BAA Asteroids & Remote Planets Section Meeting

An Introduction to Astrobiology

29 September, 2019

Peta Bosley

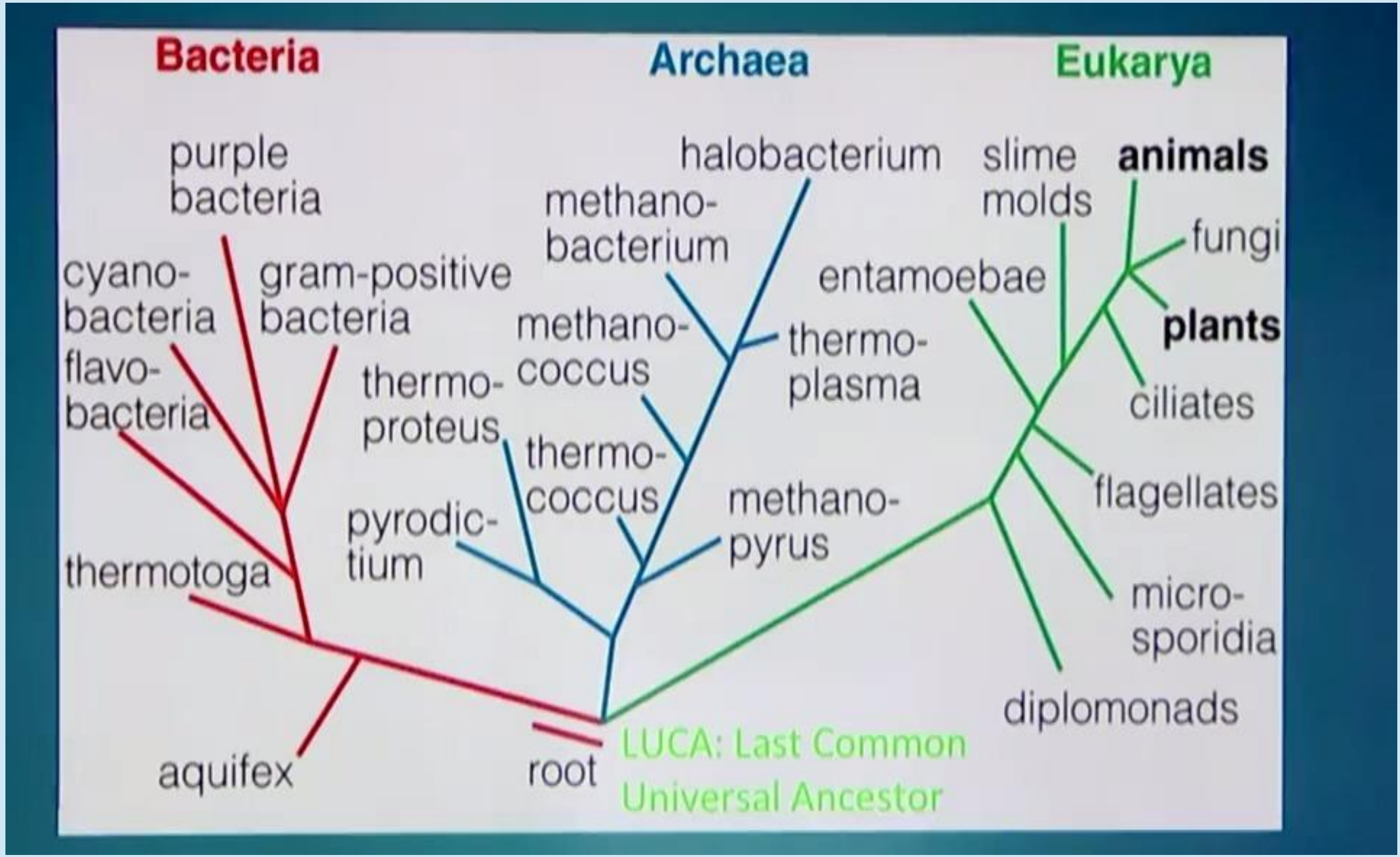
Why Astrobiology?

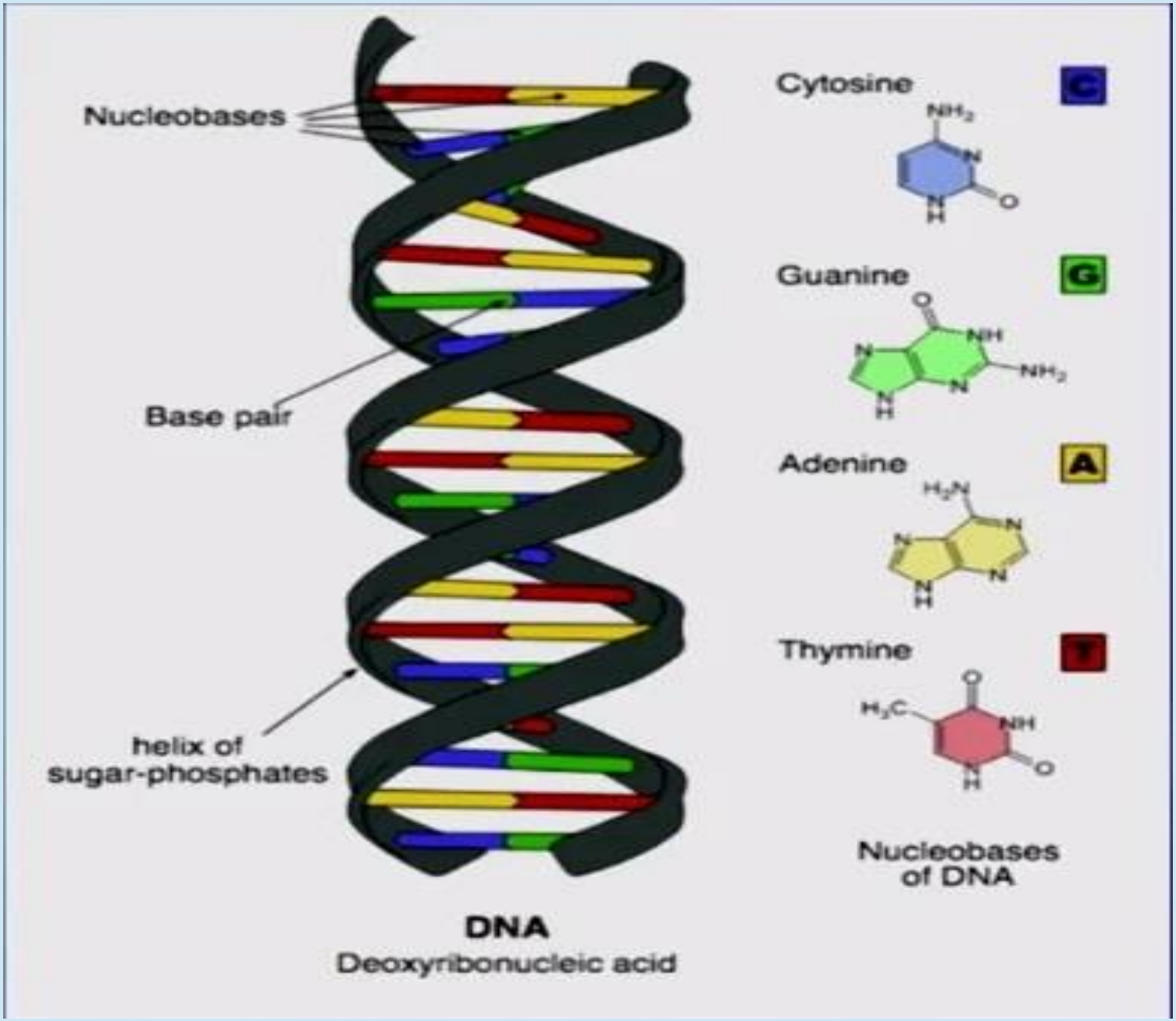
It's not observational.....

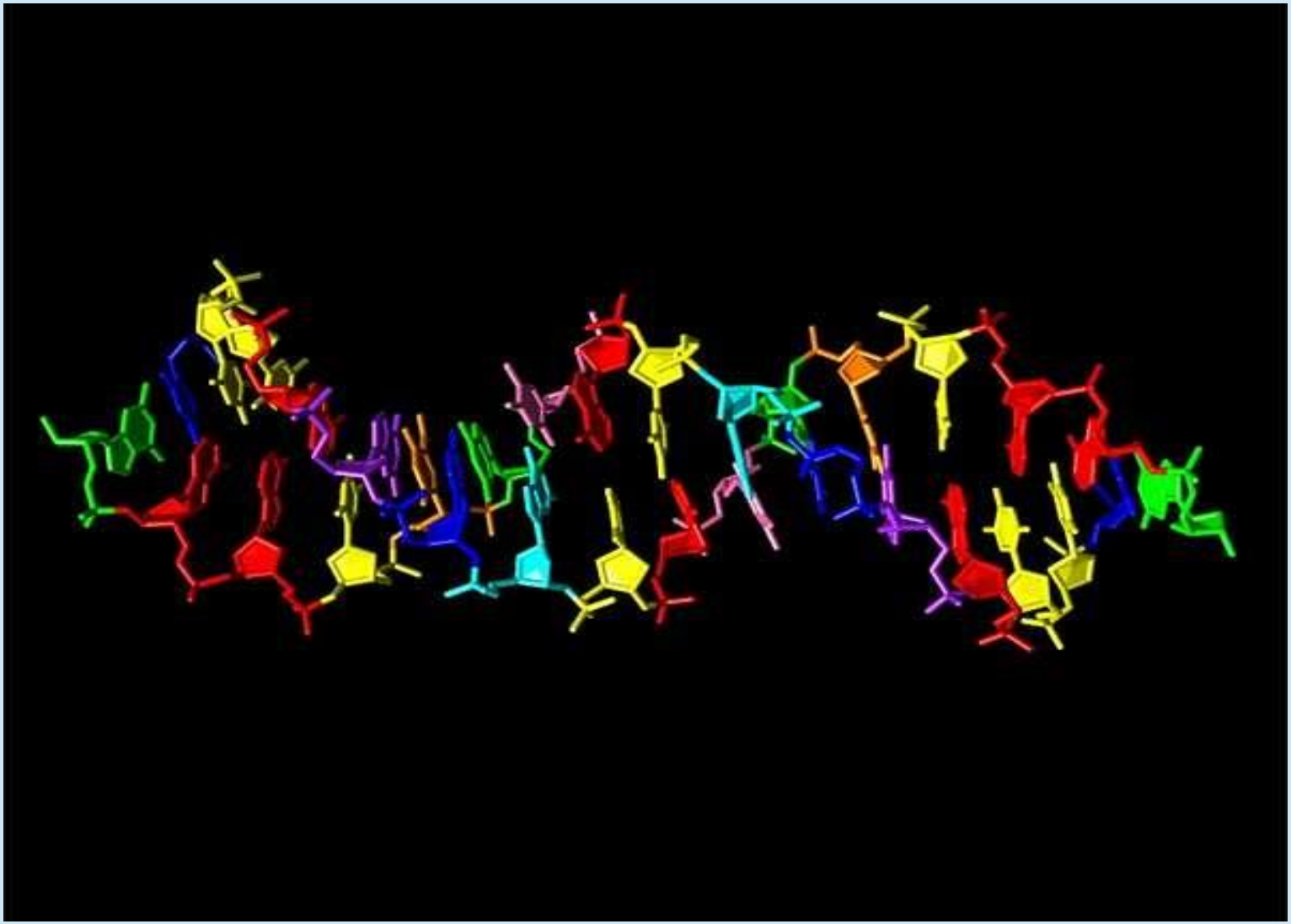
Interest is expanding

What is Life?

What was early Earth like?


Bacteria
Archaea
Eukarya
purple bacteria
cyano-bacteria
gram-positive bacteria
flavo-bacteria
thermo-proteus
pyrodic-tium
thermotoga
aquifex
root
halobacterium
methano-bacterium
methano-coccus
thermo-coccus
thermo-plasma
methano-pyrus
slime molds
animals
fungi
entamoebae
plants
ciliates
flagellates
micro-sporidia
diplomonads
LUCA: Last Common Universal Ancestor


Nucleobases
Base pair
helix of
sugar-phosphates
DNA
Deoxyribonucleic acid
Cytosine
C
Guanine
G
Adenine
A
Thymine
T
Nucleobases
of DNA



Early Earth – very different to our environment

- Constant volcanic eruptions spewed out methane

- Fatal levels of UV radiation (no ozone layer then)

- Dominant early life were unicellular anaerobic bacteria that had no need for oxygen

- The problem arose when one life-form, the cyanobacteria, developed roughly 2.7 Ga (billion years) ago

- Up to 2.45 Ga / Oxygen levels @ 0.1% current atmosphere

- Great Oxygenation Event / Catastrophe started ~ 2.3 Ga

- Produced as waste product

- Up to 1.85 Ga / Combined in “mass rusting” - banded iron formations on ocean floor
- Carboniferous O2 levels @ 35%

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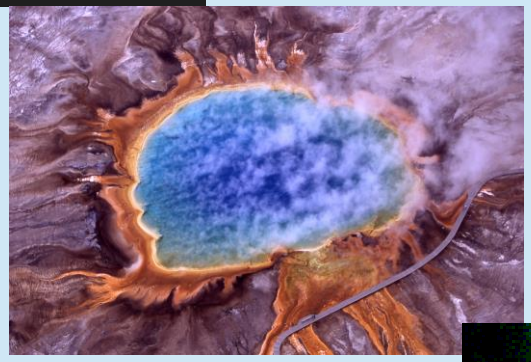
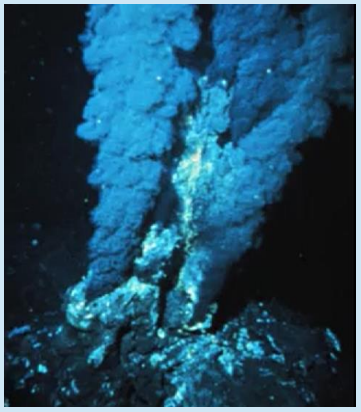
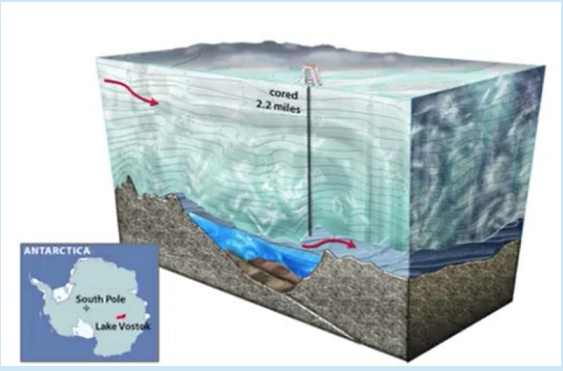
HAMPSHIRE ASTRONOMICAL GROUP







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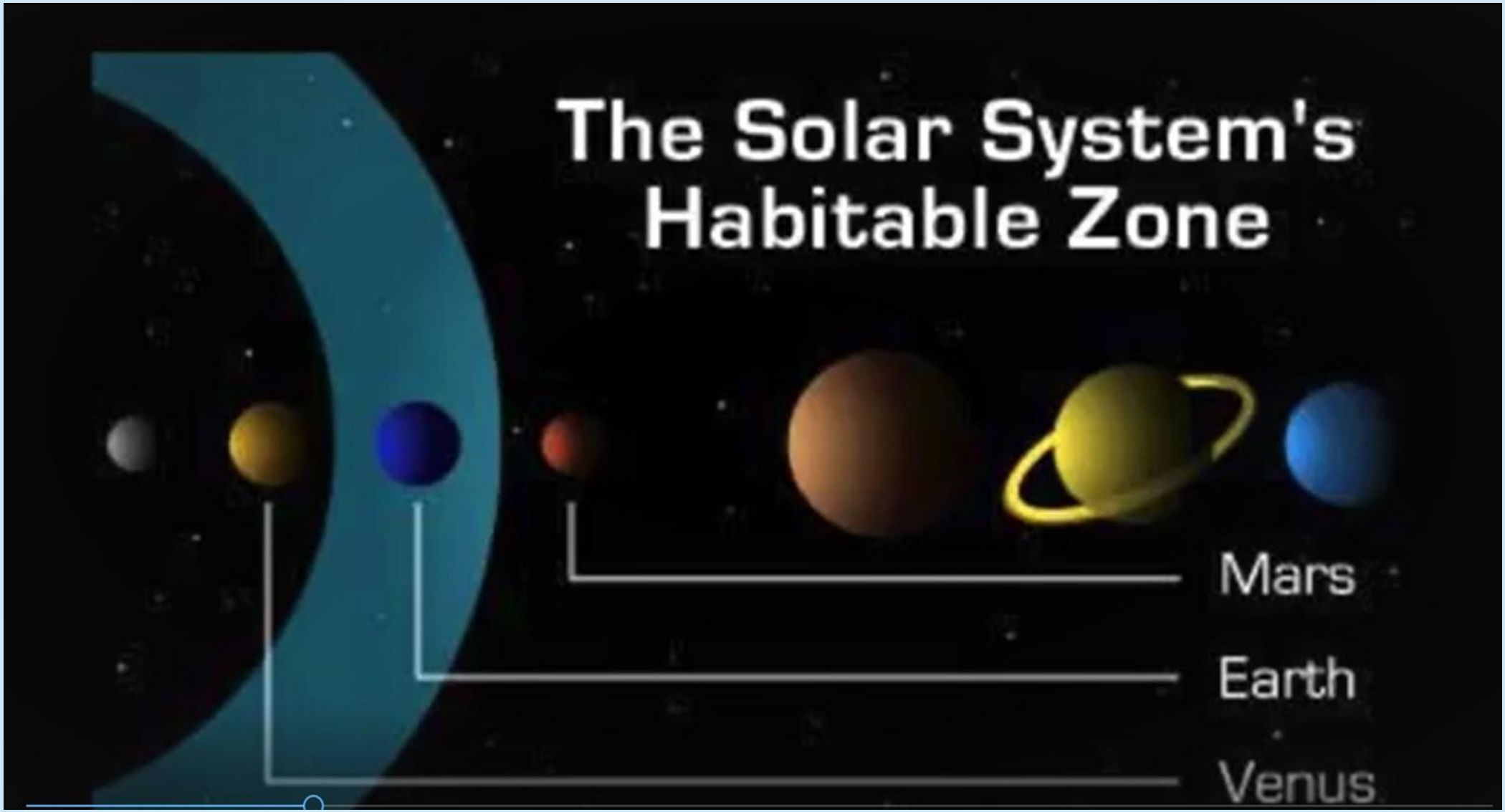
HAMPSHIRE ASTRONOMICAL GROUP

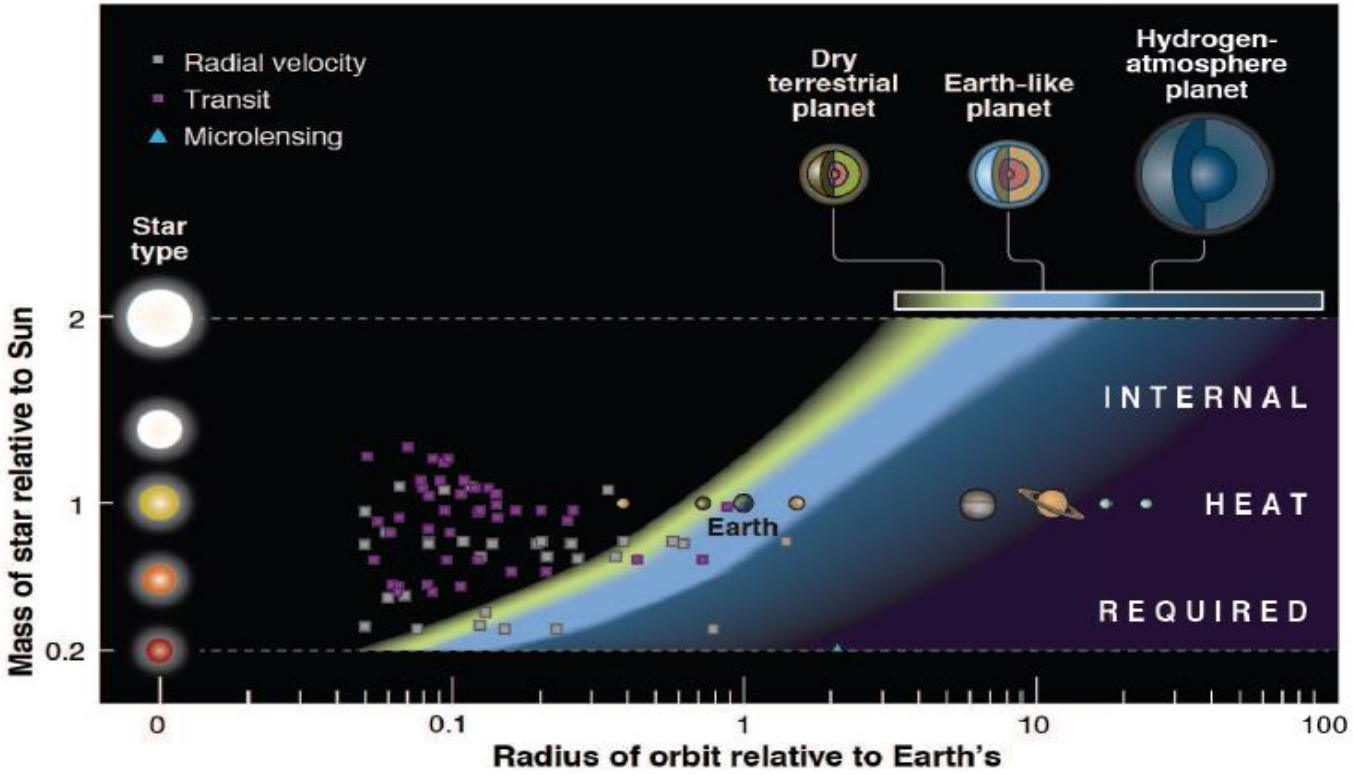
Habitable / “Goldilocks” Zone

- Traditional thinking was in terms of distance from Primary
- Liquid Water on the Surface

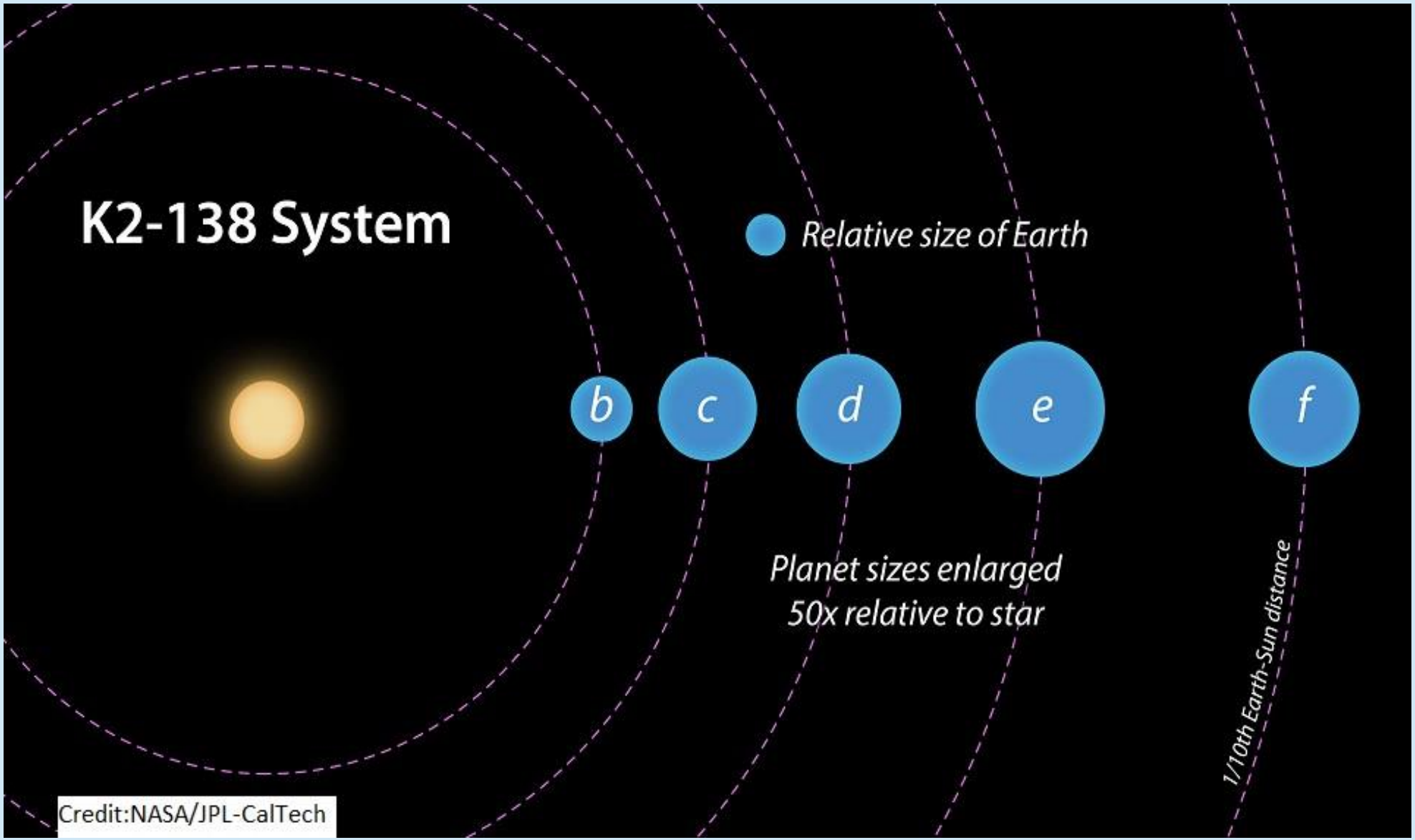
- Distance from Primary varies with star type
- Hot stars have a more distant habitable zone


The Solar System's
Habitable Zone
Mars
Earth
Venus

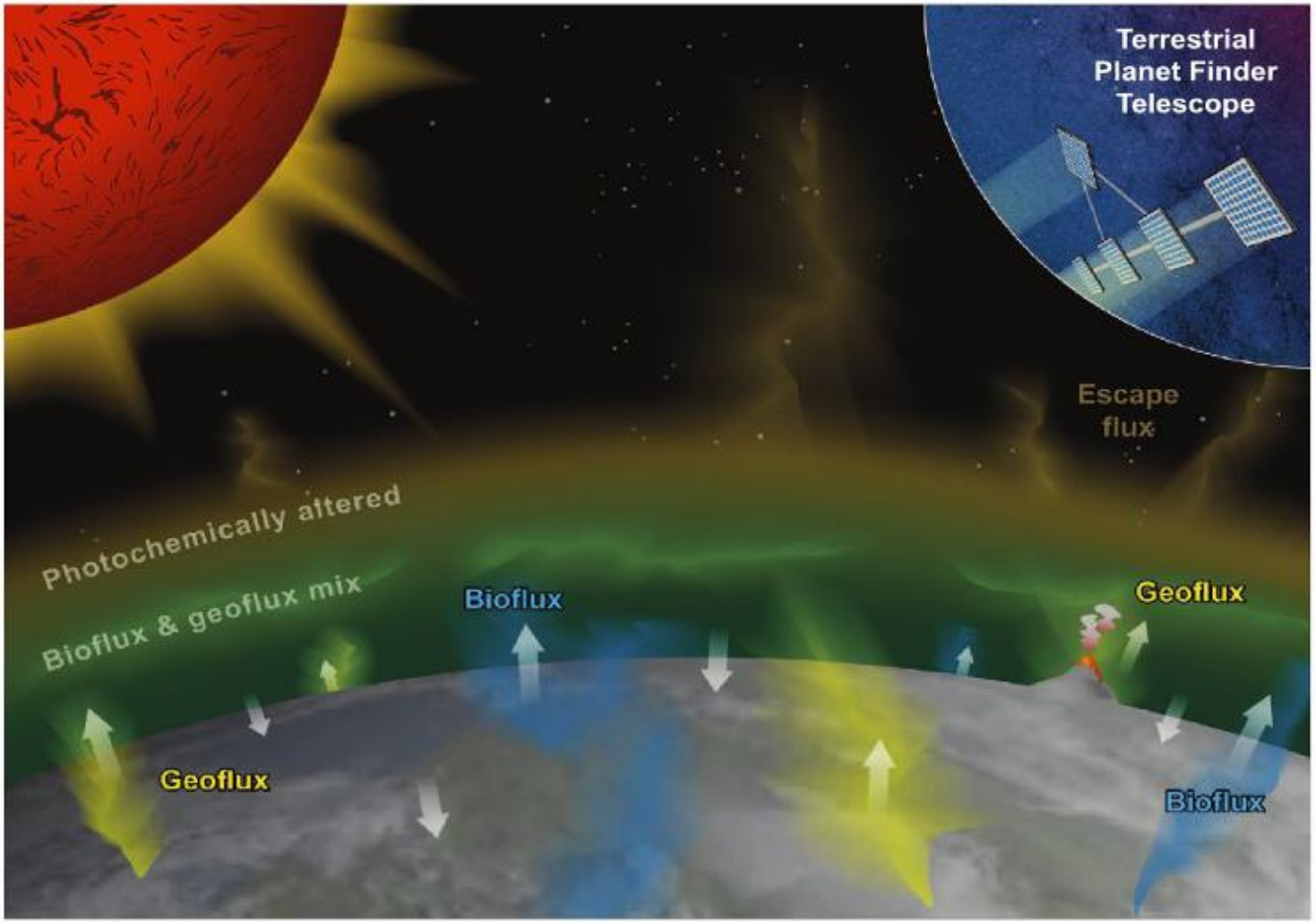
The Habitable Zone



Seager, *Science* 2013
Inner edge: Zsom, Seager, de Wit, arXiv: 1304.3714


K2-138 System
Relative size of Earth
b
c
d
e
f
Planet sizes enlarged
50x relative to star
1/10th Earth-Sun distance
Credit:NASA/JPL-CalTech

- Biological processes (eg., photosynthesis) leave traces behind
- These biosignatures can be remotely detected
- Important biosignatures
  - IR reflections of vegetation
  - Gases in fluctuating states (eg., O2/O3 & CH4)
  - Organic S compounds
- Caution : non-biological factors can interfere
- Consider environmental factors
- Life could still exist if we don't find evidence in the atmosphere

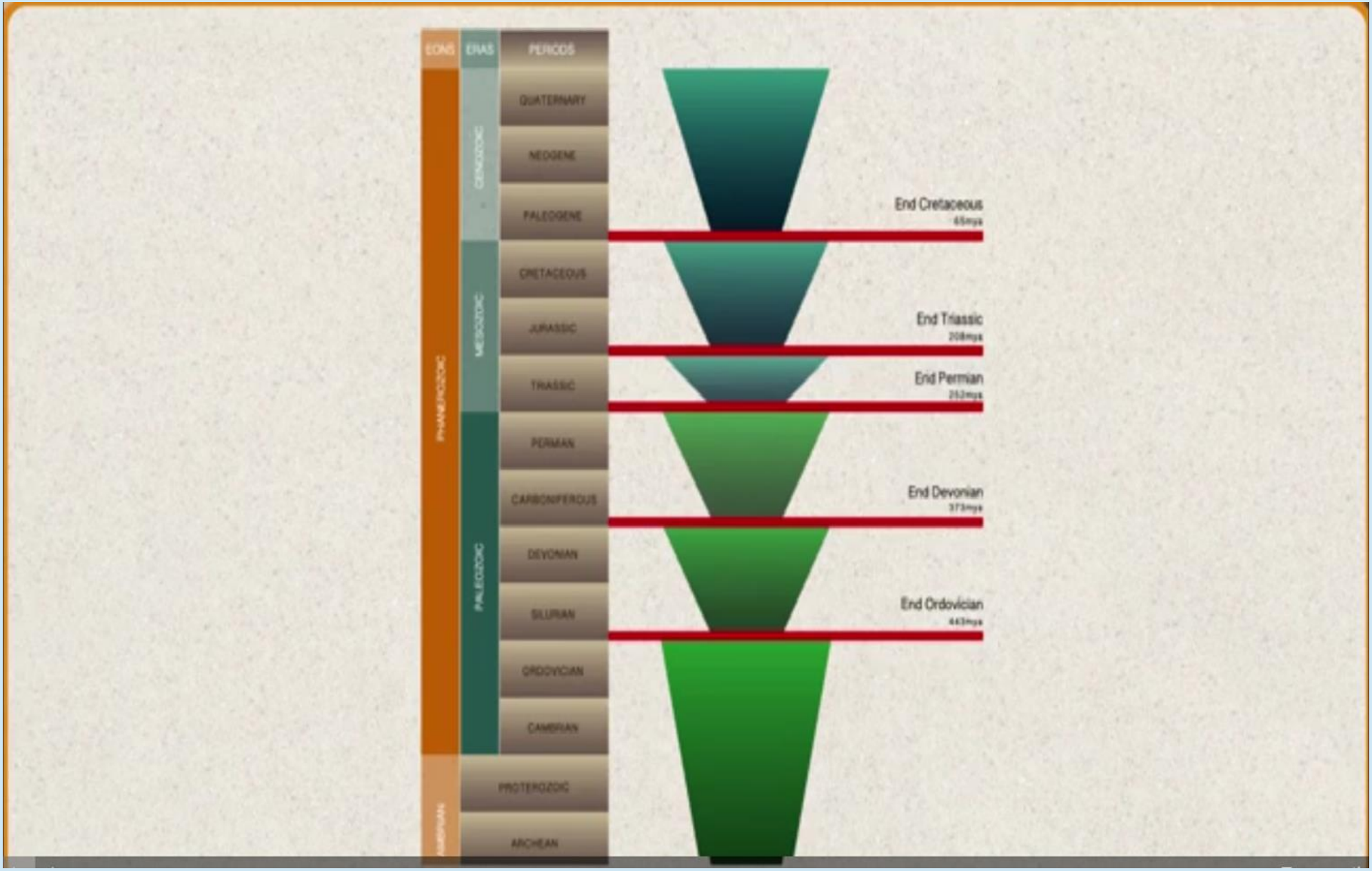

Terrestrial
Planet Finder
Telescope
Escape
flux
Photochemically altered
Bioflux & geoflux mix
Bioflux
Geoflux
Geoflux
Bioflux

Drake Equation – Number of Communicable Civilisations in our Galaxy

- N = R * fp * ne * fl * fi * fc * L
- R – Rate of star formation
- fp – Fraction of stars with planetary systems
- ne – Number of planets, per system, suitable for life
- fl – Fraction of suitable planets, where life exists
- fi – Fraction of life-bearing planets with intelligent life
- fc – Fraction of planets with intelligent life with technology and a capability for/interest in interstellar communication
- **L – Average lifetime of a communicable civilisation**

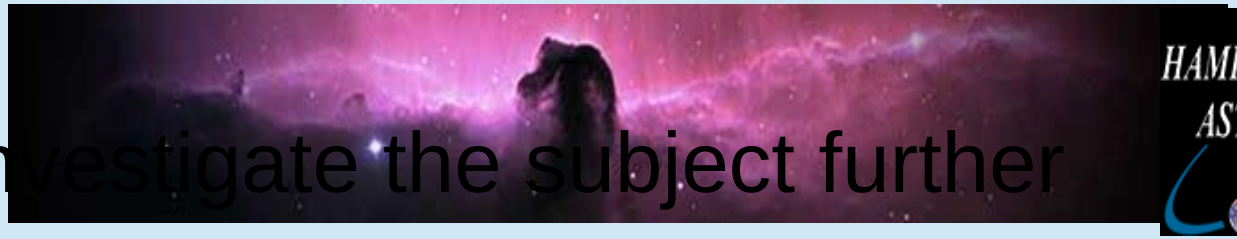
Extinction Events

- > 90% of the organisms to have lived on Earth so far are extinct
- There have been 5 major extinction events
- This is important to the Drake Equation
- If life dies out, does it ever get to the technological stage?
- Some scientists suggest that the 6th extinction event is in progress
- Will a techological civilisation survive?


EONS
ERAS
PERIODS
PHANEROZOIC
CENOZOIC
MESOZOIC
PALEOZOIC
QUATERNARY
NEOGENE
PALEOGENE
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PROTEROZOIC
ARCHEAN
End Cretaceous
65mya
End Triassic
208mya
End Permian
252mya
End Devonian
373mya
End Ordovician
443mya

We appear stuck with a terracentric view of biosignature gases

"Nothing would be more tragic in the … exploration of space than to encounter alien life and fail to recognize it" NRC report 2007



If you'd like to investigate the subject further

- Go back to Uni (probably not feasible for most of us!)

Or

- Study online

Massive

Open

Online

Courses

Online courses offered by many distinguished universities, under the umbrella of various organisations (FutureLearn, edX, Coursera are 3 of the biggest)

Imagining Other Earths

Tutor: Professor David Spergel

Dept of Astrophysics, Princeton

Delivery: Coursera

Astrobiology and the Search for Extraterrestrial Life

Tutor: Professor Charles Cockell

School of Physics & Astronomy

Delivery: Coursera

Astrobiology: Exploring Other Worlds

Tutor: Professor Chris Impey

School of Physics & Astronomy

Delivery: Coursera

Origins - Formation of the Universe, Solar System, Earth and Life – Copenhagen / Coursera

Astrophysics: Exploring Exoplanets – Australian National University (ANU) / edX

(Audit has time limits or £40 Certificate)