Conditions for Life in the Universe

Group F – Liam Duffy, Darsh Kodwani and Stuart Keenan

Introduction

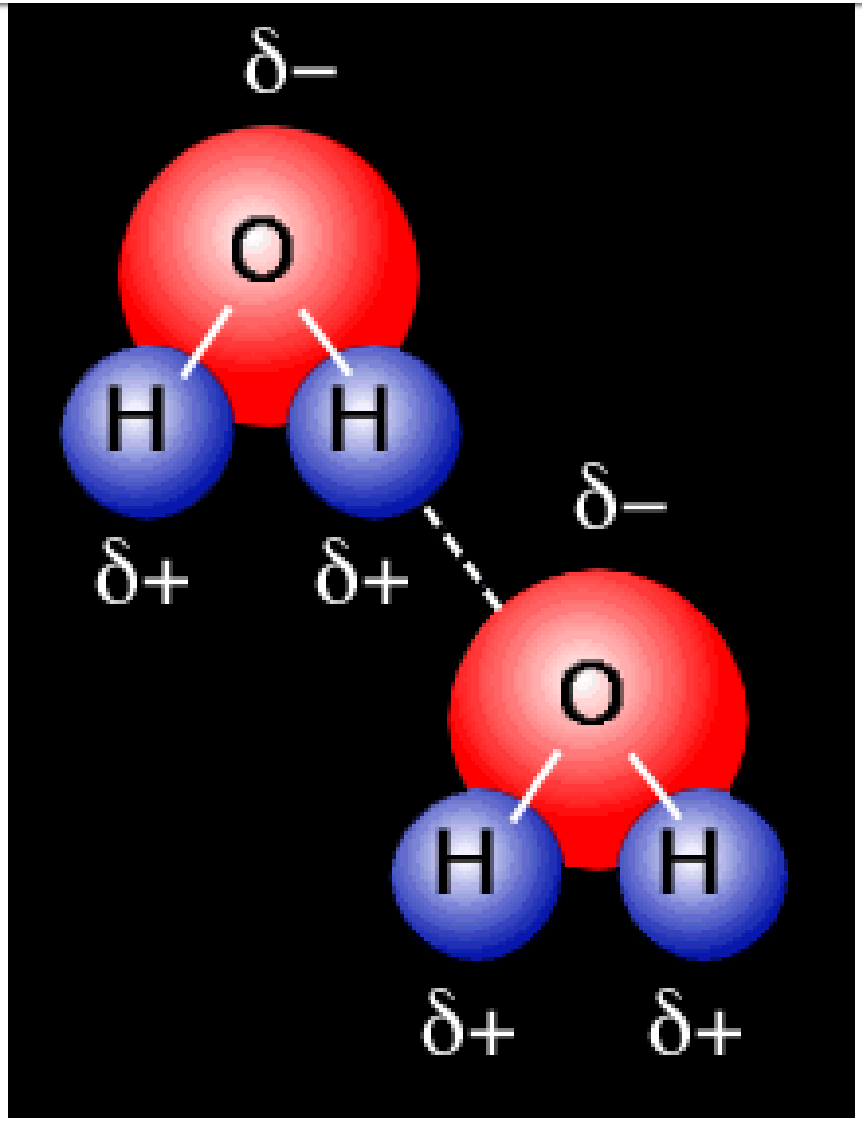
- Conditions for Life on Earth – Liam Duffy
- The Drake Equation – Darsh Kodwani
- SETI, Are we alone in the universe – Stuart Keenan
- Question and hopefully answer session

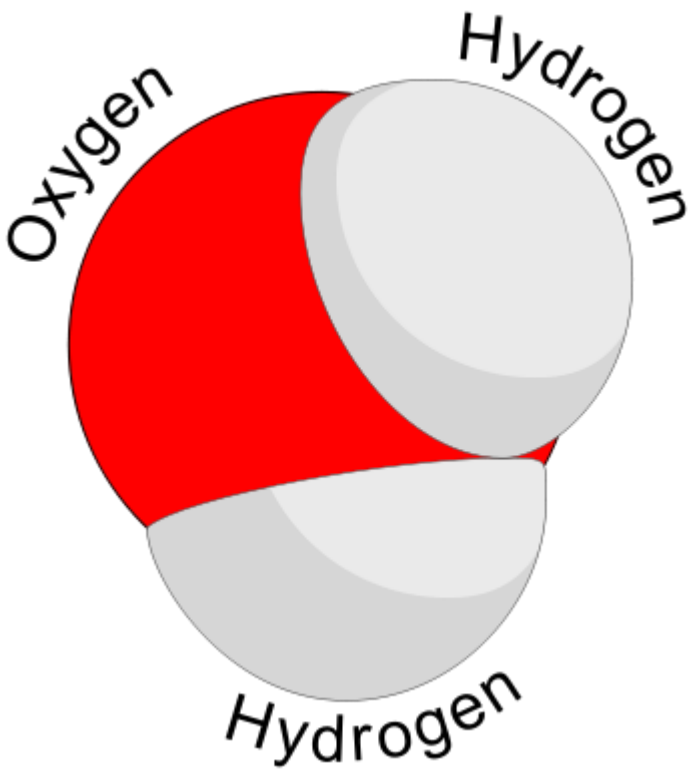
Conditions for Life on Earth

Importance of Water

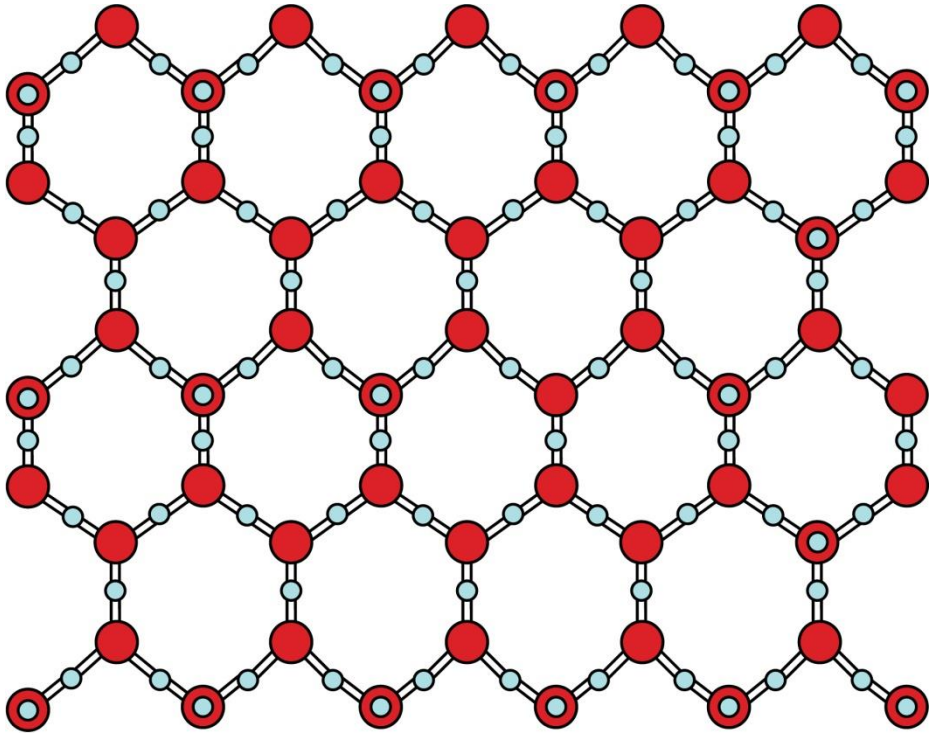
- Medium for transportation of molecules
- Excellent solvent
- Ice protects against extreme temperatures
- Absorbs powerful UV rays

Water Molecule Structure

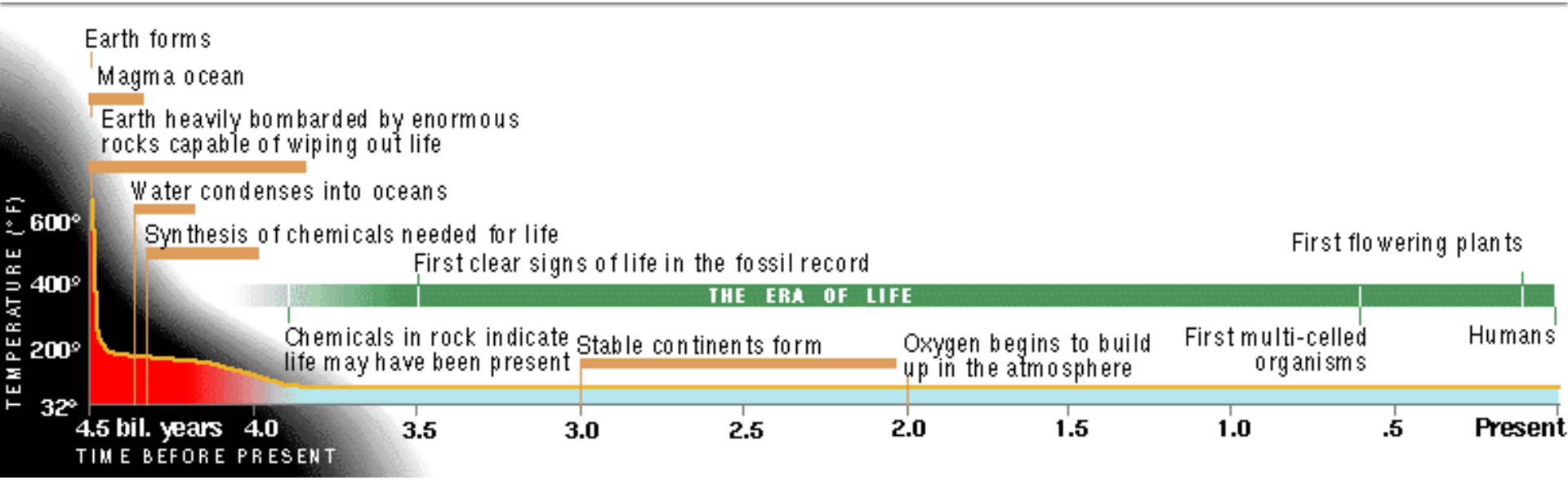




Ice Crystal Structure



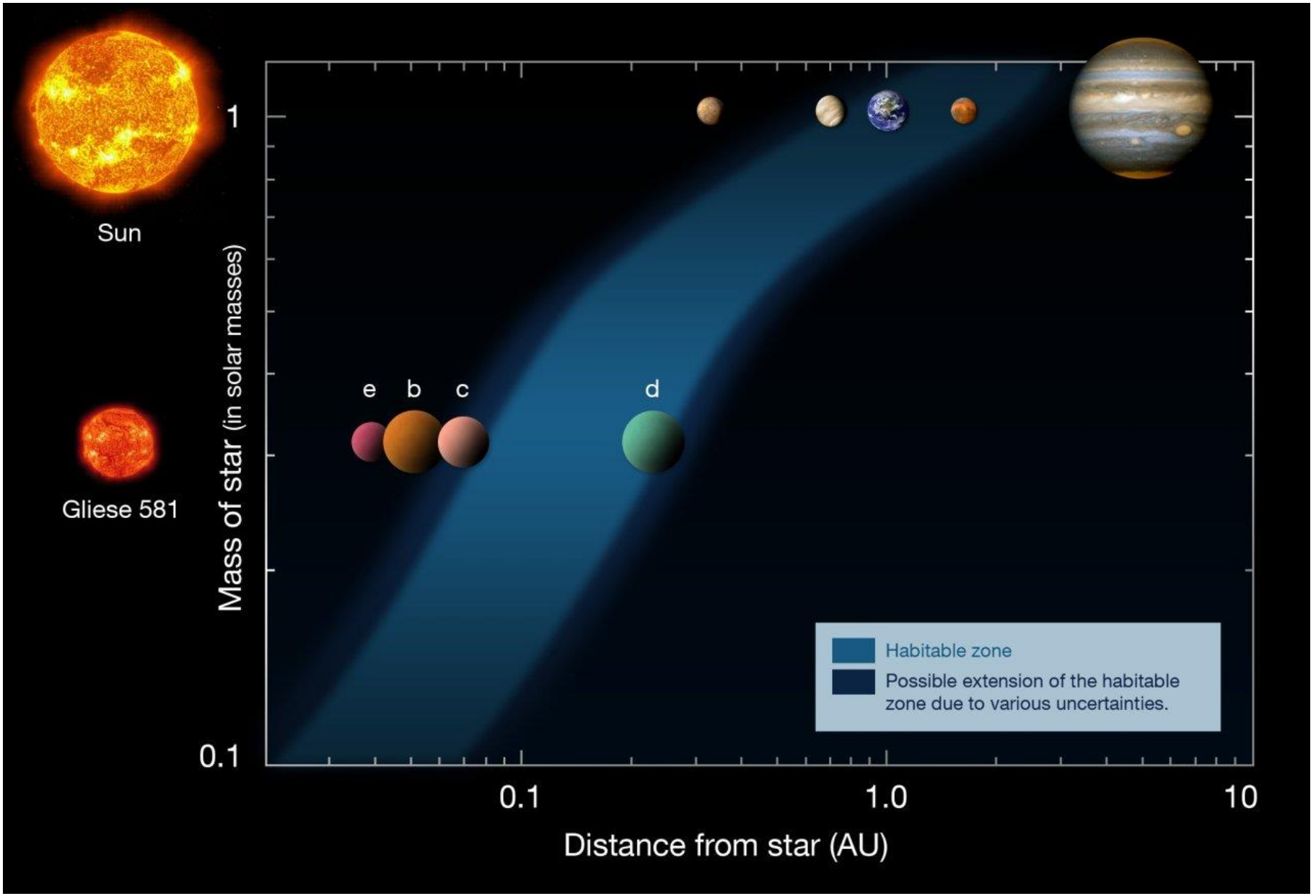
Stable Temperature Range

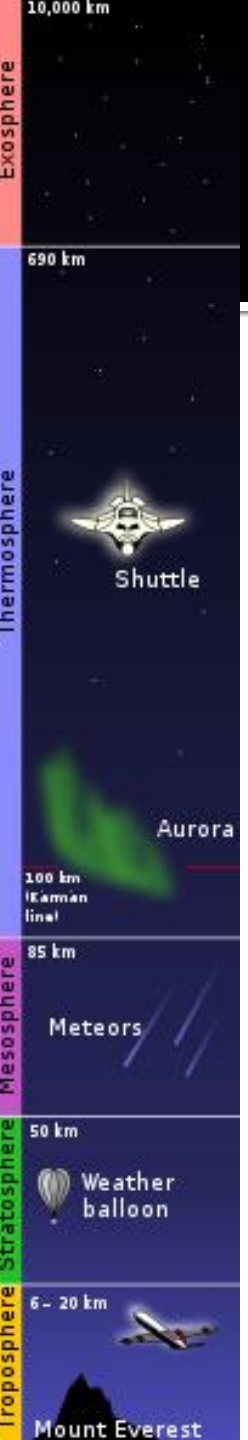


- Result of Solar System Arrangement
- Result of Conditions on Earth

Habitable Zone Model

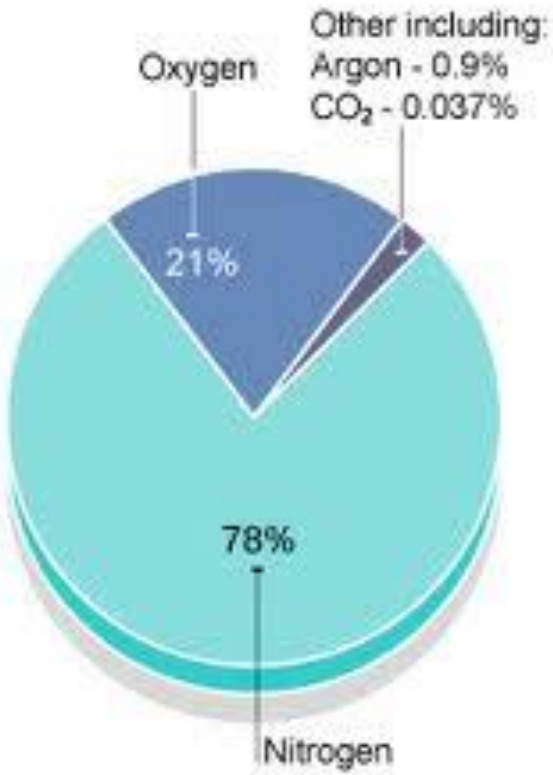
- Planets absorb incident radiation from the Sun and to remain in equilibrium must radiate the same energy
- Assume Planet is a Black Body
- Determine temperature by equating planetary luminosity to solar irradiance


Sun
Gliese 581
Mass of star (in solar masses)
1
0.1
e
b
c
d
Habitable zone
Possible extension of the habitable zone due to various uncertainties.
0.1
1.0
10
Distance from star (AU)

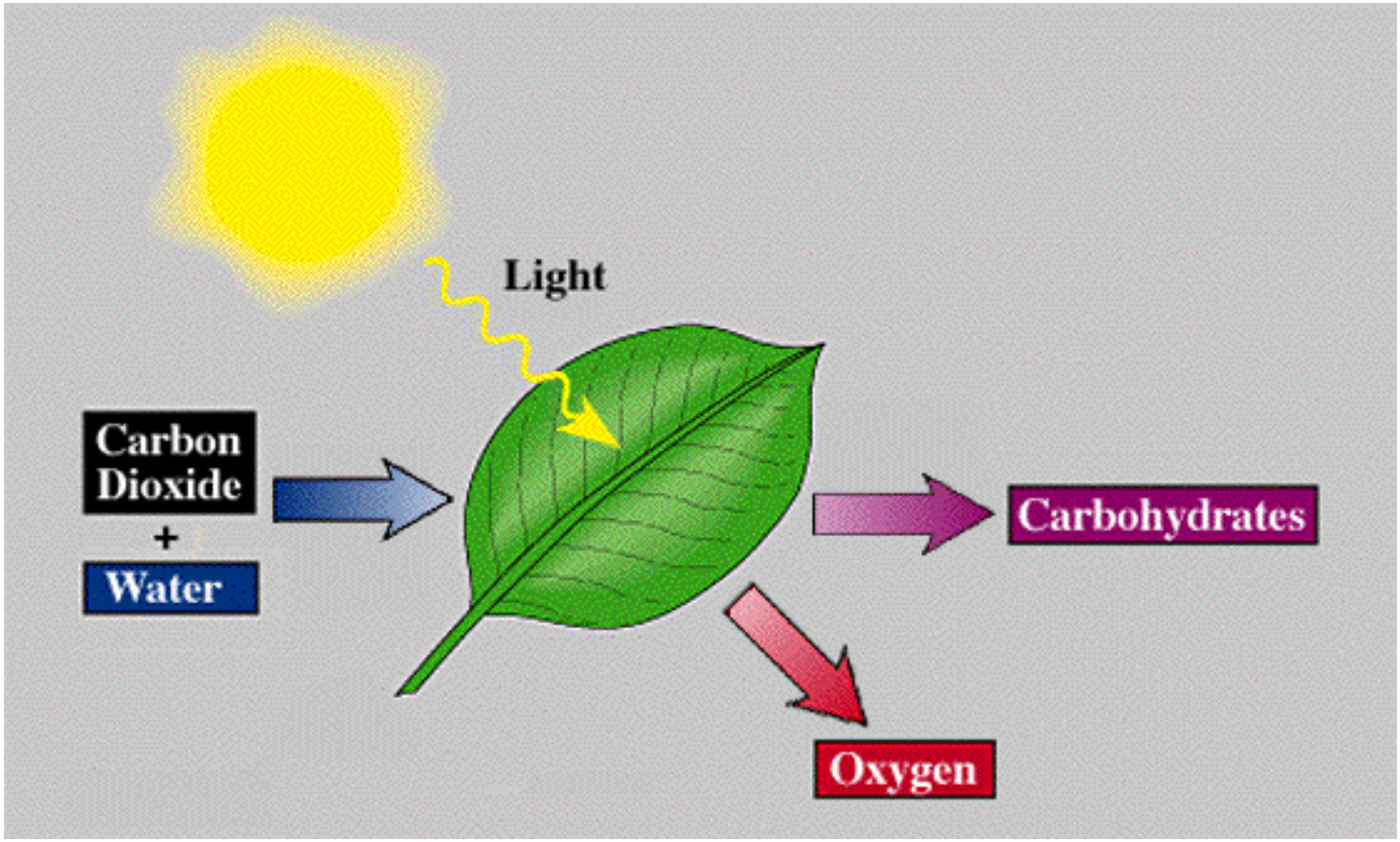


The Earth's Atmosphere

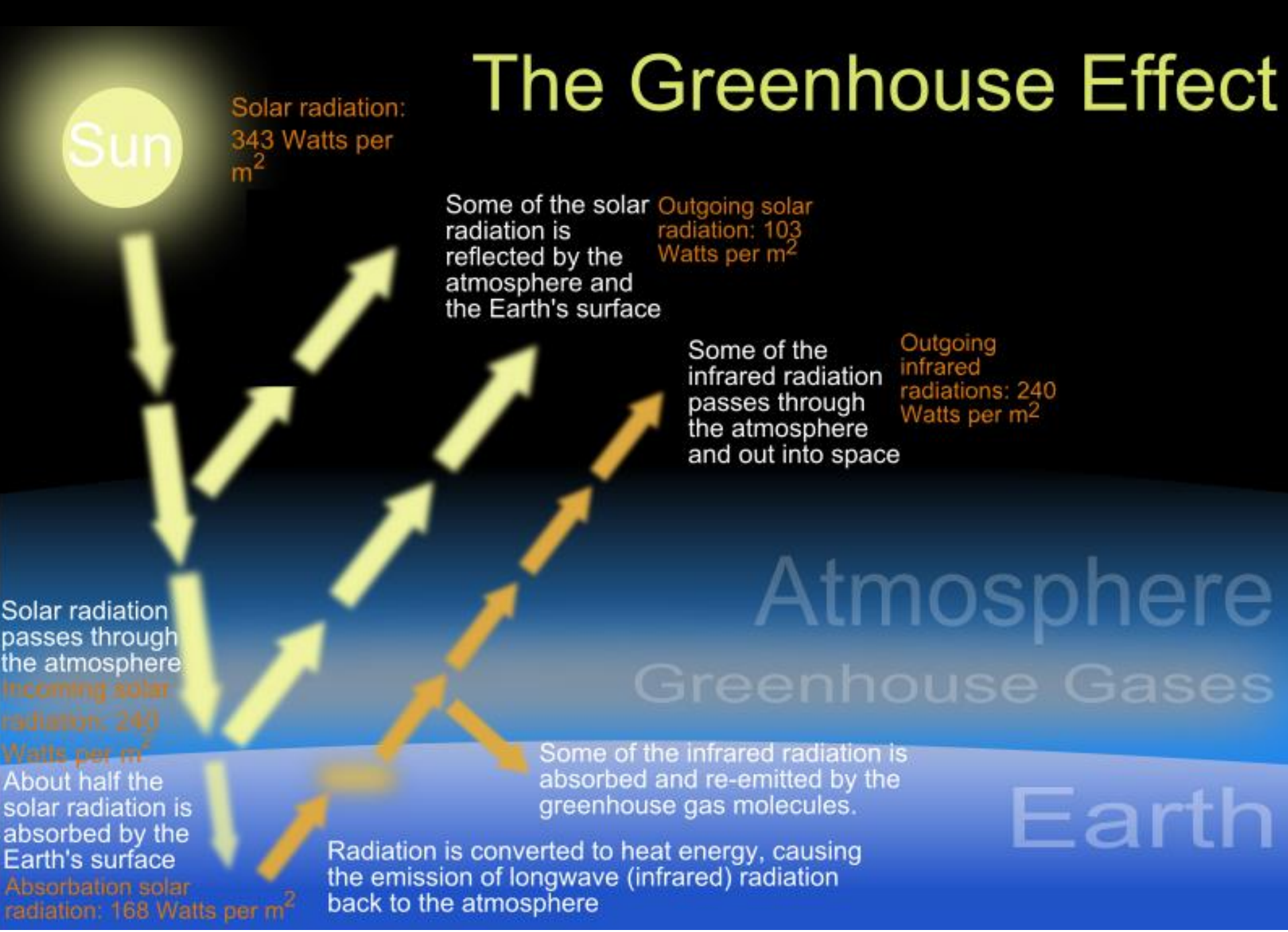
- Keeps heat in
- Acts as a shield
- Consists of Nitrogen, Carbon Dioxide and Oxygen
- Consists of 5 layers



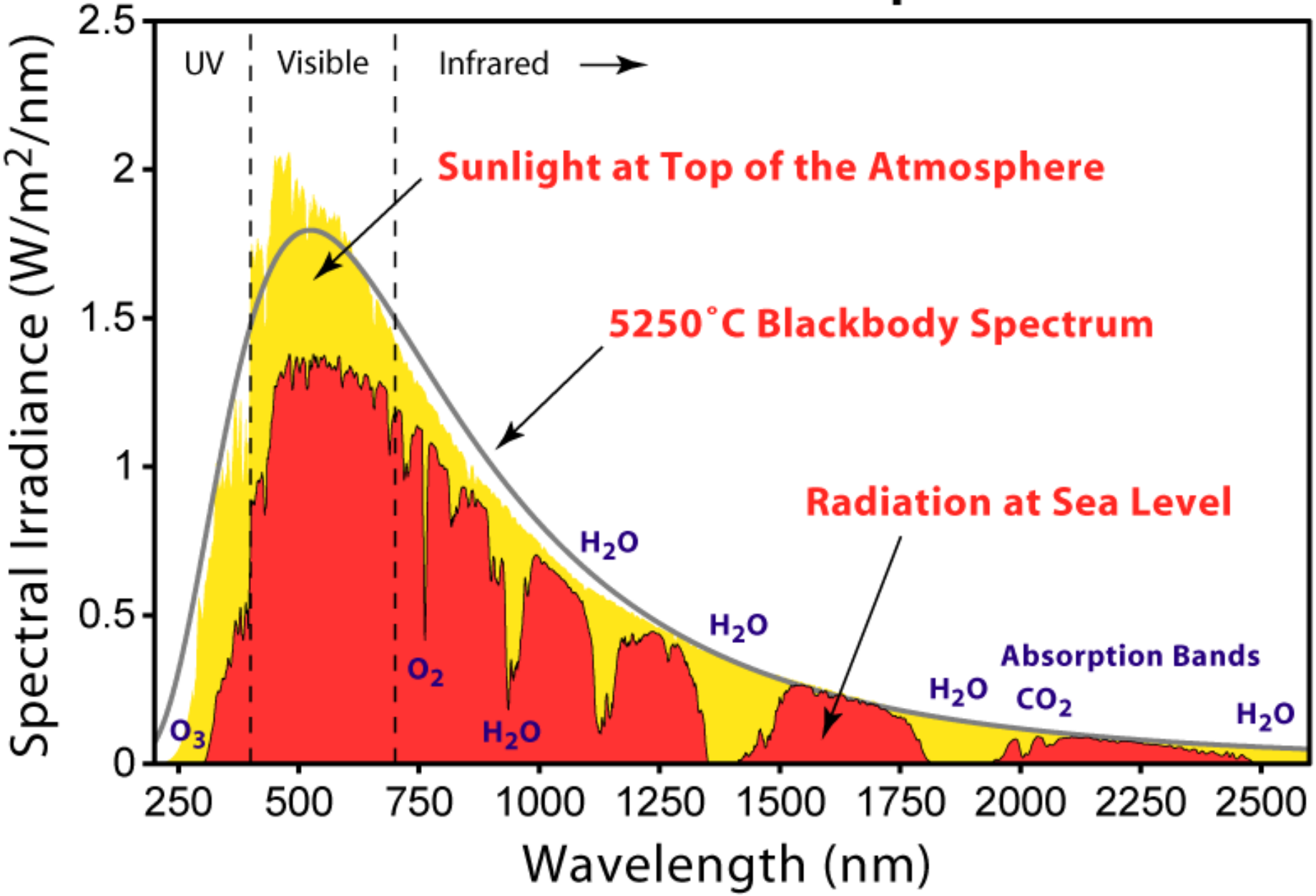
Photosynthesis

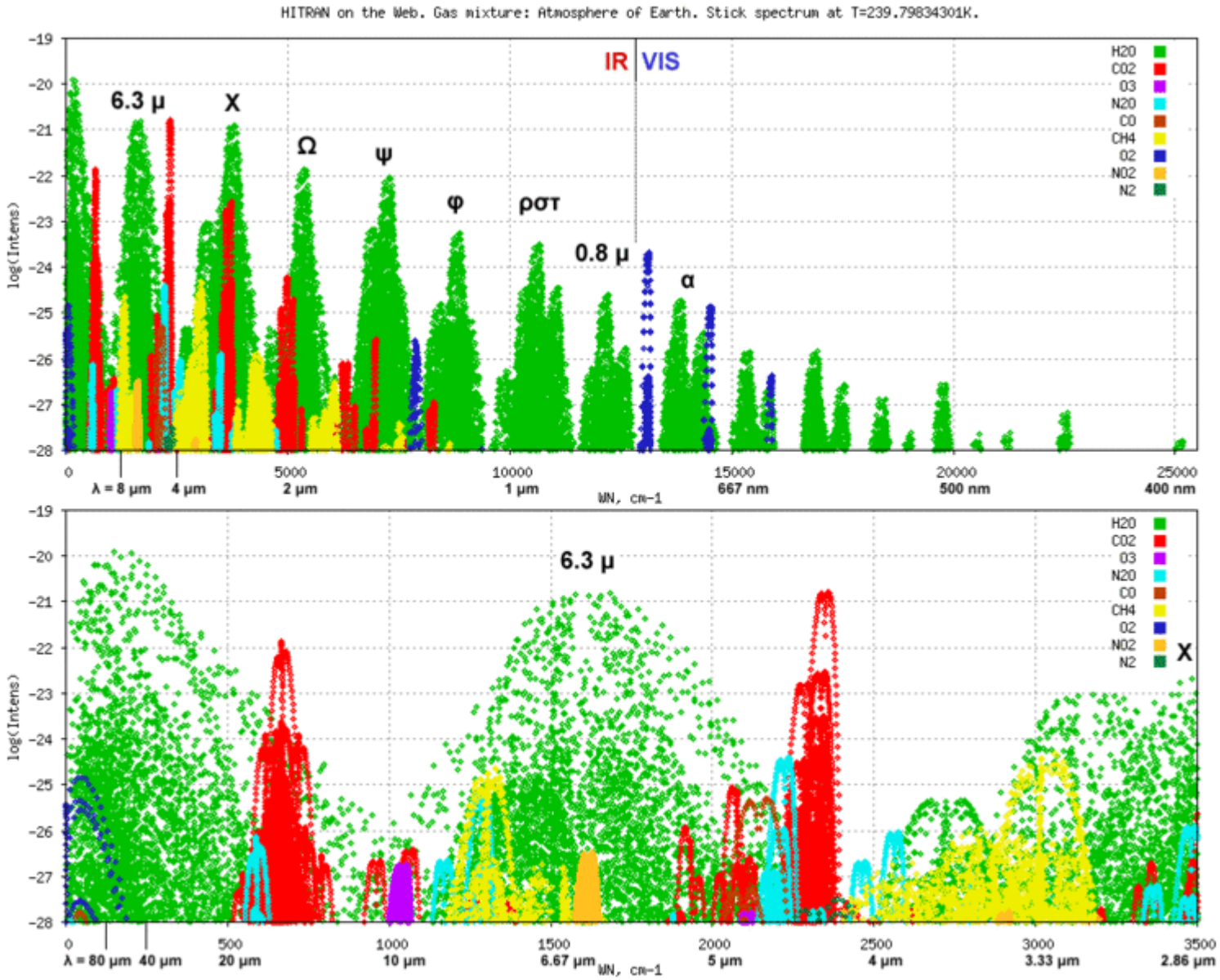


The Greenhouse Effect

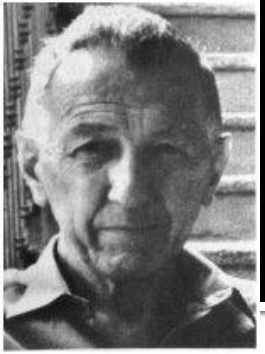


Solar Radiation Spectrum



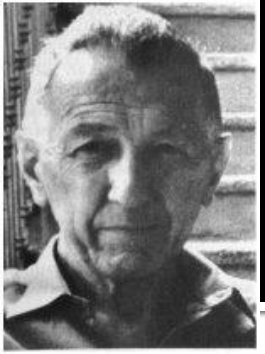

HITRAN on the Web. Gas mixture: Atmosphere of Earth. Stick spectrum at T=239.79834301K.
IR
VIS
6.3 μ
X
Ω
ψ
φ
ρστ
0.8 μ
α
log(Intens)
H2O
CO2
O3
N2O
CO
CH4
O2
NO2
N2
λ = 8 μm
4 μm
2 μm
1 μm
667 nm
500 nm
400 nm
WN, cm-1
6.3 μ
X
λ = 80 μm
40 μm
20 μm
10 μm
6.67 μm
5 μm
4 μm
3.33 μm
2.86 μm

The Drake Equation

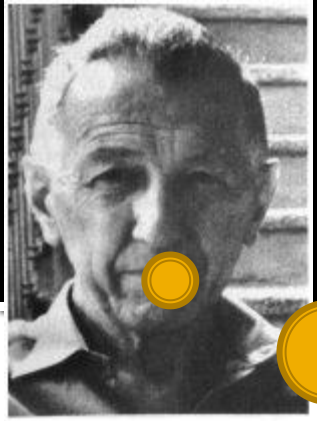


Giuseppe Cocconi

- Italian physicist, who was director of the Proton Synchrotron in CERN Geneva.



- In 1959 he and another physicist, Philip Morrison wrote a paper titled:
- “Searching for Interstellar Communications”



"No theories yet exist which enable a reliable **estimate of the probabilities** of

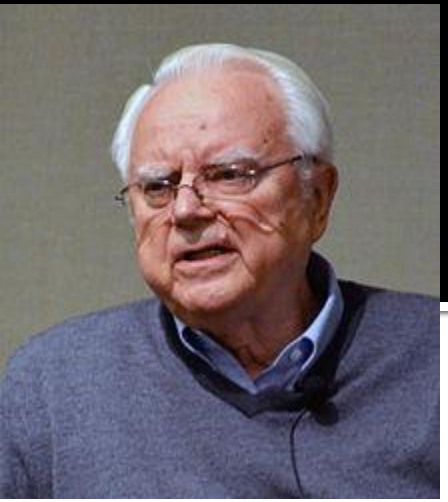
1) Planet formation
2) Origin of life
3) Evolution of societies possessing advanced scientific capabilities "

21 cm Hydrogen line

- Emission line from neutral hydrogen atoms.
- Comes from the transition between two hyperfine levels of hydrogen 1s ground state.
- Transparent to cosmic dust

Frank Drake

- American astronomer and astrophysicist .
- He tried to “listen” for this 21 cm line signal at the National Radio Astronomy Observatory, but after two years he had heard nothing.



- In 1961, he hosted a meeting for the “search for extra-terrestrial intelligence”

I have an answer for you Cocconi!

- R^* = the average number of star formed per year in our galaxy
- f_P = the fraction of those stars that have planets
- n_e = the average number of planets that can potentially support life per star that has planets
- f_l = the fraction of planets that could support life that actually develop life at some point

- f_i = the fraction of planets with life that actually go on to develop intelligent life (civilizations)

- f_c = the fraction of civilizations that develop a technology(before blowing themselves up!) that releases detectable signs of their existence into space

- L = the length of time for which such civilizations release detectable signals into space

$$N = R_* f_p n_e f_l f_i f_c L$$

Original estimate

- It was first estimated by Drake, that his equation would yield a number between 1000 and 100,000,000 civilizations in the Milky Way galaxy.

Original estimate: Key facts

- f_ℓ = 1 (100% of these planets will develop life)
- f_i = 1 (100% of which will develop intelligent life)
- f_c = 0.1-0.2 (10-20% of which will be able to communicate)

Are we alone in the universe?

SETI

What is SETI?

- SETI stands for Search for Extra-Terrestrial Intelligence.
- Collection of projects run by various institutions.
- Most well-known include Harvard, Berkeley and the University of California, as well as the SETI Institute.

A very brief history…

- First SETI experiment performed in 1960 by Frank Drake
- First SETI conference took place in 1961
- 'Big Ear' telescope set up at Ohio State University in 1963; site of the Wow! signal in 1977
- Government funding stopped in 1995

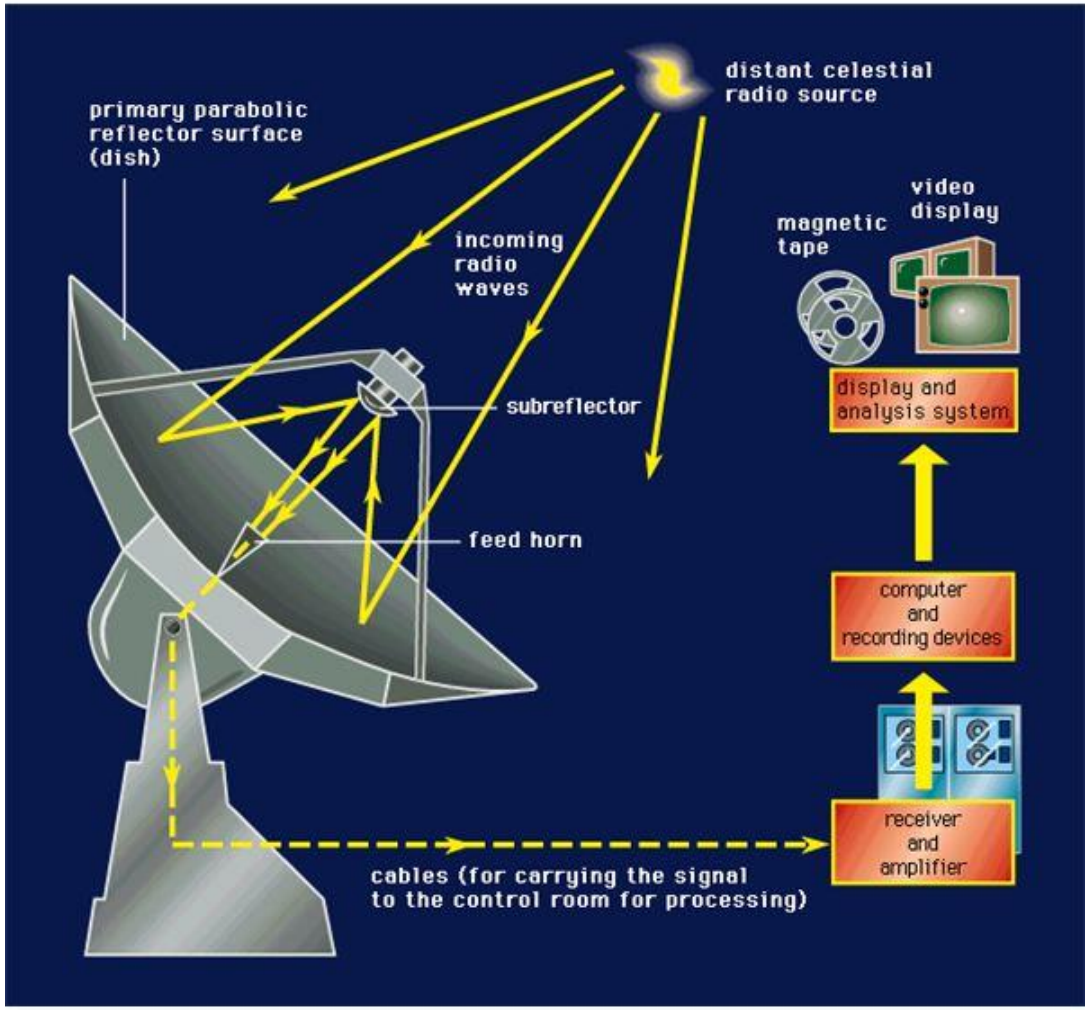
What does SETI do?

- Majority of experiments involve scanning the reaches of space for any radio waves ETI may have sent.
- Microwave radiation has also been looked for.
- Optical detection (laser beams) were deemed impractical for communication.
- Gamma-ray bursts also considered as a potential communication candidate.

What does SETI use?

- Bulk of experiments performed by radio telescopes
- Large collection of volunteer and amateur detectors.
- SETI@home

How do radio telescopes work?



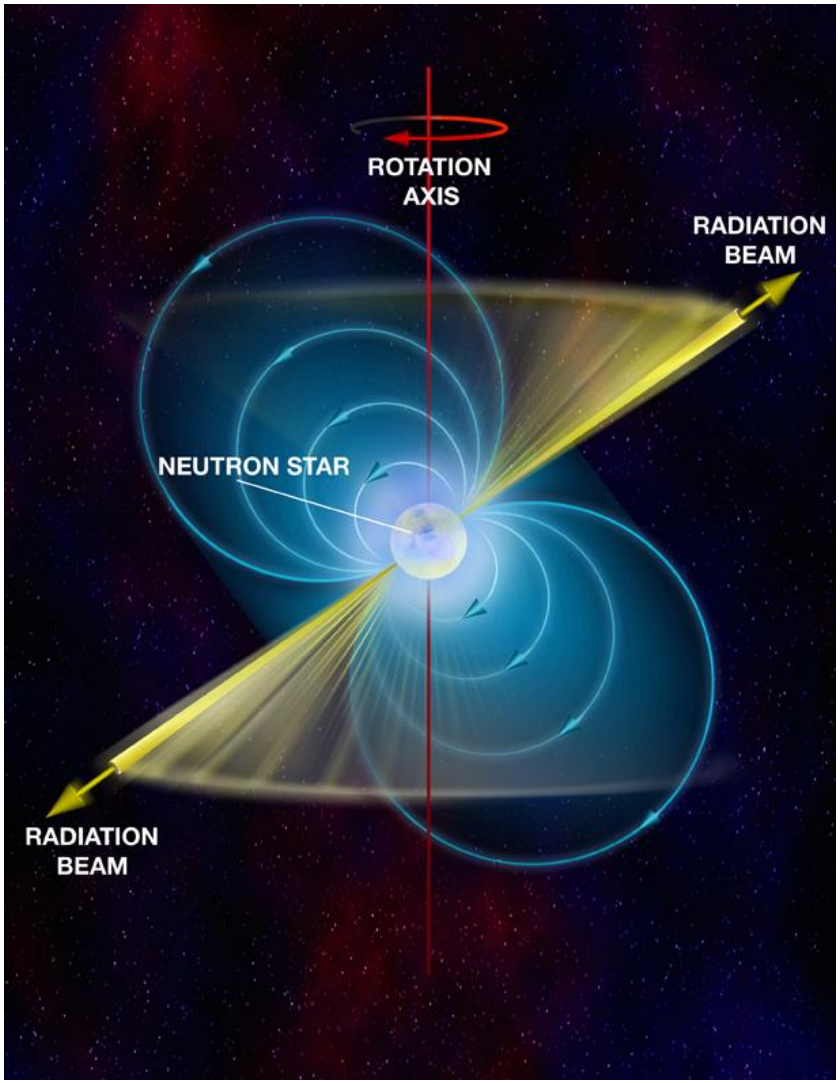
Arecibo Observatory – Puerto Rico

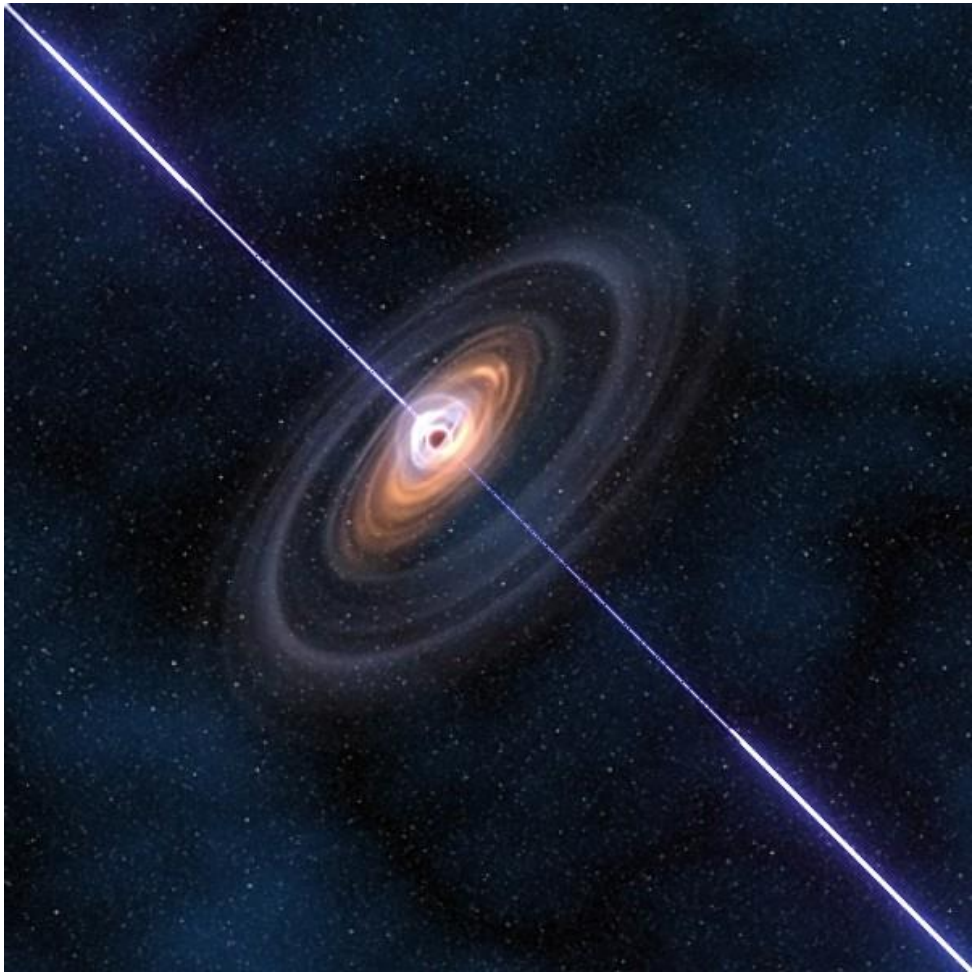
What has SETI found?

- Quasars
  - Initially postulated to be signs of ETI
- Pulsars
  - Nicknamed LGM-1, for Little Green Men
- Life?

Quasar

Pulsar





The Wow! signal

- In 1977, a particularly strong signal was detected by the Big Ear project at Ohio State University.
- Considered the best sign of ETI since SETI started.
- Never been detected again.

Wow!

```
1         2           1   4   3
1  16     1       1       1
1  11     1     1       11  1
   1                3     1
 6  2                31
1E24    3   12    1  21  1
 Q  1   16  1  2    1  1       1
 U31    1          3  7   1
2J1     31  3  111     11  1  1
 51                 1   1
   14     1     113     2   11
 1  3    1     1     1
 1  4          1    1  1    11
    4    1  1   1  11      111
    1             1     2  1
 1  1    1            11   1
    1          1            14
```