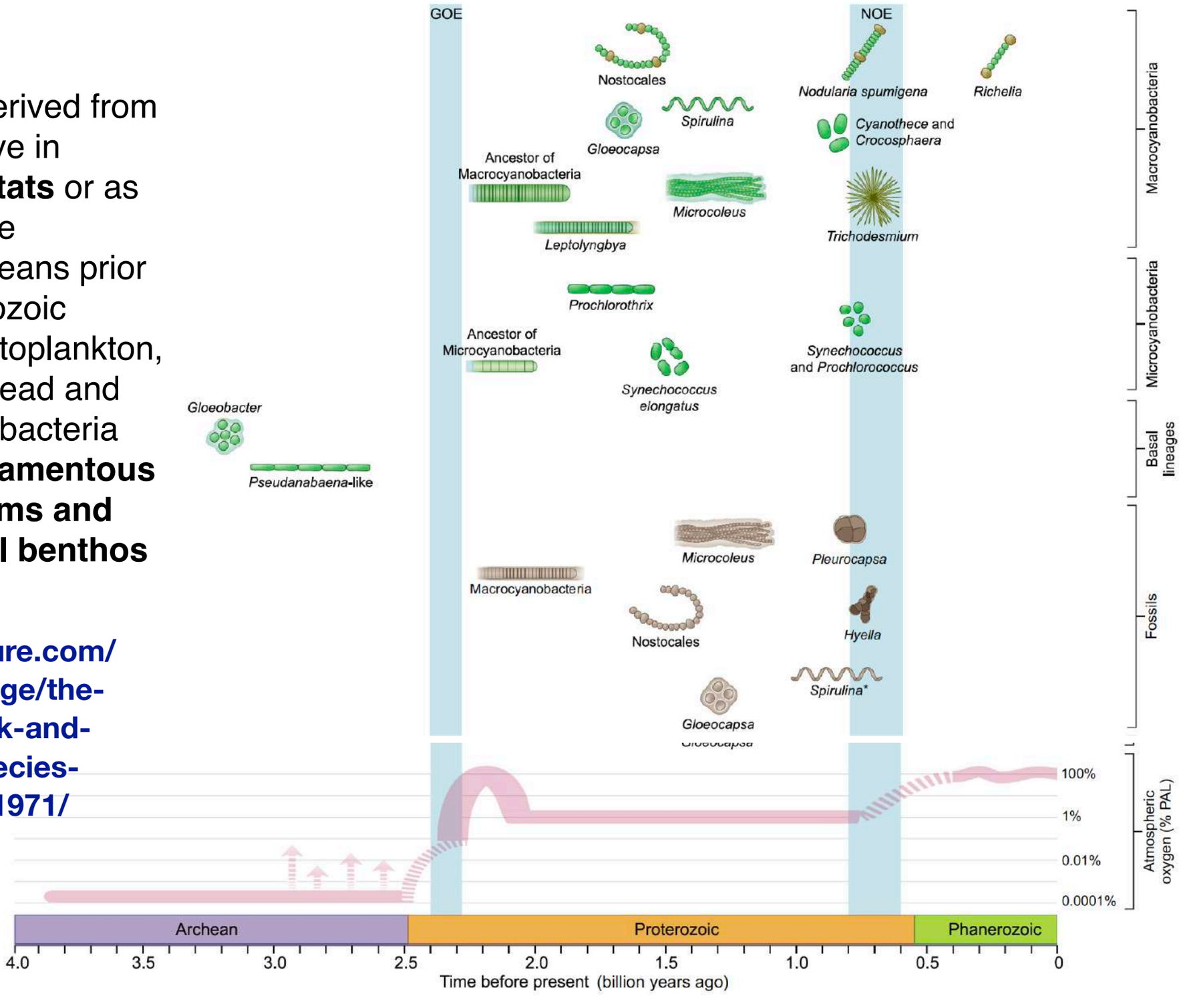
# Cyanobacteria II

# Timeline of oxygen concentration in the atmosphere, the antiquity of cyanobacterial lineages based on molecular clock estimates and fossil occurrences

Cyanobacteria derived from early branches live in **nonmarine habitats** or as benthos within the shallow, sunlit oceans prior to the Neoproterozoic expansion of phytoplankton, the most widespread and productive cyanobacteria were (**mostly) filamentous mat-forming forms and other - microbial benthos**

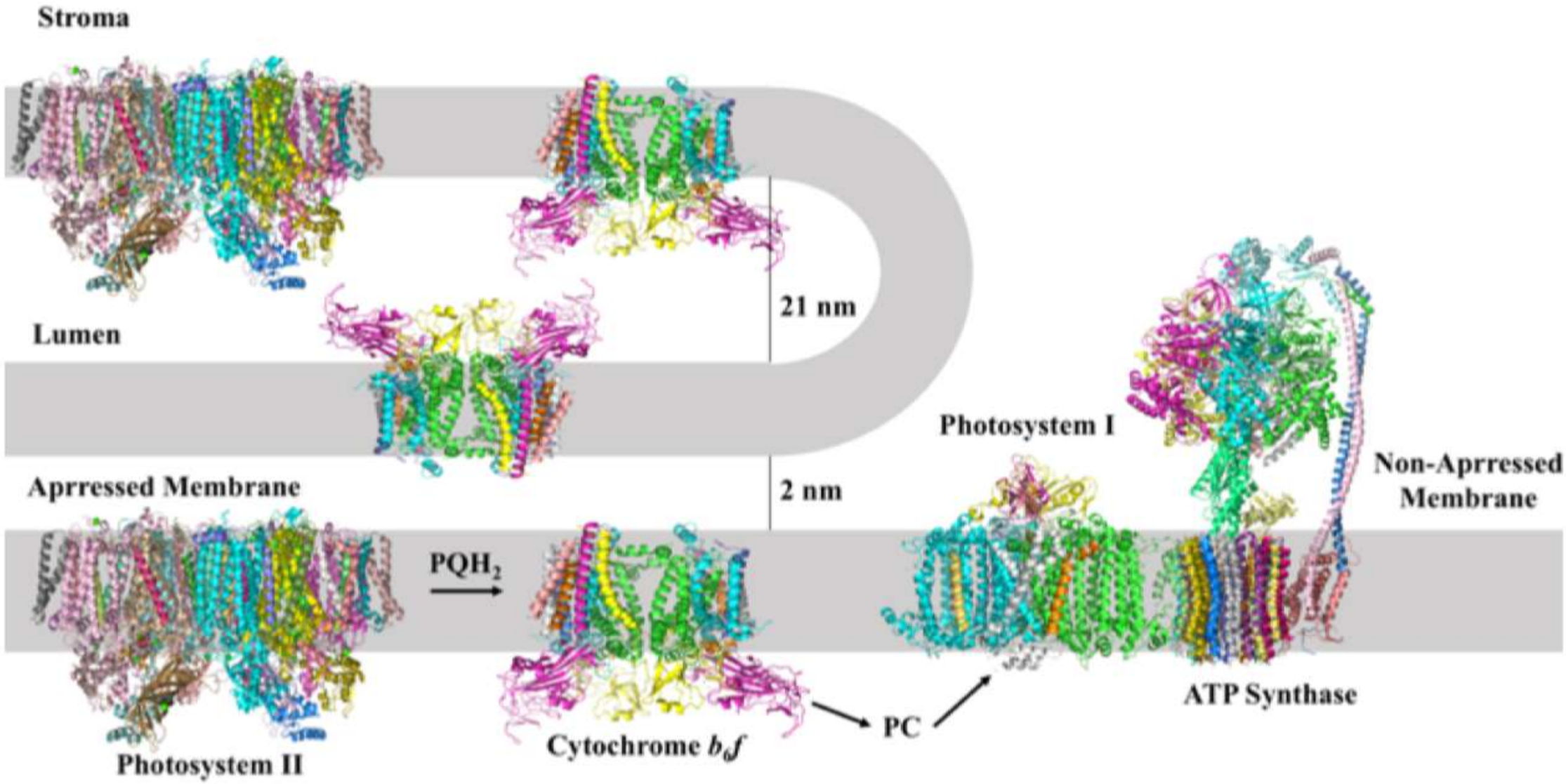
**https://www.nature.com/scitable/topicpage/the-molecular-clock-and-estimating-species-divergence-41971/**




Sánchez-Baracaldo et al., 2021

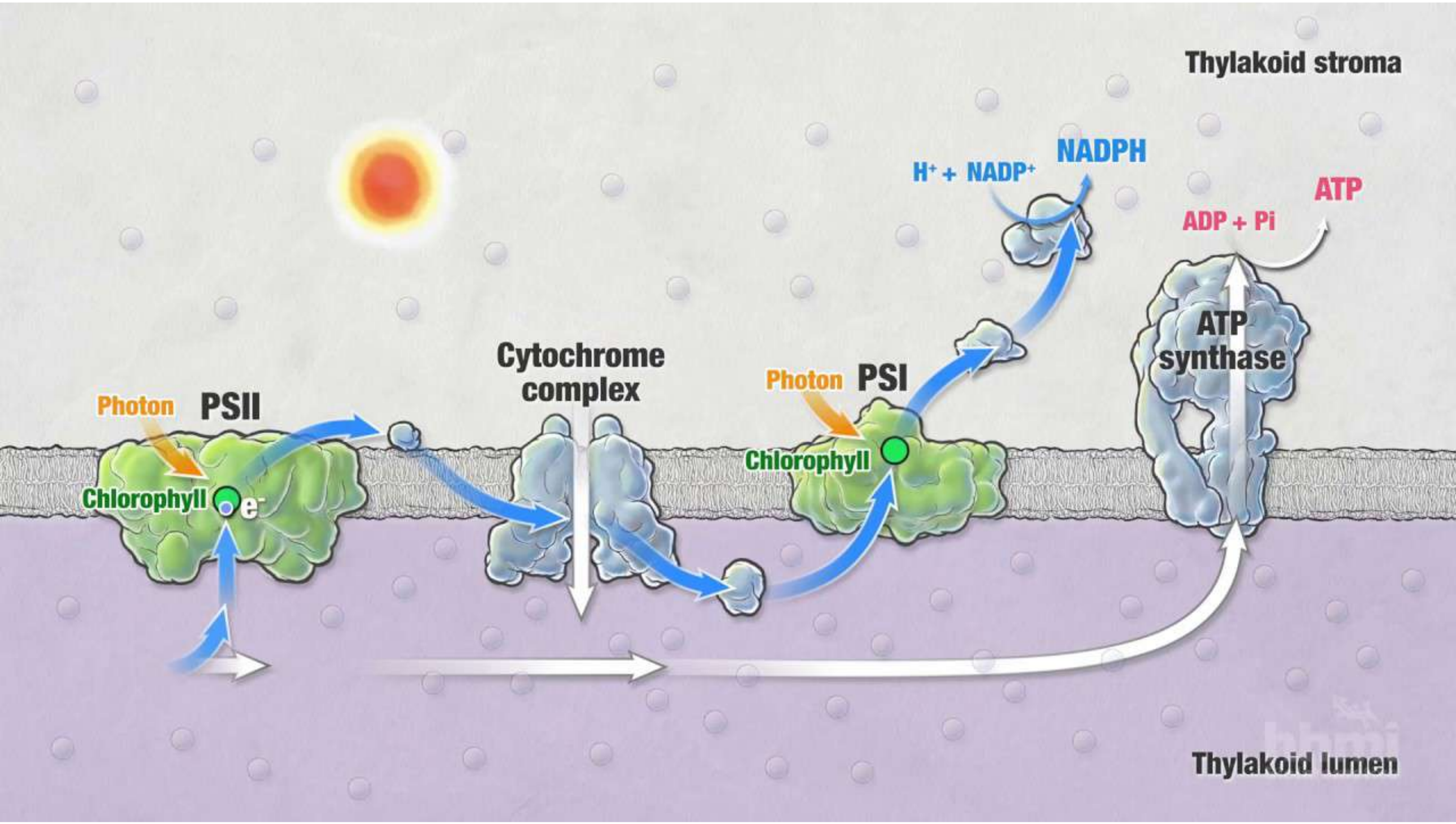
# Photosynthetic reaction centres

Eight known extant bacterial phyla contain groups with photosynthetic reaction centres (RCs, **https://pdb101.rcsb.org/motm/22)**: Cyanobacteria, Proteobacteria, Chloroflexi, Acidobacteria, Chlorobi, Firmicutes, Gemmatimonadetes, and Candidatus Eremiobacterota

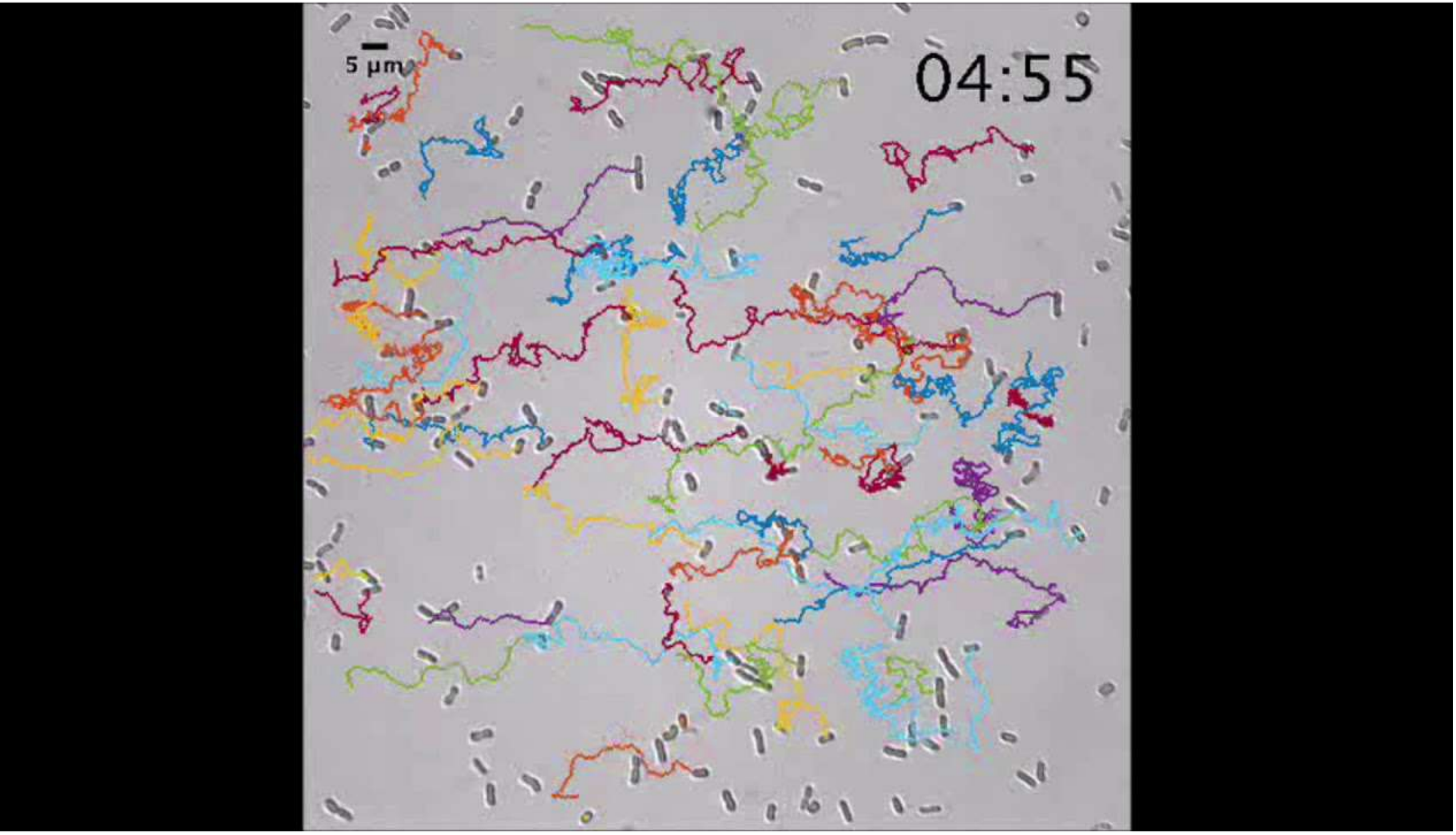



Bhaduri et al. 2021

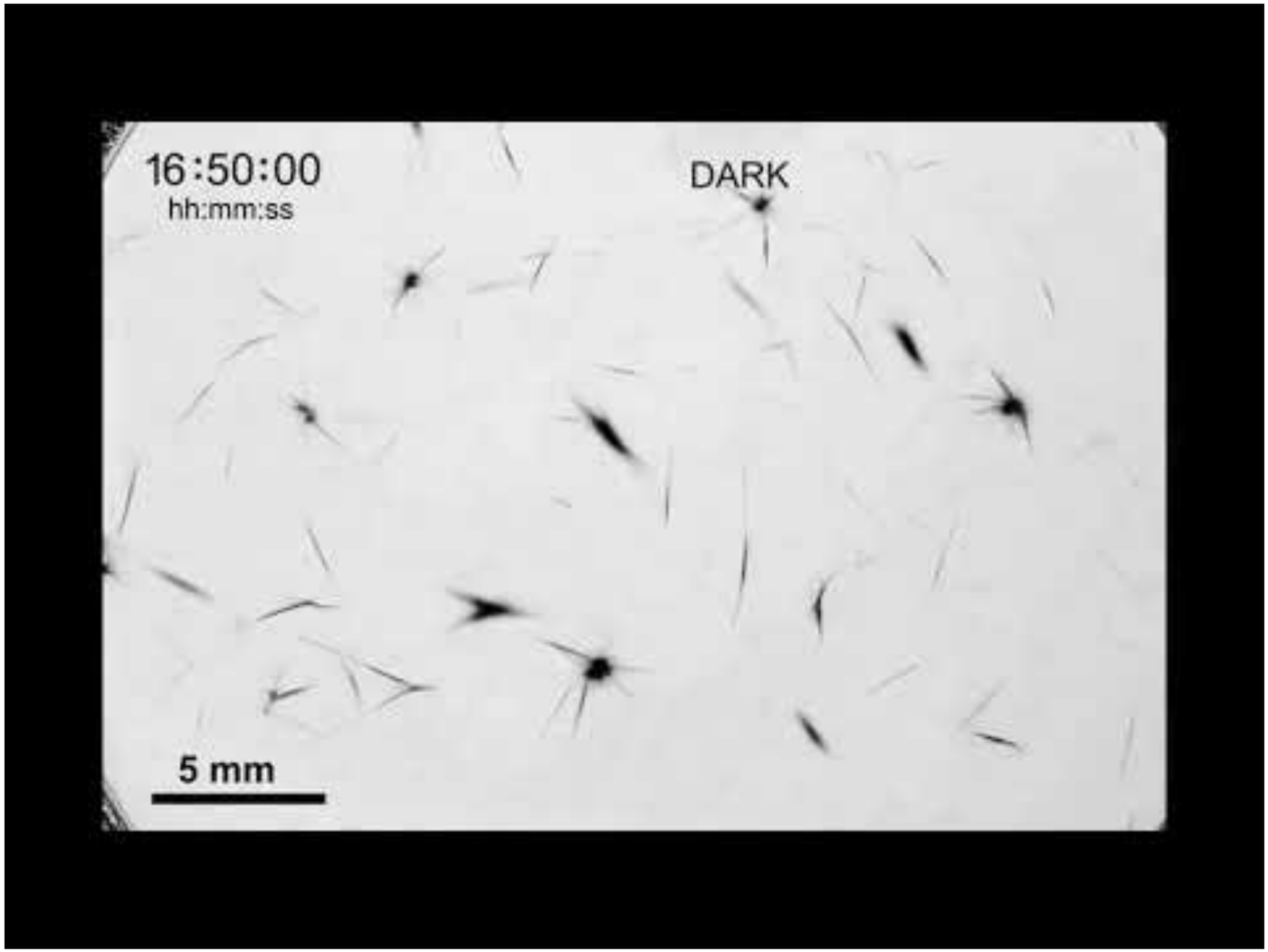
The availability of electron donors likely limited primary production by early anoxygenic photoautotrophs providing strong selection pressure for bacteria able to extract electrons from readily abundant water.


Thylakoid stroma
NADPH
H⁺ + NADP⁺
ATP
ADP + Pi
ATP synthase
Cytochrome complex
Photon
PSII
Photon
PSI
Chlorophyll
e⁻
Chlorophyll
Chlorophyll
Thylakoid lumen

# *Synechococcus* phototaxis



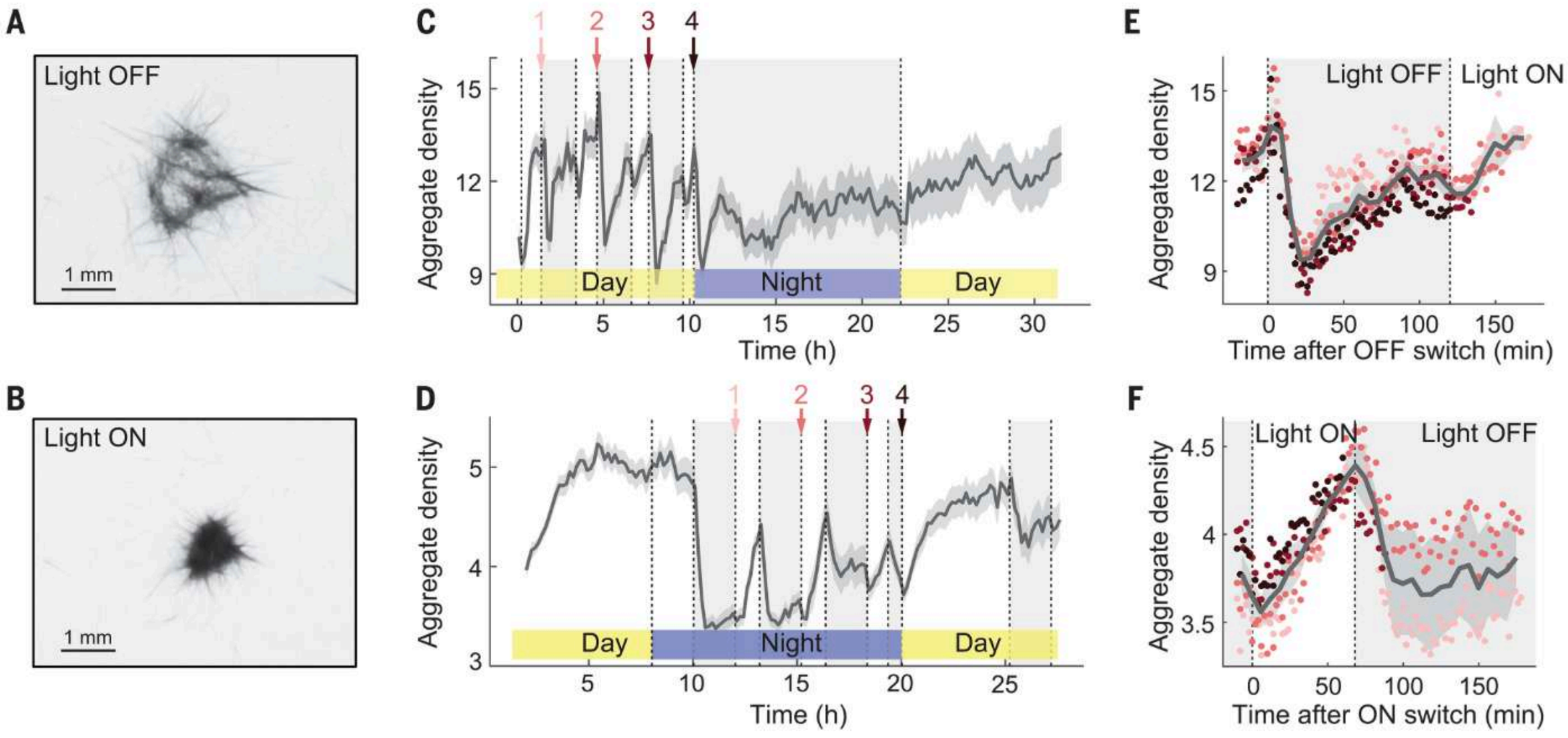
# *Trichodesmium* gliding motility




Pfreundt et al. 2023

Credit: Science (2023). DOI: 10.1126/science.adf2753

# *Trichodesmium* aggregate density changes rapidly upon switches in light intensity




Pfreundt et al. 2023

# *Trichodesmium* dust capturing, as a source of Fe

# Circadian rhythms in gene transcription

Circadian clocks have evolved within the cyanobacteria (an extremely diverse group of oxygenic photosynthesizing bacteria) and many, if not all, eukaryotes

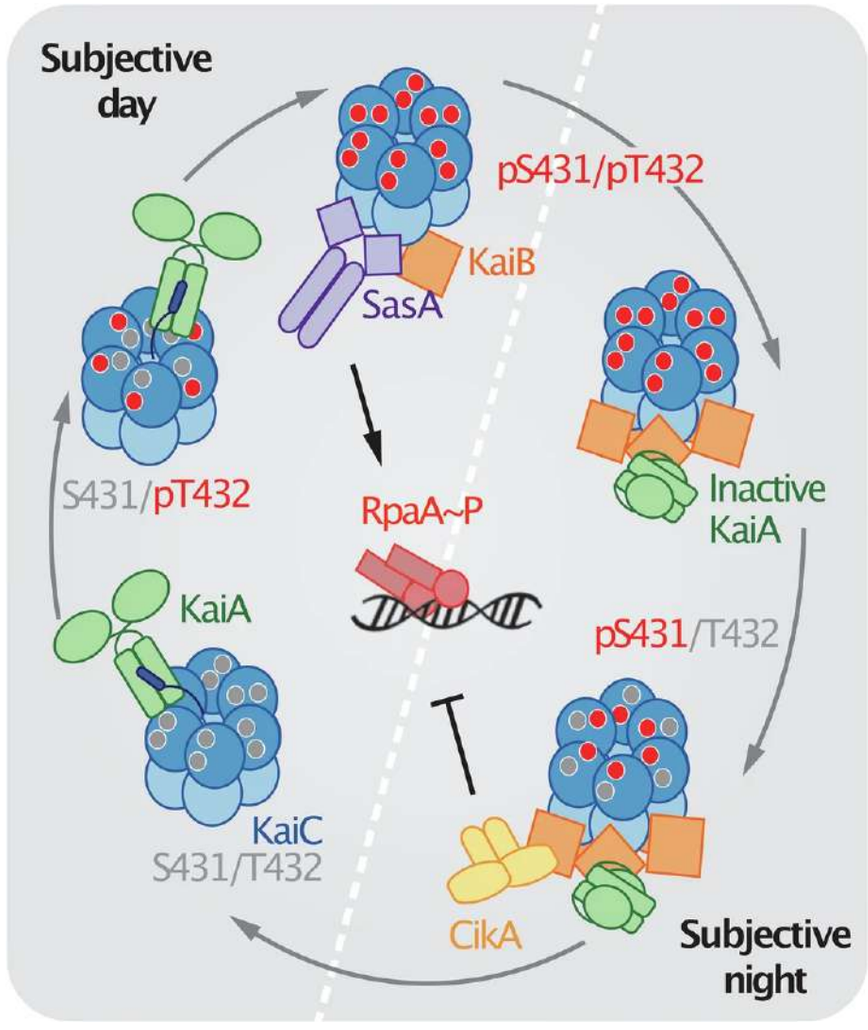
These clocks effectively tune gene expression patterns, and thus metabolic activity and behavior, to distinct daily frequencies

Suggesting a strong evolutionary advantage for anticipating regular fluctuations in the environment

Regulation timing of cell division and metabolism in order to have enough nutrients, competence (DNA uptake) and type IV

The three hallmarks of bona fide circadian clocks are that:

i) their phase can be entrained by environmental cues
ii) they continue to generate circadian rhythms under constant environmental conditions
iii) their periodicity is relatively insensitive to modest changes in ambient temperature due to a temperature-compensation mechanism



# ordial Cyanobacteria
# in microbial mats

Microbial mats are **highly productive ecosystems** in which feedbacks between cyanobacteria and sulfate-reducing bacteria take place within a few **densely packed vertical millimetres**

Geobiological studies point to the widespread importance of microbial mat ecosystems on the Precambrian Earth it is unknown the their quantitative contribution to global primary production

While estimates of **benthic** oxygenic primary productivity **exceed** those for the **pelagic** realm by 1000–10000-fold on a per-volume basis, sunlit benthic habitats (including the terrestrial, biological soil crusts) occupy a small area in contrast to the open ocean

The **global biogeochemical impact of oxygenic photosynthesis** may have increased markedly when **cyanobacteria started colonizing the open ocean**


An image of a vertically stratified microbial community, taken from a hypersaline mat at Guerrero Negro basin, Mexico. (Photo Credit: John Spear and Norman Pace)

**https://kids.frontiersin.org/articles/10.3389/frym.2022.654148**

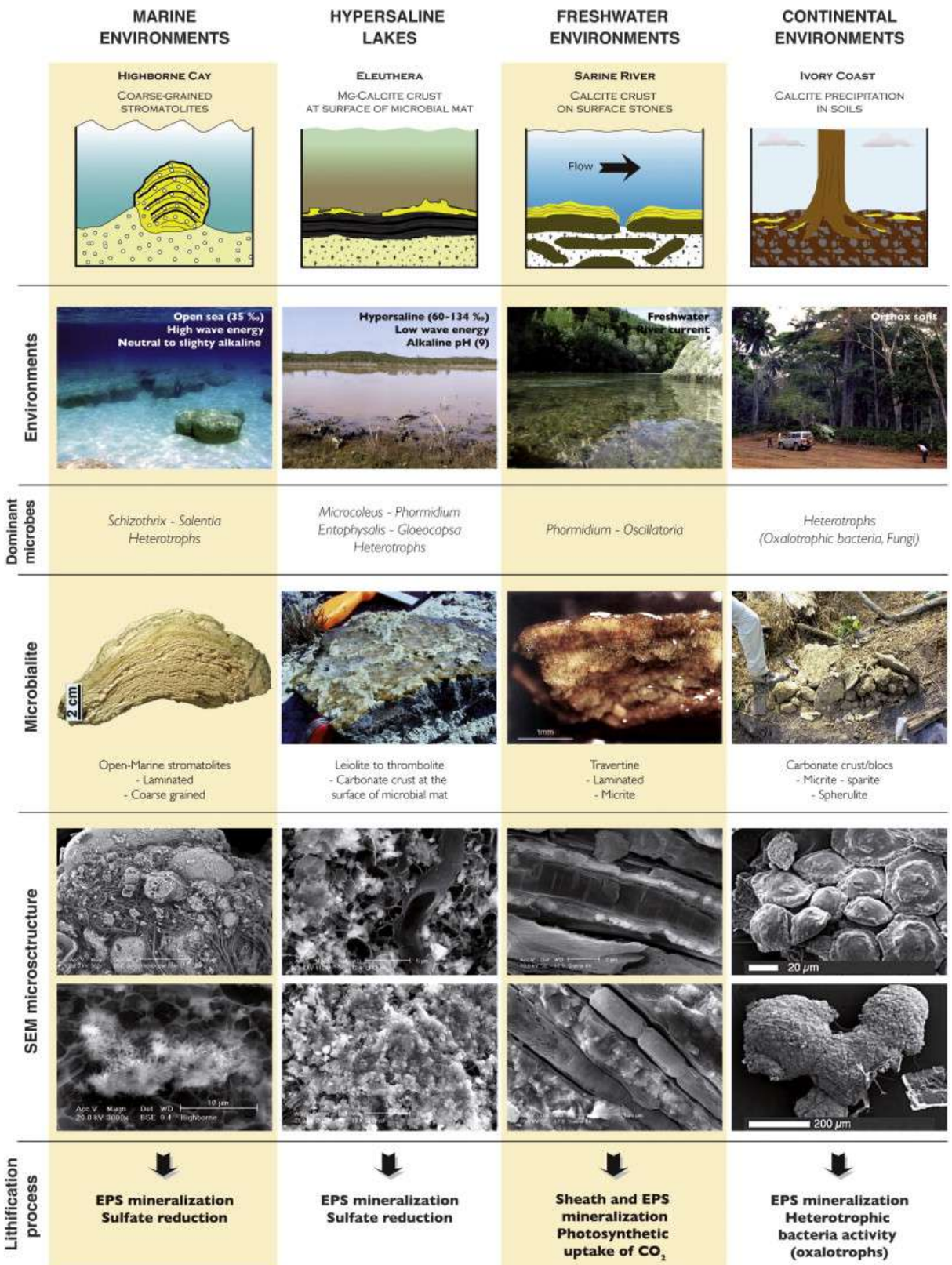
# Modern microbial mats


https://kids.frontiersin.org/articles/
10.3389/frym.2022.654148


Examples of structures made by microorganisms using soil, water, rocks, and minerals.

(A) Oncolites from Casey Falls locality, Canning Basin, Western Australia (photograph credit: Heidi Allen). (B) Endoevaporite. (C) Microbial mat. (D,E,G,H) Microbial mats in the Yucatán Peninsula in Mexico. (F) Microbial mats from the Middle Island Sinkhole, Lake Huron in North America (photo credit: John Bright, NOAA Thunder Bay National Marine Sanctuary). (I) A cross-section of a microbial mat from Guerrero Negro, Mexico.

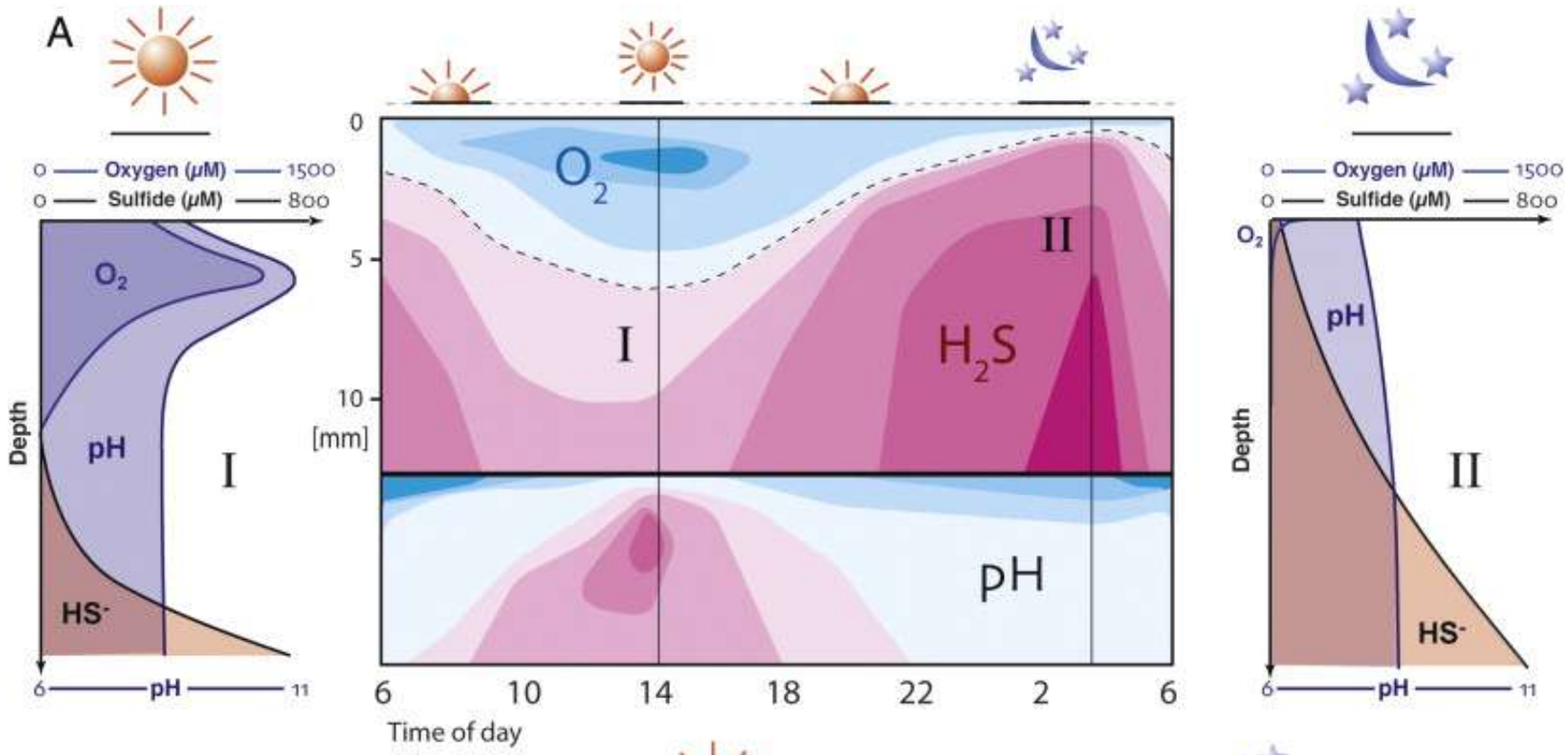
# Examples of modern microbialites

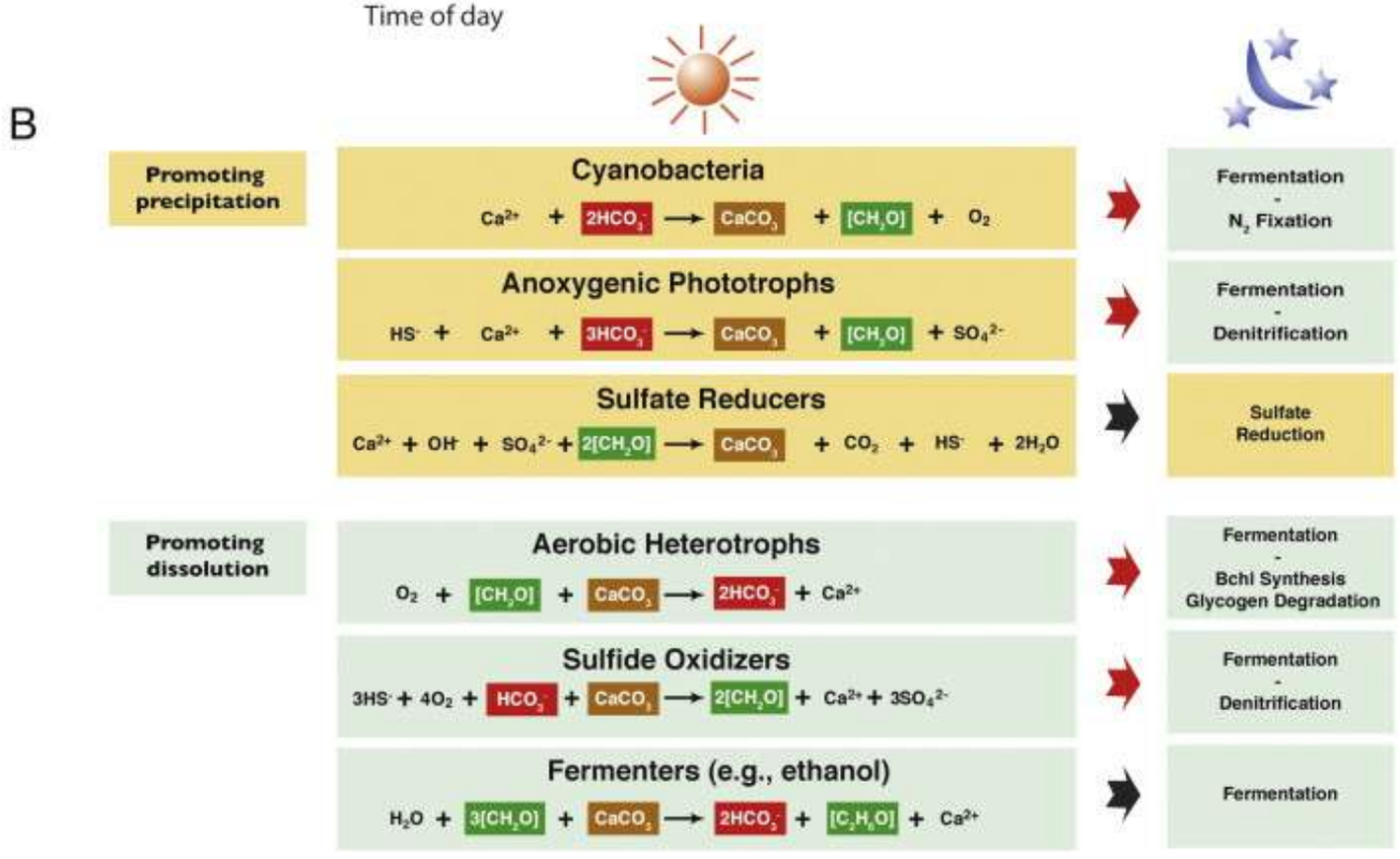



A. Open-marine stromatolite (Exumas, Bahamas). B. Hypersaline microbialites (Eleuthera, Bahamas). C. Freshwater travertine (Sarine River, Switzerland). D. Carbonate deposits in tropical soils (Ivory Coast, Africa)

Dupraz et al. 2009

# Diel fluctuations of vertical geochemical gradients in a microbial mat and combined metabolic–geochemical reactions




Dupraz et al. 2009