Where should we look to find vestiges of life in exoplanets?

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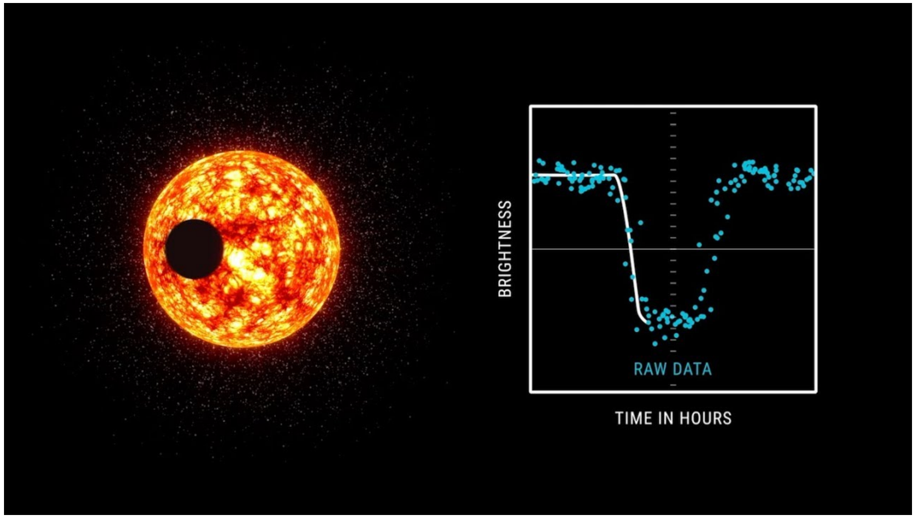
Are we alone in the universe?

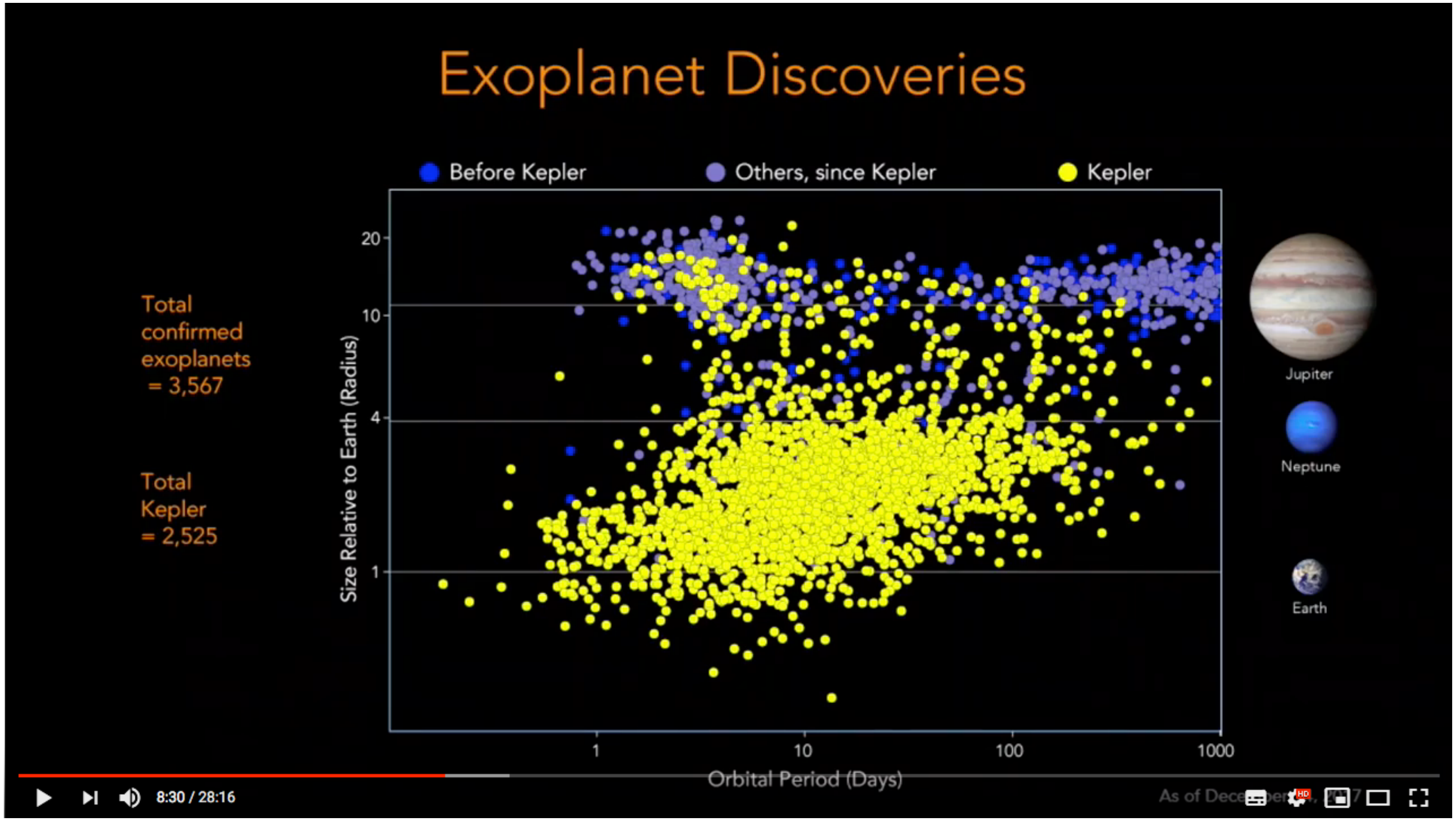
1) There are hundreds of BILLIONS OF galaxies
2) The Milkyway alone has hundreds of BILLIONS of stars
3) Each star has at least ONE plantet

4) THE POSSIBILITY OF FINDING LIFE OUTSIDE OF EARTH IS NOT SO LOW

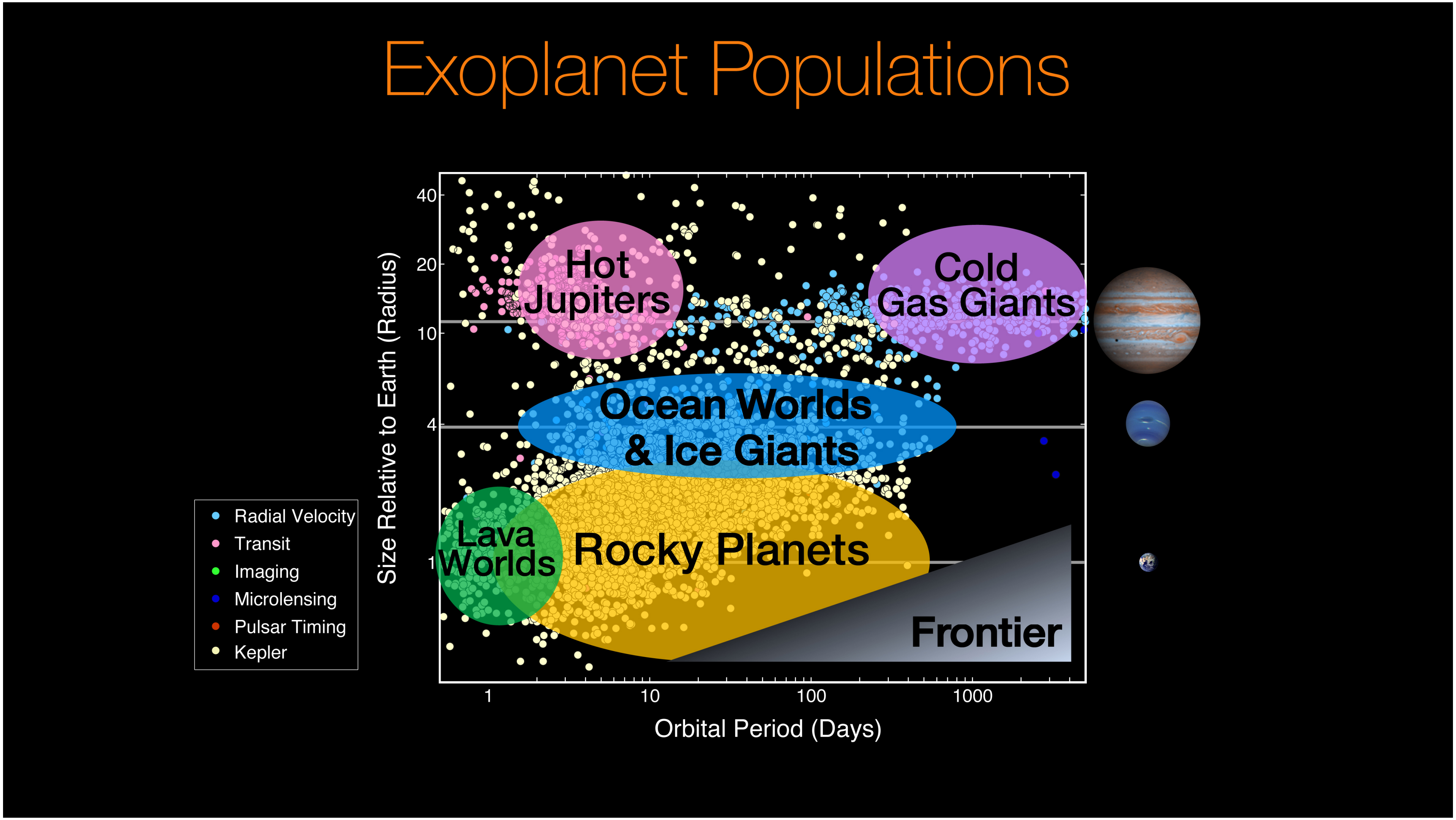
KEPLER and K2 MISSION

finding exoplanets using the transit technic

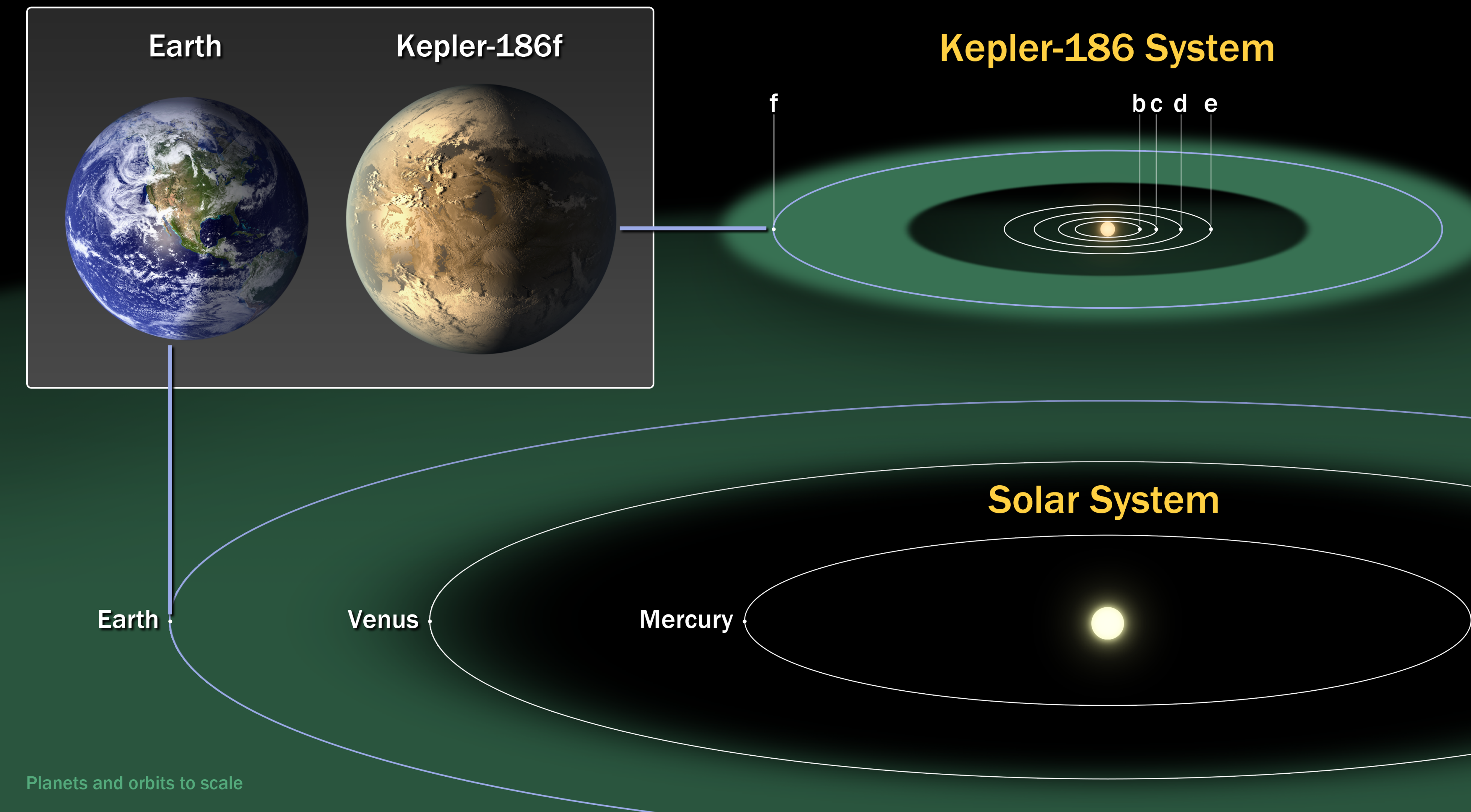


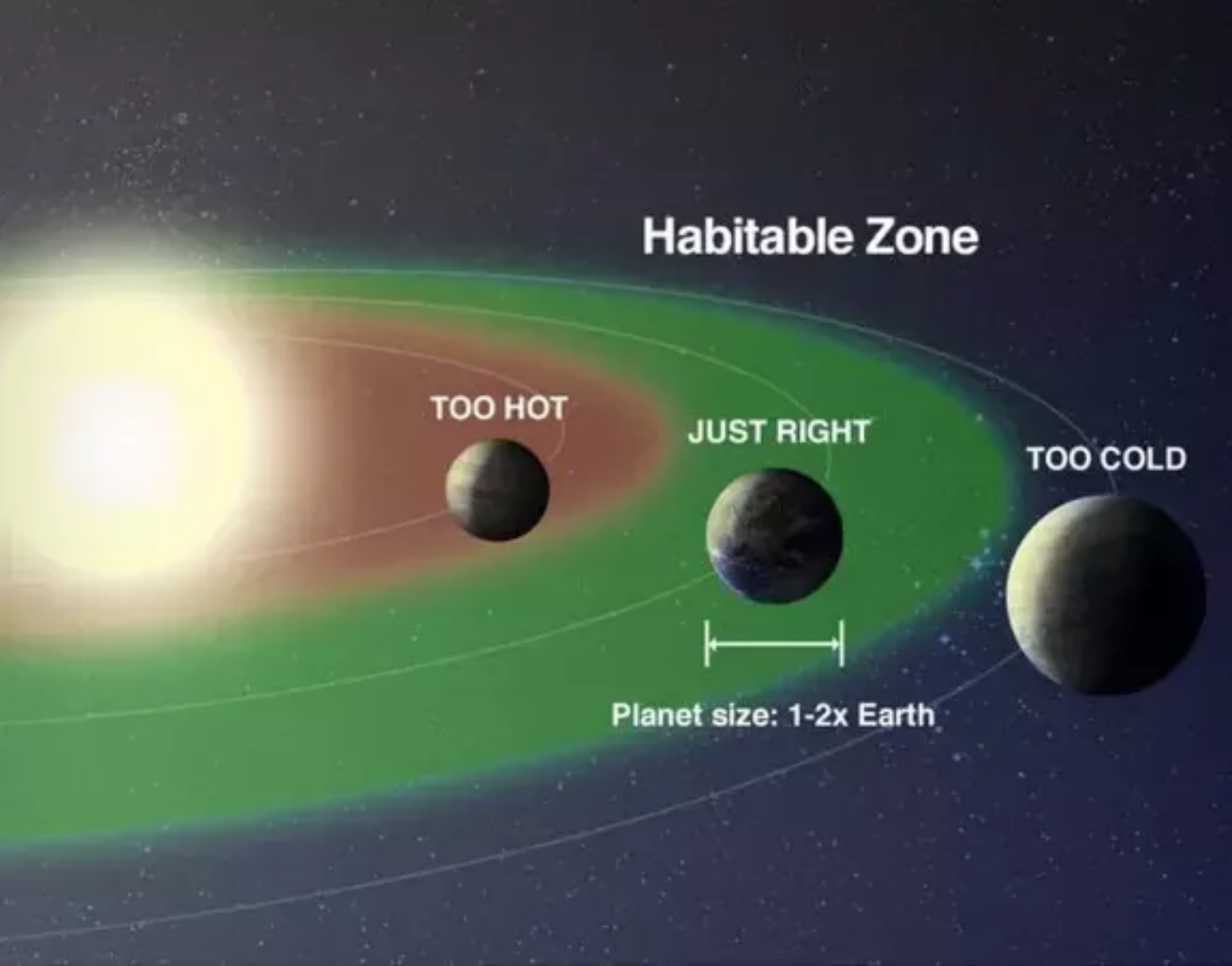


PLANTEDIVERSITY



KEPLER 186f Similar conditions to the Earth Orbits a Red Star

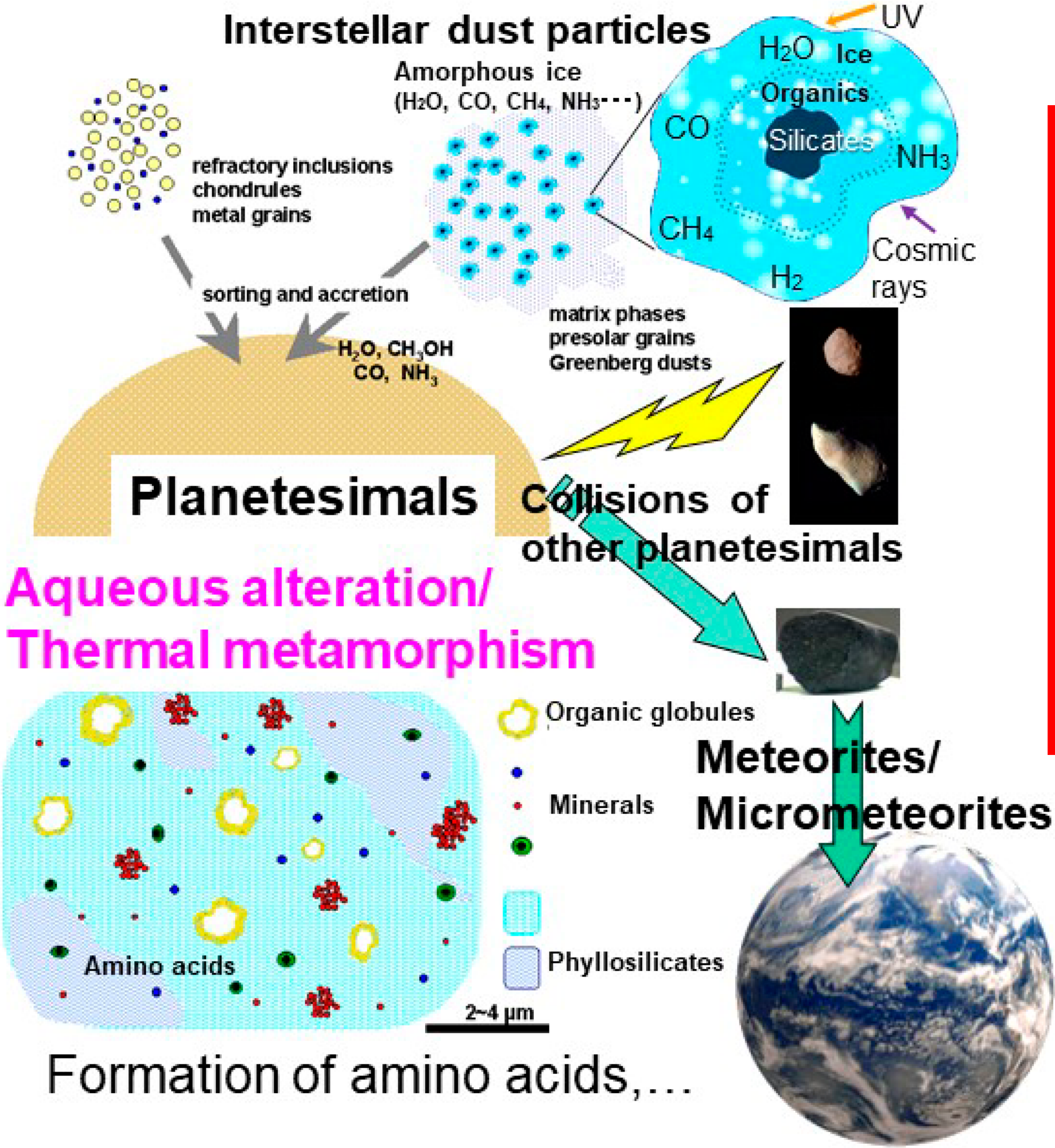



Habitable Zone
TOO HOT
JUST RIGHT
TOO COLD
Planet size: 1-2x Earth

EXAMPLES OF TYPES OF BIOCHEMISTRY ATERNATIVE ALTERNATIVE TO EARTH´S BIODIVERSITY

Overview of hypothetical types of biochemistry

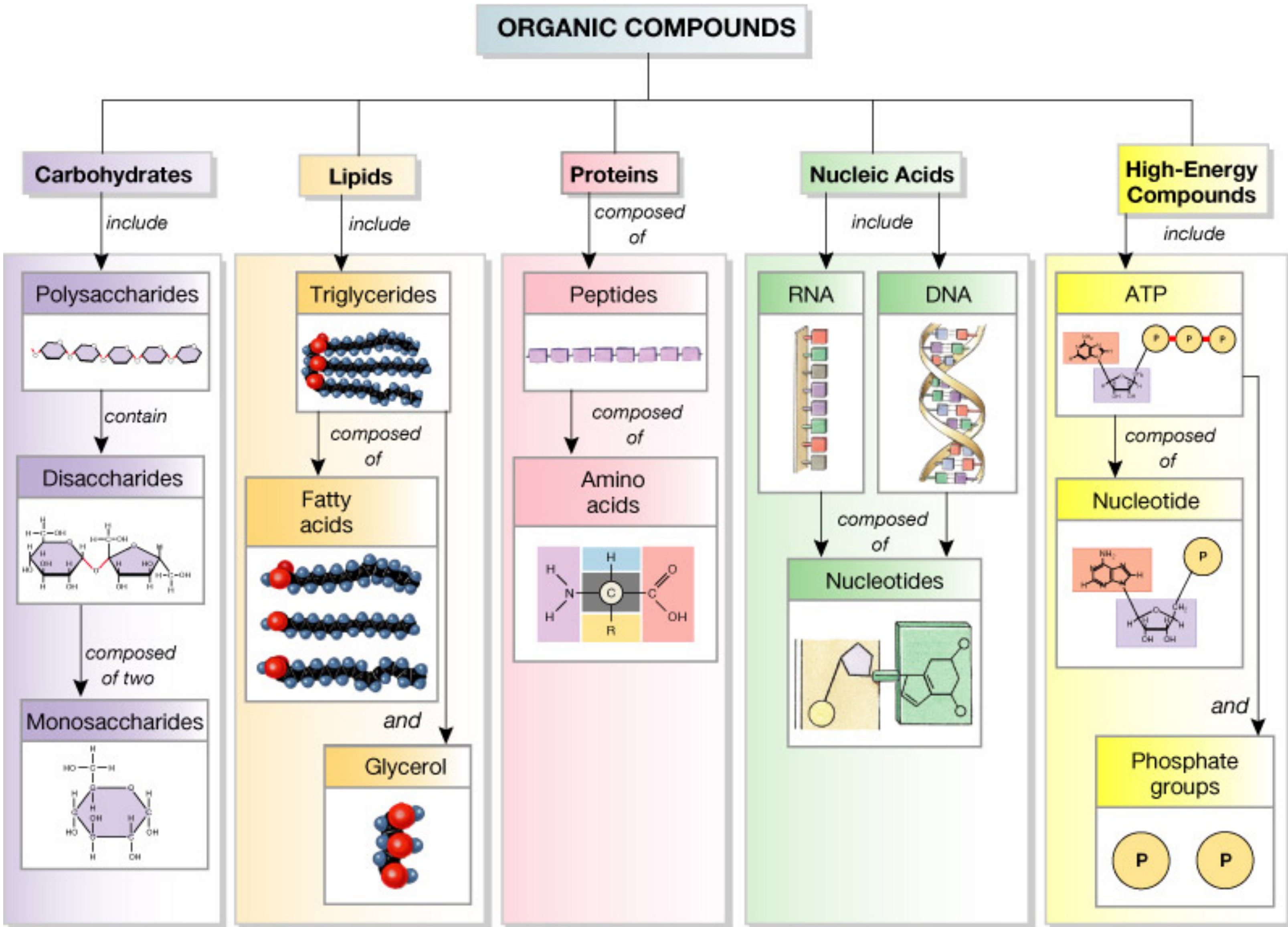
Type	Synopsis	Basis	Remarks
Ammonia biochemistry	Ammonia-based life	Non-water solvents	The possible role of liquid ammonia as an alternative solvent for life is an idea that goes back at least to 1954, when JBS Haldane raised the topic at a symposium about life's origin.
Arsenic biochemistry	Arsenic-based life	Alternate biochemistry	Arsenic, which is chemically similar to phosphorus, while poisonous for most life forms on Earth, is incorporated into the biochemistry of some organisms. I
Dust and plasma-based biochemistry	Exotic matrix life	Nonplanetary life	In 2007, Vadim N. Tsytovich and colleagues proposed that lifelike behaviors could be exhibited by dust particles suspended in a plasma, under conditions that might exist in space.
Extremophiles	Life in variable environments	Alternate environment	It would be biochemically possible to sustain life in environments that are only periodically consistent with life as we know it.
Methane biochemistry (Azotosome)	Methane-based life	Non-water solvents	Methane(CH_4) is a simple hydrocarbon: that is, a compound of two of the most common elements in the cosmos: hydrogen and carbon. Methane life is hypothetically possible.
Non-green photosynthesizers	Alternate plant life	Other speculations	Physicists have noted that, although photosynthesis on Earth generally involves green plants, a variety of other-colored plants could also support photosynthesis, essential for most life on Earth, and that other colors might be preferred in places that receive a different mix of stellar radiation than Earth.
Silicon biochemistry (Organosilico)	Silicon-based life	Alternate biochemistry	Like carbon, silicon can create molecules that are sufficiently large to carry biological information.
Sulfur biochemistry	Sulfur-based life	Alternate biochemistry	The biological use of sulfur as an alternative to carbon is purely hypothetical, especially because sulfur usually forms only linear chains rather than branched ones.



Did life come from outside the Earth?

If so, carbon based life may be spread through the universe

Molecules of life



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Topological assessment of metabolic networks reveals evolutionary information

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Jeaneth Machicao[1], Humberto A. Filho[1], Daniel J. G. Lahr[2], Marcos Buckeridge[2] & Odemir M. Bruno[1]

Evolutionary information was inferred from the topology of metabolic networks corresponding to 17 plant species belonging to major plant lineages *Chlorophytes*, *Bryophytes*, *Lycophytes* and *Angiosperms*. The plant metabolic networks were built using the substrate-product network modeling based on the metabolic reactions available on the PlantCyc database (version 9.5), from which their local topological

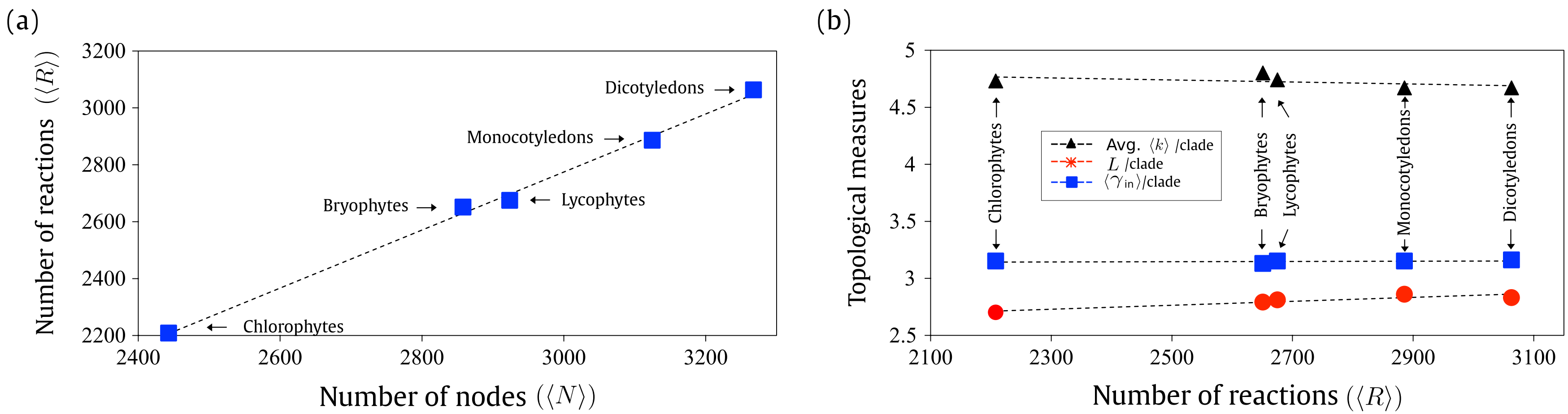
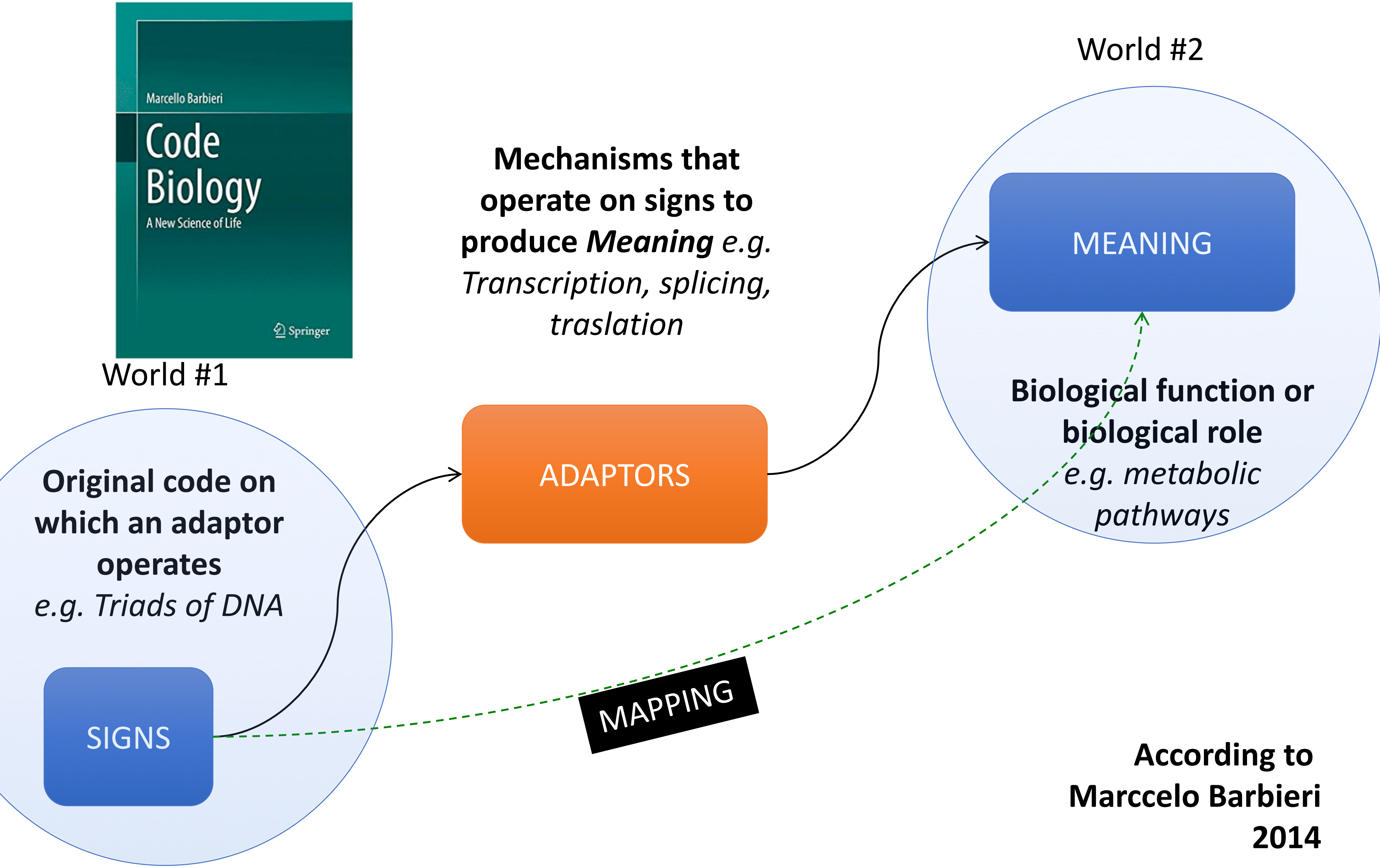


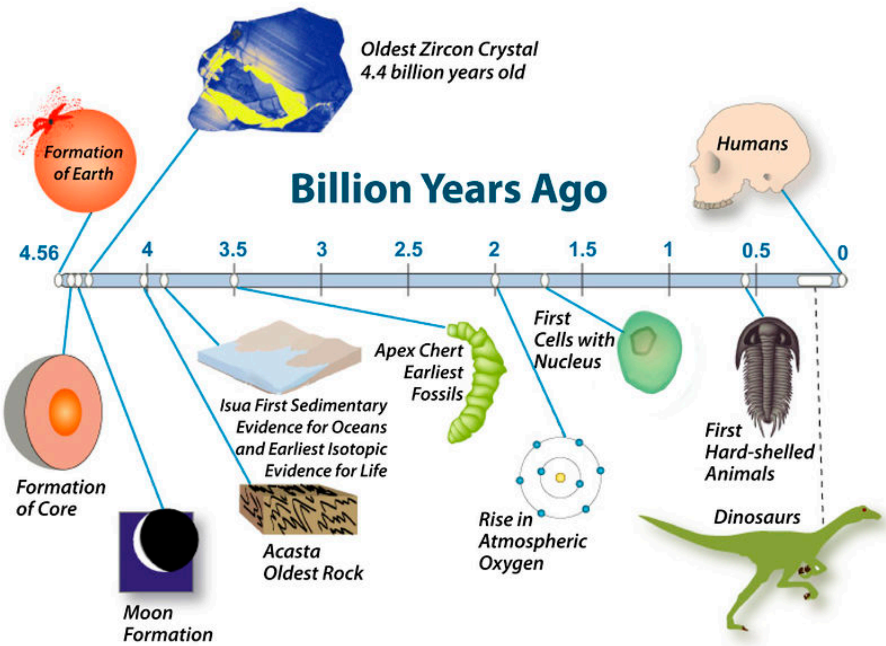
Figure 1. (**a**) Average number of reactions ($\langle R \rangle$) versus the average number of metabolites ($\langle N \rangle$) per plant clade. The plant clades: *Dicotyledons*, *Monocotyledons*, *Lycophytes*, *Bryophytes* and *Chlorophytes* are listed according with their average number of nodes and reactions. (**b**) The average number of plant metabolic reactions in function of the average values of three topological measures namely, mean degree $\langle \bar{k} \rangle$ (triangle), average path length L (circle) and the incoming power-law exponent γ_{in} (square), per each plant clade.

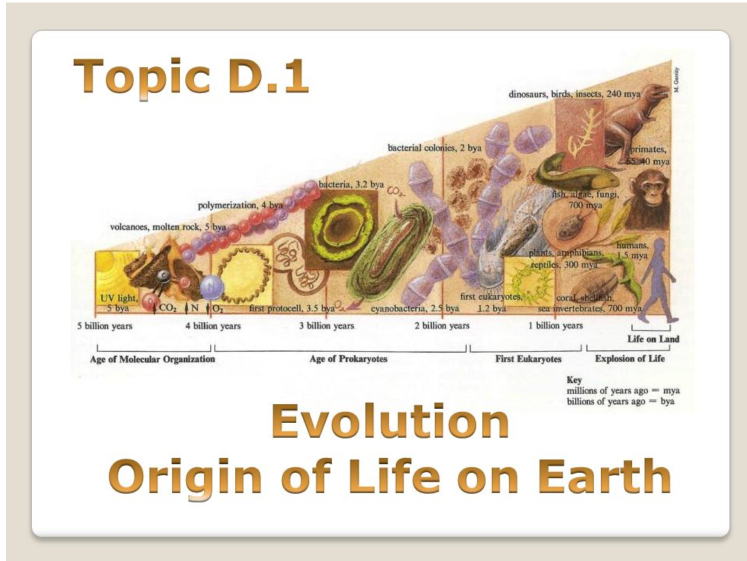
Code Biology: the semiotics of life



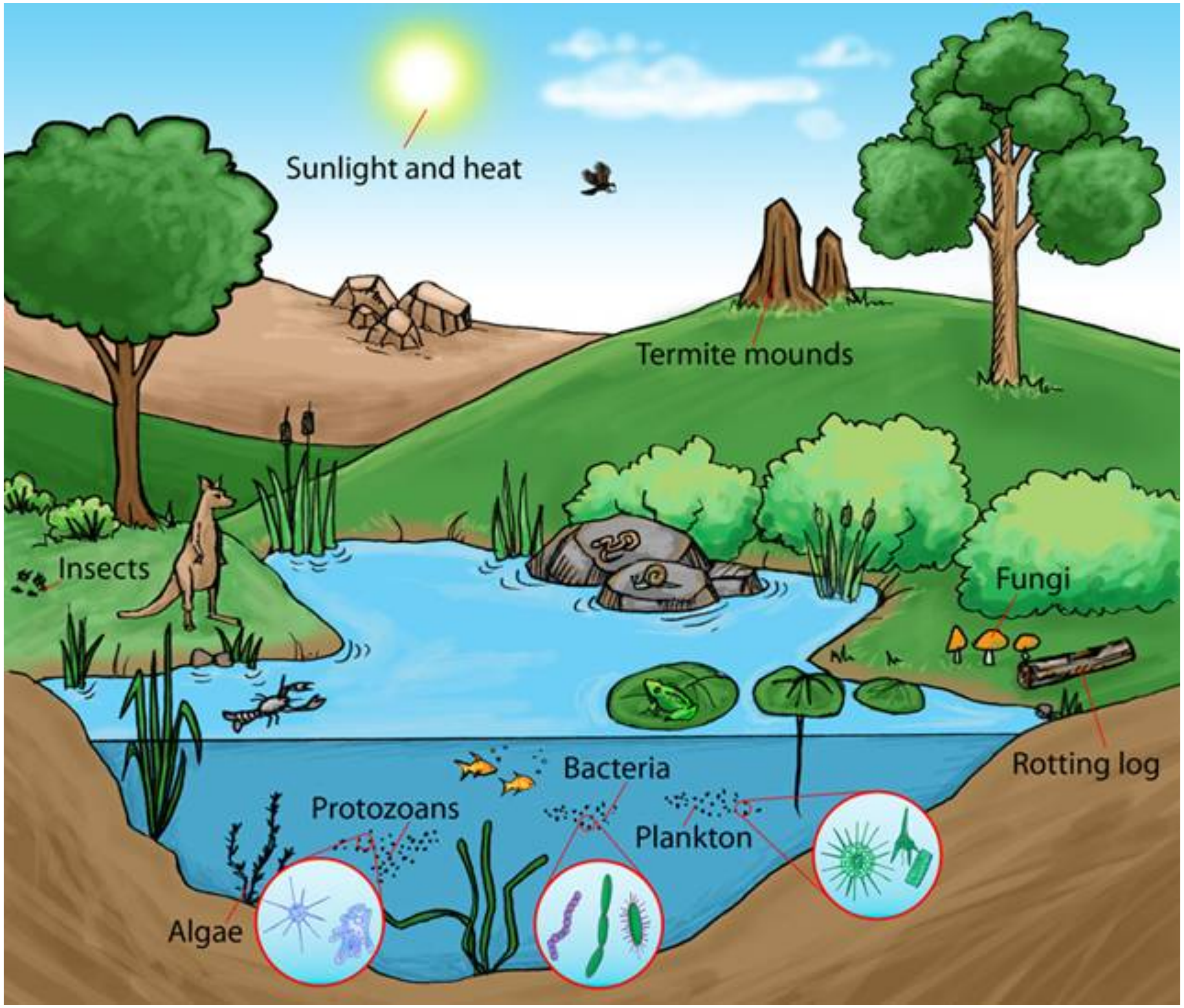
According to Marccelo Barbieri 2014

"Life" on Earth: strong bias to animal life



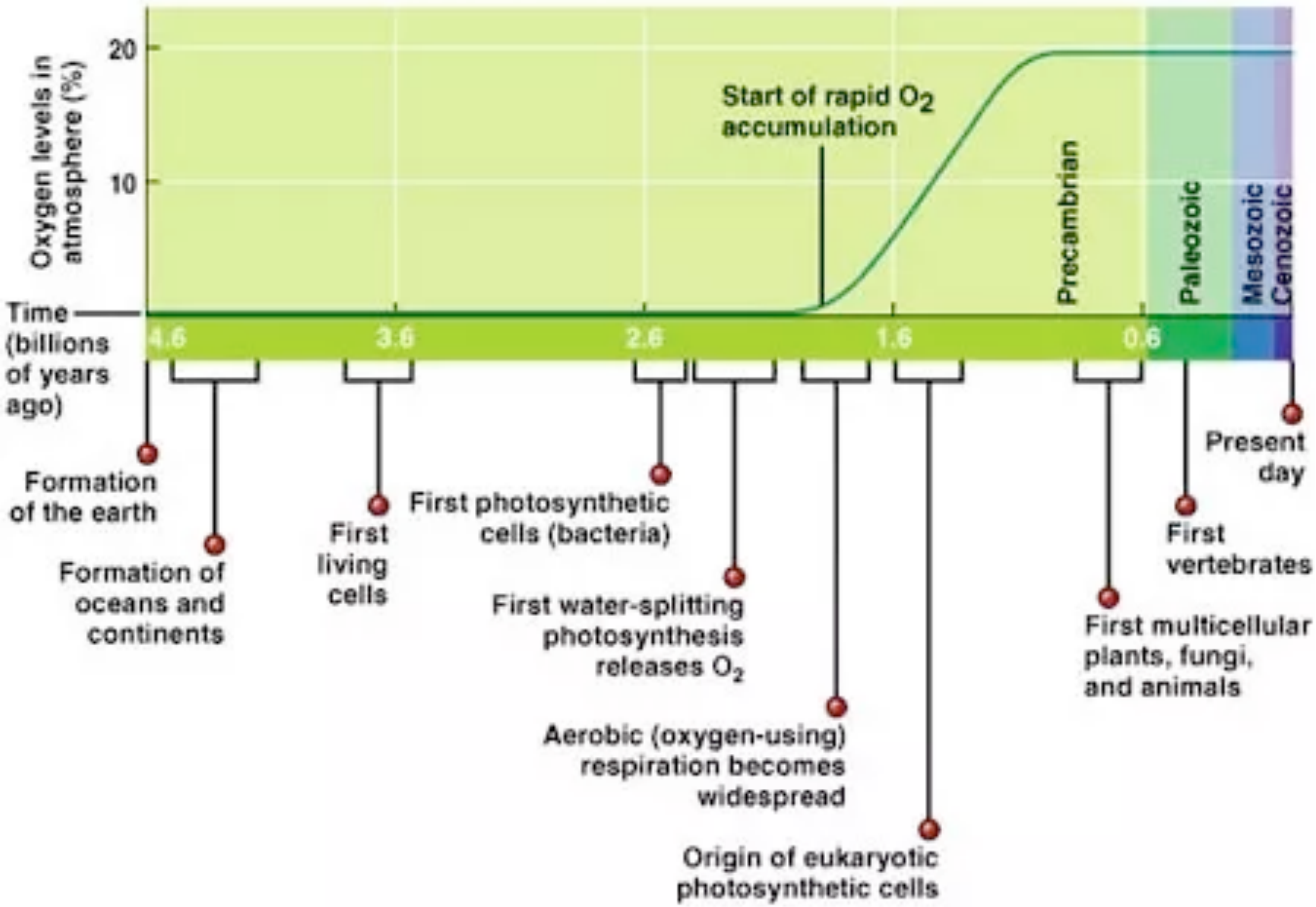


For life to exist as we know, ecosystems are needed



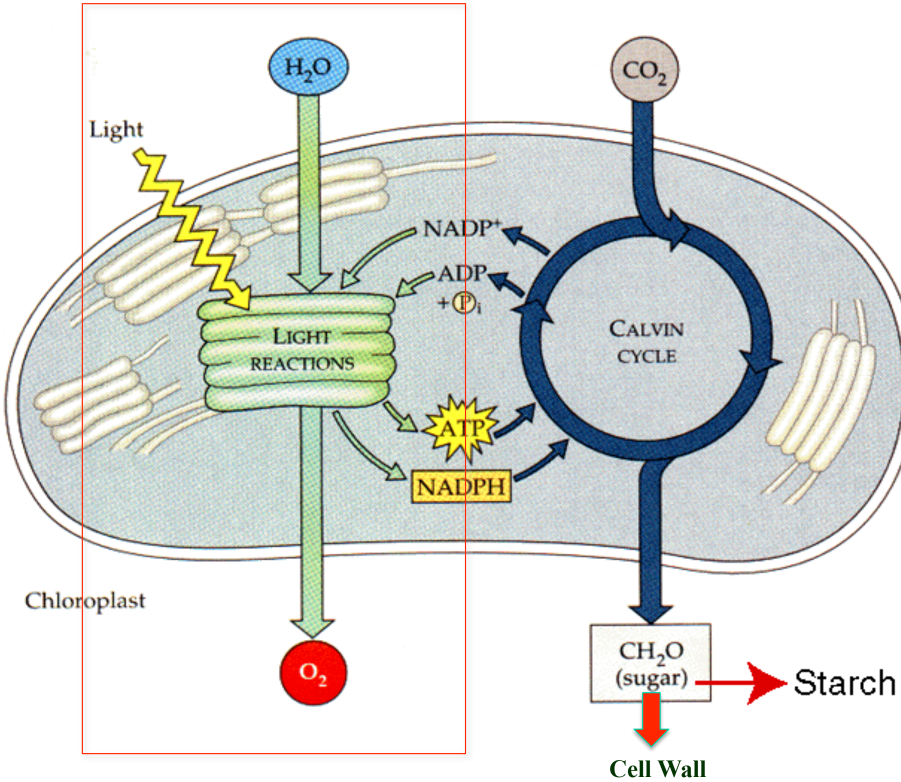
THE AMAZON

What do you see? Animals?

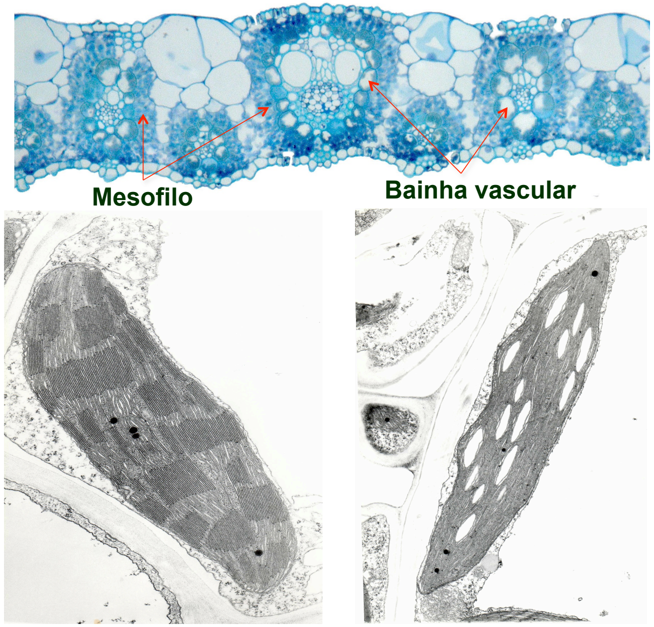


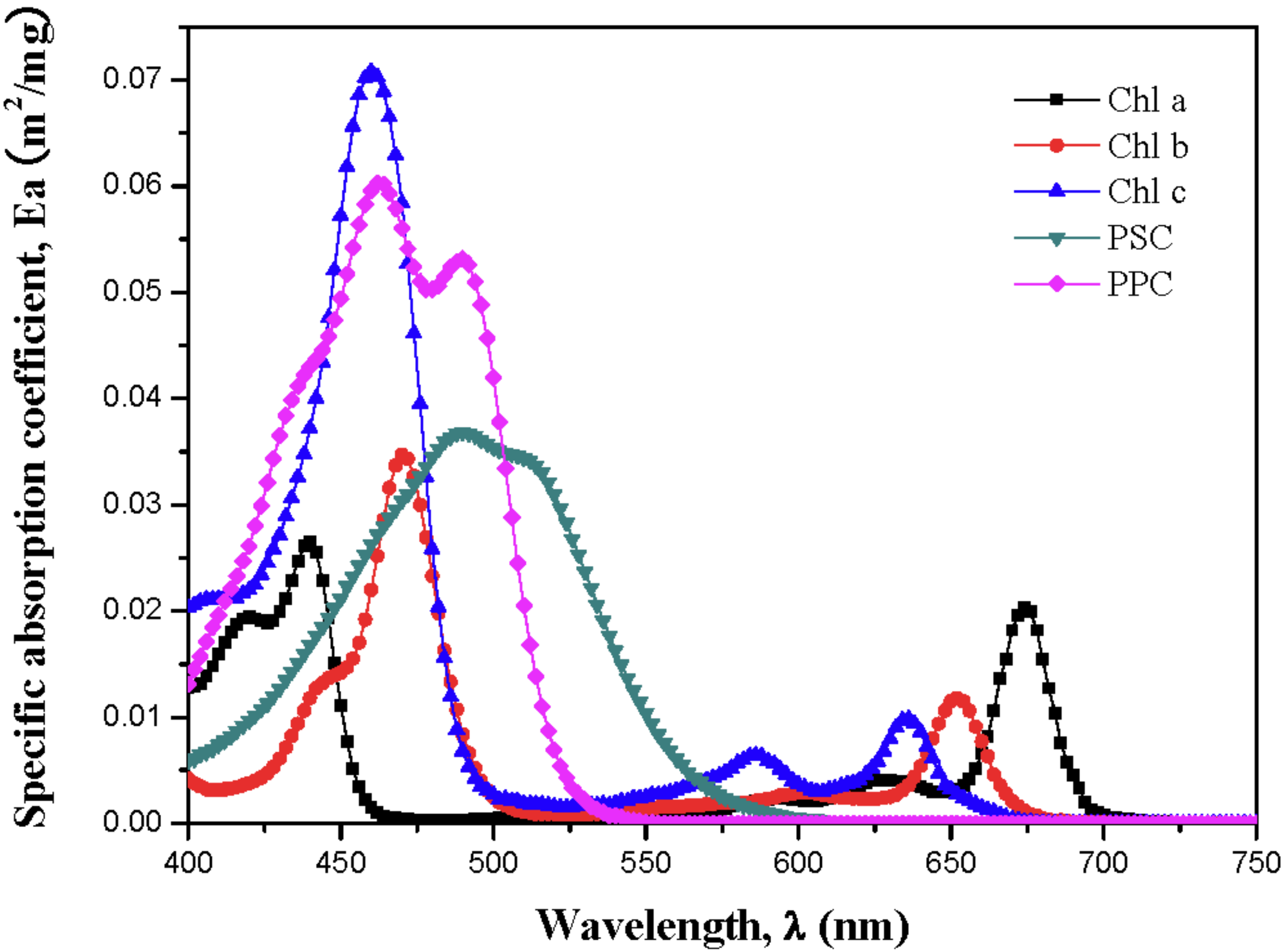
Evolution of photosythesis and O_2 production on Earth

BASIC MECHANISM OF PHOTOSYNTHESIS



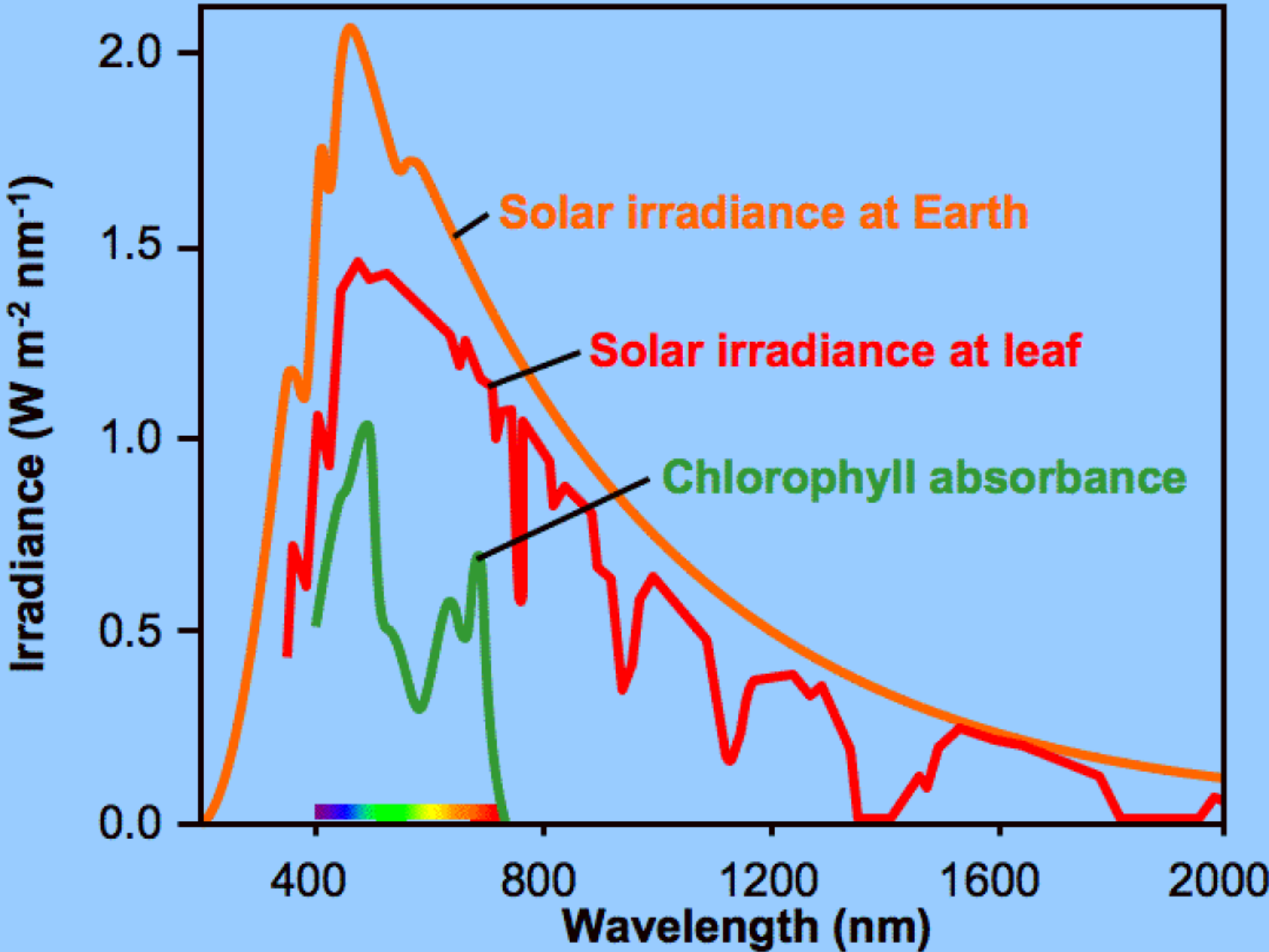
Cloroplastos de cana de açúcar



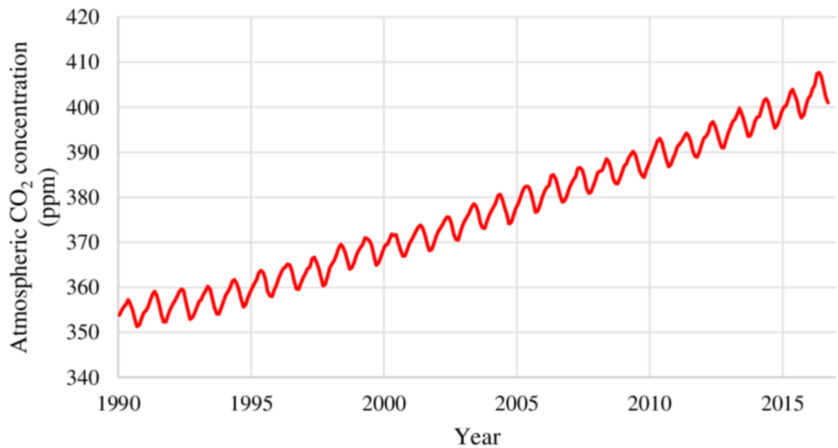


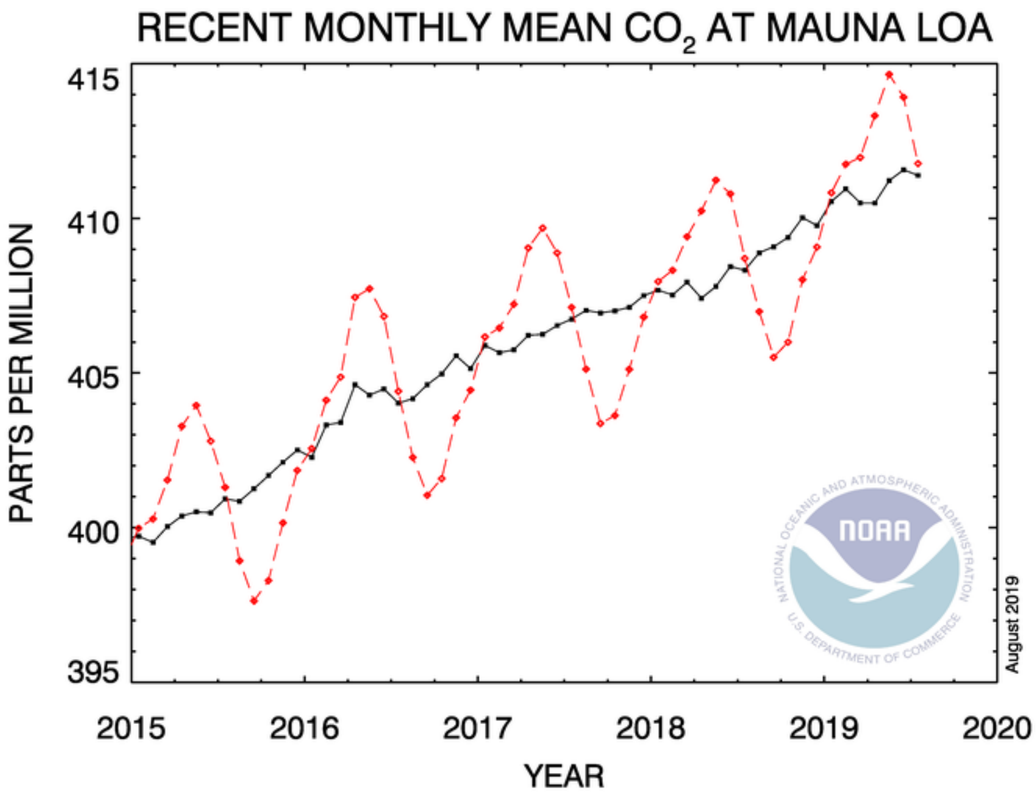
Specific absorption coefficient, Ea (m²/mg)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
400
450
500
550
600
650
700
750
Wavelength, λ (nm)
Chl a
Chl b
Chl c
PSC
PPC

Chlorophyll is well-adapted to use Solar Energy

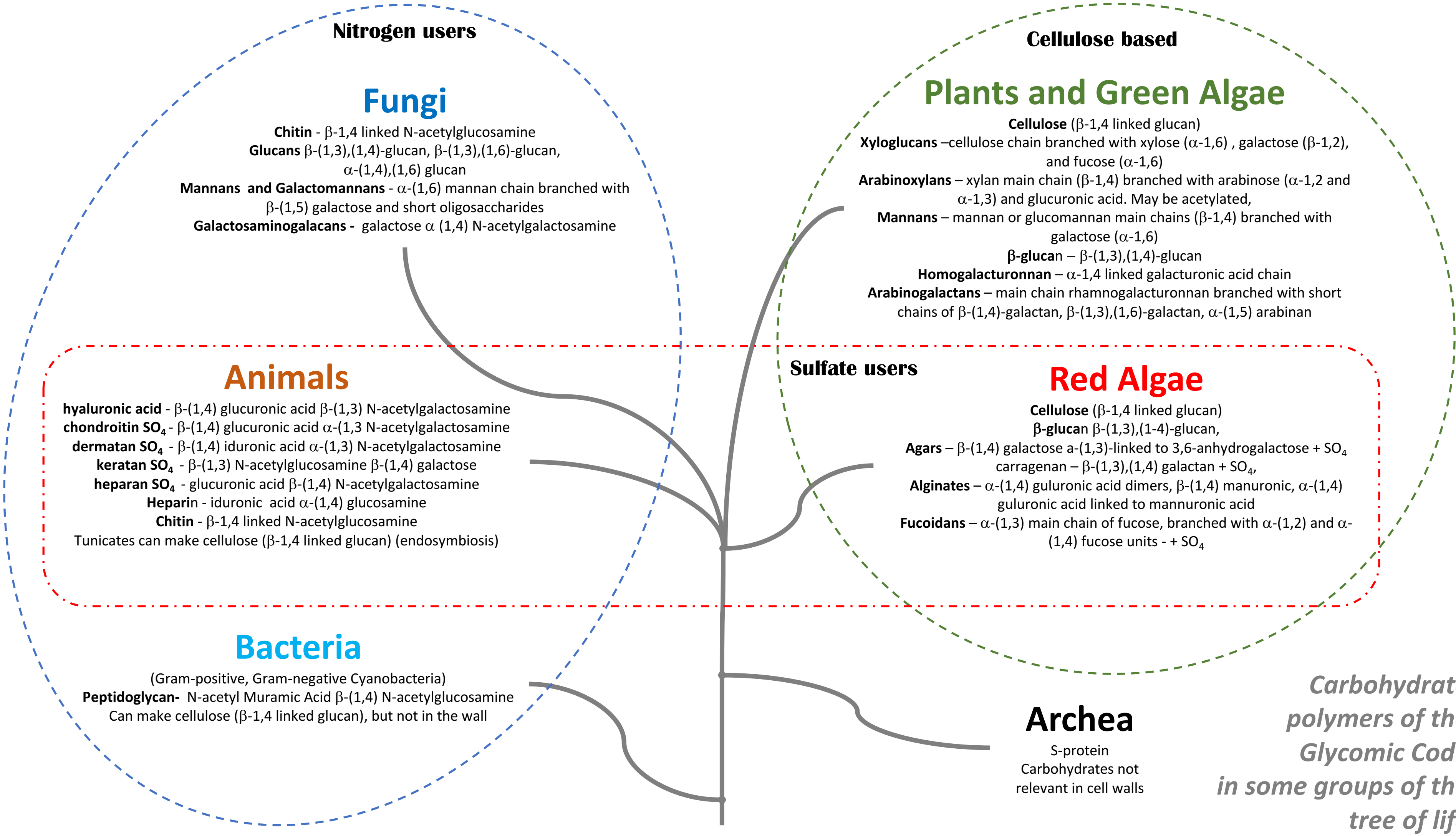


Photosynthesis provokes periodic changes in atmospheric CO2 concentration



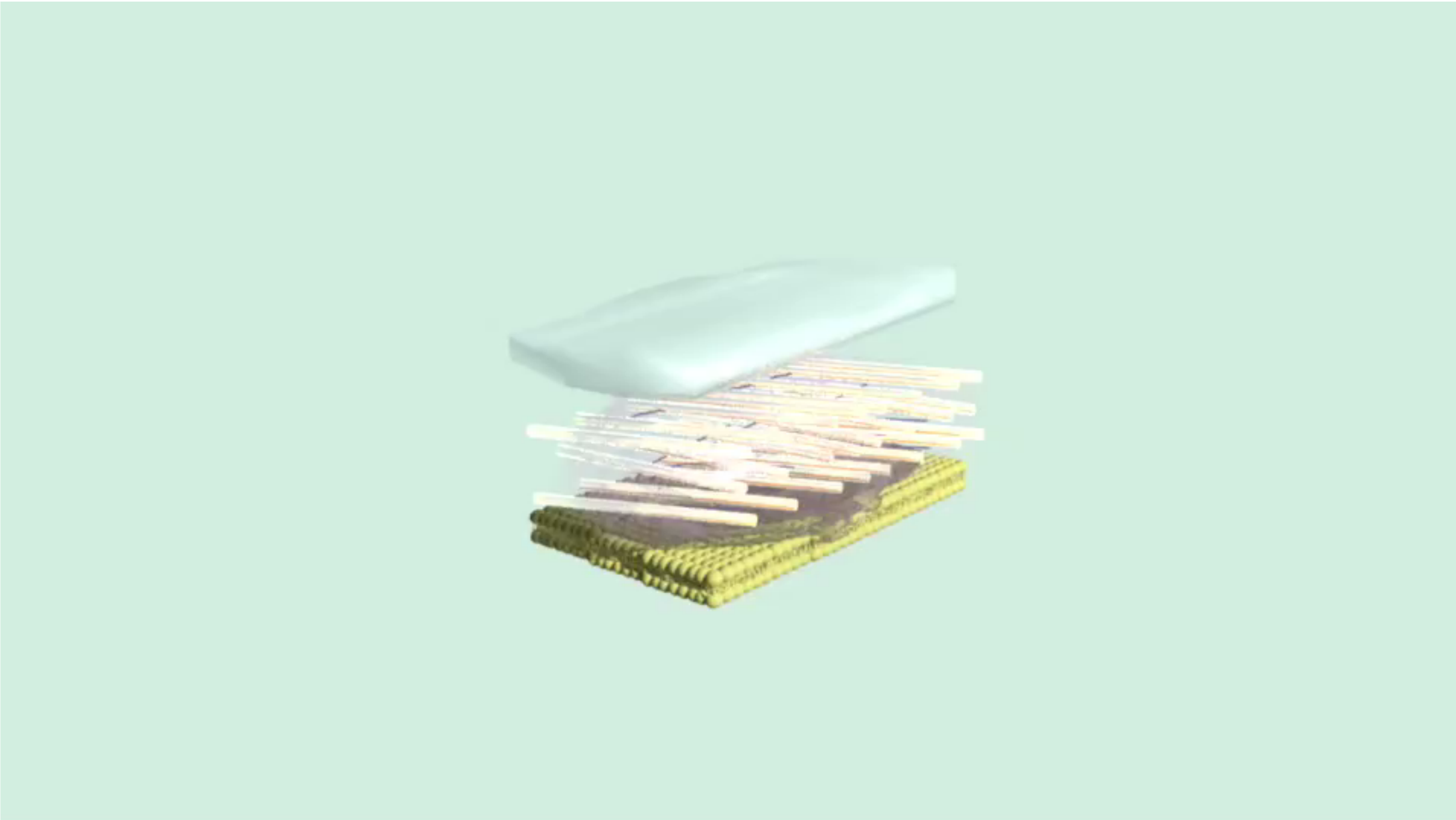


THE EVOLUTION OF THE GLYCOMIC CODE IN LIFE



Carbohydrate polymers of the Glycomic Code in some groups of the tree of life

Cell wall model



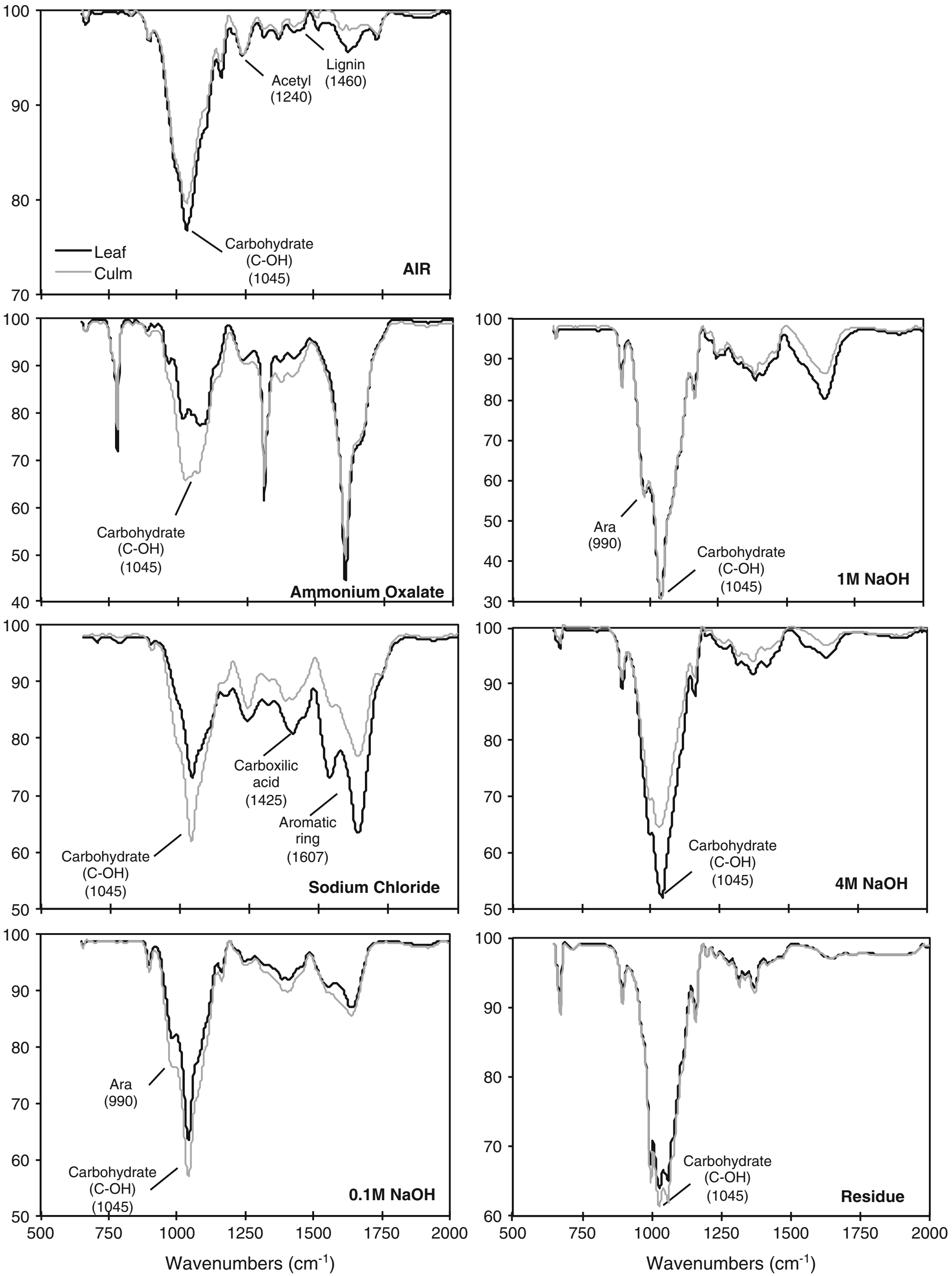


Fig. 5 Fourier Transformed Infra-Red (FTIR) spectroscopy of alcohol-insoluble residue (AIR) and cell wall extracts of leaves (*black lines*) and culm (*grey lines*) of sugarcane

The most abundant biological structure on Earth is the plant cell wall

…and the most abundant compound on Earth is cellulose

We can detect cellulose and other polymers using FTIR

Would we be able to detect such compounds on the surface of exoplanets?

WHAT TO LOOK FOR?

Plants are the more abundant organisms on earth in terms of biomass. They are the energy capture machines of ecosystems. Thus, if we want to search for Earth´s-like life in exoplanets, we should look for......

1) green color reflection from the surface of exoplanets be detectable?

2) Fluorescence of chlorophyll would also be an option;

3) Look for a combination of vibrations that could reveal the presence of cellulose-like polymers;

4) O2and CO2 daily variations, combined with green color and fluorescence could be a sign of plant life and even of ecosystems functioning in exoplanets that are in the habitable zone in solar systems similar to ours.

IT IS A VERY NARROW WINDOW, BUT IF LIFE EVOLVED IN ONE OF SOME OF THE EXOPLANTS IN THE MILKY WAY, WITH THE ADVANCE OF TECHNIQUES OF DETECTION OF CERTAIN SUBSTANCES AS WELL AS THEIR DINAMICS, COULD LEAD US TO THE CONCLUSION THAT LIFE SIMILAR TO EARTH'S ARE PRESENT.

AS PLANTS DON´T EXIST ALONE, THEIR VERY PRESENCE WOULD BE INDIRECT EVIDENCE OF OTHER TYPES OF ORGANISMS

Thank you

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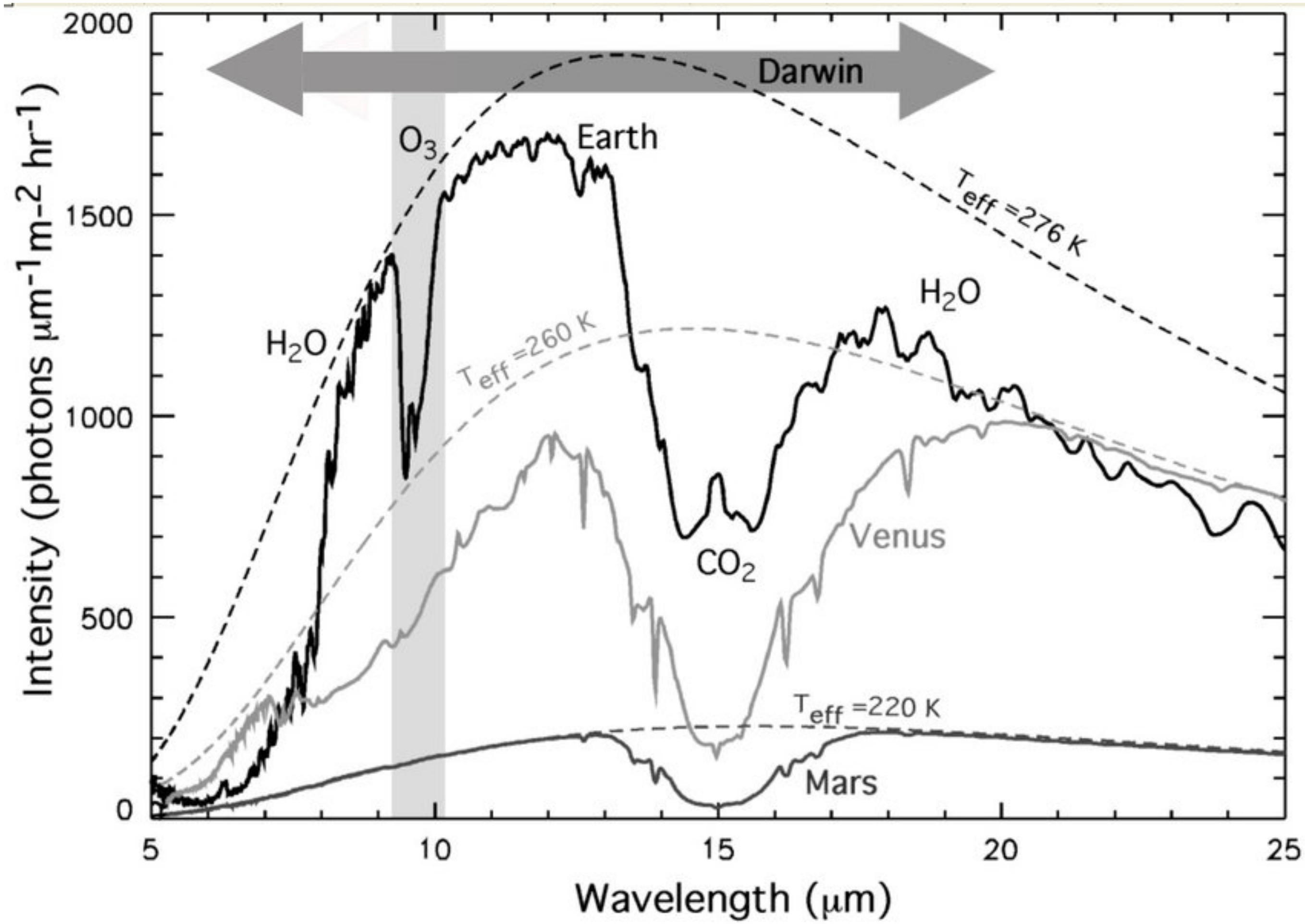

Darwin
Earth
O3
H2O
H2O
Teff =276 K
Teff =260 K
Teff =220 K
CO2
Venus
Mars
Intensity (photons µm-1m-2 hr-1)
Wavelength (µm)
2000
1500
1000
500
0
5
10
15
20
25

Spectrum of Solar Radiation (Earth)