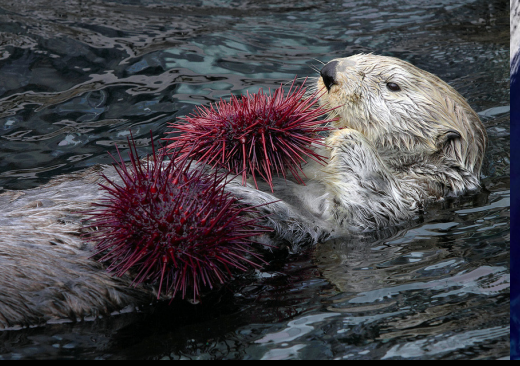




Marine Bioinformatics

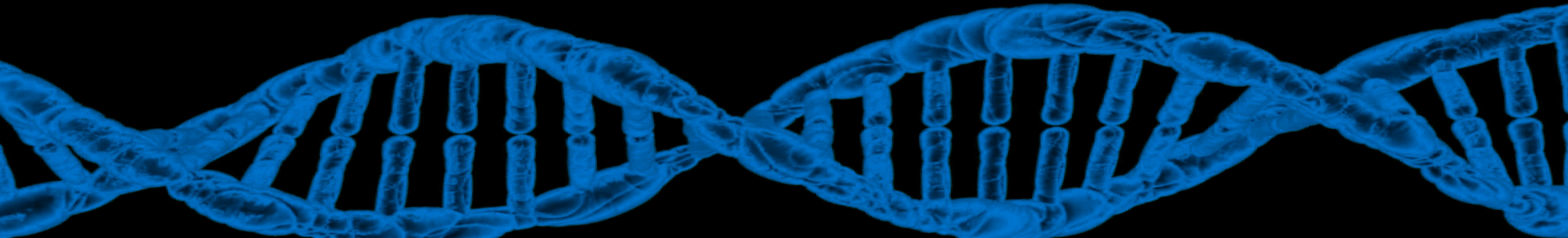
CS 185C sec 01 / Biol 145 sec 03 (3 units)

Spring 2023

Lec: Tu/Th 9:00-10:15, Duncan Hall 344

Co-Instructors: Dr. Phil Heller (CS) and Dr. Maya deVries (Biol)

TA: Anson Pham



Marine Bioinformatics

Marine = anything about or in the ocean

Bioinformatics = “an interdisciplinary field that develops methods and software tools for understanding biological data…” (mostly deals with genetic data)
- Wikipedia

Marine Bioinformatics = developing methods and software to better understand life in the ocean

Marine Bioinformatics

Marine Bioinformatics = developing methods and software to better understand life in the ocean

By the end of this course, you will be able to:

- describe basic principles about the evolution of life on Earth, with a particular focus on patterns and processes in marine systems

- Identify marine communities that can be explored bioinformatically, apply bioinformatic tools to marine datasets, and interpret bioinformatic data from experiments and observations to test hypotheses about key patterns, processes, and concepts

A little bit about you!

Name

Preferred pronouns

Year at SJSU

Major/concentration

Why are you interested in this course?

What is your favorite marine organism?

Syllabus

Spring 2023

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Zoom
NameCoach
Ally Course

Course Syllabus

Jump to Today

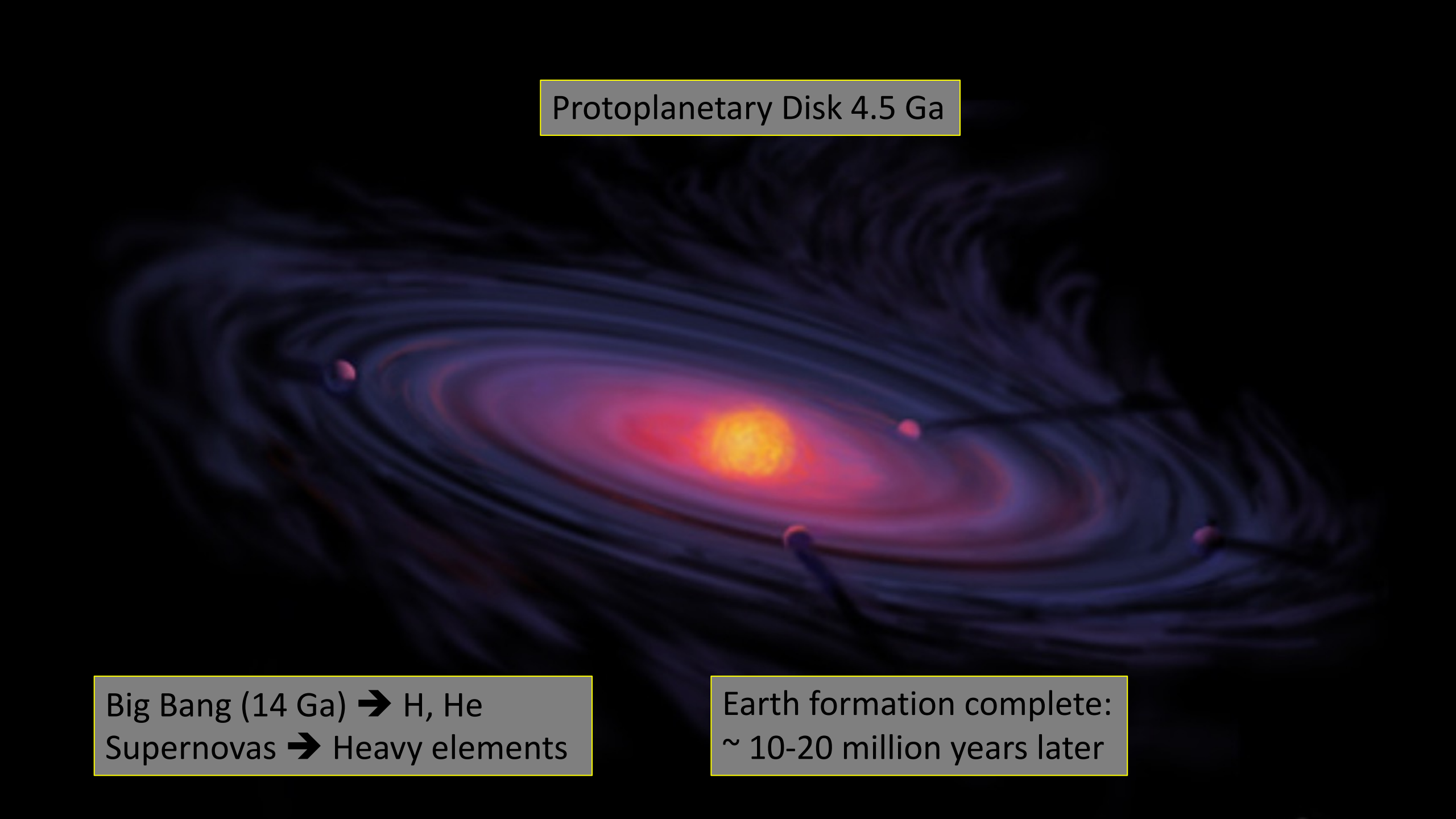
Edit

San José State University
Computer Science & Biological Sciences Department
Biology 145 / Computer Science 185C: Marine Bioinformatics
Spring 2023

Course and Contact Information

Instructors:	Maya deVries (BIOL) / Philip Heller (CS)
Office Locations:	340 Duncan Hall / 211 MacQuarrie Hall
Email:	maya.devries@sjsu.edu / philip.heller@sjsu.edu
Office Hours:	Dr. deVries: Tues 10:30-11:30 (Virtual); Thurs 10:30-11:30 (In person) (Zoom link: https://sjsu.zoom.us/j/85204429438?pwd=eEIzZXl3YUNYa0NmZ0RCSURPK202Zz09) Dr. Heller: Weds 2:00-3:00 (Virtual); Thurs 1:45-2:45 (In person) (Zoom link: https://sjsu.zoom.us/j/81228820144?pwd=ZHRpeFVLazJVMW1uTHFZOU96blJnQT09)
Class Days/Time:	T/Th 9:00 – 10:15
Classroom:	344 Duncan Hall

Protoplanetary Disk 4.5 Ga

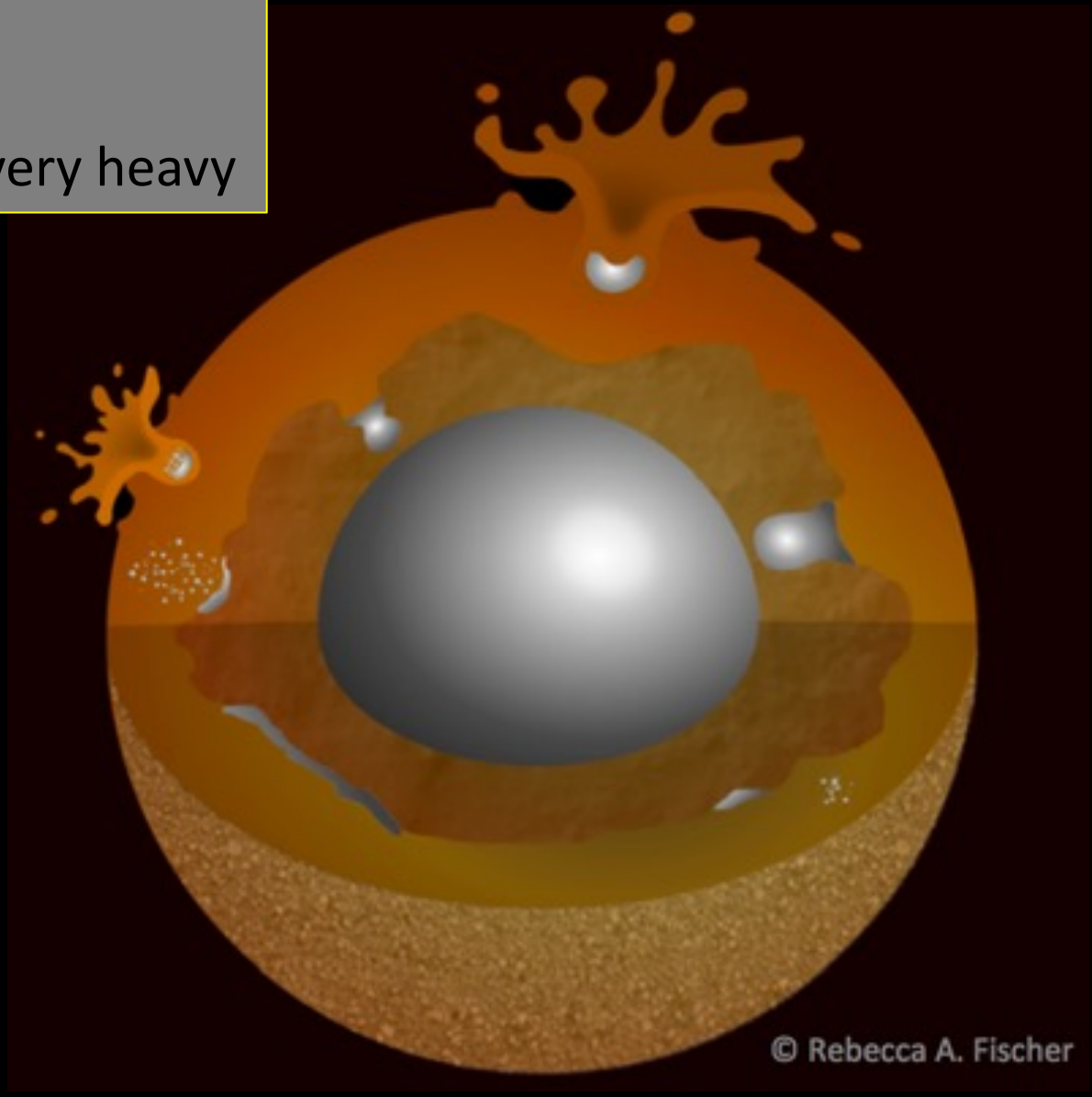


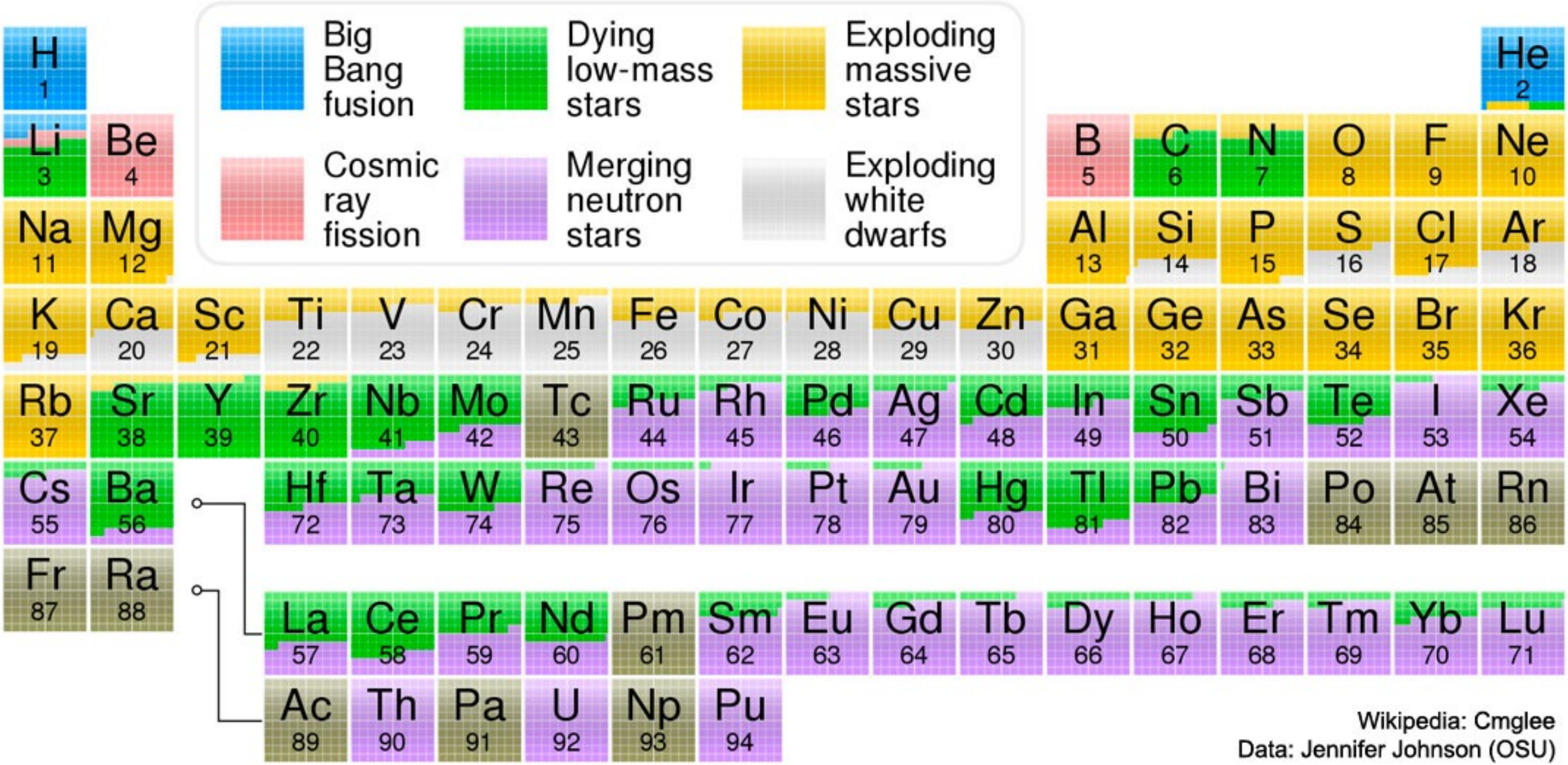
Big Bang (14 Ga) ➔ H, He
Supernovas ➔ Heavy elements

Earth formation complete:
~ 10-20 million years later

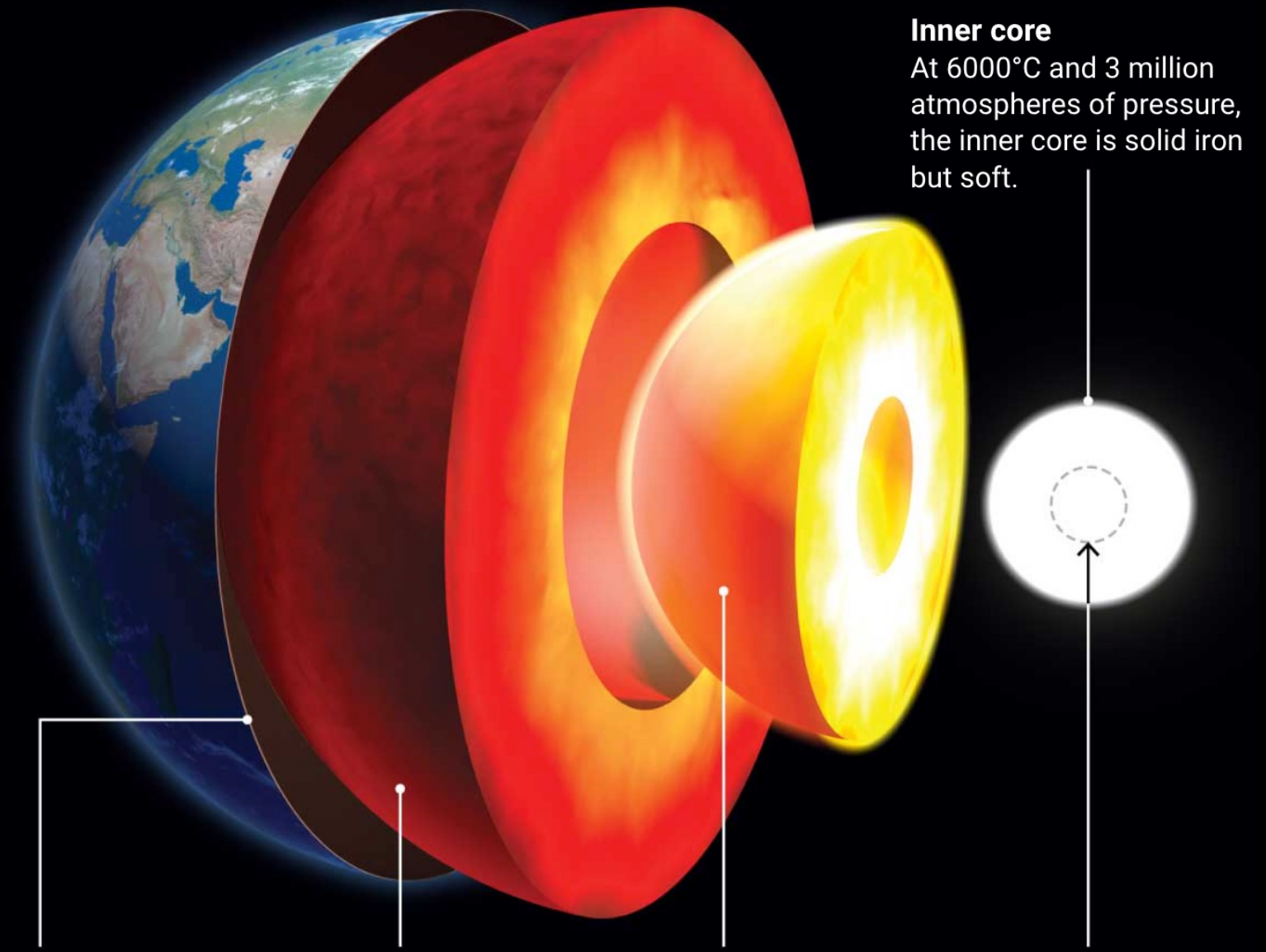
Heavy elements:

- Silicates: moderately heavy
- Iron and siderophiles (“iron’s friends”): very heavy

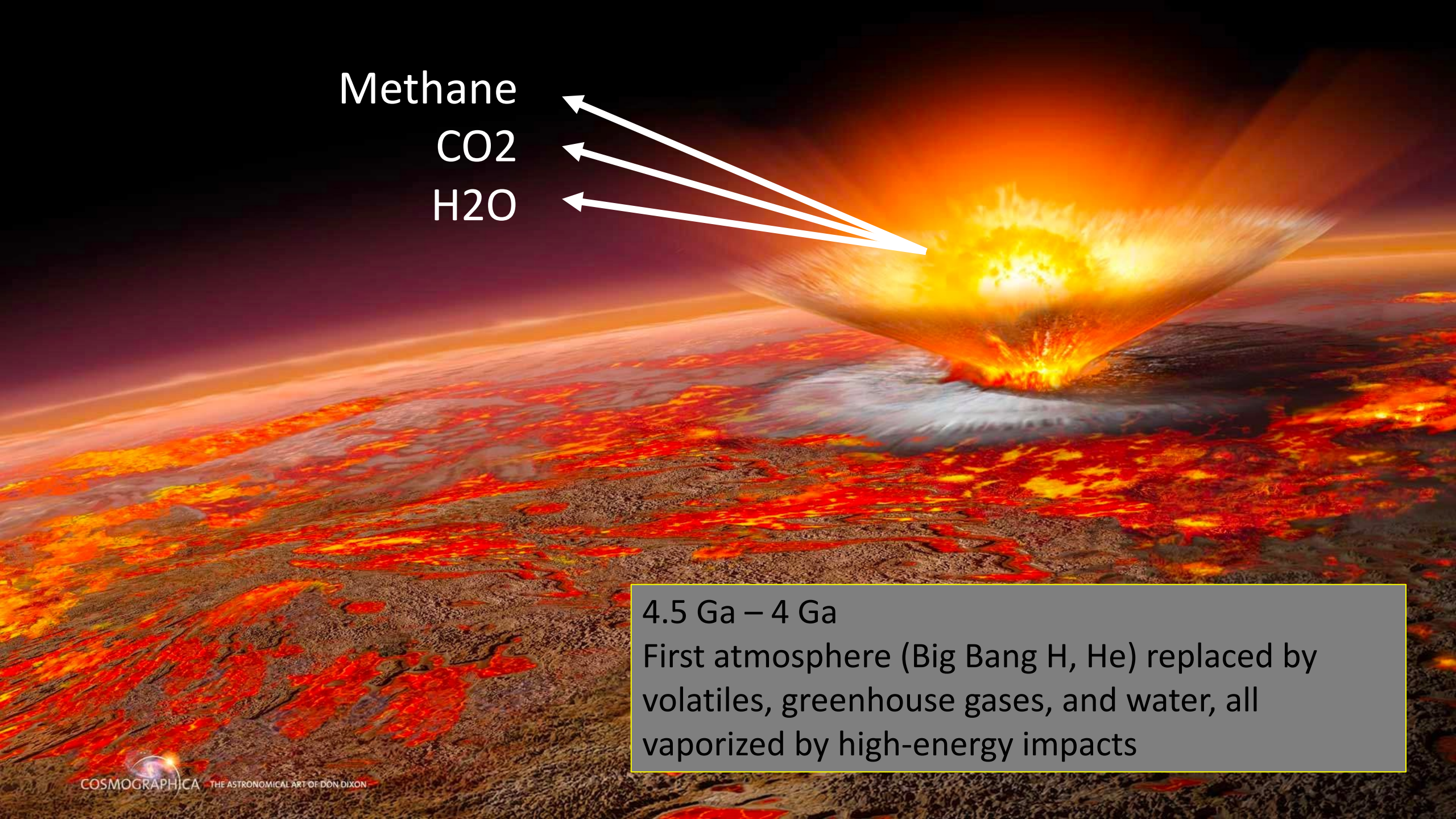




https://apod.nasa.gov/apod/ap230108.html



Science.org 2022



4.5 Ga – 4 Ga

First atmosphere (Big Bang H, He) replaced by volatiles, greenhouse gases, and water, all vaporized by high-energy impacts

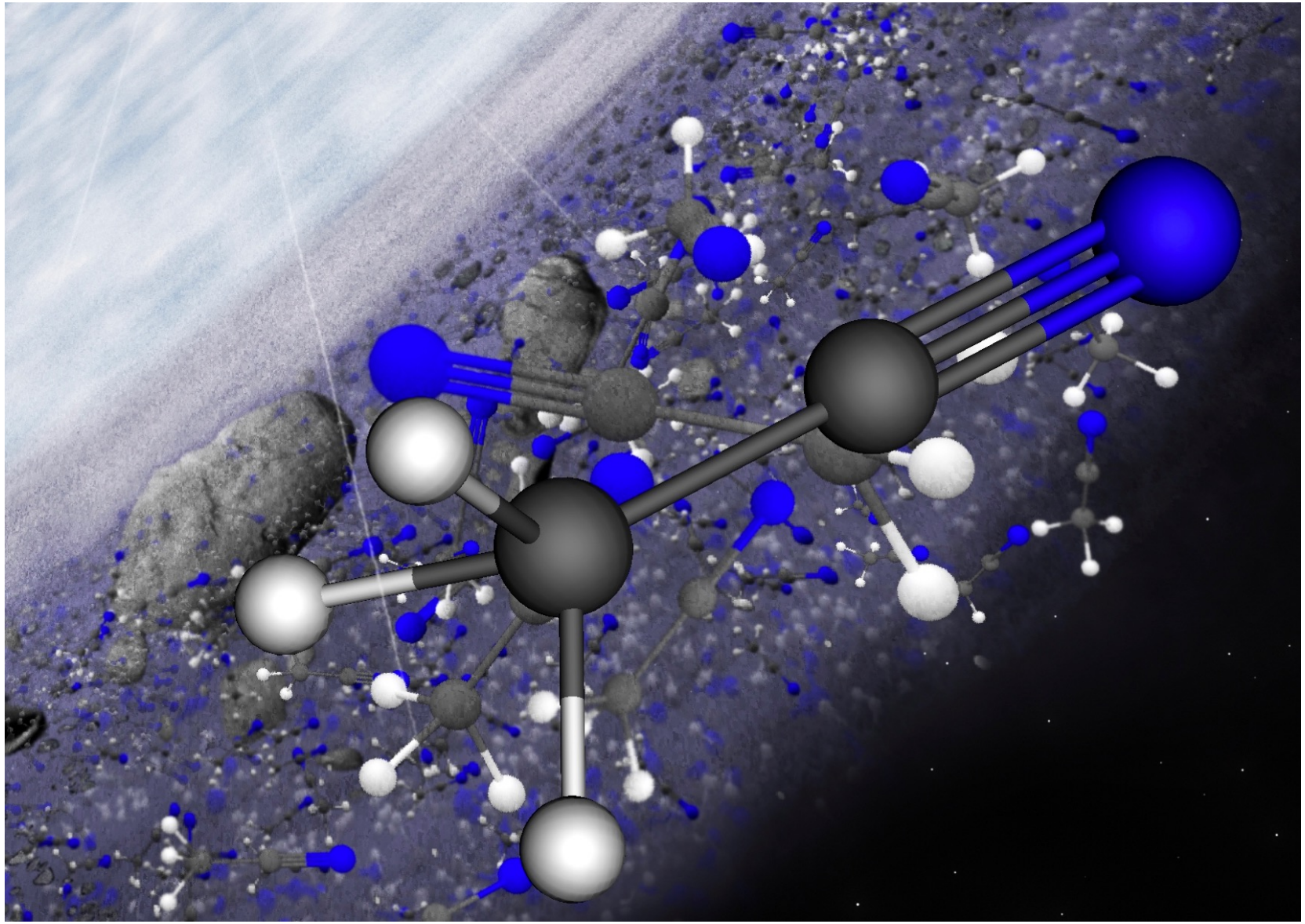
And then the Earth cooled

- Water vapor in atmosphere becomes liquid water on surface.
- Hey – why is the sky brown?
- 4 Ga: End of intense bombardment + liquid surface water.
- Conditions for life, which soon arose.
- Maybe “arose” isn’t the right word…

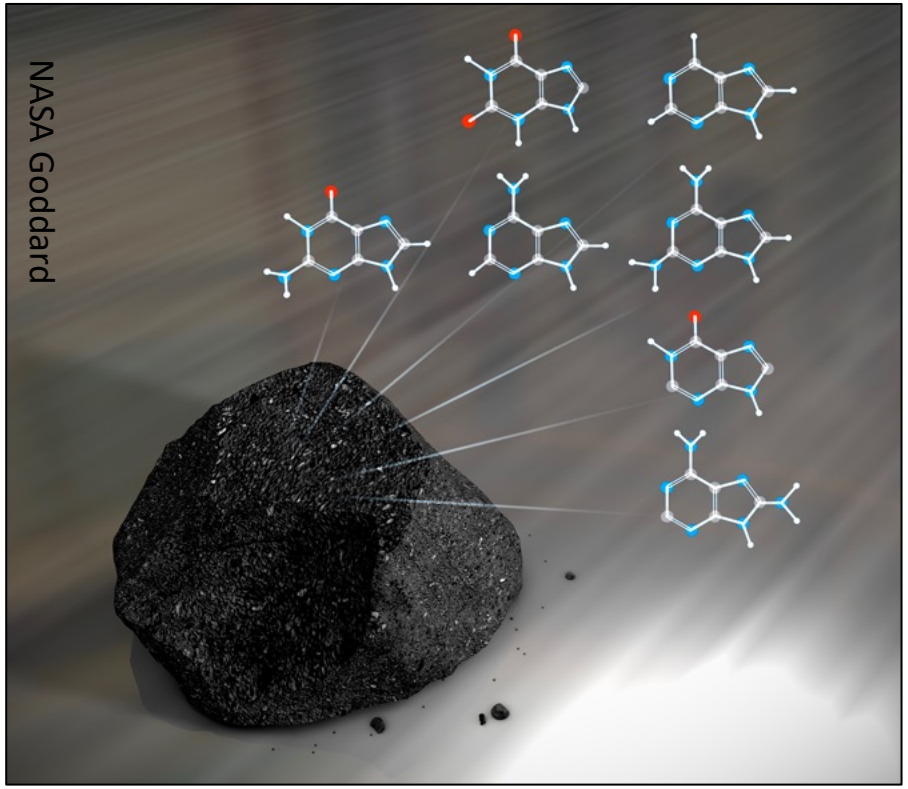
Molecules of life can form in protostellar space

"Complex Organic Molecules Discovered in Infant Star System"

Smithsonian press release, 2015



Including building blocks of self-replicating molecules and nucleotides



3 necessary conditions for emergence of life

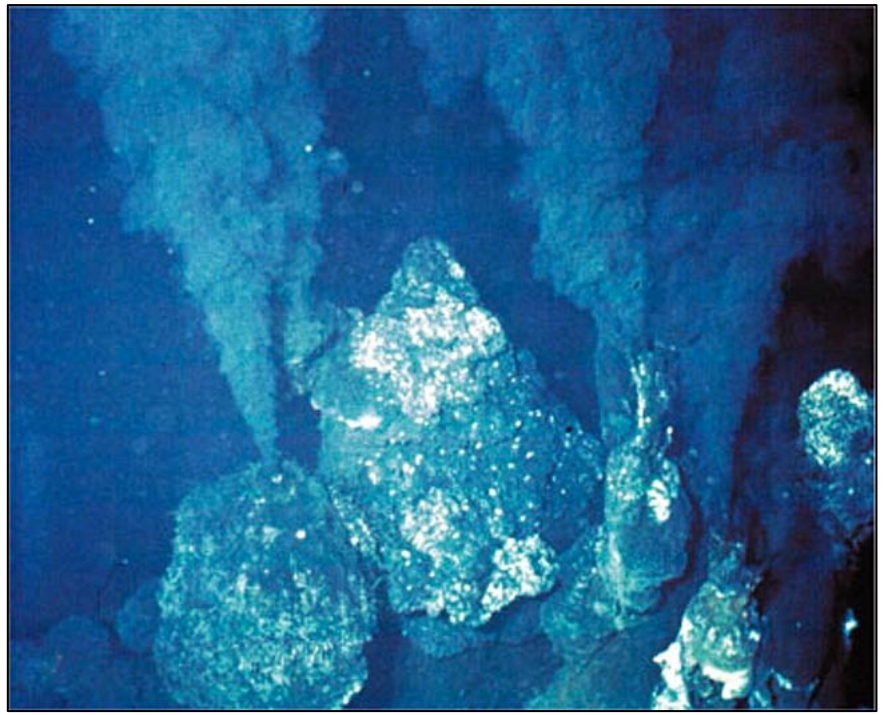
NIST

Self replication

Energy

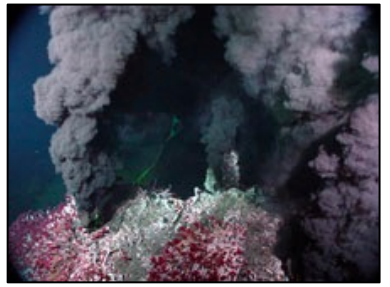
And …

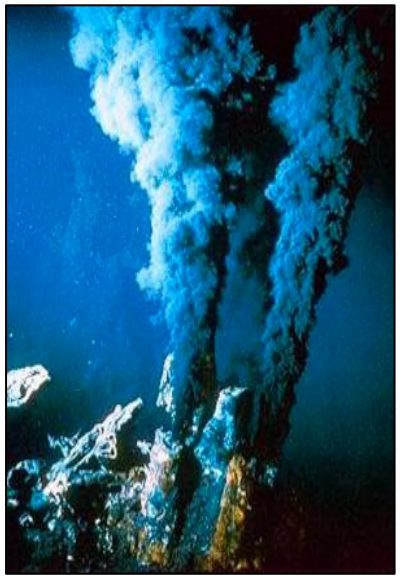
Self-replication, energy, and *a safe space for reactions*

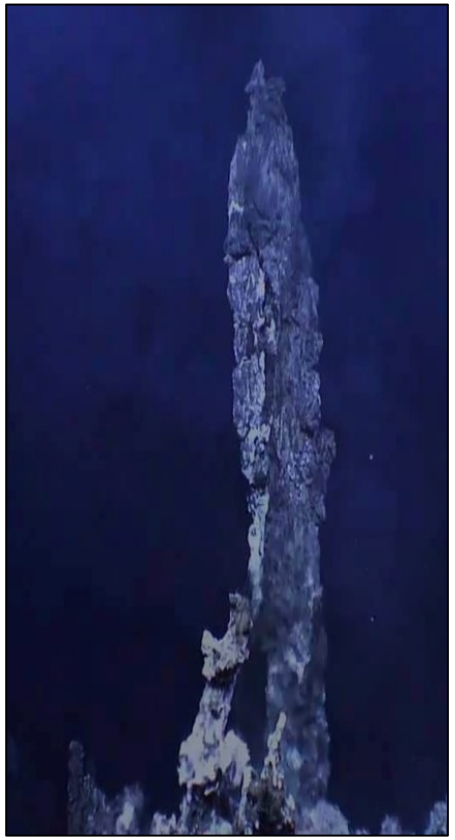


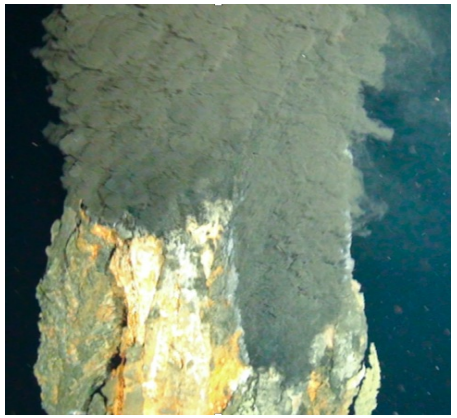
“Black Smokers”

- Undersea towers of pumice-like rock
- Up to 180’ tall
- Rich in minerals
- “English muffins of the mineral world”
- Nooks & crannies where reactions can happen





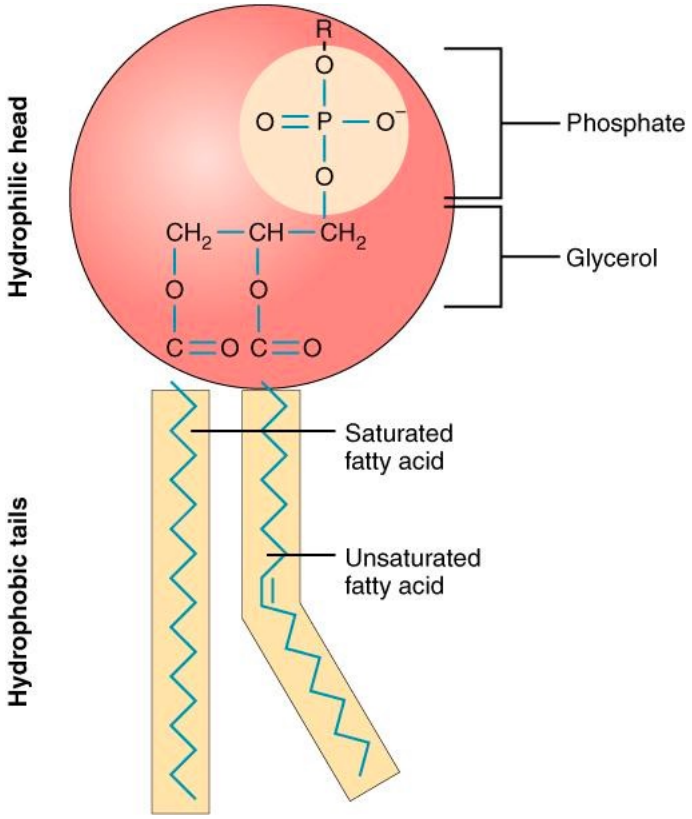




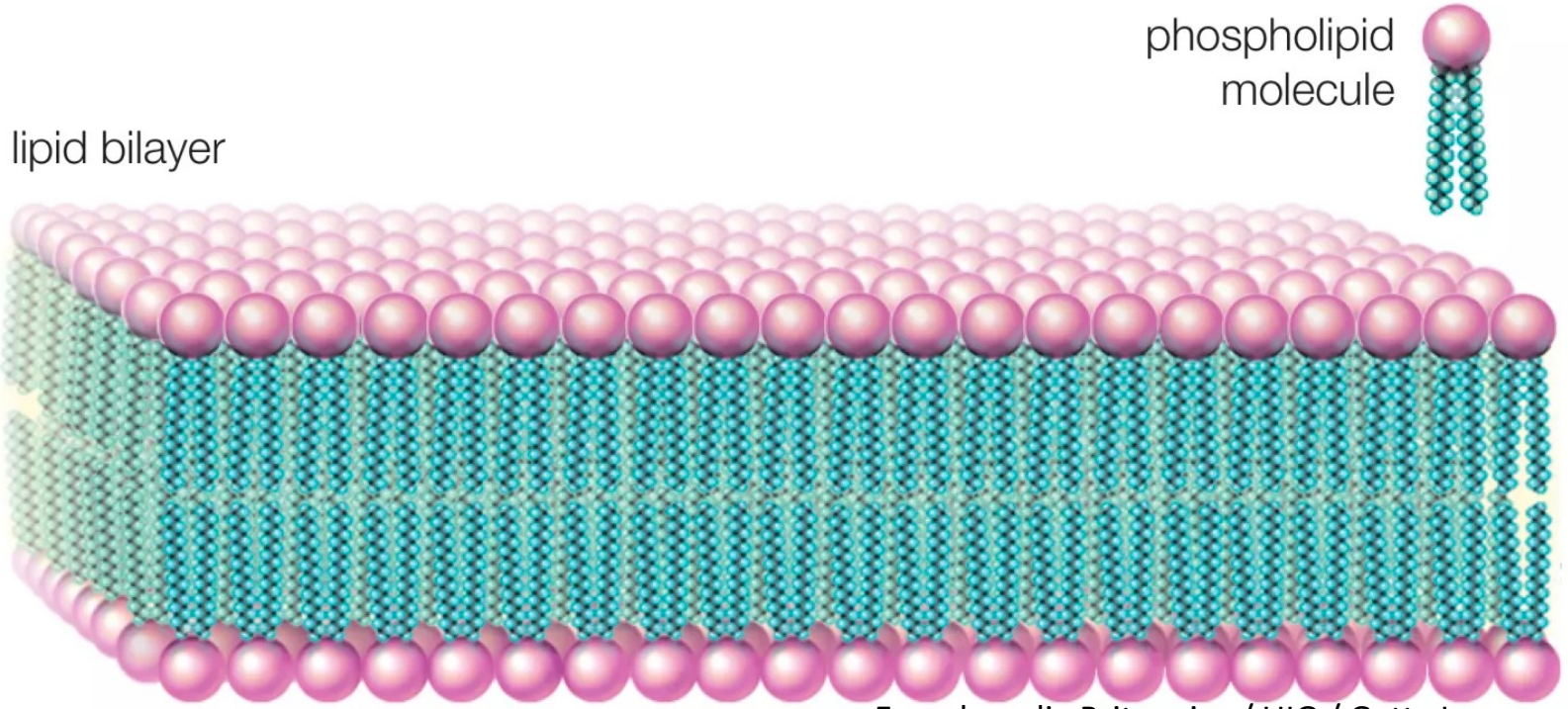
What if a tiny reaction chamber invents lipids?

Hydrophilic head:
attracted to water

Hydrophobic tails:
avoid water



Lipids in water spontaneously form “bilayer” sheets



Encyclopedia Britannica / UIG / Getty Images

I don’t know how to draw this …

- Imagine a tiny chamber in a black smoker tower
- Nice-n-warm, lots of energy, lots of minerals
- Lipids
- Chamber wall gets “wallpapered” with lipids
- A fatty/waxy boundary for reactions
- And when the smoker collapses ➔ Tiny cell-like objects are released into the water column, with an intact membrane
- Maybe their self-replication used RNA (the “RNA world” hypothesis)
- By 4 Ga: Single-celled organisms using DNA

8 slides back…

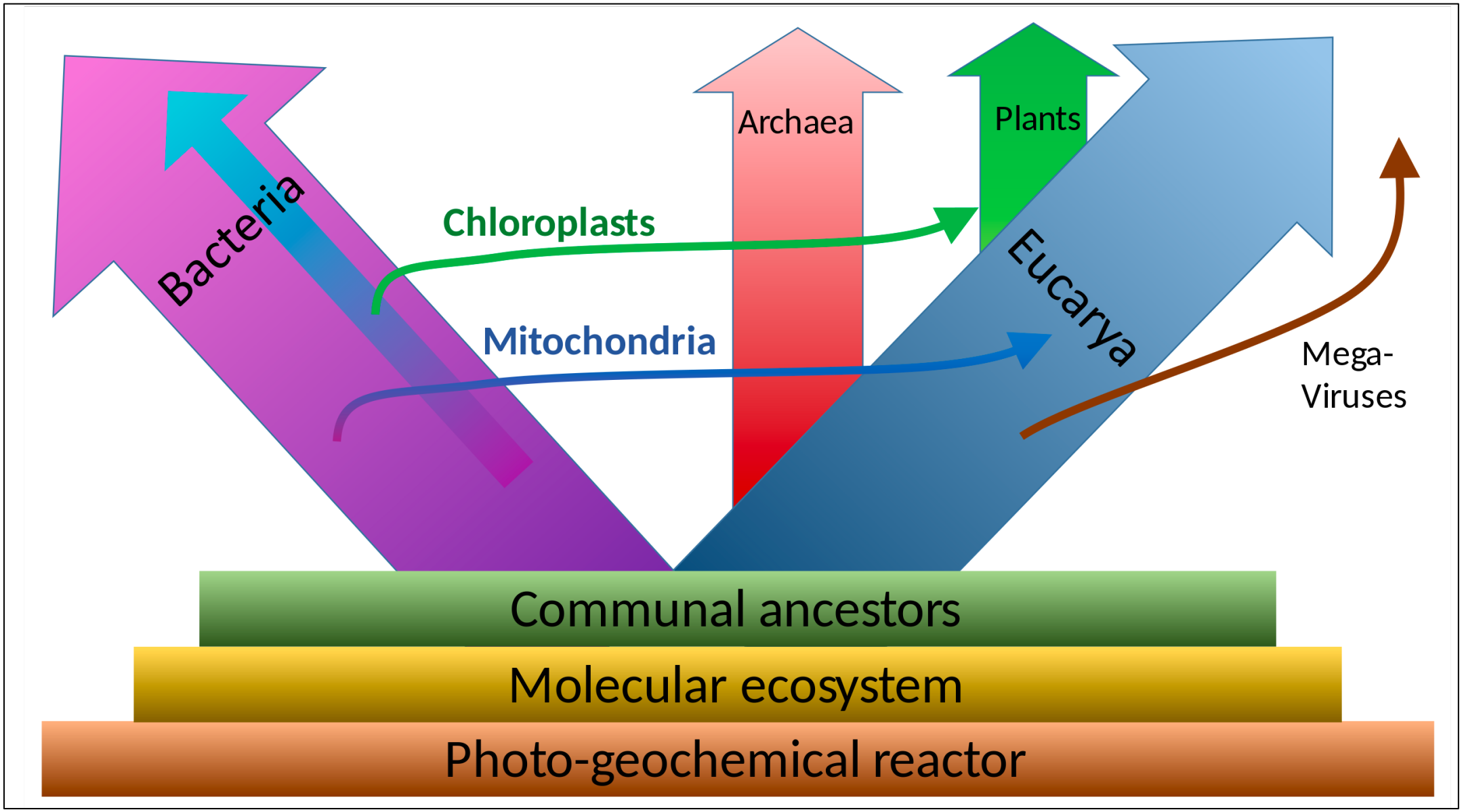
- Hey – why is the sky brown?
- 4 Ga: End of intense bombardment + liquid surface water.
- 3.2 Ga: Photosynthesis
- Only an oxygen-rich atmosphere is blue

8 slides back…

- Hey – why is the sky brown?
- 4 Ga: End of intense bombardment + liquid surface water
- 3.2 Ga: Photosynthesis
- Only an oxygen-rich atmosphere is blue
- Today: 21% O2

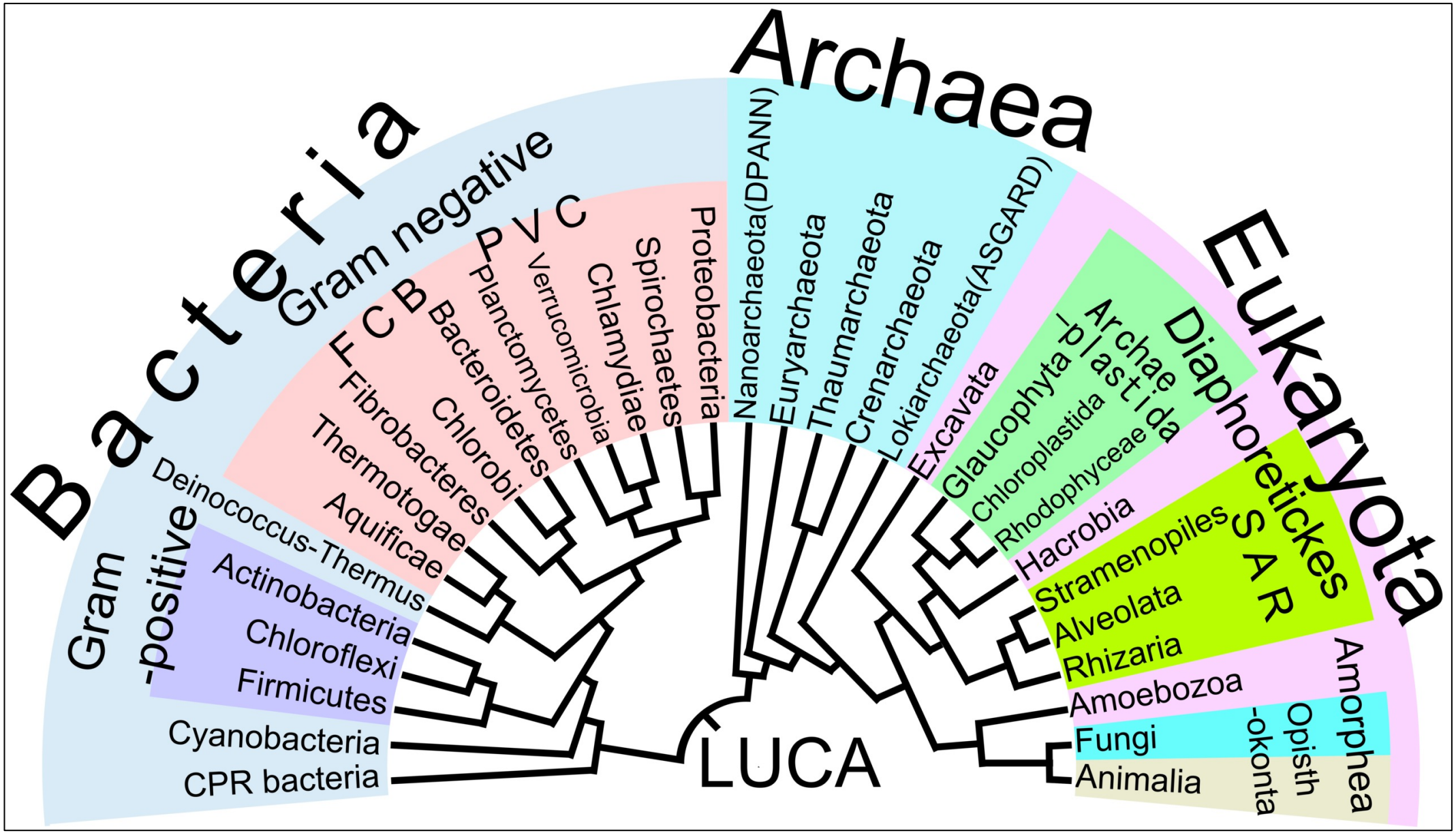
Time passed …

2.7 Ga: Eukaryotes



Wikipedia

2.7 Ga: Eukaryotes



Wikipedia

600 Ma: Multicellular life

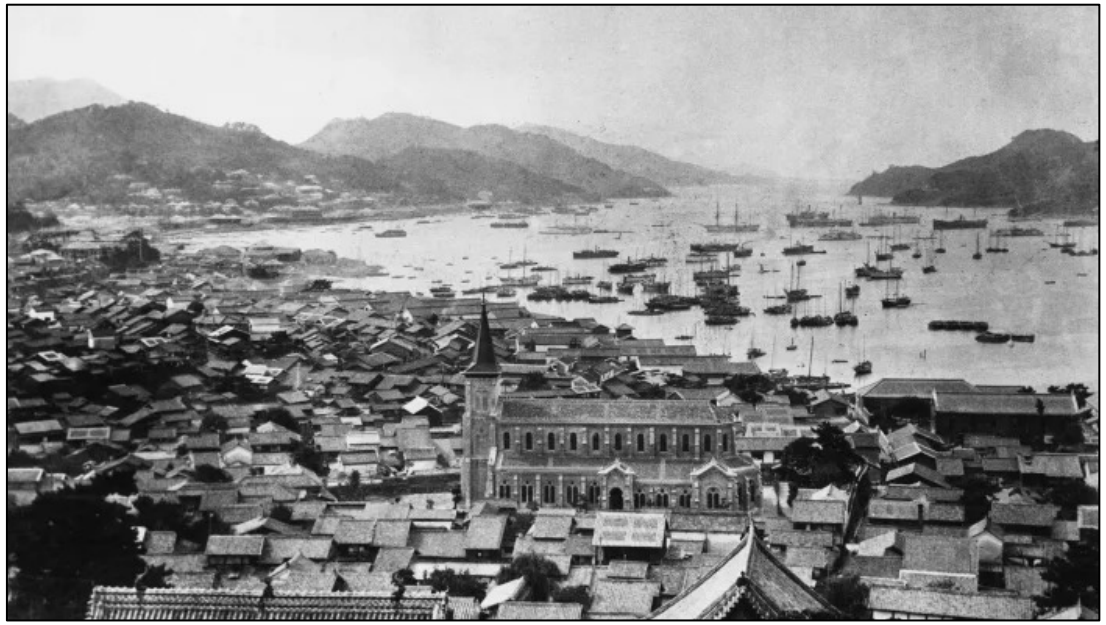
"One hypothesis for the origin of multicellularity is that a group of function-specific cells aggregated into a slug-like mass called a grex, which moved as a multicellular unit. This is essentially what slime molds do." - Wikipedia

Between uni- and multicellular: Filaments of specialized individuals

- Genetically identical
- Functionally different

More time passed …

Time passed … until August 1945



Nagasaki, before and after detonation of one of the smallest nuclear weapons ever made

Nuclear nations tested increasingly powerful nukes through 1963

Nagasaki, 1945: 20Kt

Nuclear nations tested increasingly powerful nukes through 1963

Castle Bravo, Bikini Atoll, 1954: 15 Mt

Nuclear nations tested increasingly powerful nukes through 1963

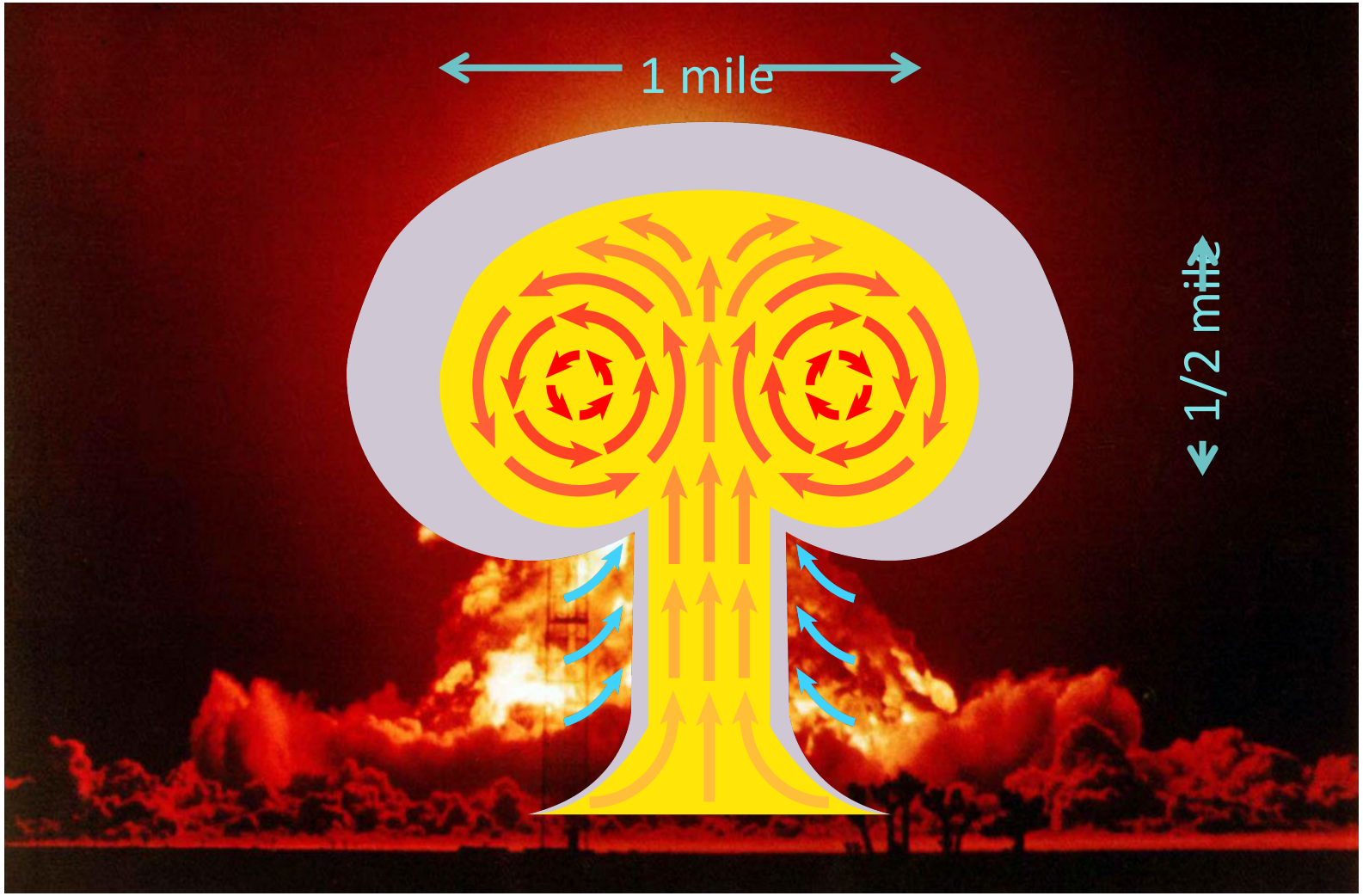
Tsar Bomba, USSR, 1961: 50 Mt

50 miles away

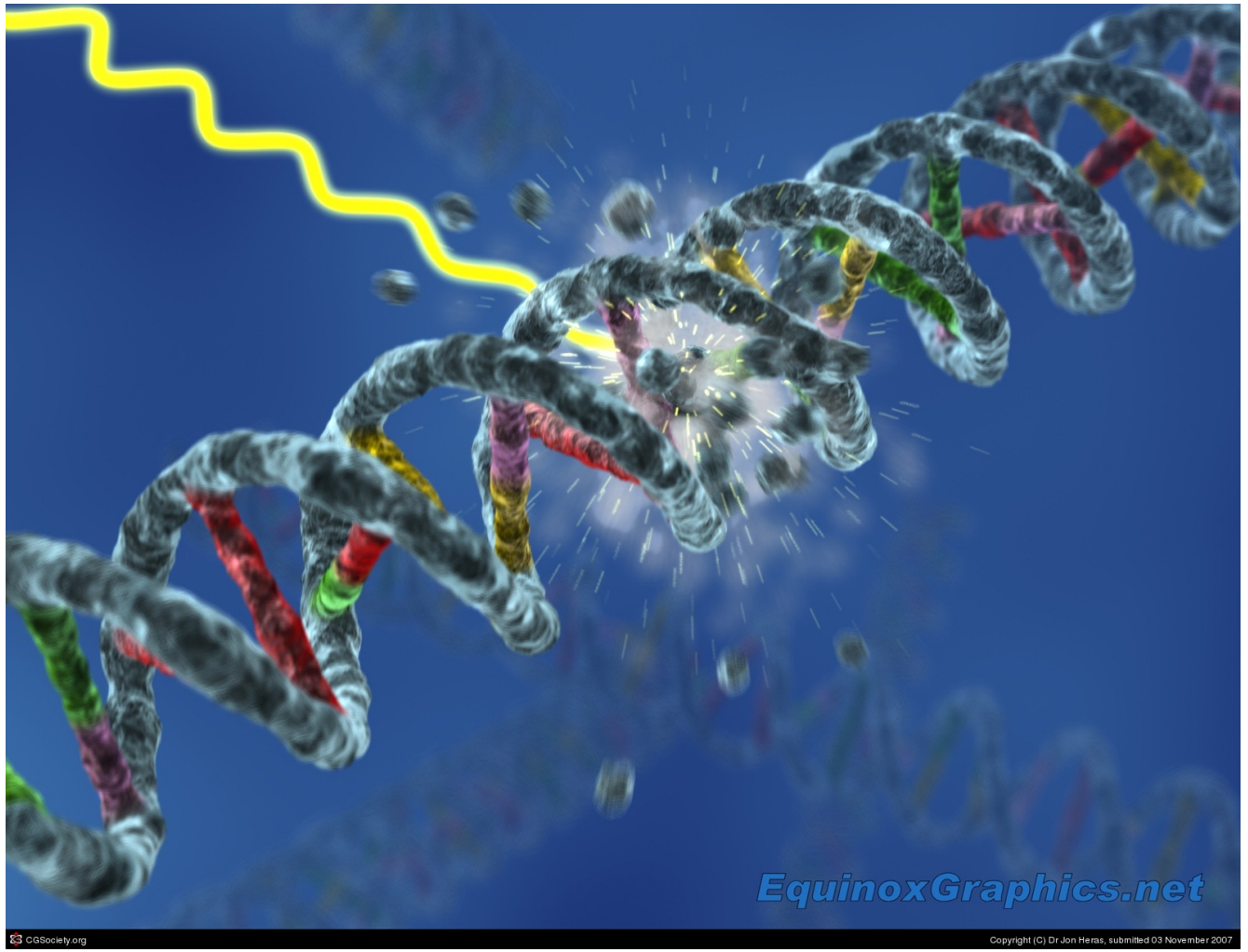
Nuclear nations tested increasingly powerful nukes through 1963

Nuclear test ban treaty … still in effect

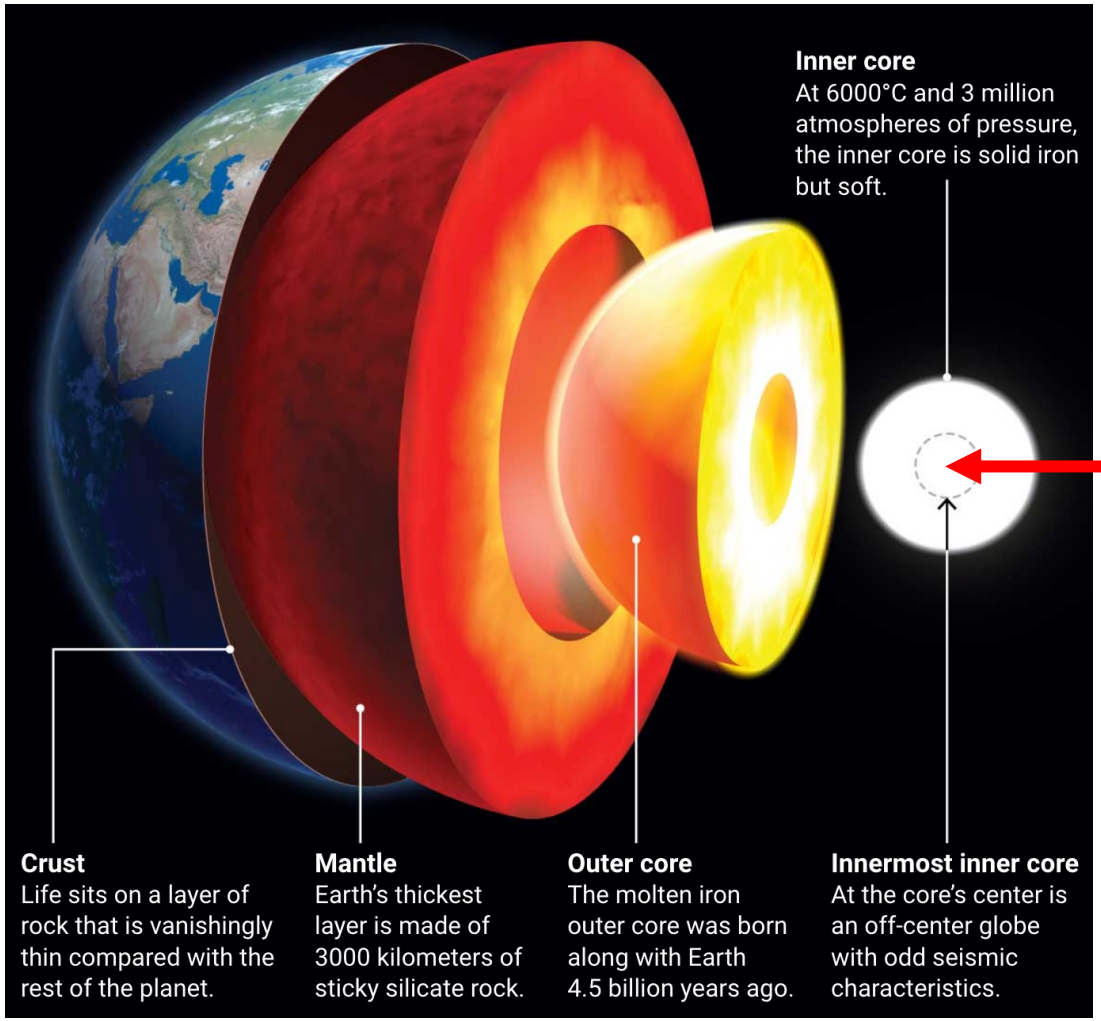
The threat of nuclear testing: fallout



My point, and I do have one, is this …

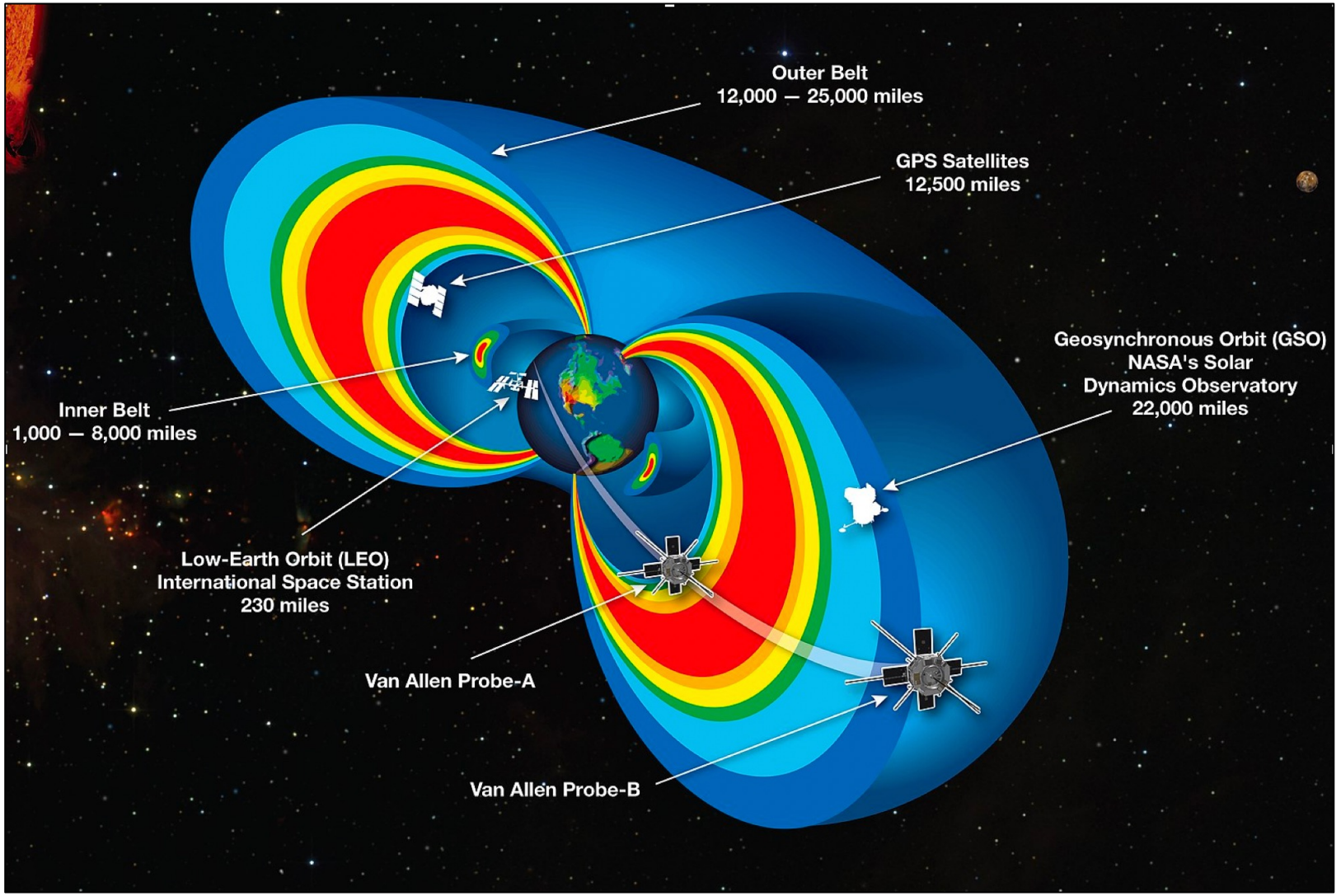


Harmful radiation also reaches us from space, especially from the sun, but…

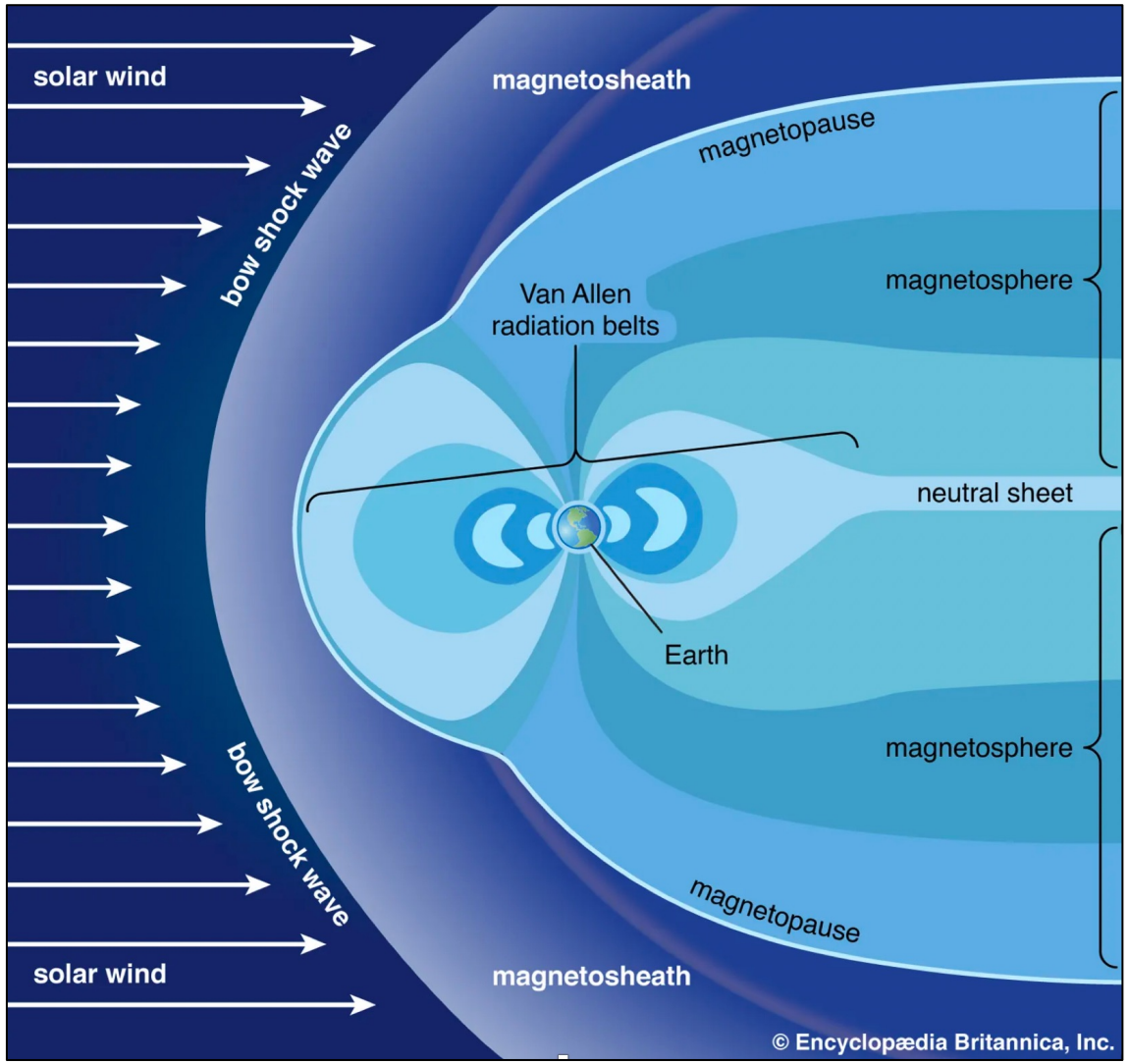


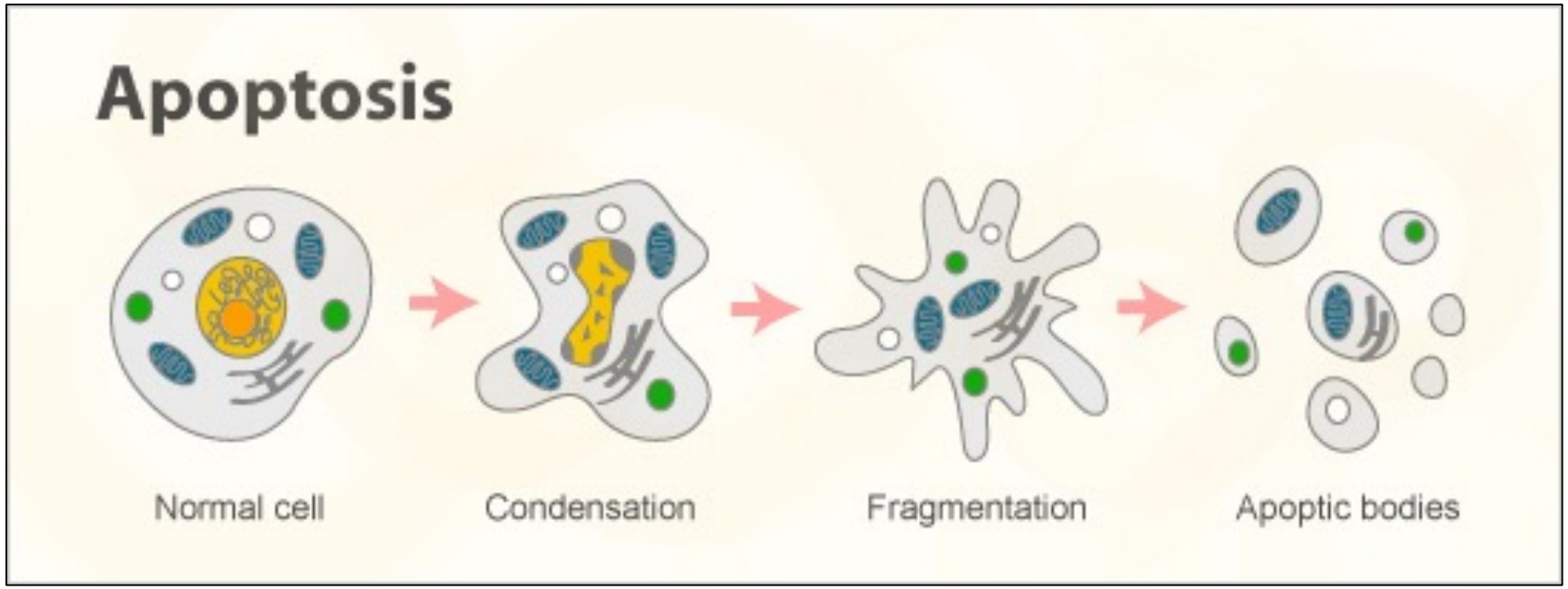
Remember that iron innermost core?

Harmful radiation also reaches us from space, especially from the sun, but…



Harmful radiation also reaches us from space, especially from the sun, but…




Apoptosis
Normal cell
Condensation
Fragmentation
Apoptic bodies

Effects of gene disruption

- Ion transport gene → cell can't transport ions → apoptosis kills the cell
- Cell division gene → cell can't divide → apoptosis kills the cell
- tRNA gene → cell can't translate → apoptosis kills the cell
- Apoptosis gene → cell can't do apoptosis → cell doesn't die → ???

- Prevalence of disease & death downwind of test sites drove interest in Genomics and, eventually, Bioinformatics.

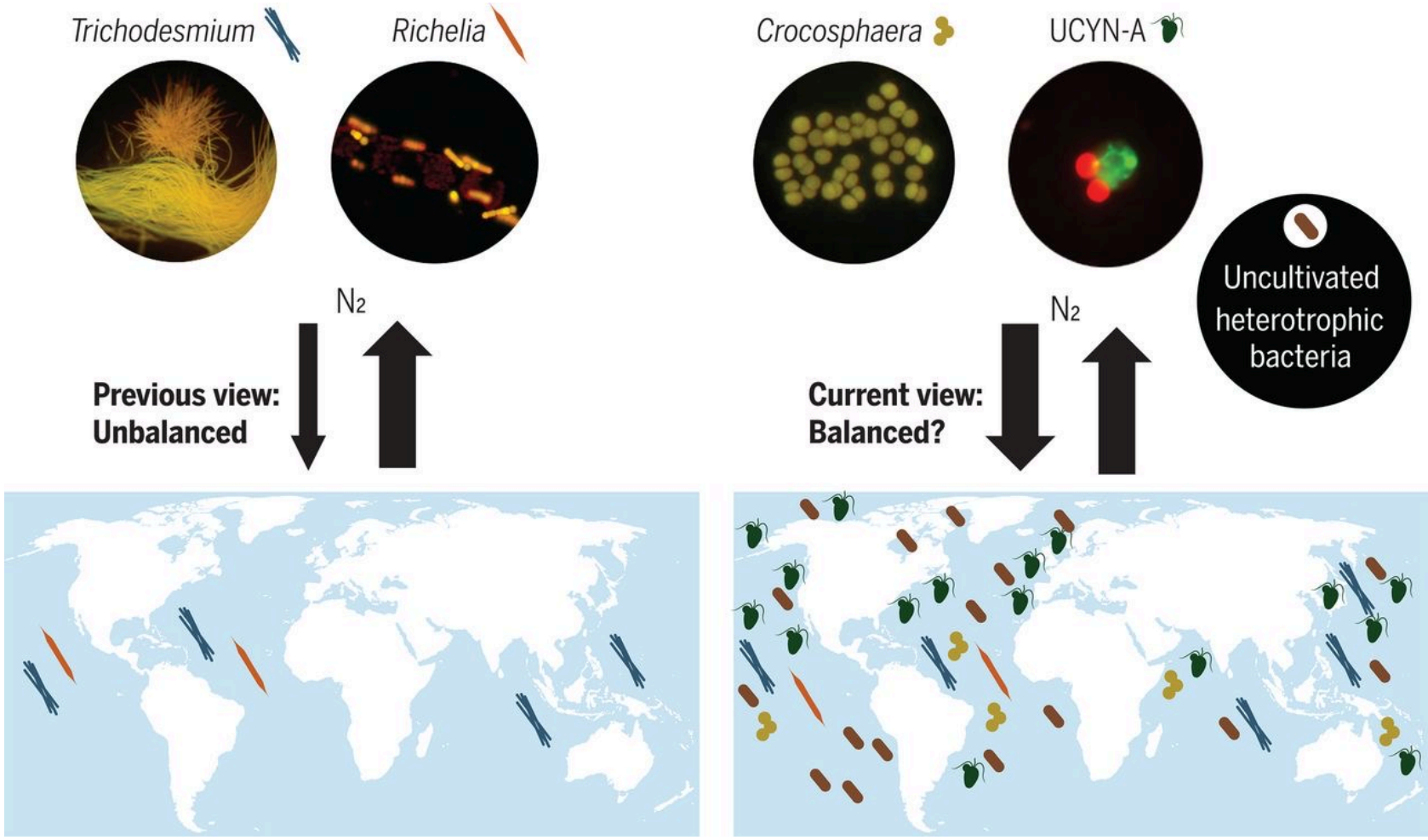
Applying bioinformatics to marine systems

- Understand ecology
  - patterns and processes that govern abundances and distributions of marine organisms
  - Meaning how many and where marine organisms are located

- Understand the evolution of life in the ocean

From microbes to charismatic megafauna

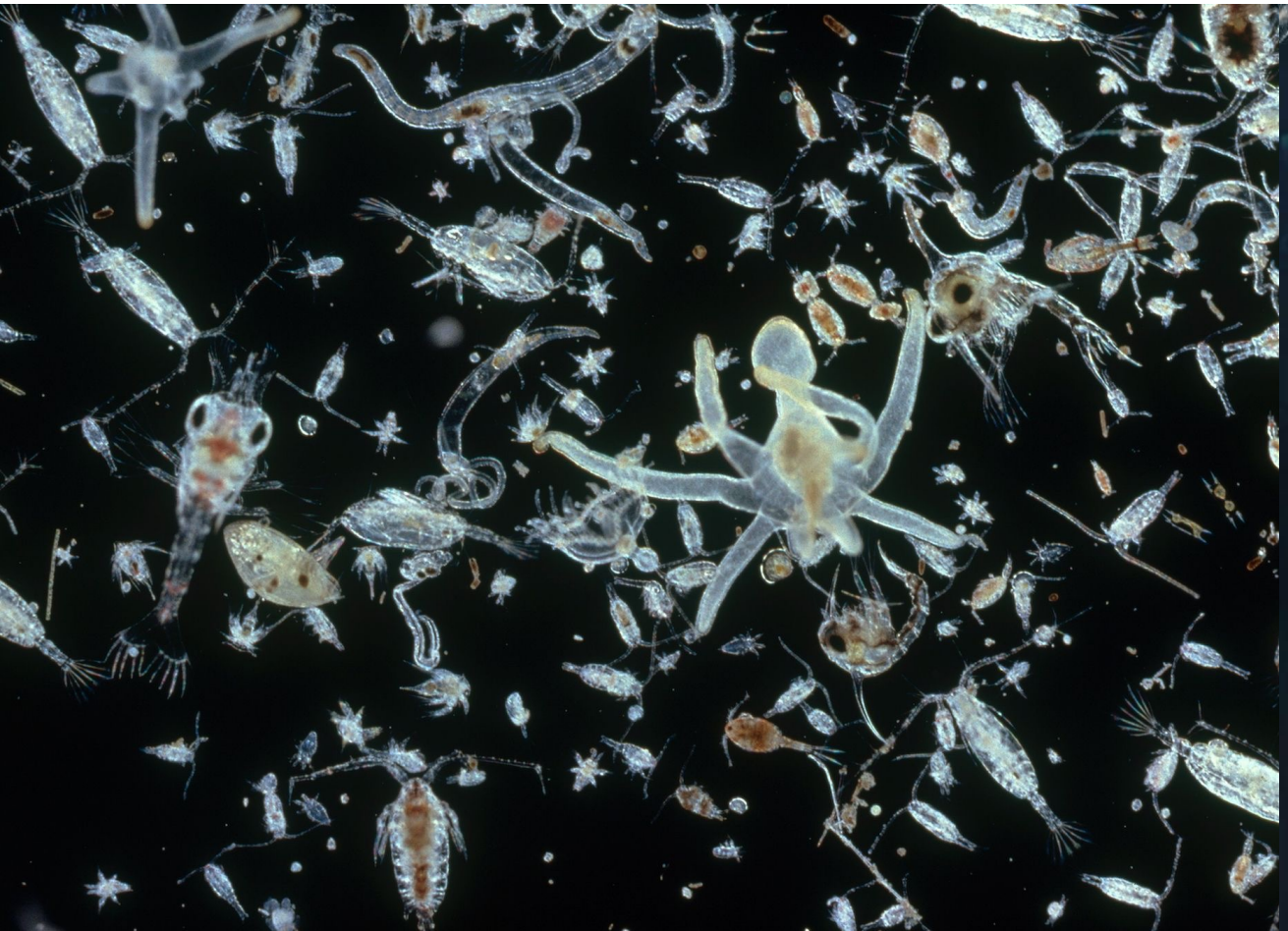
How are the building blocks of life (i.e. DNA) generated in the sea? - nitrogen fixation



Zehr and Capone. 2020. *Science*.

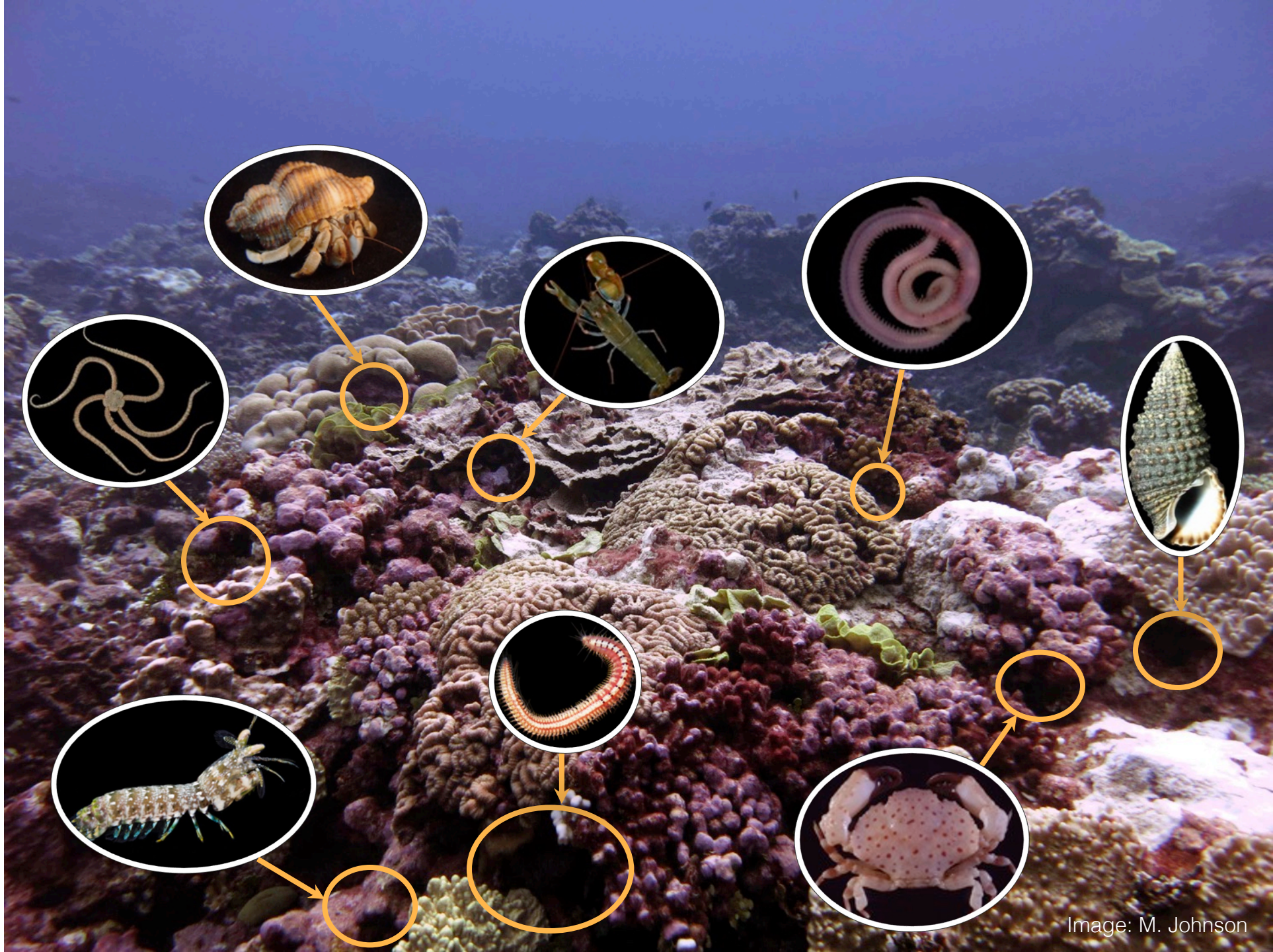
From microbes to charismatic megafauna

What is the basis of most marine food webs? - plankton



From microbes to charismatic megafauna

What is one of the most diverse ecosystems on the planet? – coral reefs



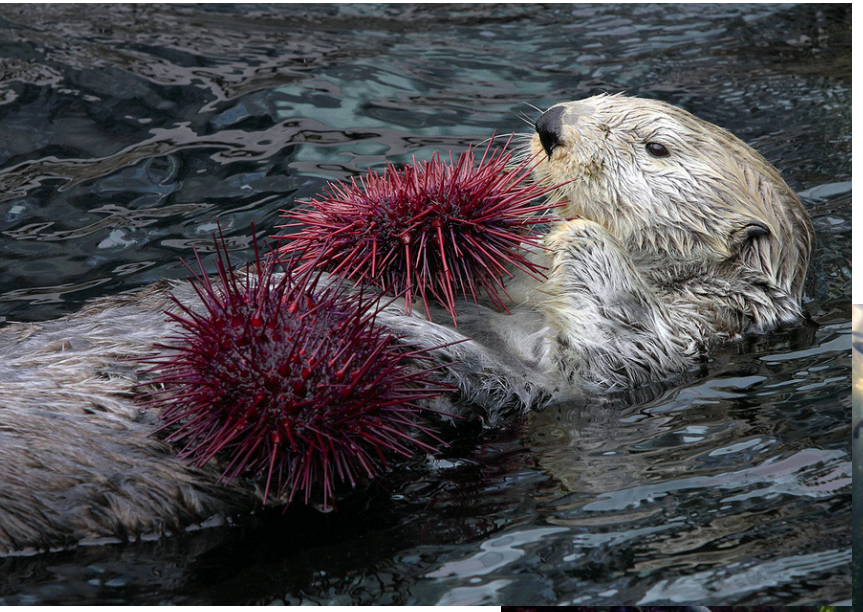
From microbes to charismatic megafauna

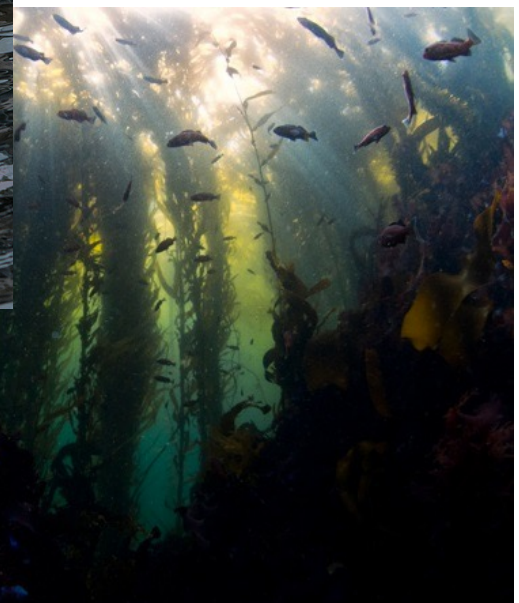
What helps sustain life on coral reefs? – sponges and calcified coralline algae

How do organisms make a living on coral reefs? – mantis shrimp example

From microbes to charismatic megafauna

What keystone species helps control kelp forest dynamics? – sea otters





What is the most charismatic marine organism? – whales

Conservation genetics