolana.it/>



Microscale

- Microbes live in a microbial world
- Microbes interact intimately with molecules
- Gradients are ephemeral in space and time
- Unknown is behind the corner...dark corner!
- On a face value, at the microscale all living things/organisms are the same —> sugars, proteins and lipids —> hot spot of organic matter
- All the surfaces are the same, due to the molecular coating

<https://unesdoc.unesco.org/search/592f5d69-cb9e-4d96-8b23-f77bb4050676>

<https://www.oceandecade.org/vision-mission/>

<https://www.ipcc.ch/srocc/chapter/chapter-5/>

<https://oceanliteracy.unesco.org/?post-types=all&sort=popular>

<https://www.marinetraffic.com/en/ais/home/centerx:-63.9/centery:26.9/zoom:2>

<https://www.emodnet-humanactivities.eu/view-data.php>

<https://oceanservice.noaa.gov/facts/>

<https://education.nationalgeographic.org/resource/ocean/>