

# SIO: 121 Biology of the Cryosphere

Jeff Bowman

- Course logistic and introduction
  - Introduce the cryosphere
  - Biology/ecology review

Index card:

Name

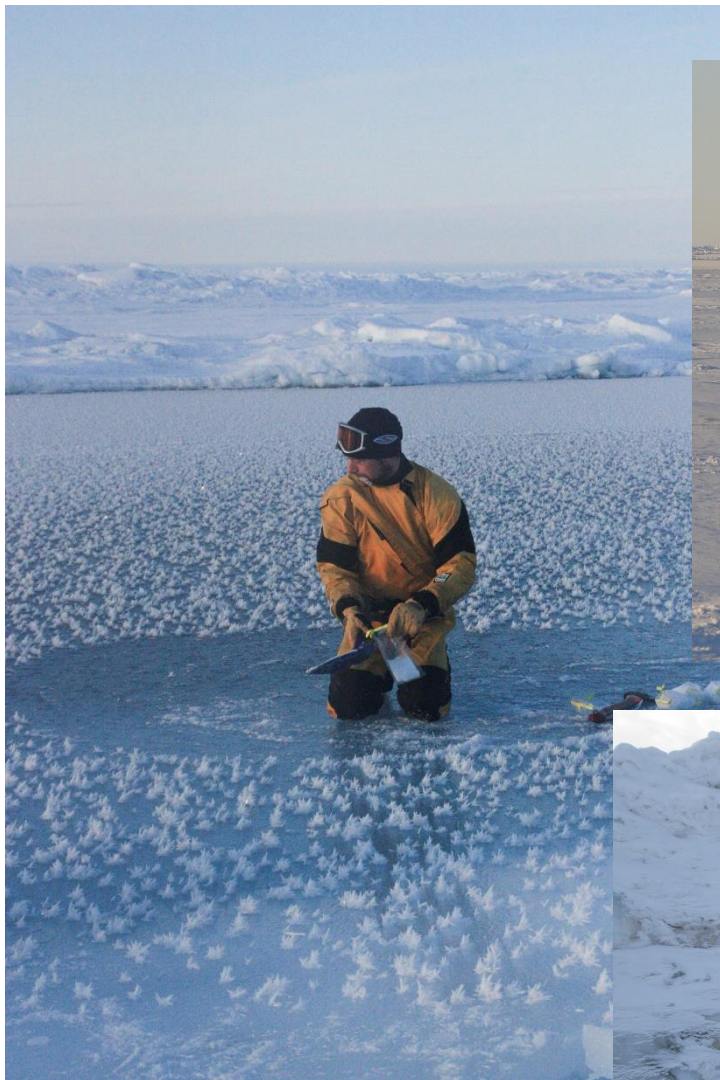
College

Major

Year

Post-BA/BS goals (“I don’t know” is an appropriate answer)

One interesting fact about you



Central Arctic, 2009



Barrow, 2009-2013

# Syllabus

The possible topics for your major assignments should be a natural process relevant to the cryosphere.

Static things vs. processes:

- a (1): a natural phenomenon marked by gradual changes that lead toward a particular result; the process of growth
- (2): a continuing natural or biological activity or function, such life processes as breathing
- b: a series of actions or operations conducing to an end; especially: a continuous operation or treatment especially in manufacture

(Merriam-Webster)

Climate change

Incident radiation

Polar bear

Polar bear reproduction

Sea ice algae

Sea ice primary production

Cryosphere: from Greek word for cold, “kryos”. Those portions of our planet that are cold enough for water to *freeze*. **Thus it is the interaction between biology and ice, not just biology and cold, that is the focus of our discussions.**

Major components of the cryosphere:

- Sea ice
- Glacier/ice cap ice
- Lake/river ice
- Snow
- Permafrost
- Ice clouds

Other cold environments that are not explicitly part of the cryosphere:

- Deep ocean
- Temperate lakes
- Clouds
- Water clouds
- ...



Sea ice



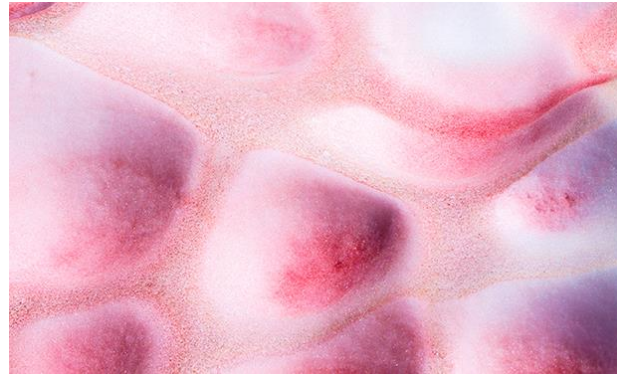
Glacier Ice



Lake/river ice



Snow



Permafrost

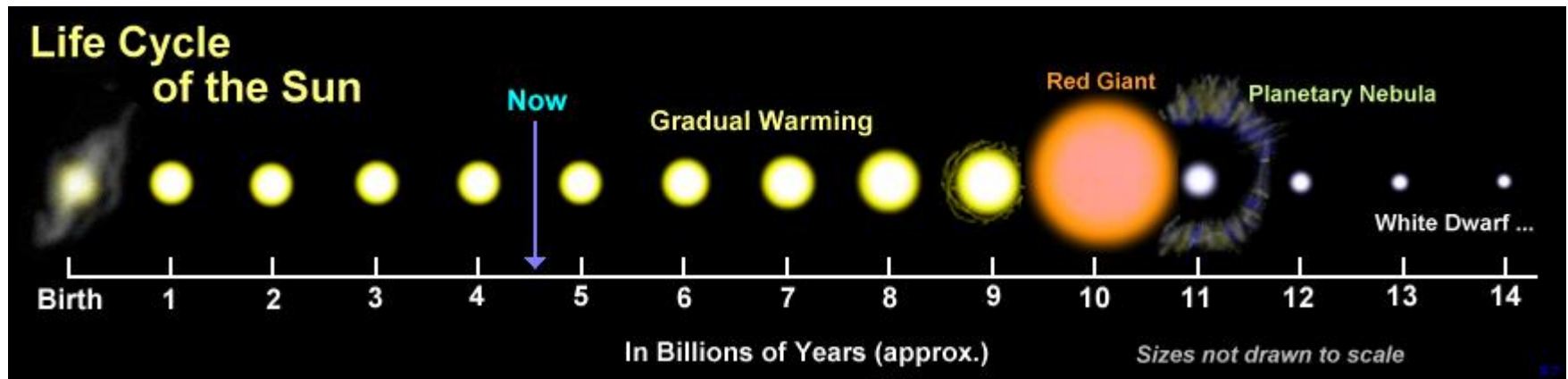




Q: Did Earth always have a cryosphere?

A: We don't know! But it's had one for a long time...

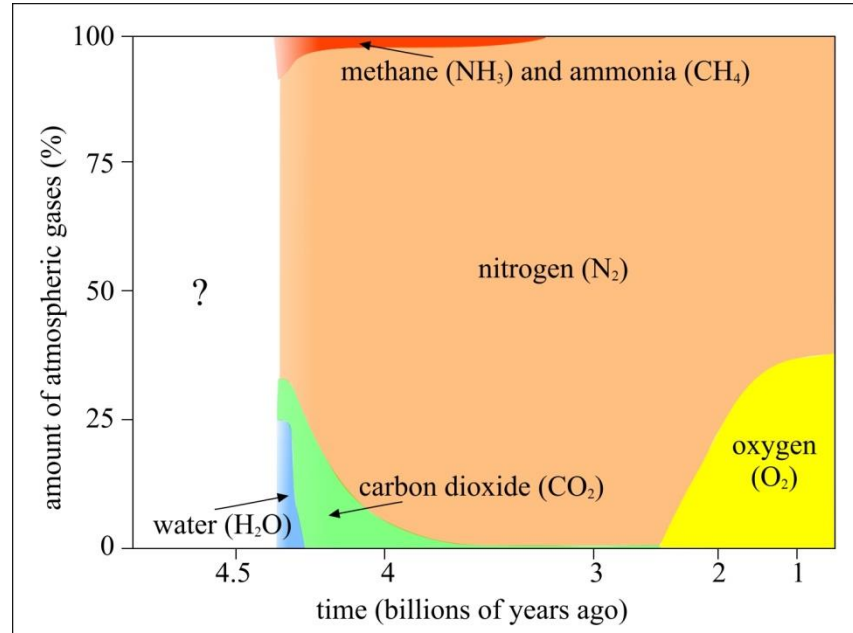
In the beginning the sun was smaller than today (70 % of current output), leading to the *faint young sun paradox*: there is geological evidence for liquid water very early in Earth's history, how was this water liquid?



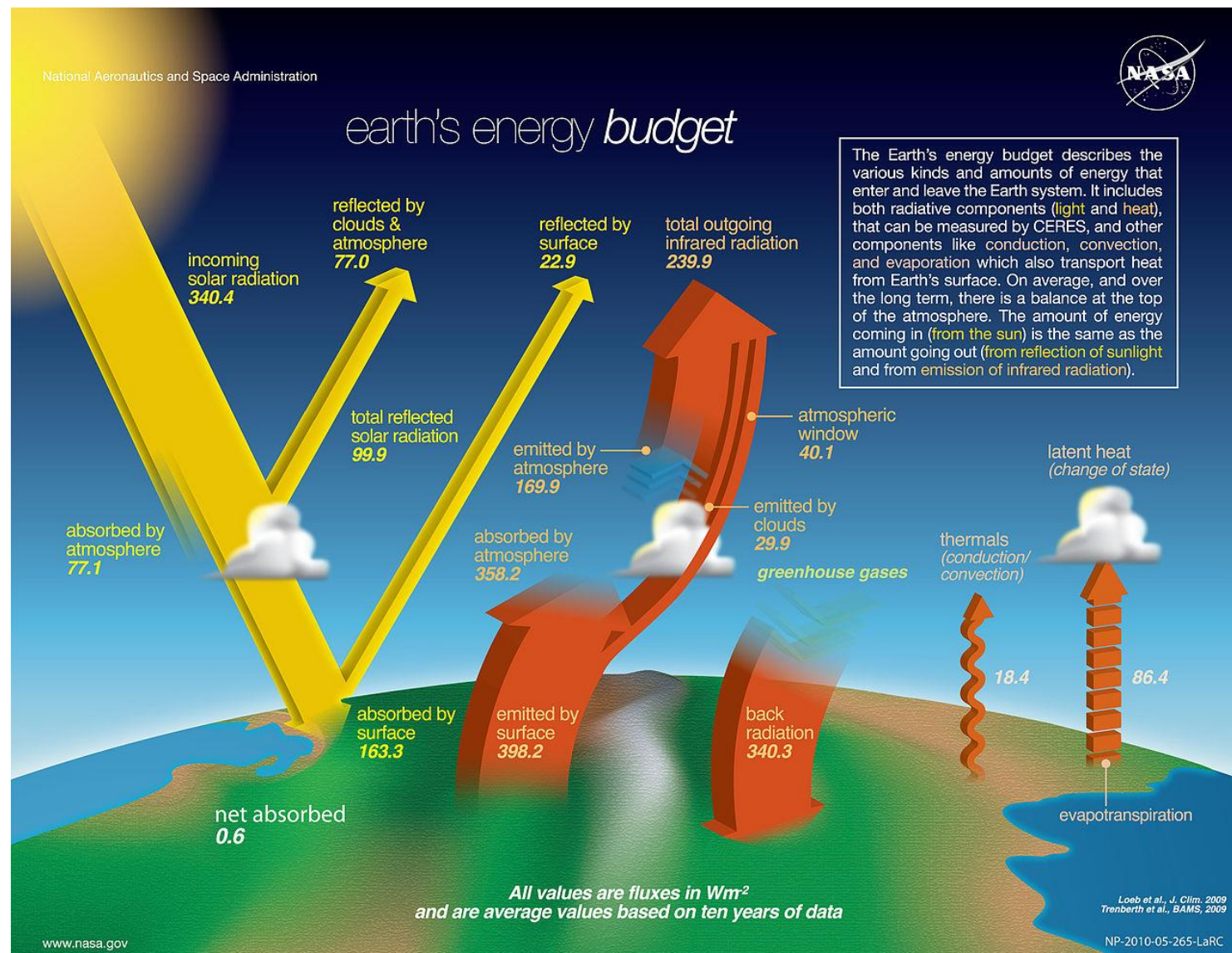
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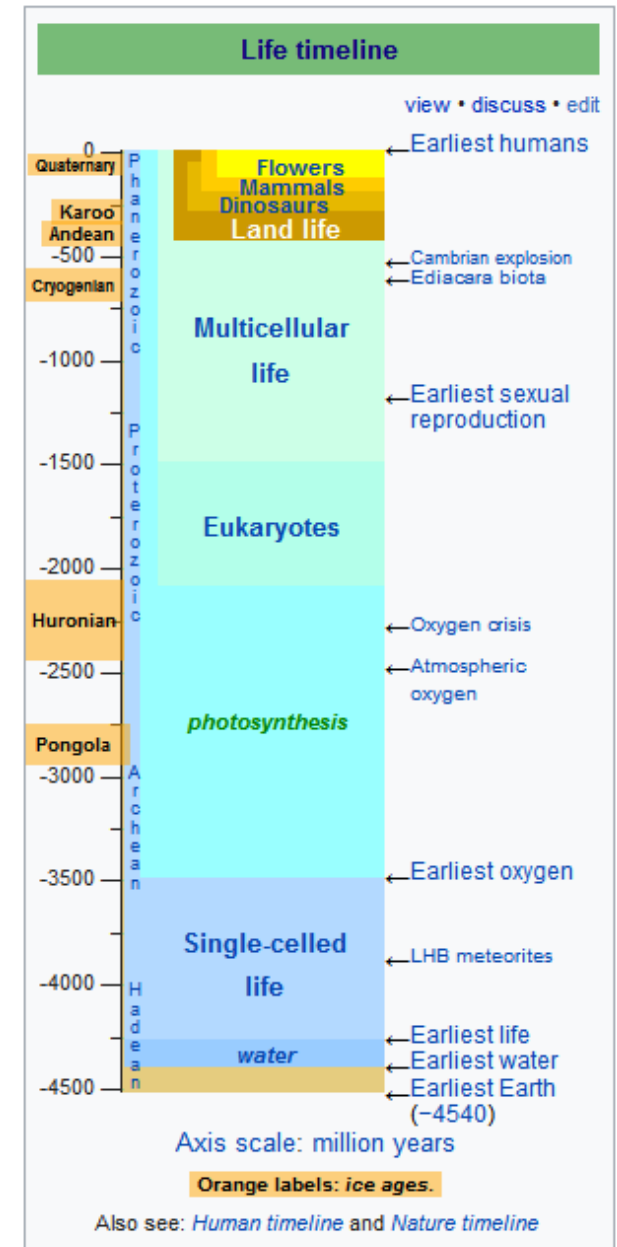
The abundance of ice is always linked to the composition of the atmosphere. There is a strong *positive feedback* at work.



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Q: How do we know when a landscape is glaciated (i.e., how do we know the cryosphere was present?)

A: Glaciers leave distinct physical and chemical marks on the environment



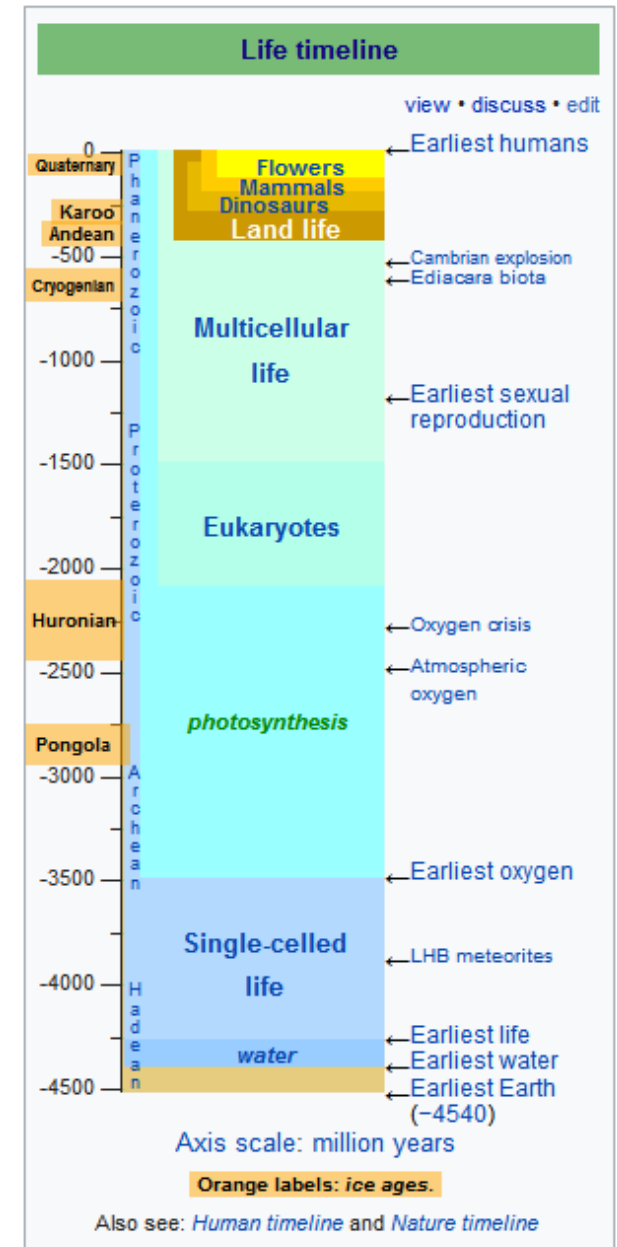


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Glacial drop stones



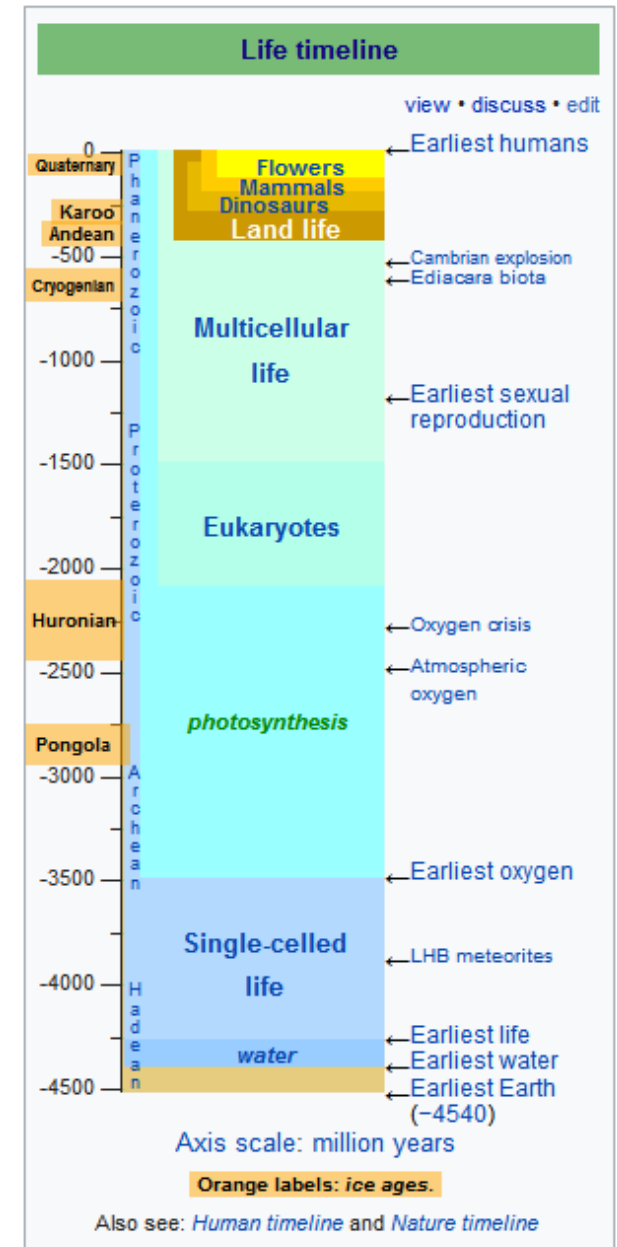


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Glacial striations



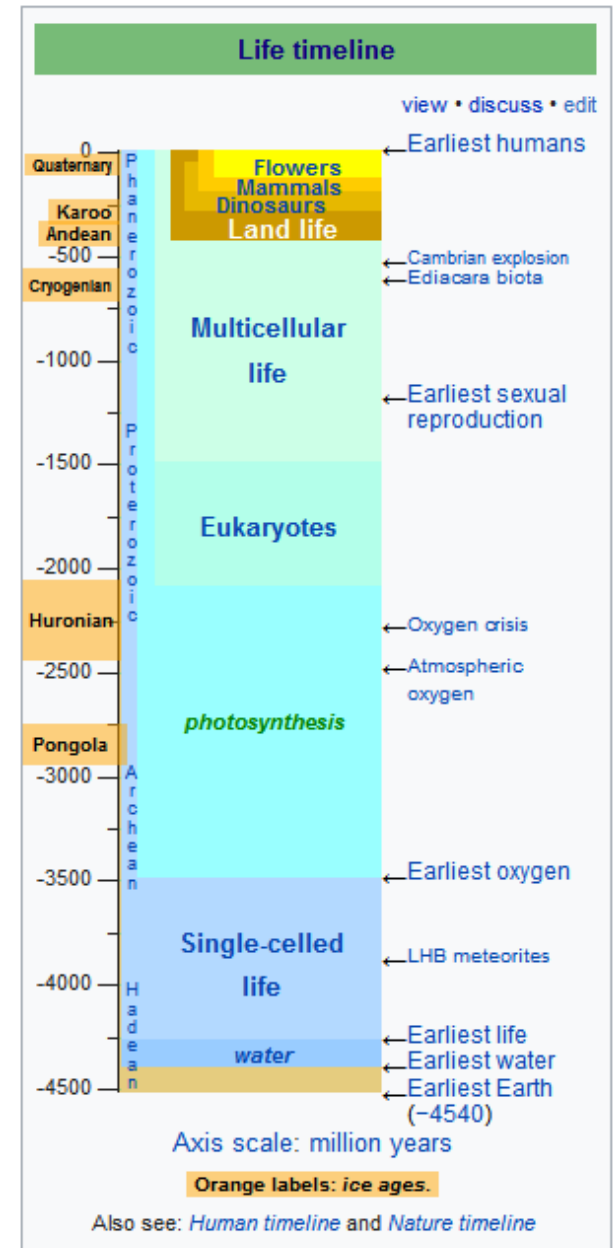
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- The first geological evidence for glaciers occurs at 2.9 Ga, but very little is known about this period.
- The Huronian glaciation at 2.2 Ga is the first event for which there is global geological evidence.
- These and other global glaciations are termed *snowball Earth* events.

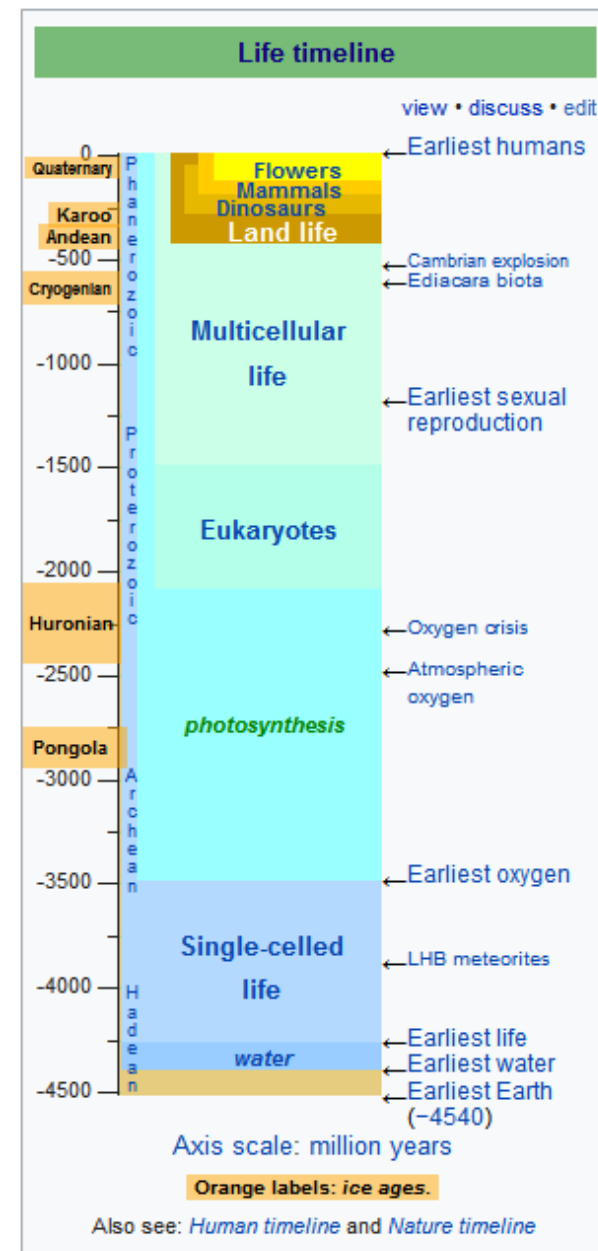
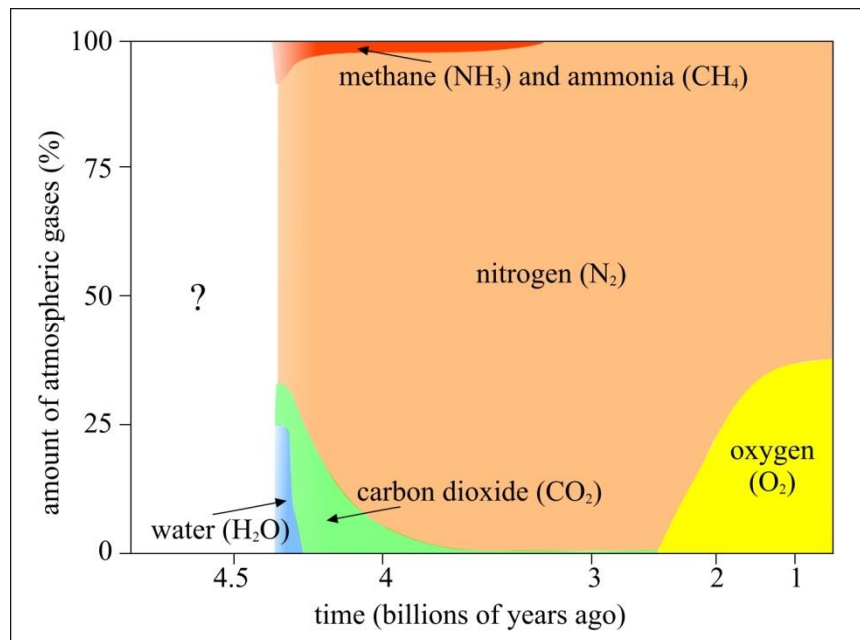
Q: What biological event likely initiated this global climate “catastrophe”?

A: The rise of oxygenic photosynthesis drew down atmospheric CO<sub>2</sub> and methane, creating a strong reverse-greenhouse



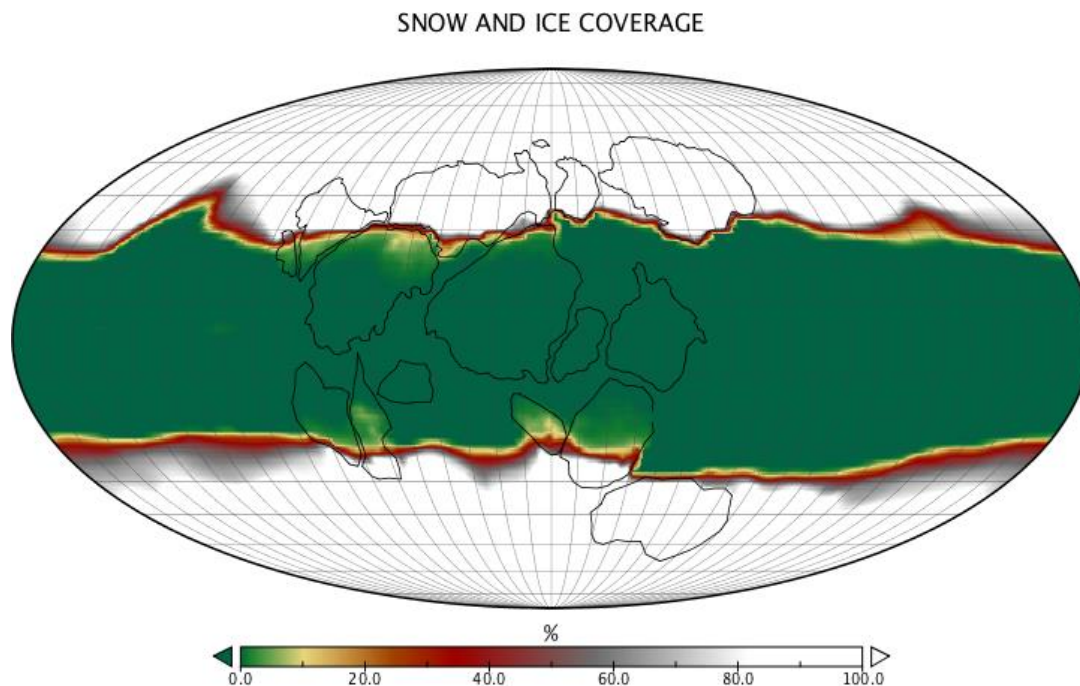
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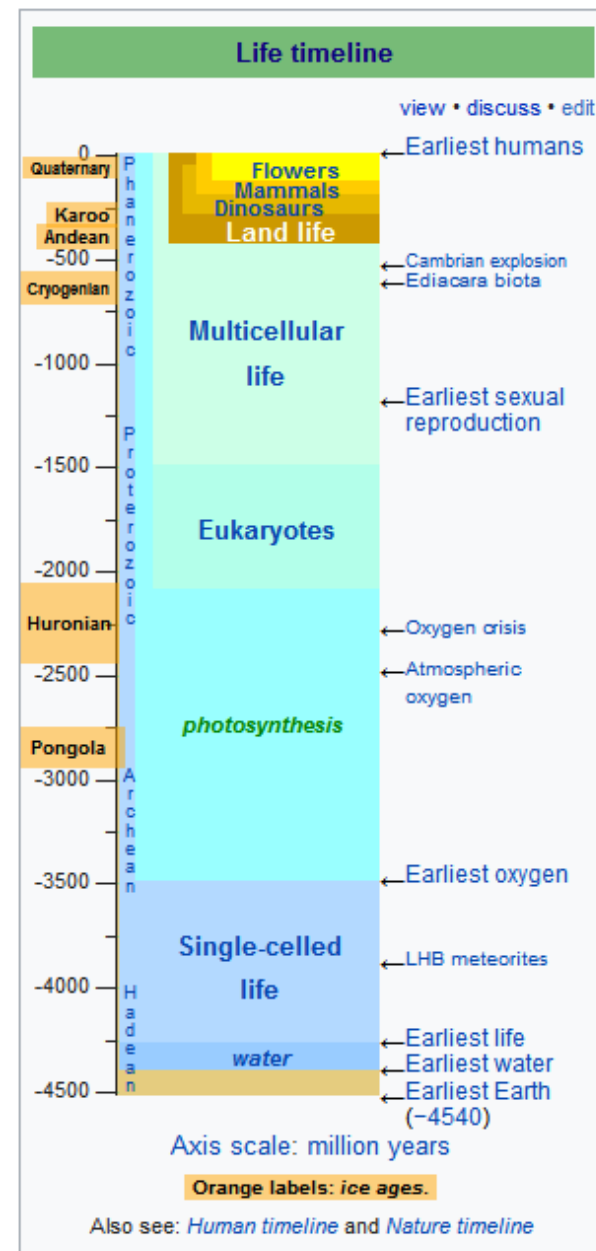


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Predicted ice extant during the Silurian snowball Earth event at ~715 Ma



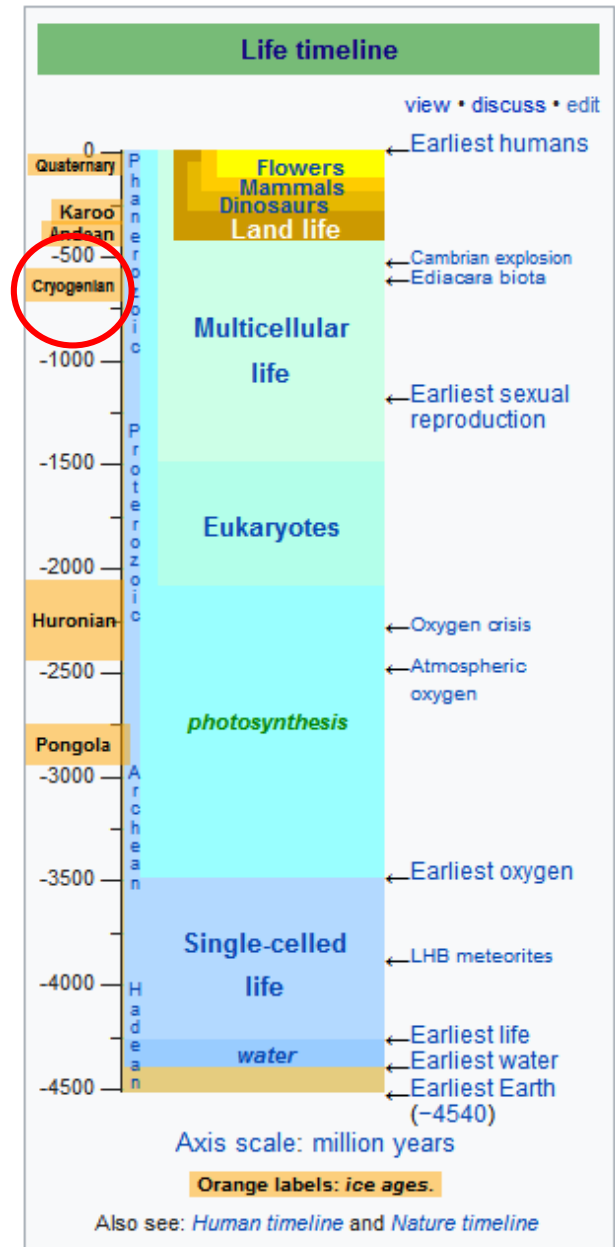


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Q: What important biological event follows the snowball Earth event ending ~600 Ma?

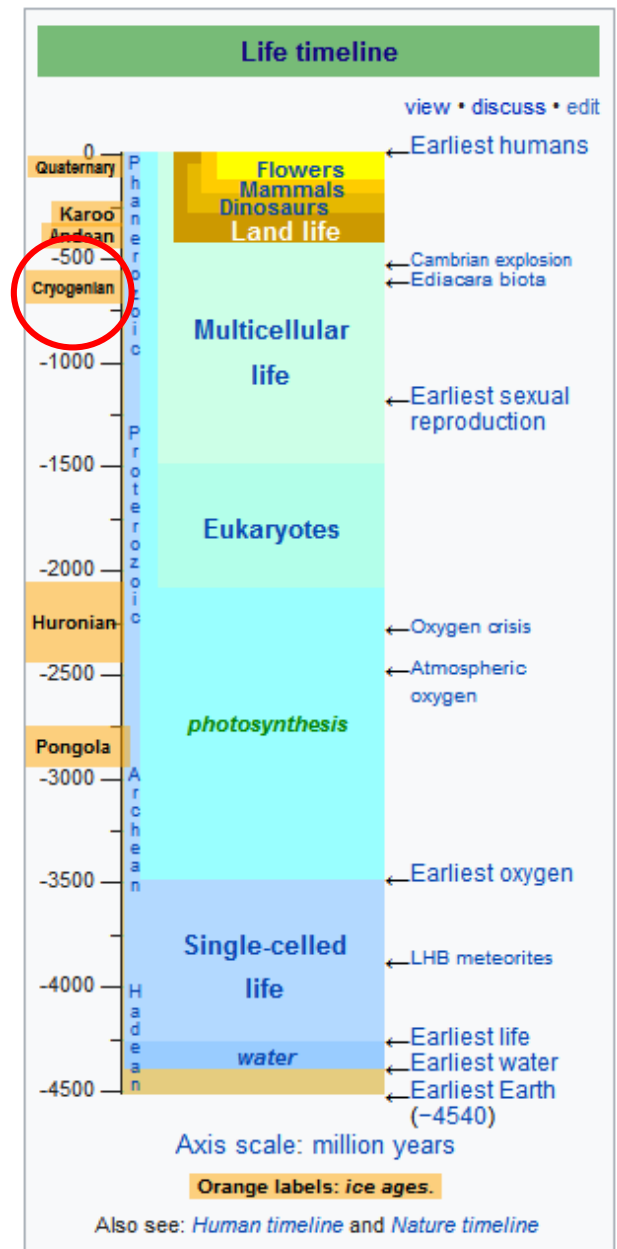
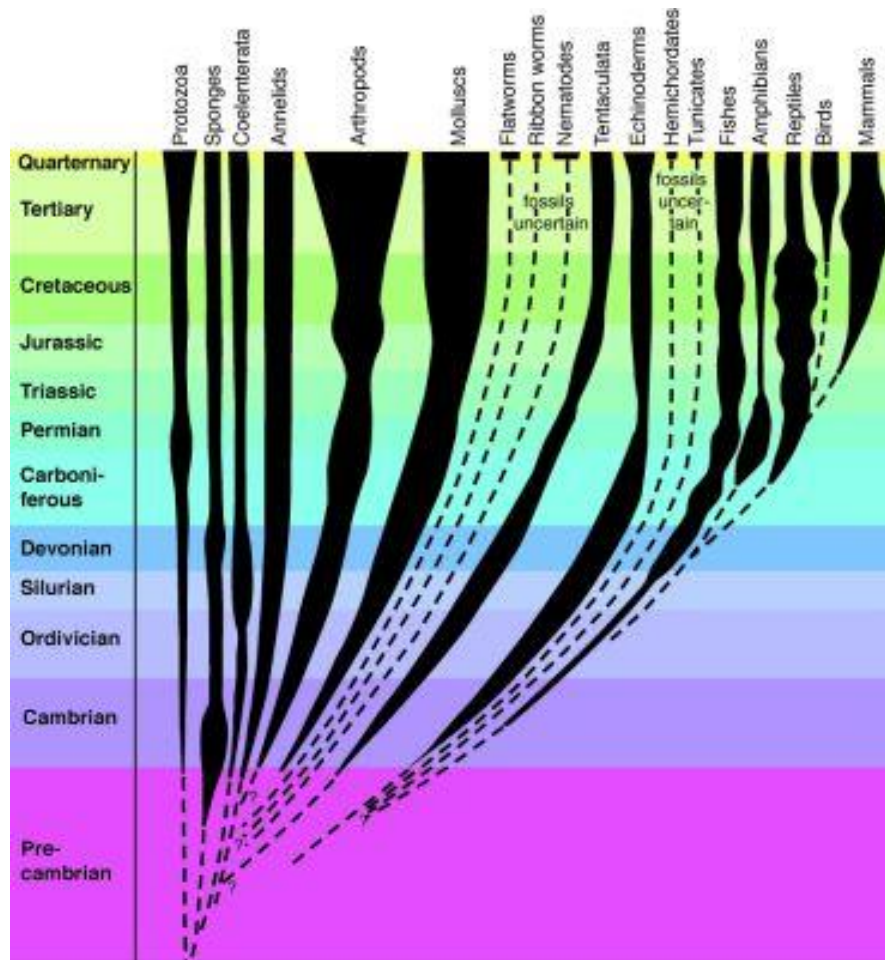
A: The Cambrian explosion – a profound increase in metazoan diversity. May have been initiated by the sudden creation of many new ecological niches.





Q: How do we know when a landscape is glaciated (i.e., how do we know the cryosphere was present?)

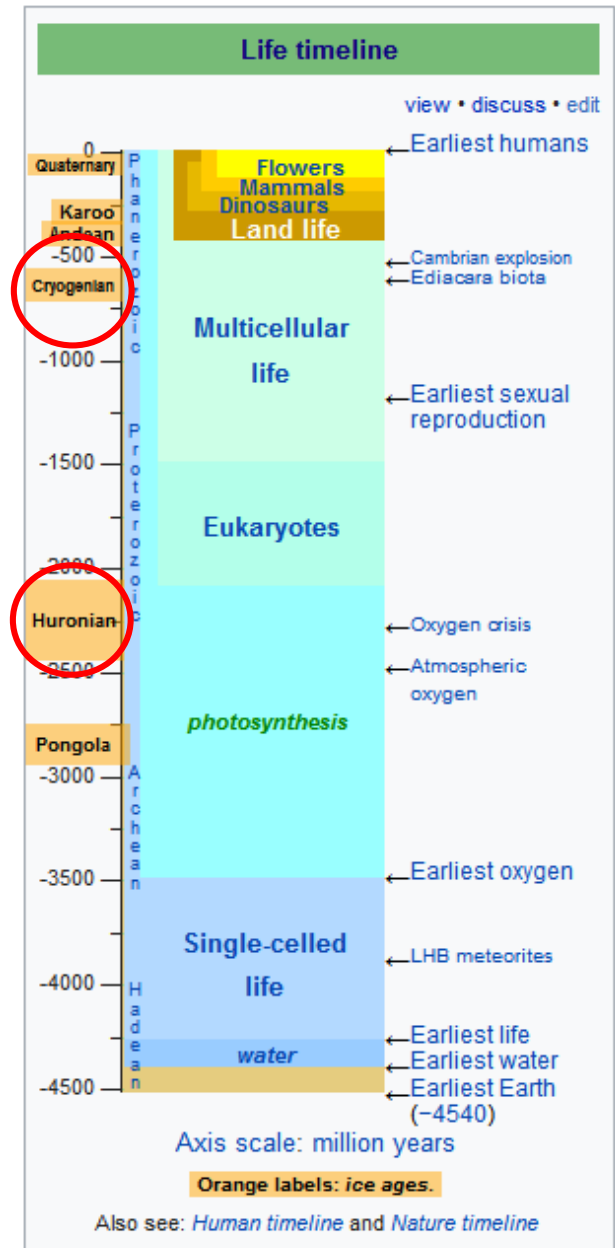
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Lessons from snowball Earth(s): The biosphere and geosphere – and by extension biology and the cryosphere – are intimately linked. Each effects the other.



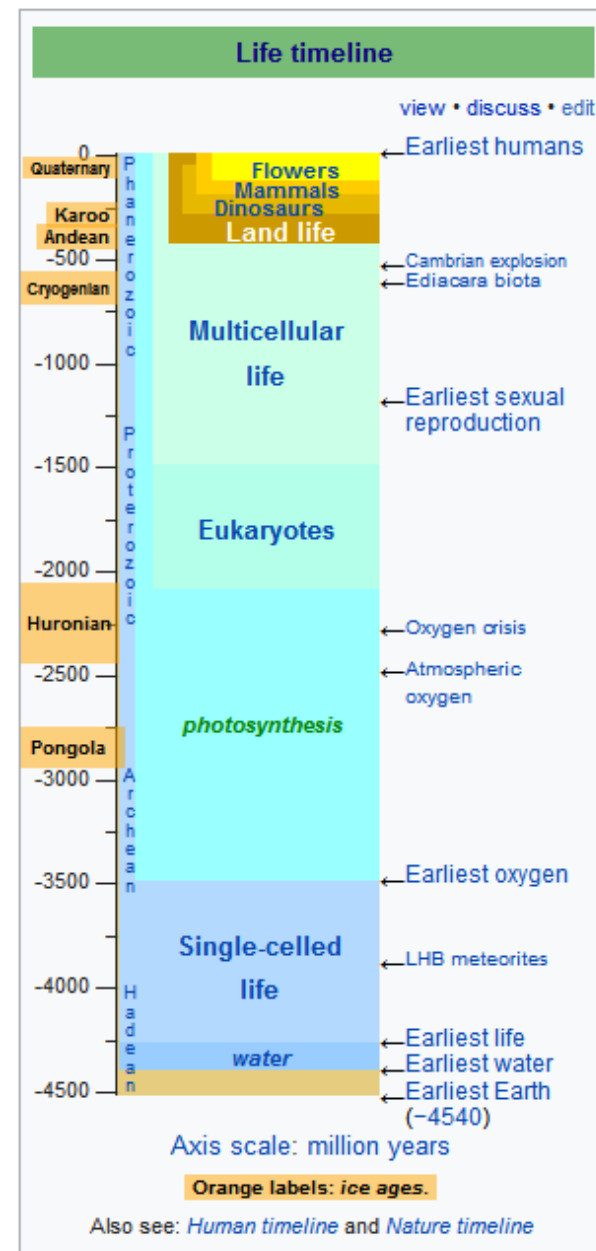
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We know much more about the cryosphere over the last ~600 Ma because of a better geological record

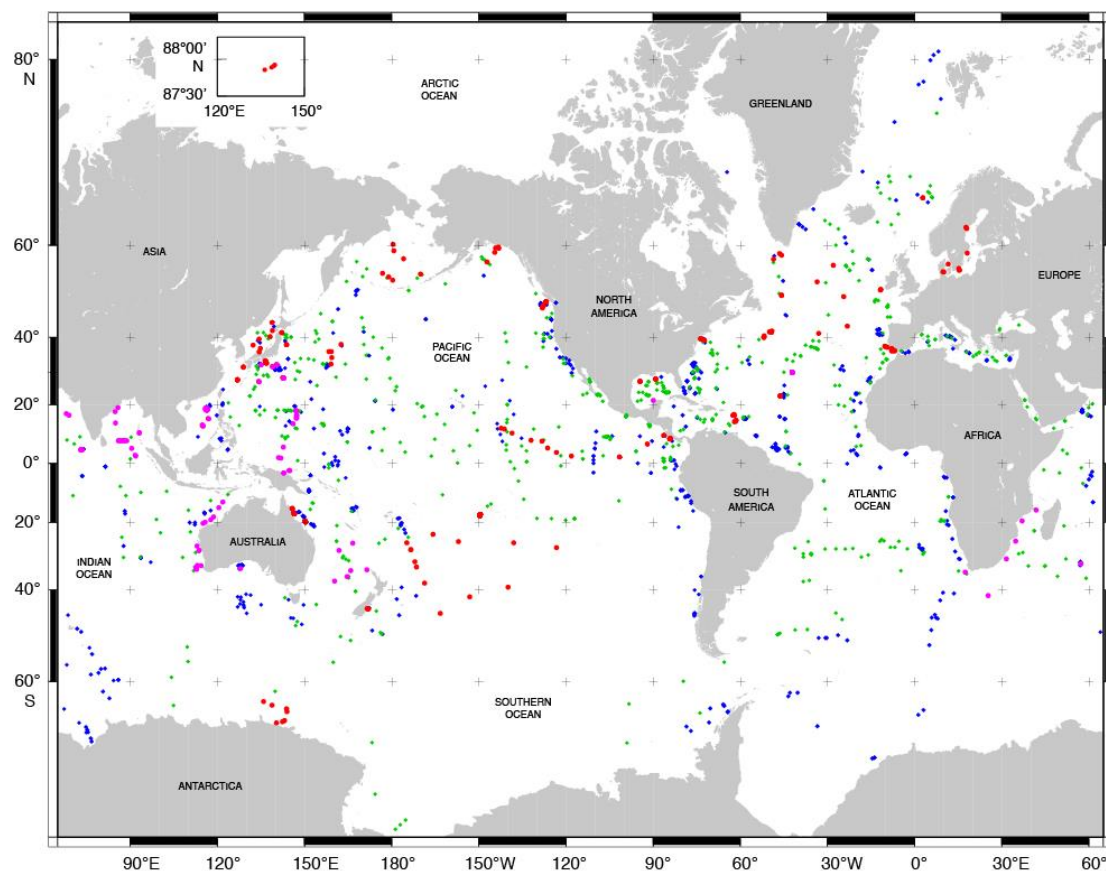


*JOIDES Resolution*

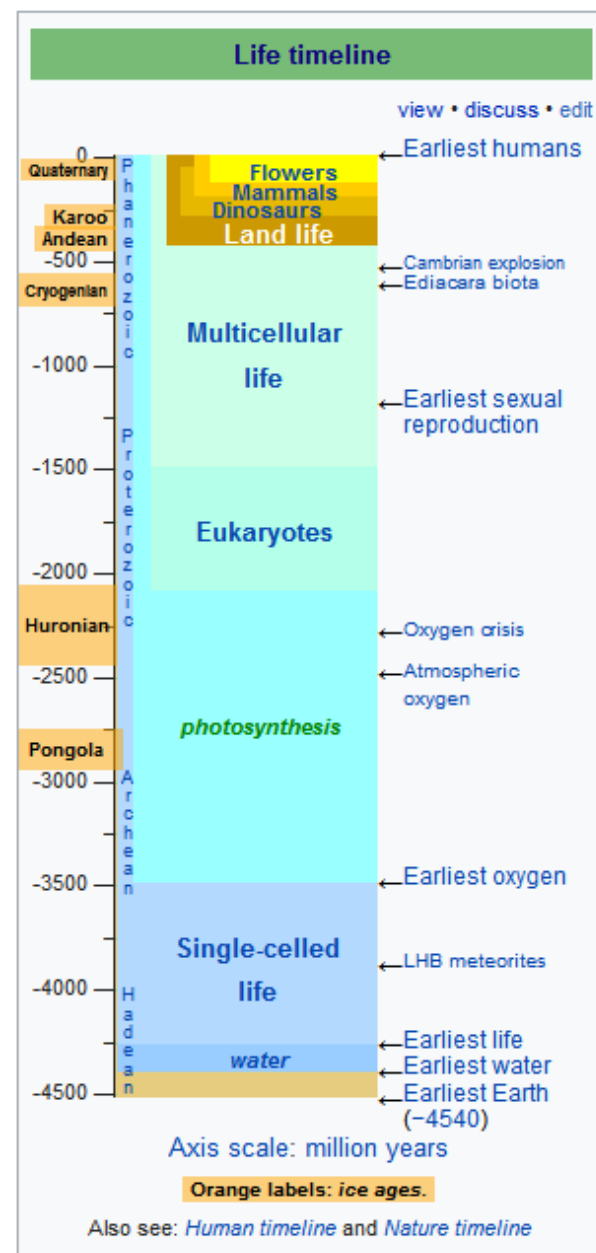


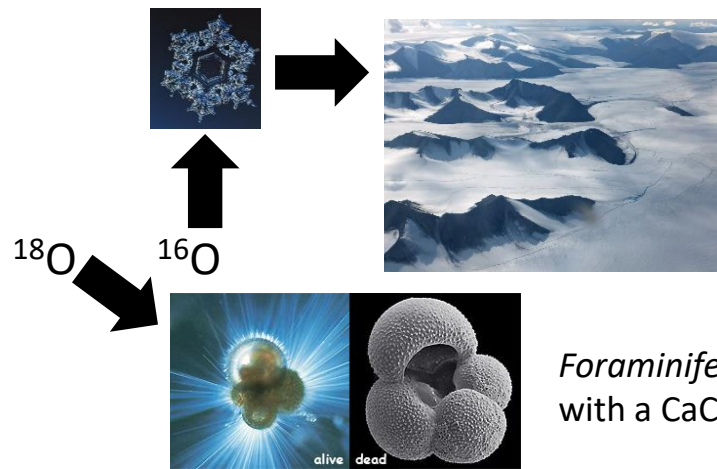
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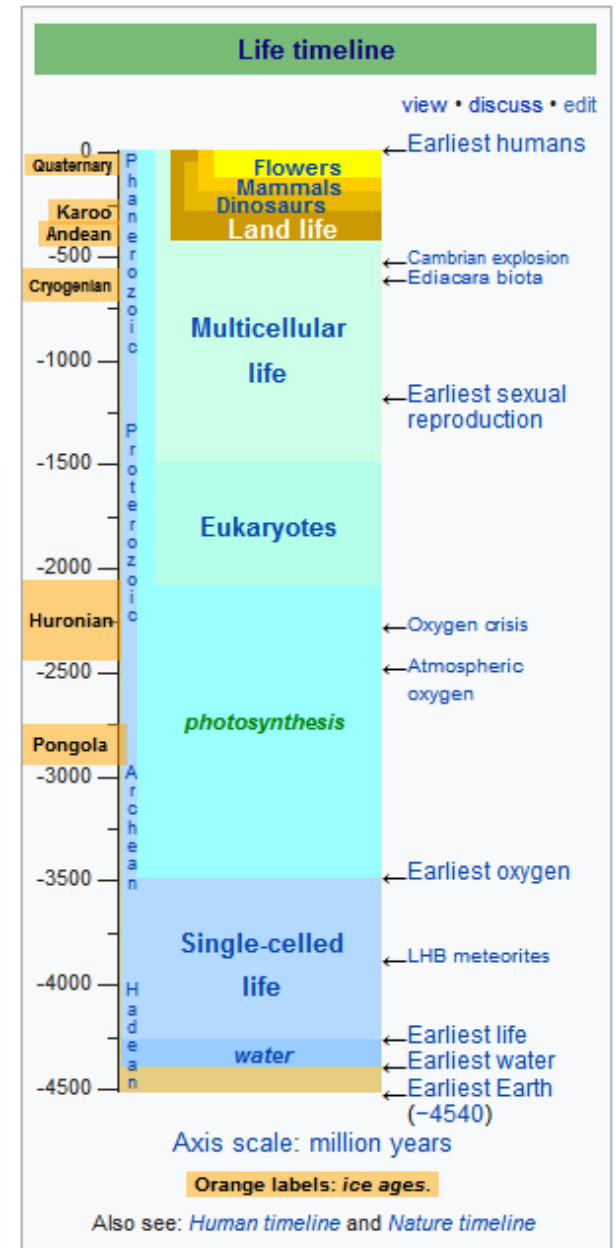
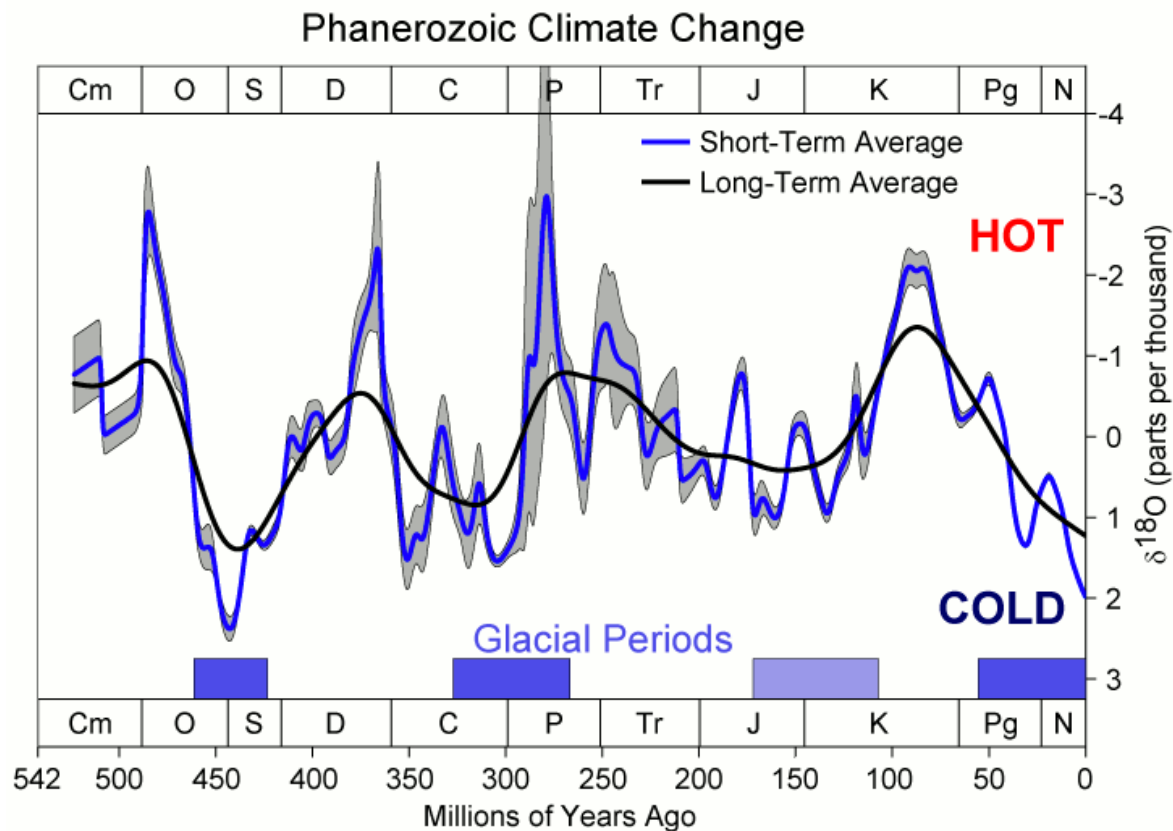


DSDP Legs 1-96 (●), ODP Legs 100-210 (●), IODP Expeditions 301-348 (●), IODP Expeditions 349-371 (●)

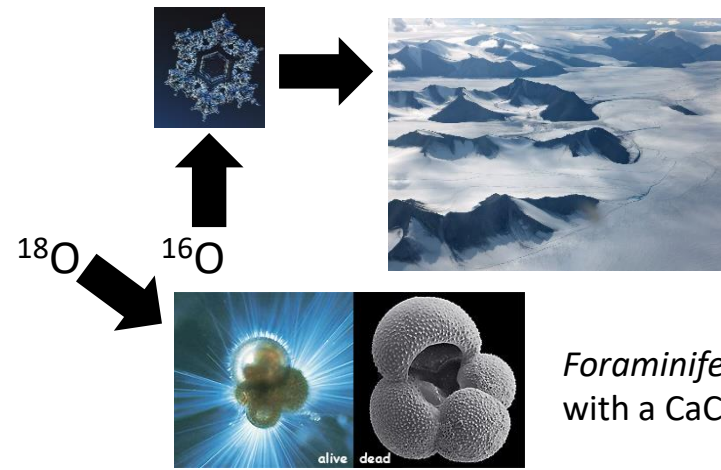




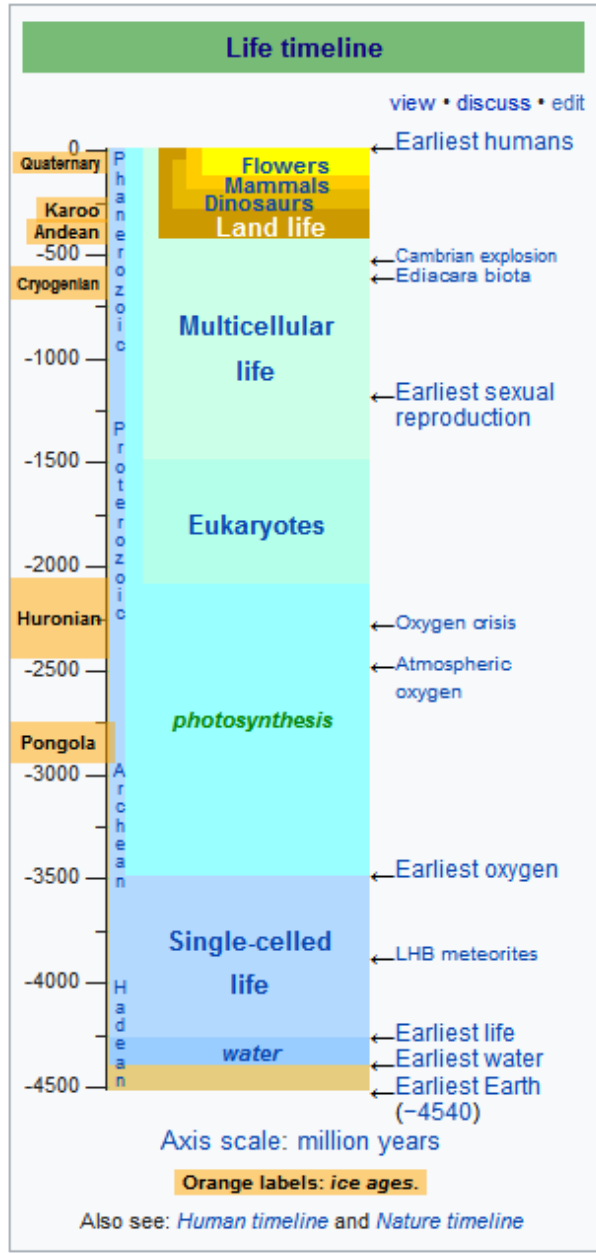
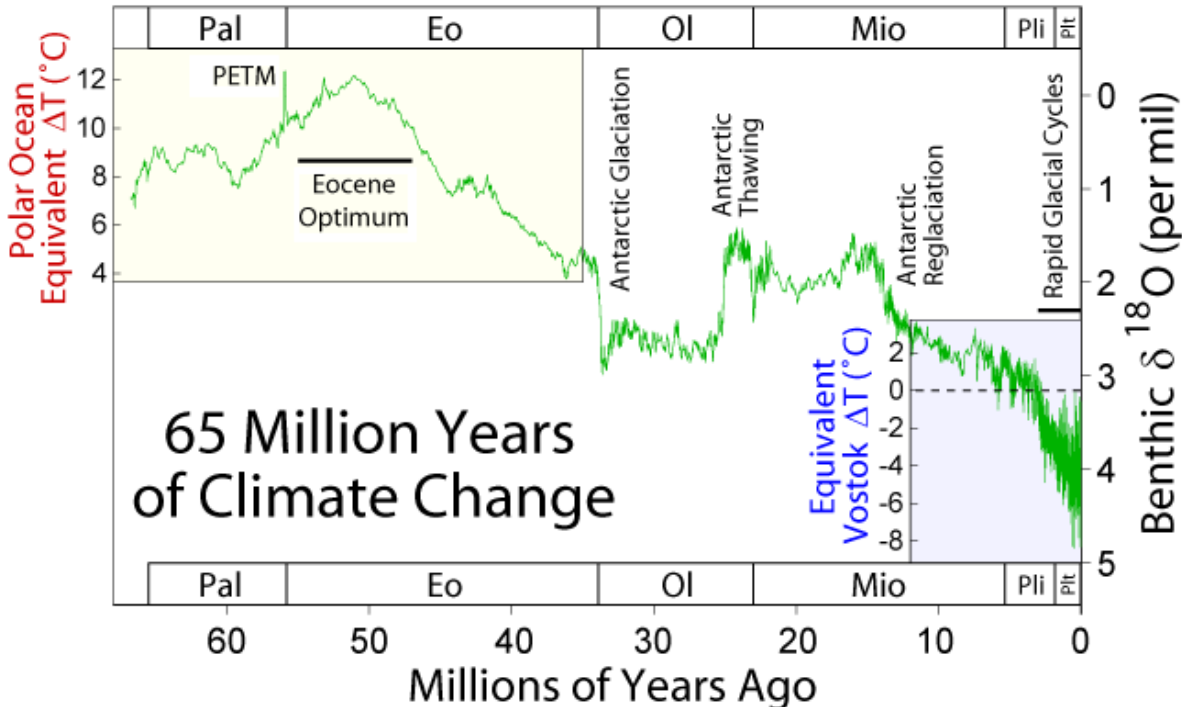
*Foraminifera*: small organisms with a  $\text{CaCO}_3$  shell

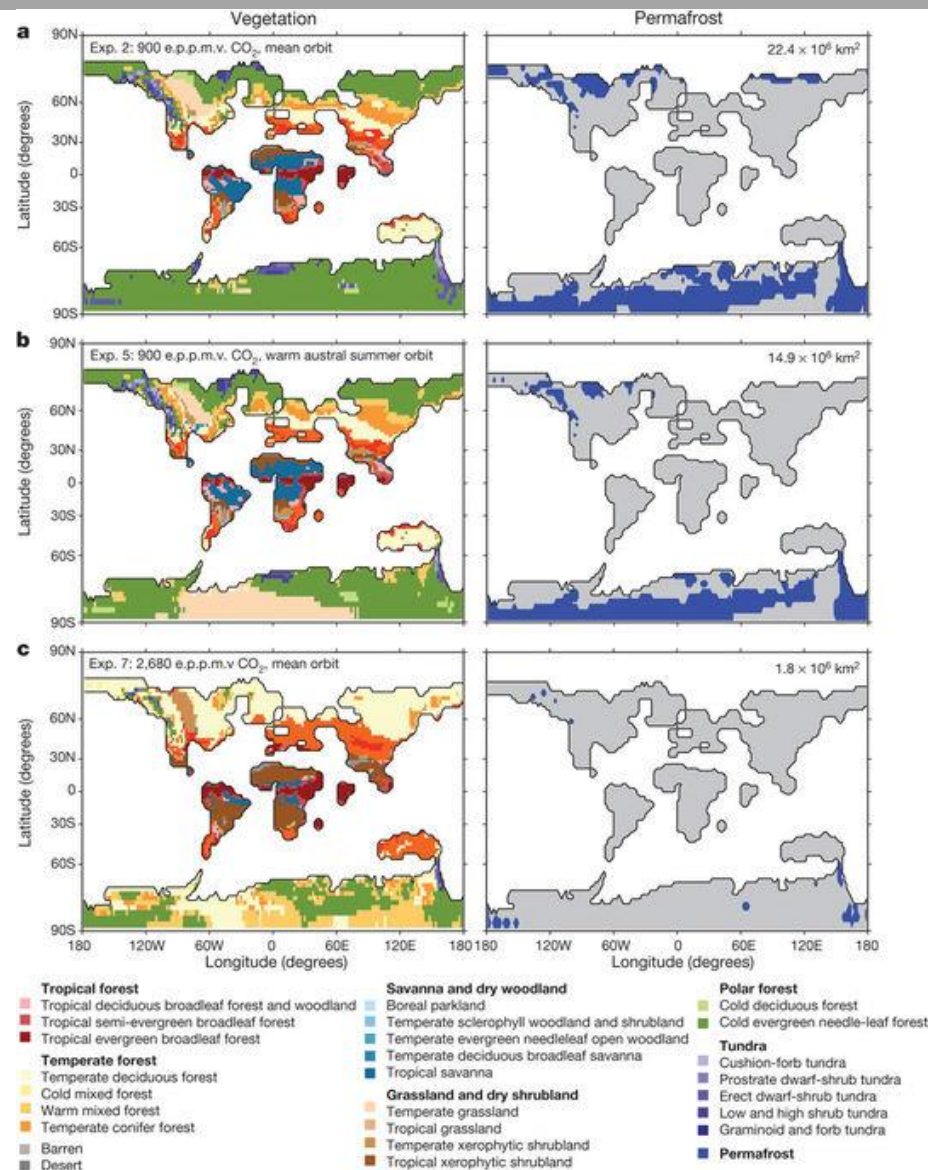






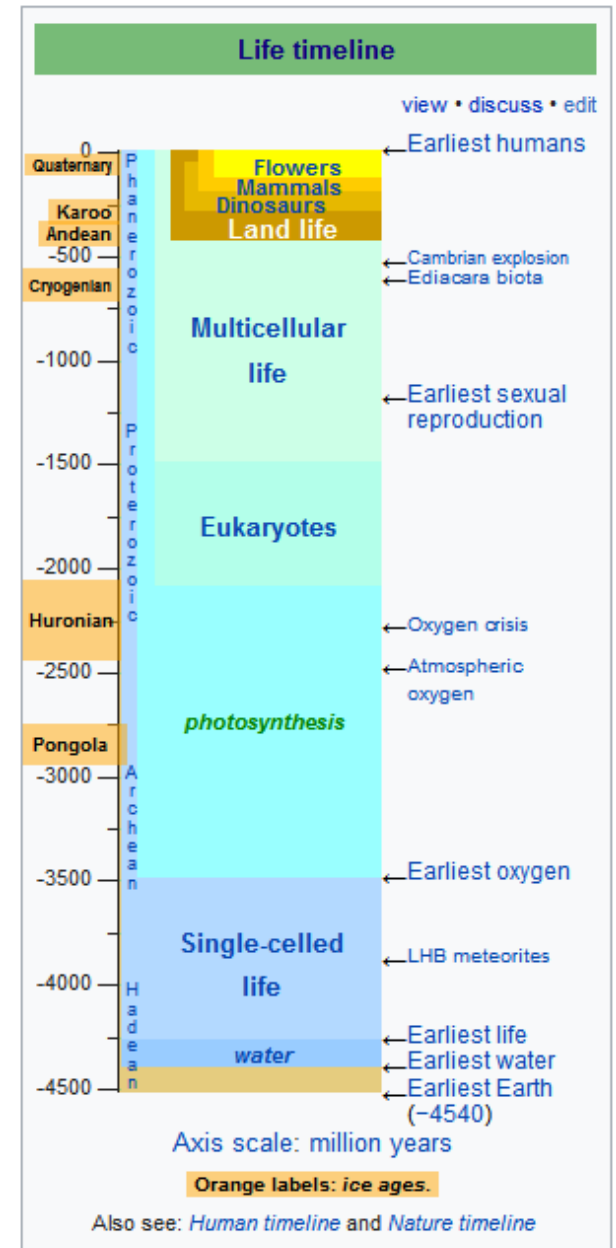
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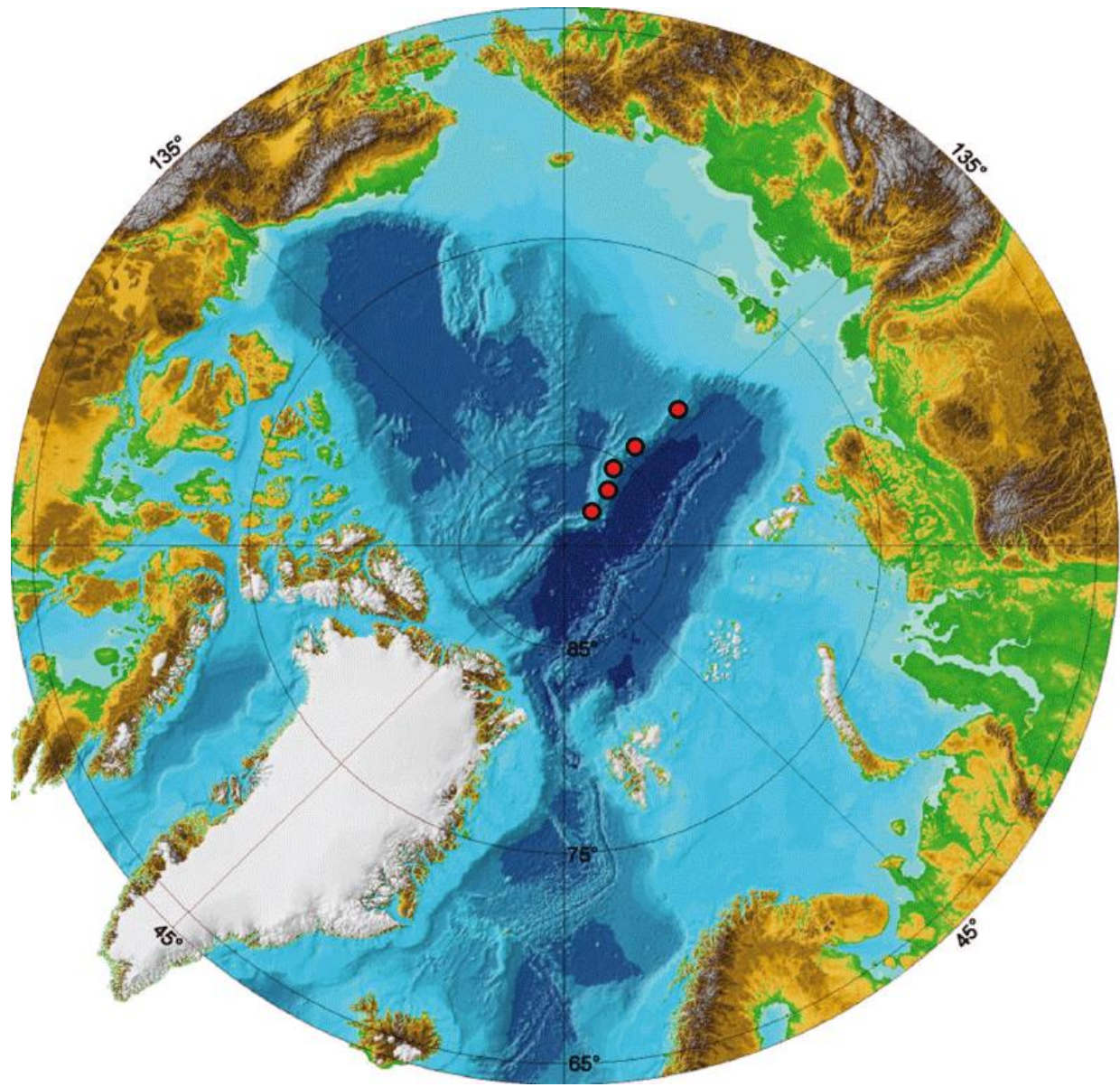




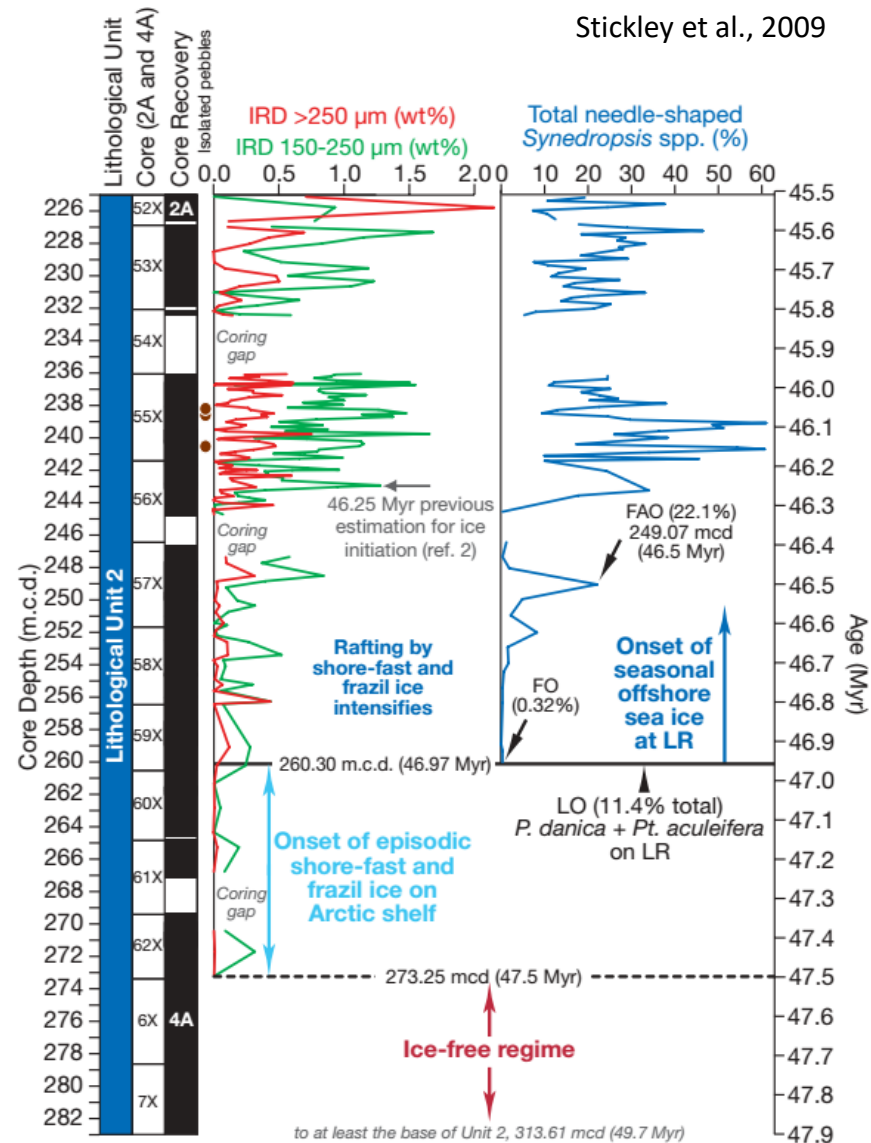
Deconto et al., 2012

- Even under extreme climate scenarios “refugia” persist





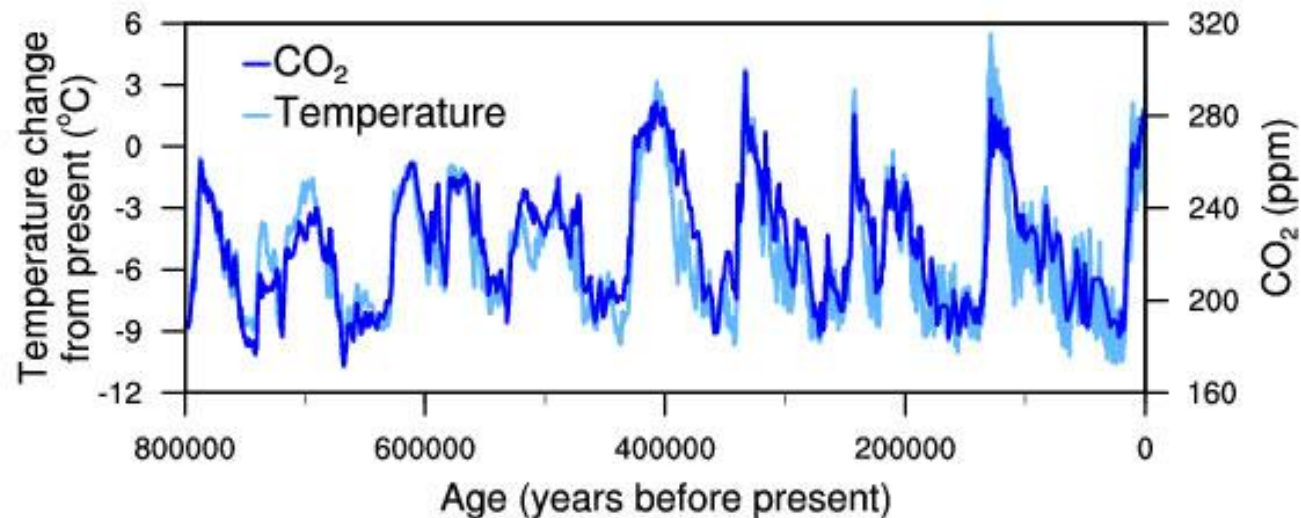




© Gert Hansen

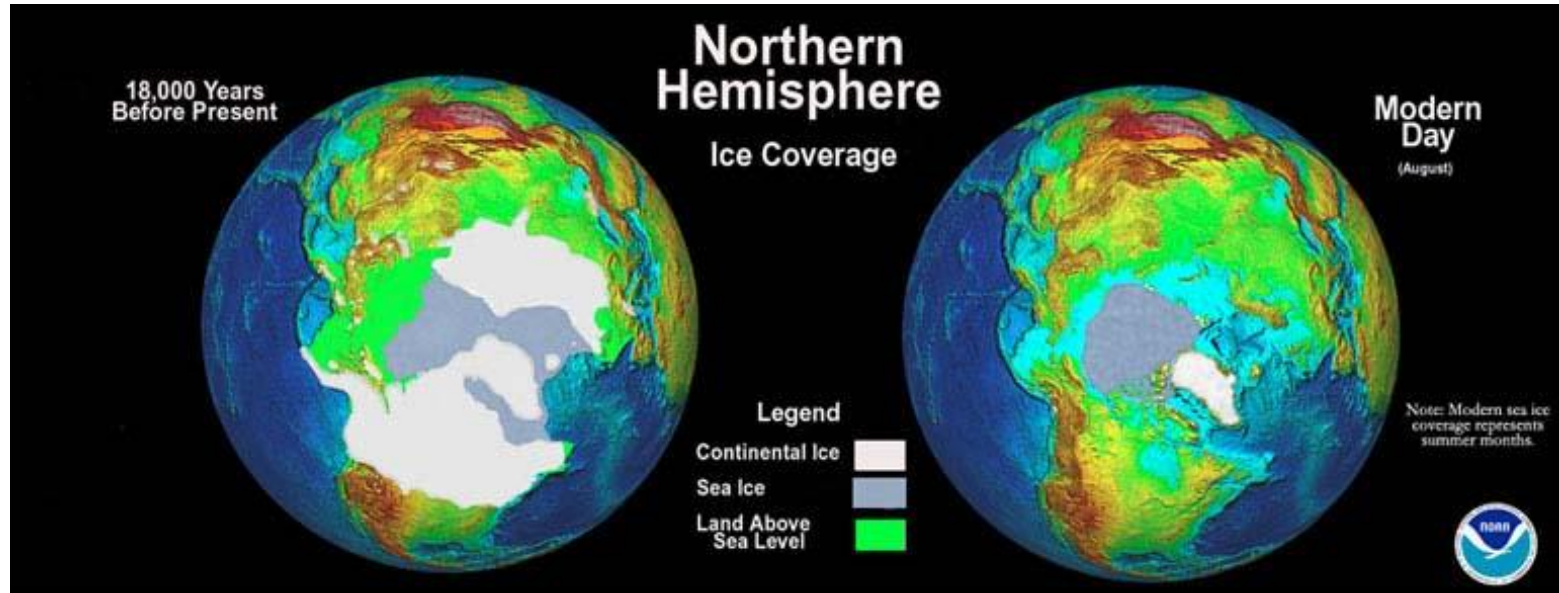


The last 800,000 years of glacial history can be observed directly in ice cores obtained from Greenland and the Antarctic interior

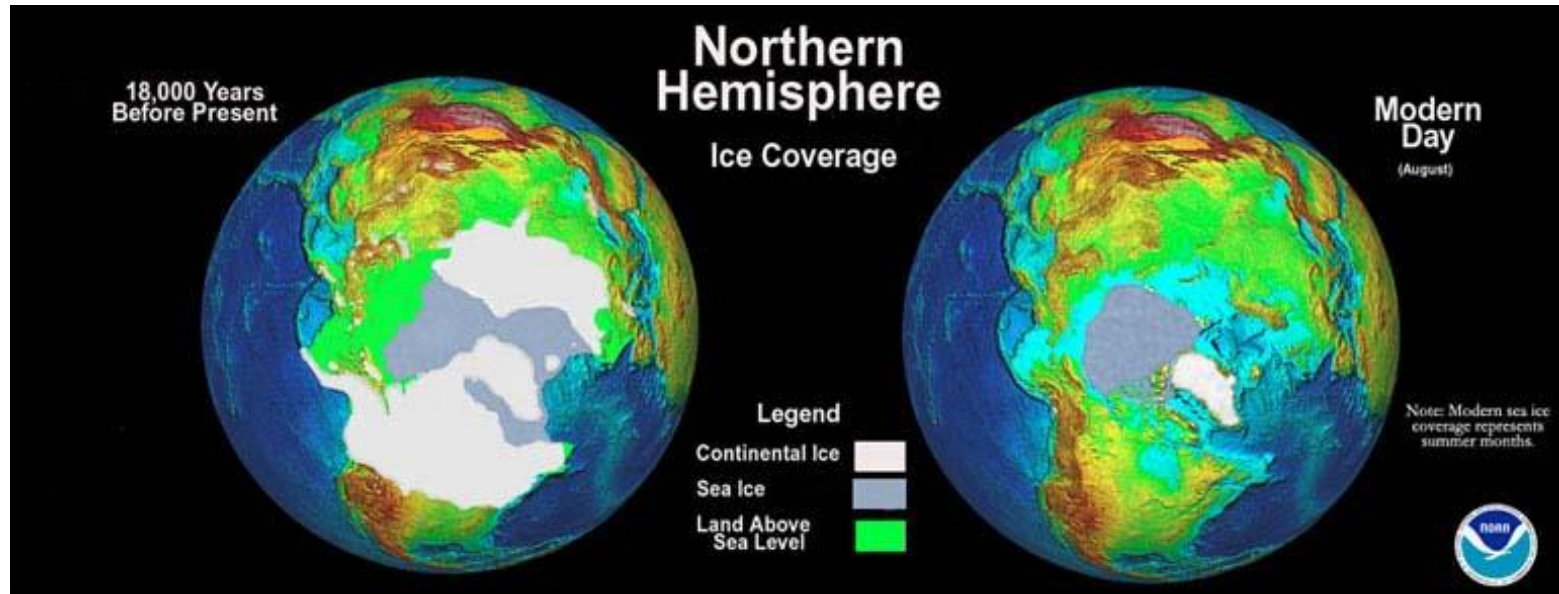




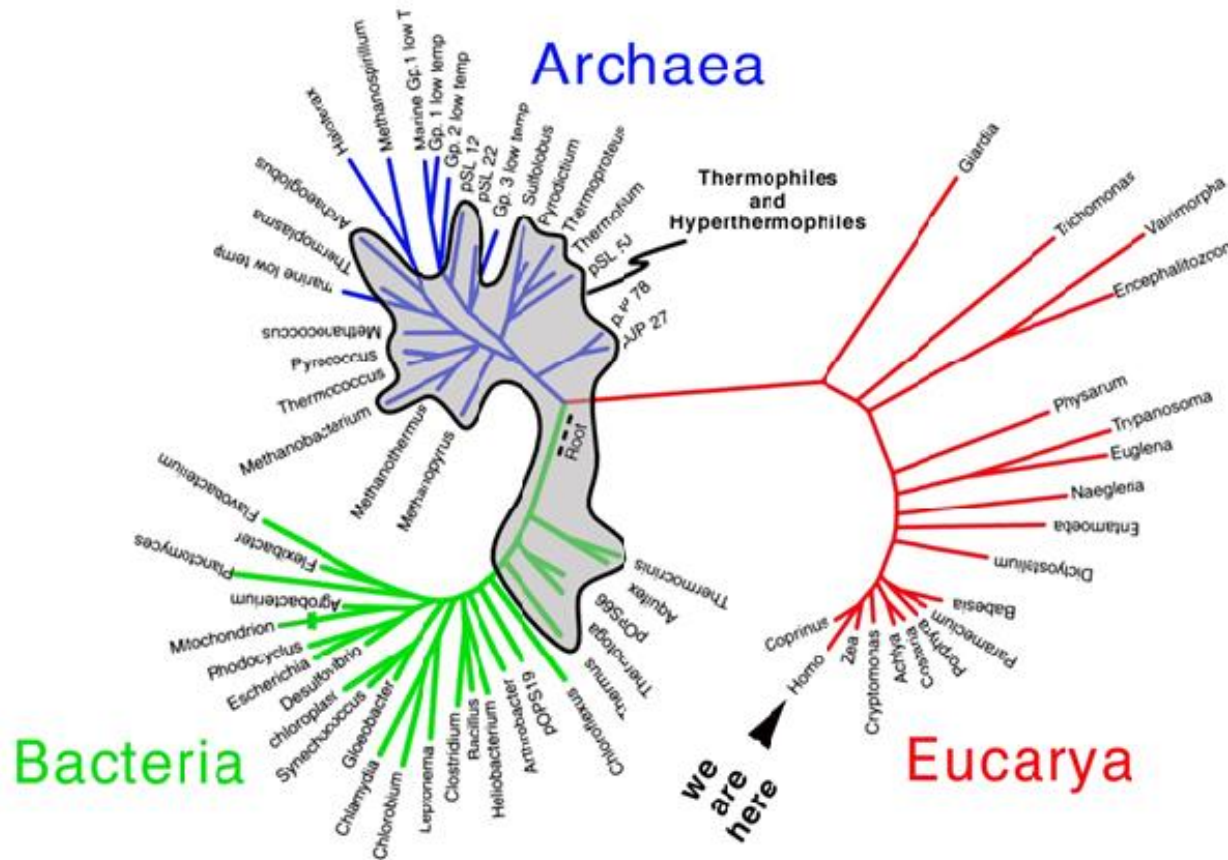
Currently we are in a warm *interglacial period* called the *Holocene*. Ice sheets are largely confined to Greenland, Antarctica, Patagonia, and the Himalaya



Next peak in glaciation is expected in 85,000 years, BUT we are now an important (but not unprecedented) driving force in Earth's climate. Future atmospheric composition is extremely difficult to predict!



# The Tree of Life

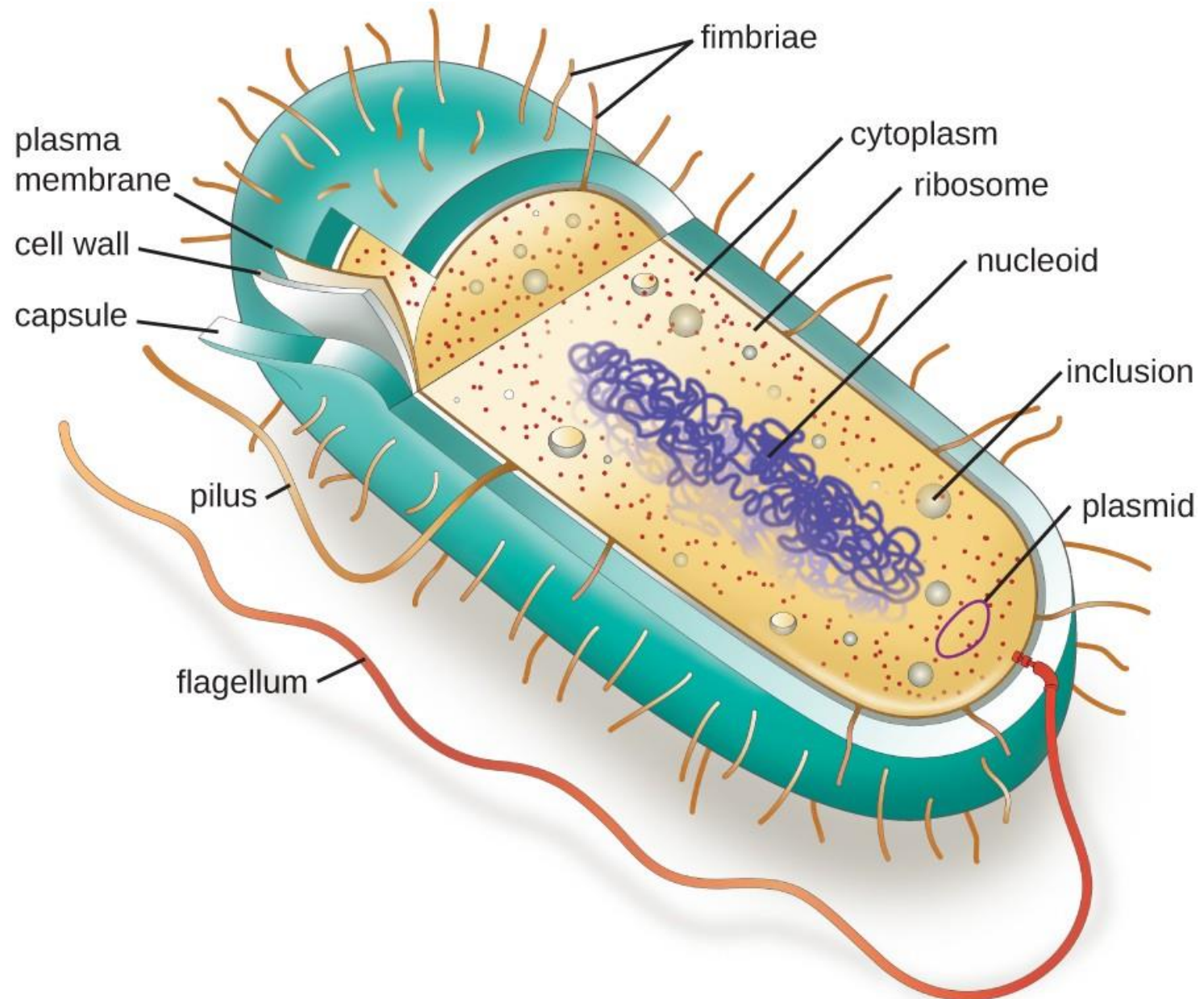


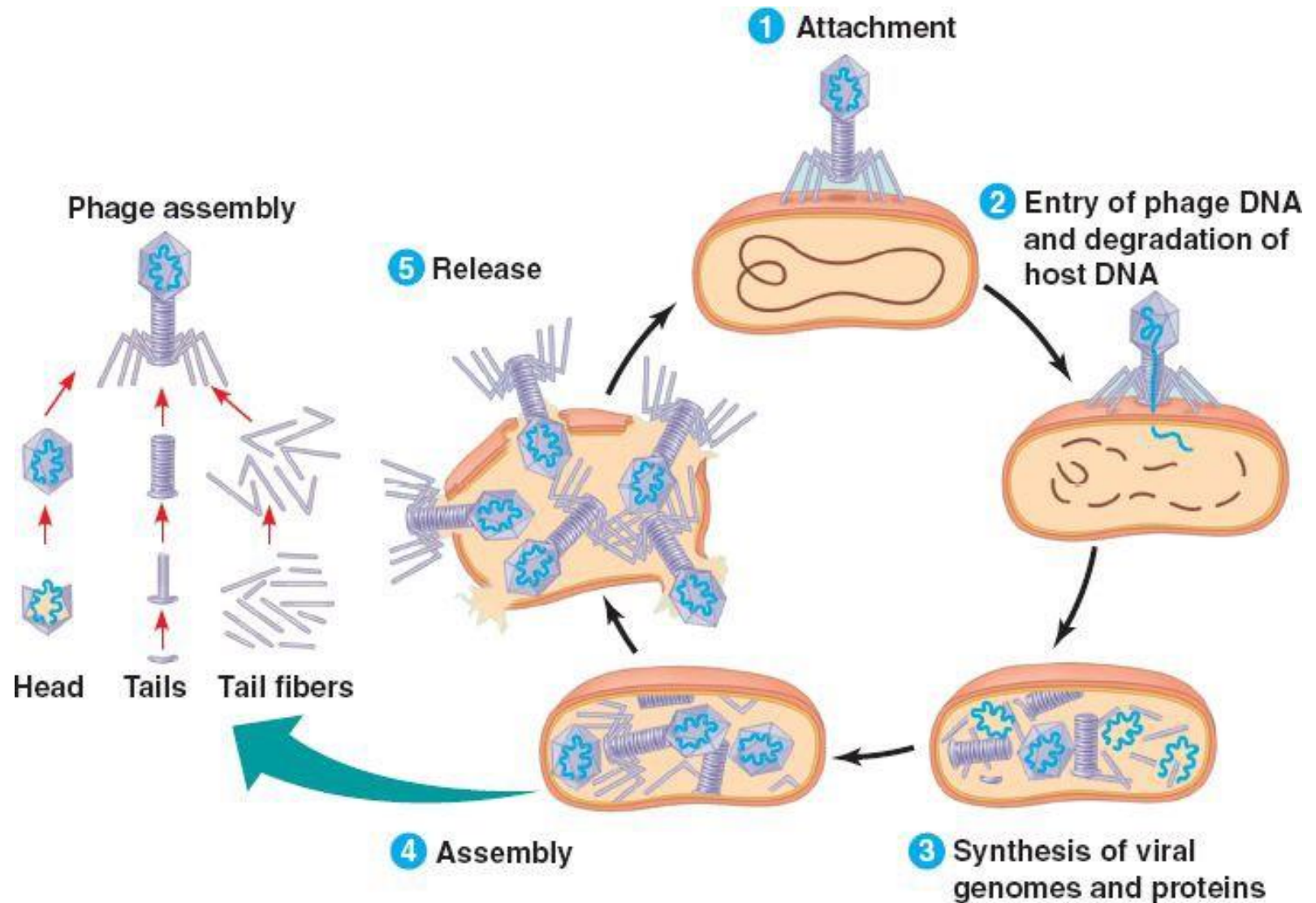
## Any other types of “life”?



Plastid  
Mitochondria  
Vacuole  
Golgi apparatus  
Endoplasmic reticulum  
Ribosome  
Cytoplasm  
Membrane

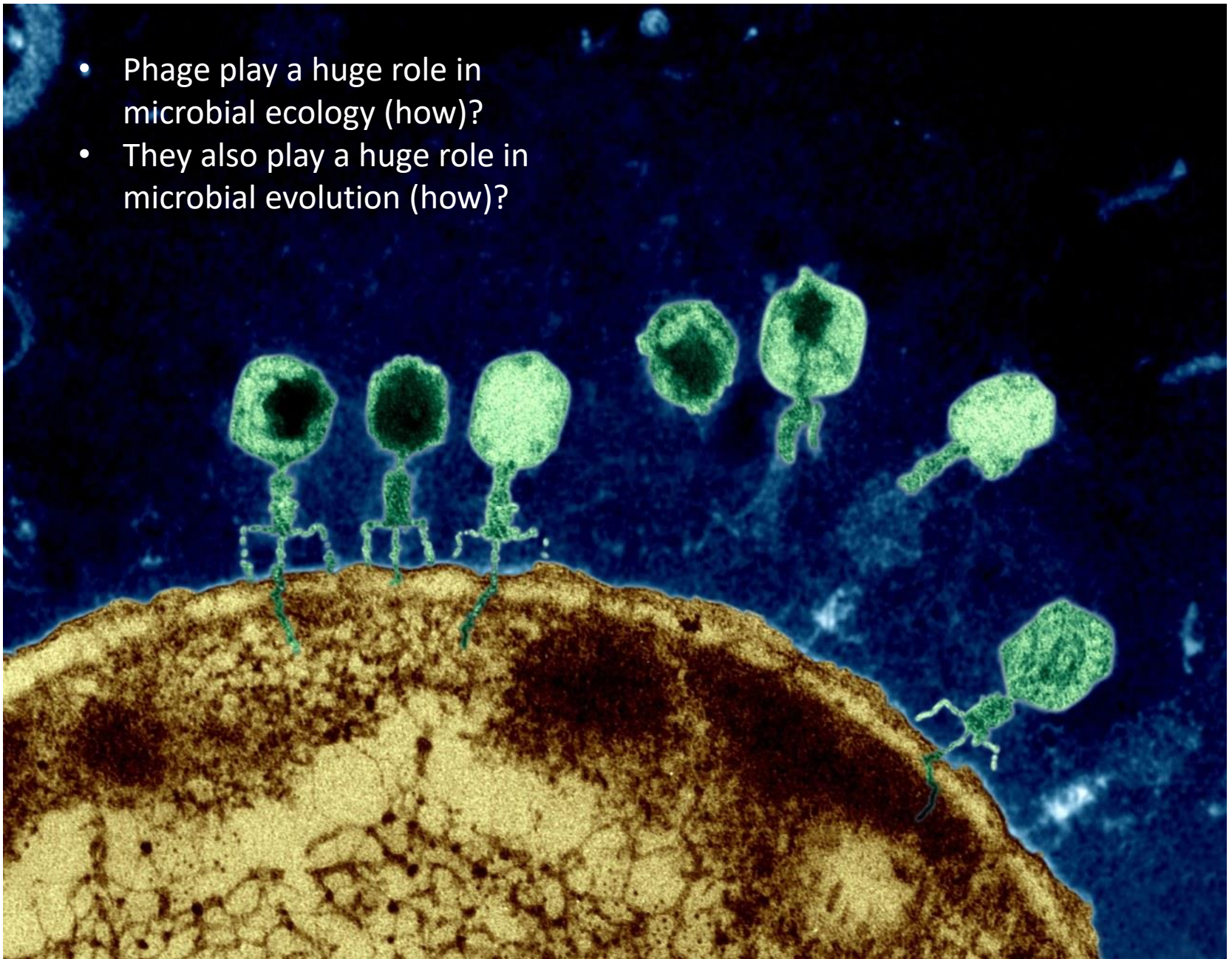






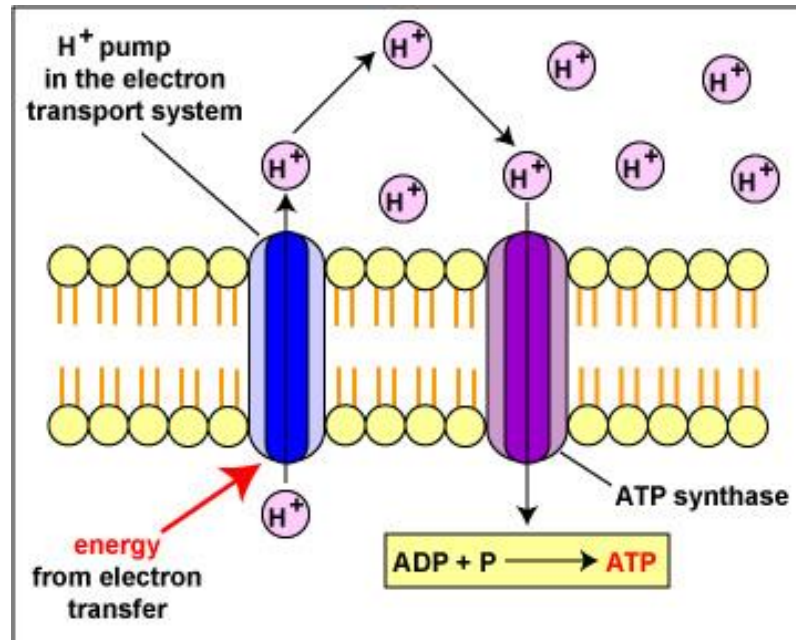


- Phage play a huge role in microbial ecology (how)?
- They also play a huge role in microbial evolution (how)?



## Energy

- What is the basic unit of energy in the cell?
  - Adenosine triphosphate or ATP
- How is ATP regenerated?
  - ATP synthase, a membrane-spanning protein
- Where does ATP synthase get its energy?
  - From the proton motive force, essentially the voltage potential across the cell membrane
- How is the proton motive force established?
  - Many different ways! But fundamentally through redox (reduction-oxidation) reactions.

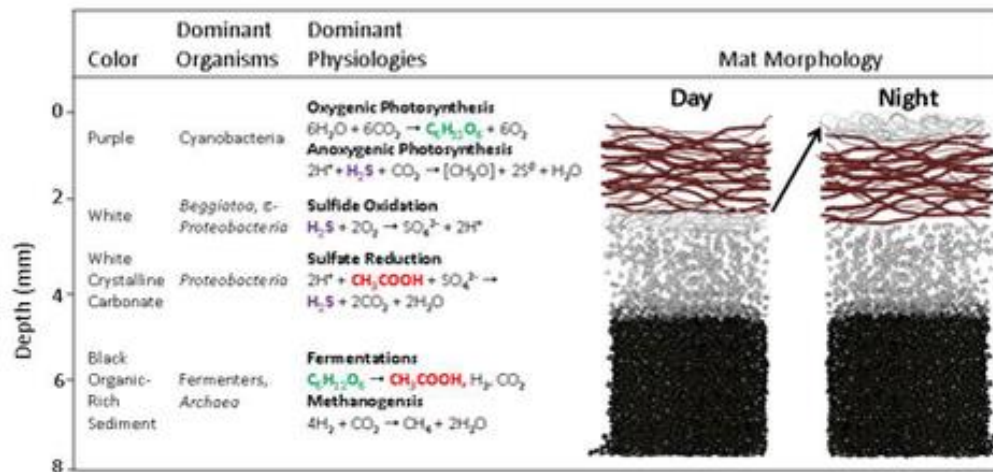
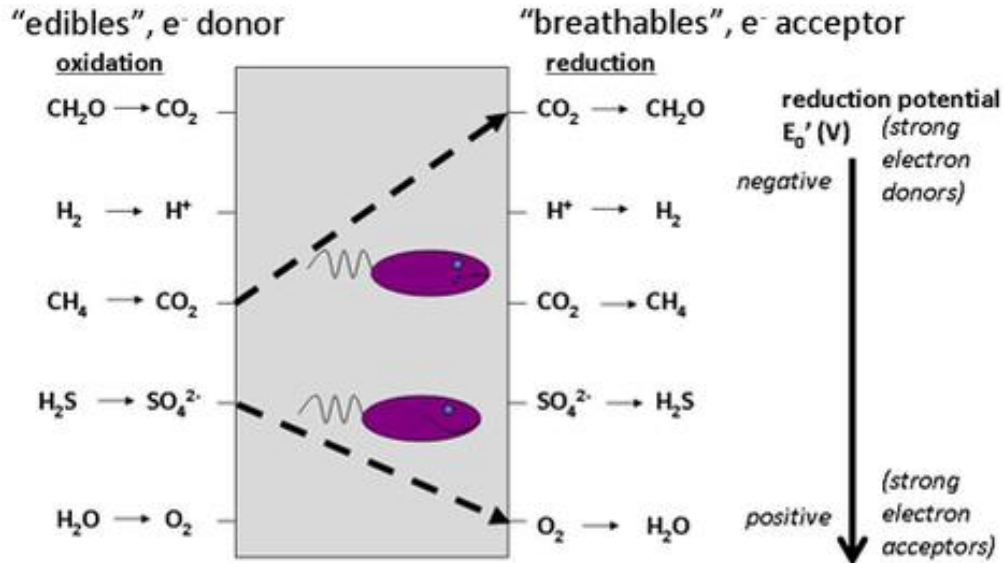




# Energy

## OIL-RIG

Oxidation involves loss (of electron), reduction involved gain (of electron)



Q: What is the fundamental role of photosynthesis?

A: Generate reducing power.

Source of energy	Source of carbon		
	Organic	Inorganic	
	Sunlight	Photoheterotrophs	Photoautotrophs
	Organic	Chemoorganotrophs	Special case
	Inorganic	Chemolithoheterotroph	Chemolithoautotrophs

