Studies on photosynthetic organisms as a tool for improving the success of future space missions

Mariano Battistuzzi, 10/10/2017

DBCA

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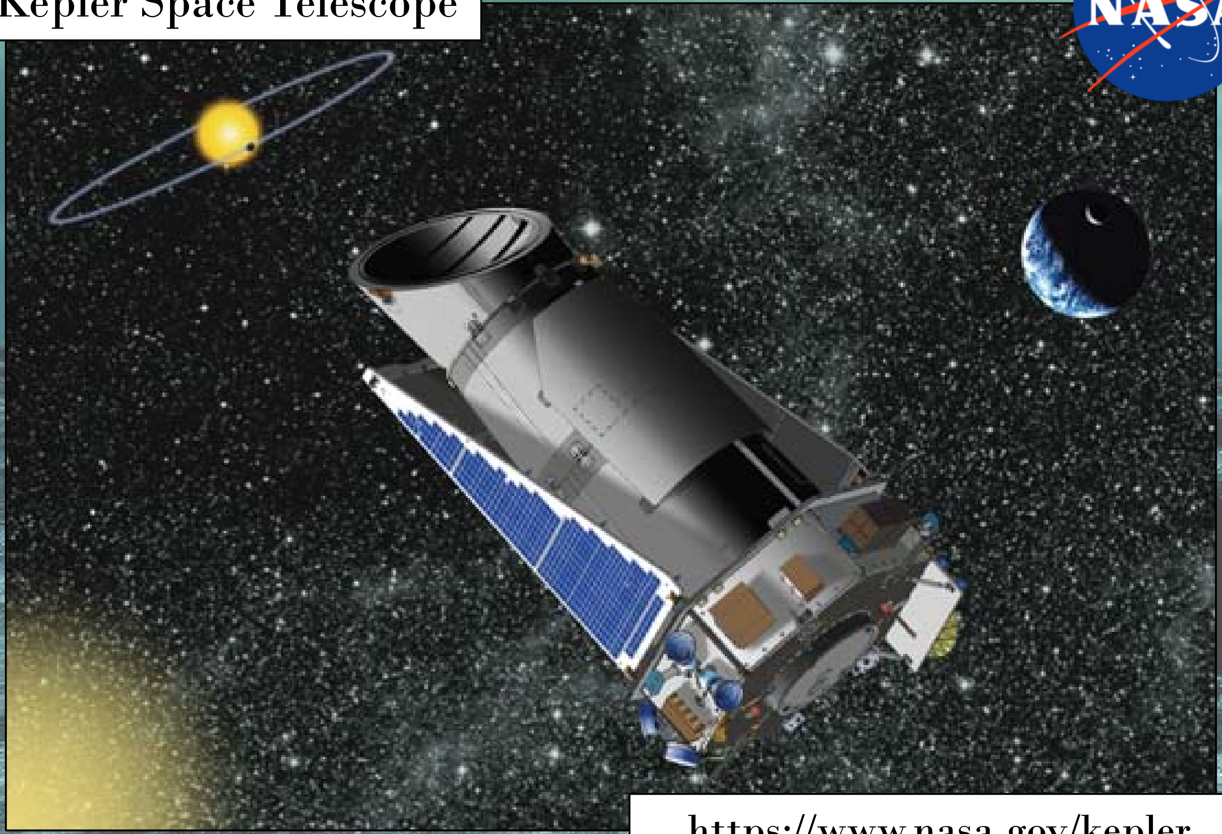
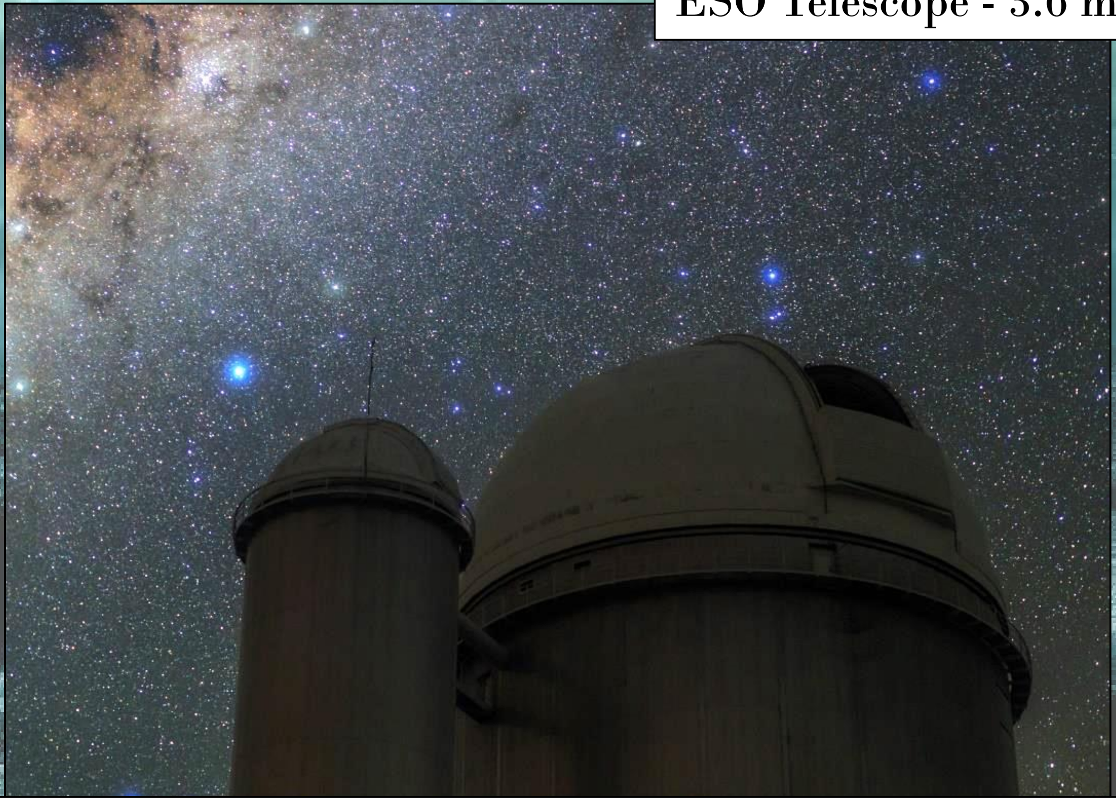
On our galaxy found about 3500 new extrasolar planets.

Kepler Space Telescope



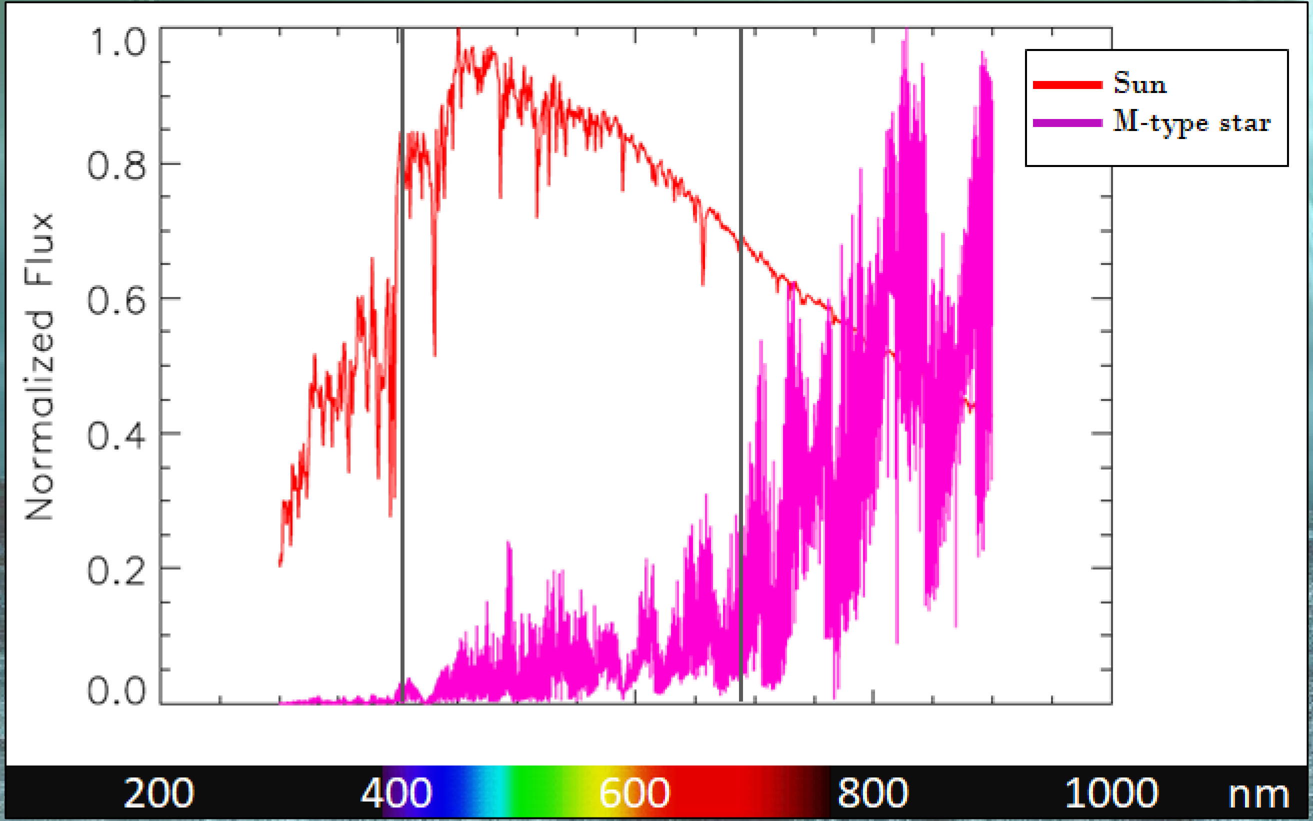
https://www.nasa.gov/kepler

ESO Telescope - 3.6 m



European Southern Observatory (ESO) La Silla, Chile

Many of them in the Habitable Zone (HZ) of M-Type Stars



Visible light

FR

IR

Live long enough to sustain life evolution

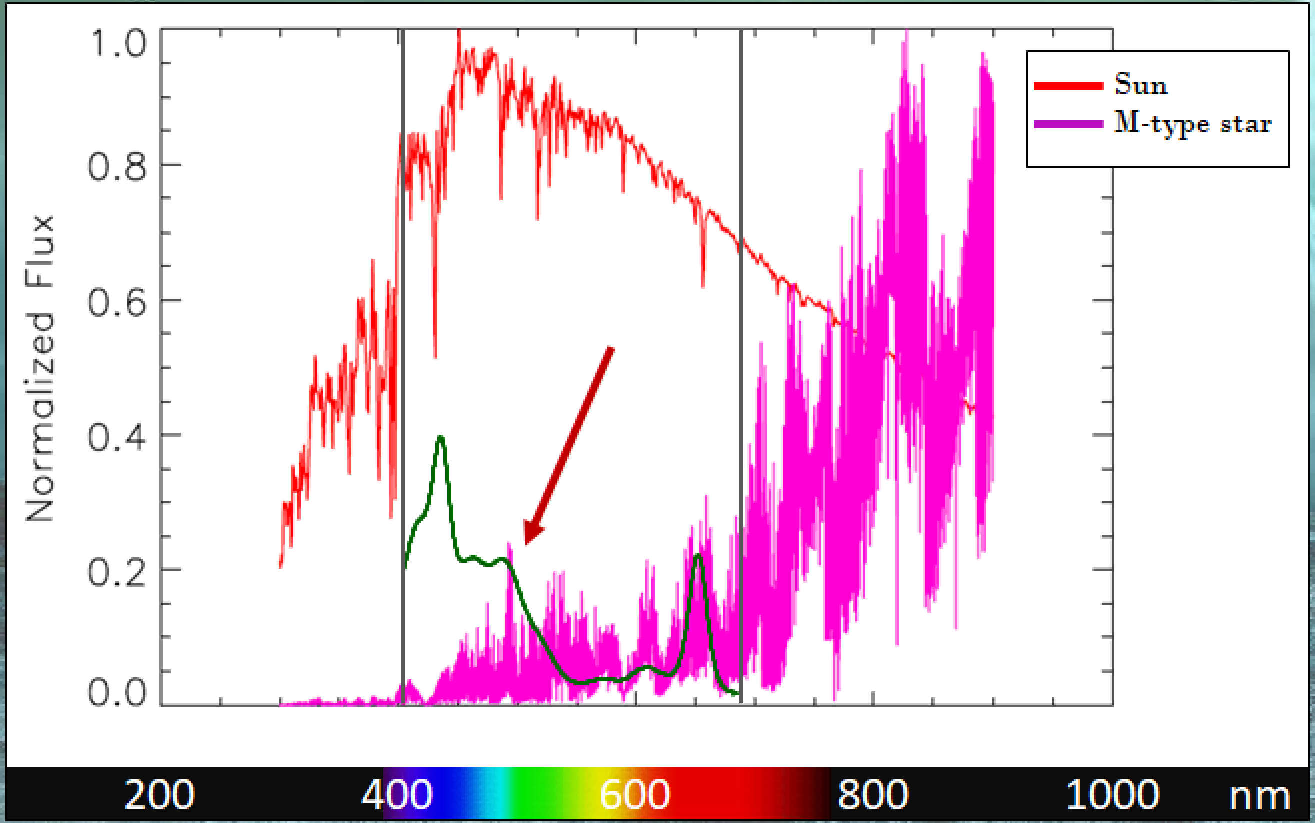
Most common stars in the Milky Way (76% of total stars)

10 times less luminous than G-type stars

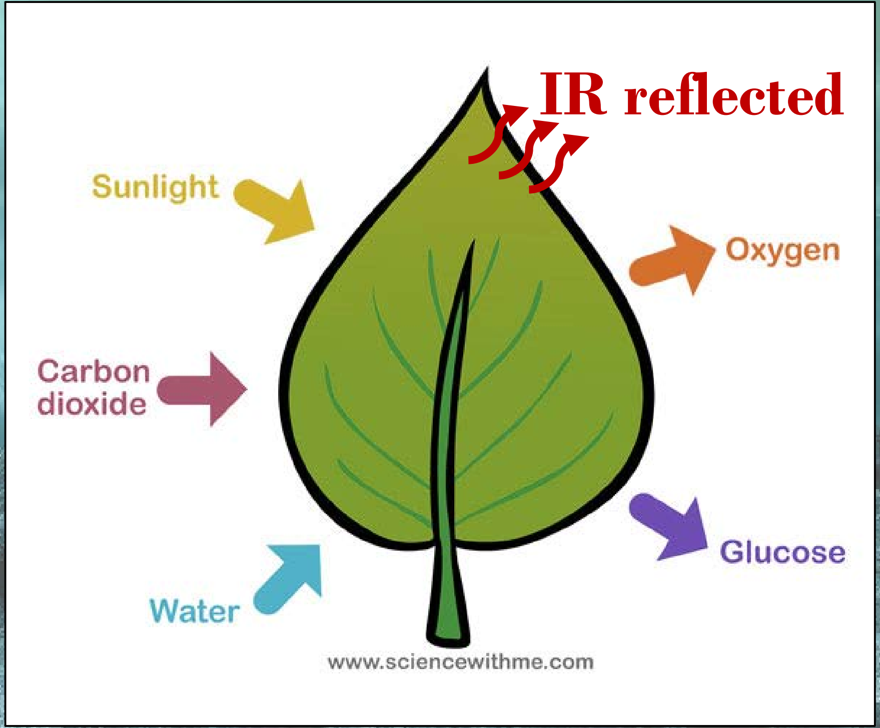
Different light spectrum (Major component FR and IR)

Life as we know it depends on the presence of water and oxygen

Oxygenic Photosynthesis uses only the VISIBLE light
Photosynthetically Active Radiation (PAR)



Visible light
FR
IR



The presence of water and oxygen produces atmospheric biosignatures observable by remote sensing

Aim of the Project

Biological Questions:

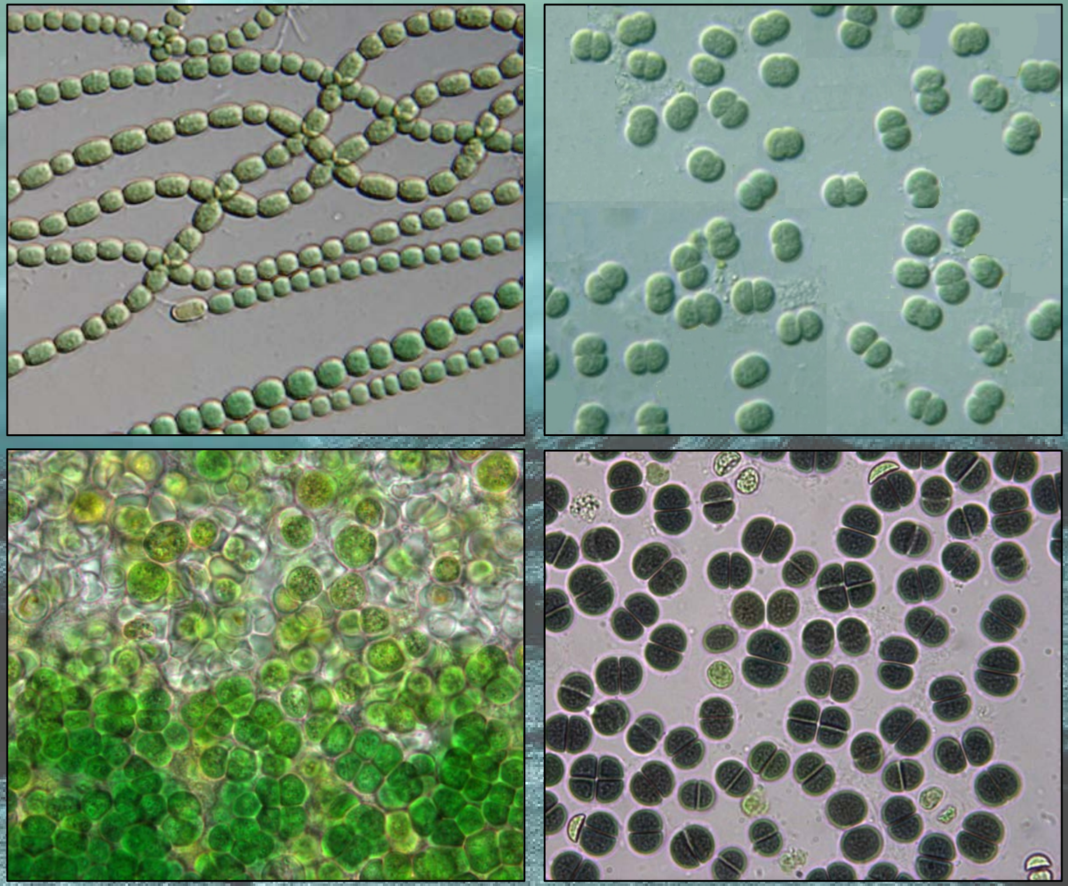
1. Could Oxygenic Photosynthetic organisms survive under M-type star light spectra?

2. Could Oxygenic photosynthesis be performed and which impact would it have on the atmosphere of a planet?

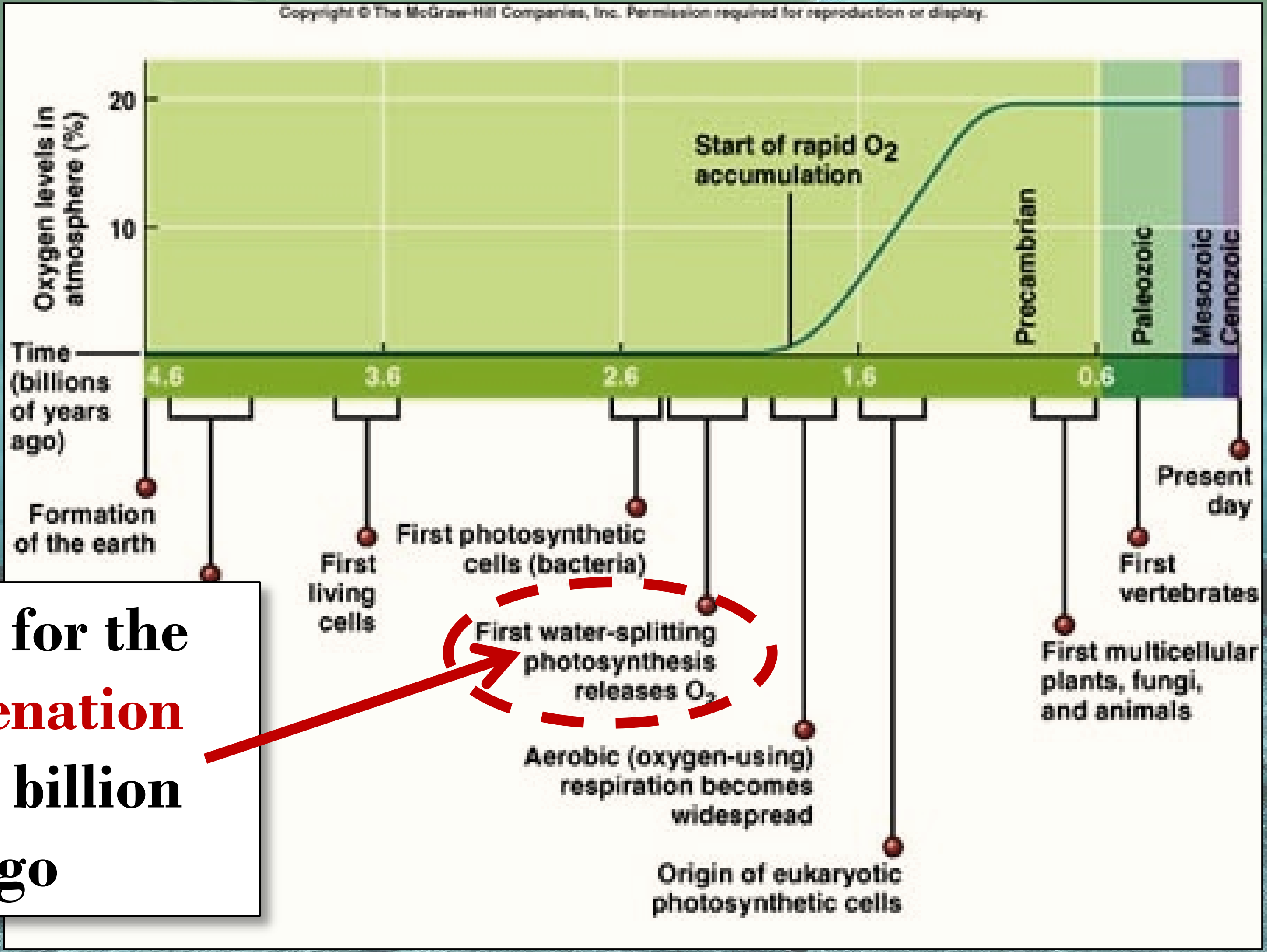
3. An atmospheric biosignature could be generated by the activity of these organisms?

What to use? Cyanobacteria!

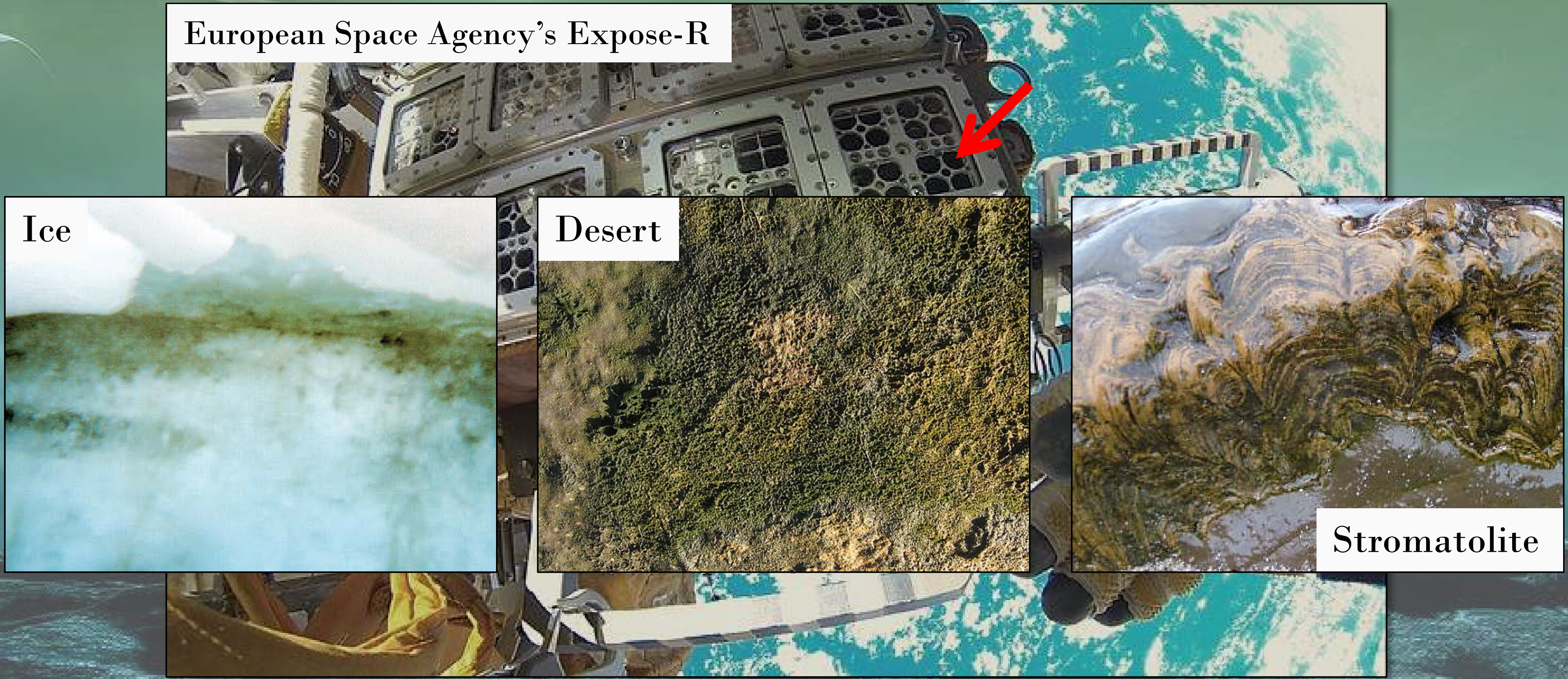
Photosynthetic Microorganisms with great methabolic and adaptive plasticity



Cyanobacteria first to evolve the Oxygenic photosynthesis

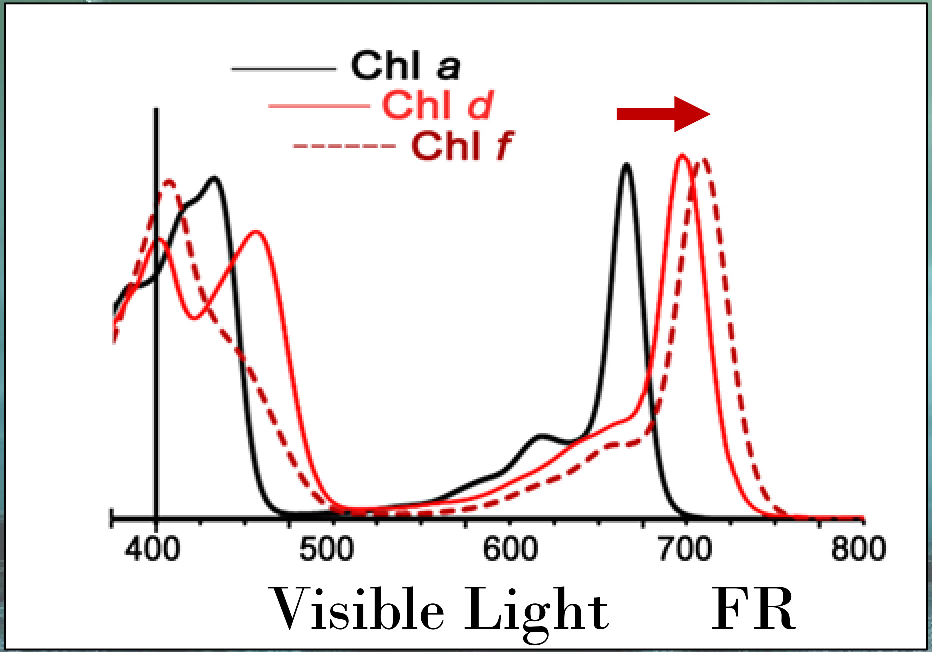


Responsible for the Great Oxygenation Event ~ 2,4 billion years ago

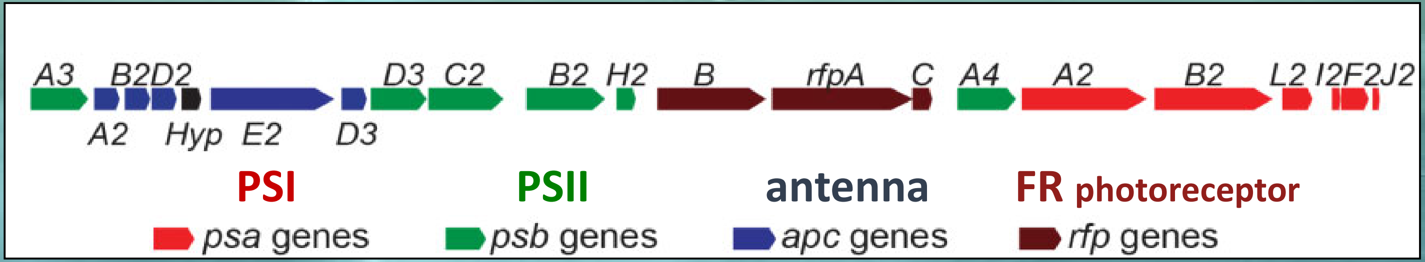


Survived 6 months to UV and cosmic rays, vacuum, and extreme temperature variations in a box outside the International Space Station

Photoacclimation to 720 nm FR light



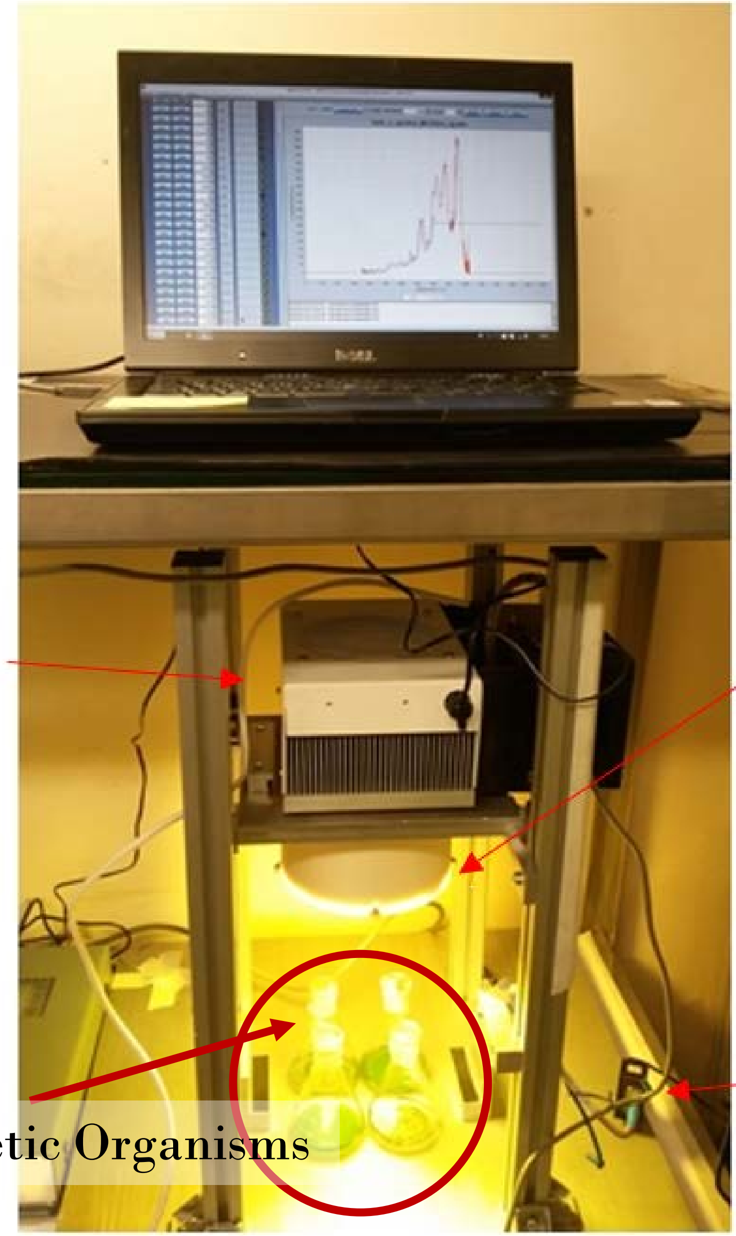
17 genes



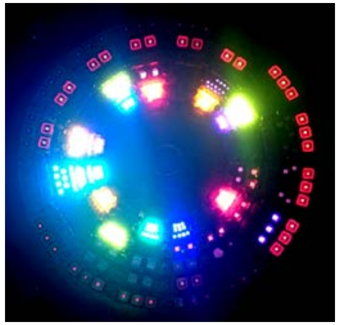
Gan et al., 2014 *Science*
Gan and Bryant., 2015

Instruments:
Star Light Simulator

Cooling Fan



Radiation Source



Spectrograph

Photosynthetic Organisms

365 – 940 nm

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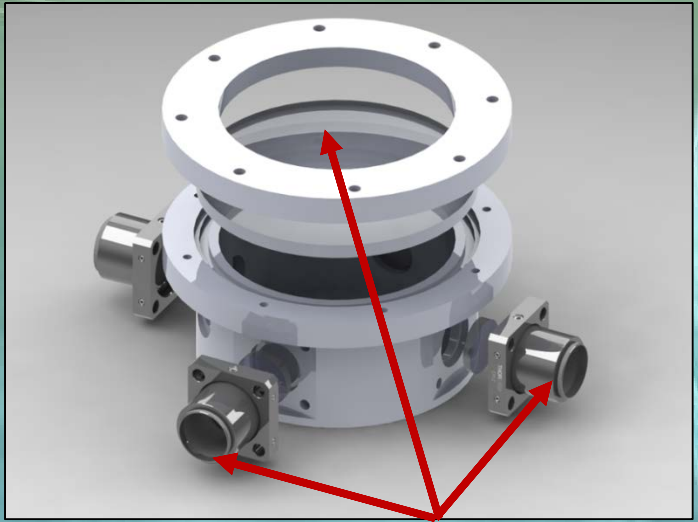
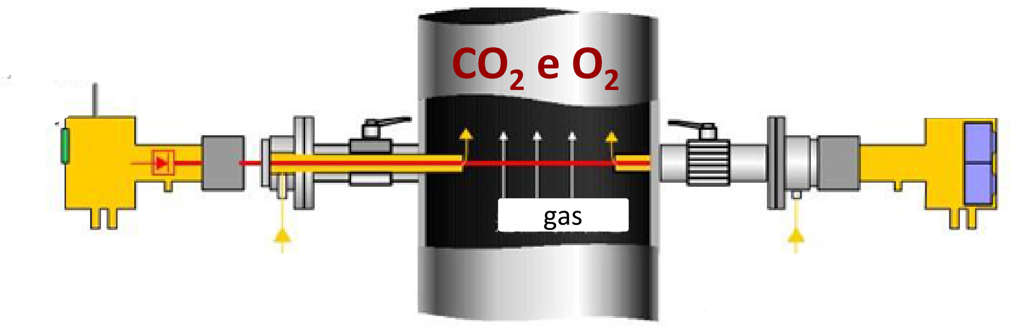
Instruments: Atmosphere Simulator Chamber

Star Light Simulator

Photosynthetic Organisms



Windows



Tunable Diode Laser Absorption Spectroscopy (TDLAS)

- Pressure
- Temperature
- Atmospheric Composition

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Growth Experiments into the Atmosphere Simulator Chamber

Phase 1: Short-term experiments

(Pressure OR Spectrum OR Irradiance OR Atmospheric Composition OR…)

↓

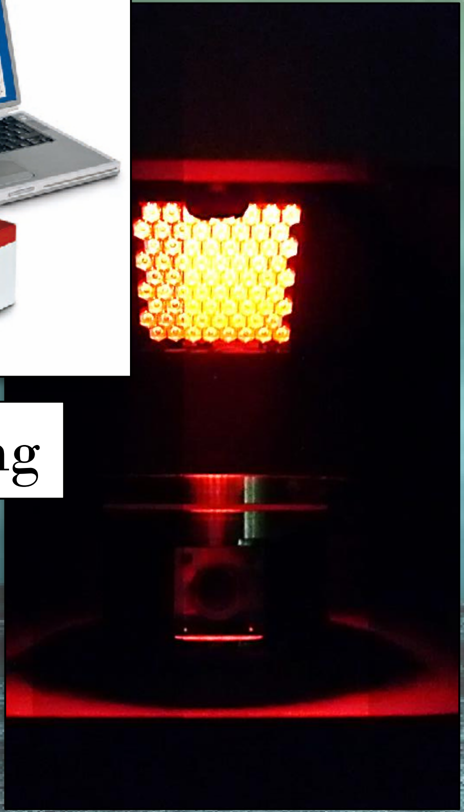
Data Analysis

↓

Phase 2: Long-term experiments

(Pressure; Spectrum; Irradiance; Atmospheric Composition; …)

Non-invasive analysis



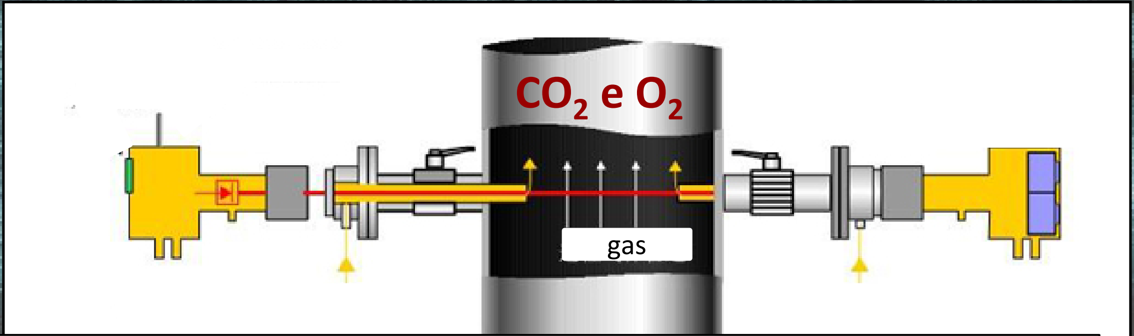
PAM Imaging

Growth Level

NDVI Reader

O_2 Production and CO_2 Consumption

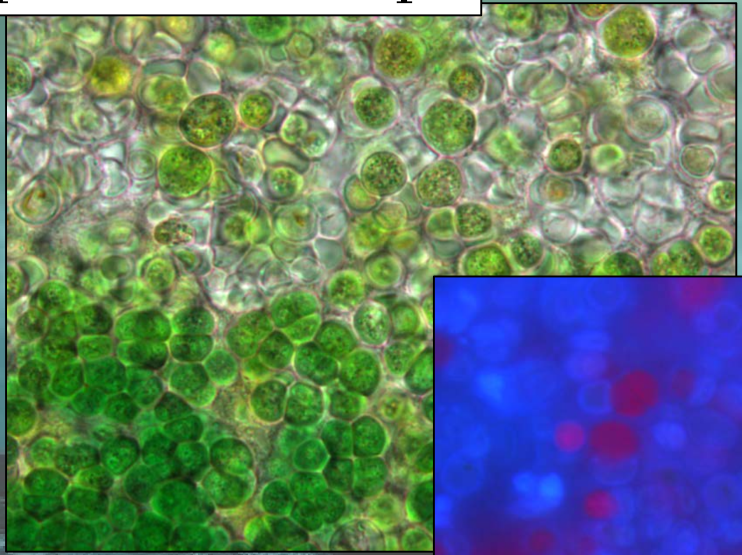
Photosynthetic Efficiency and Functionality



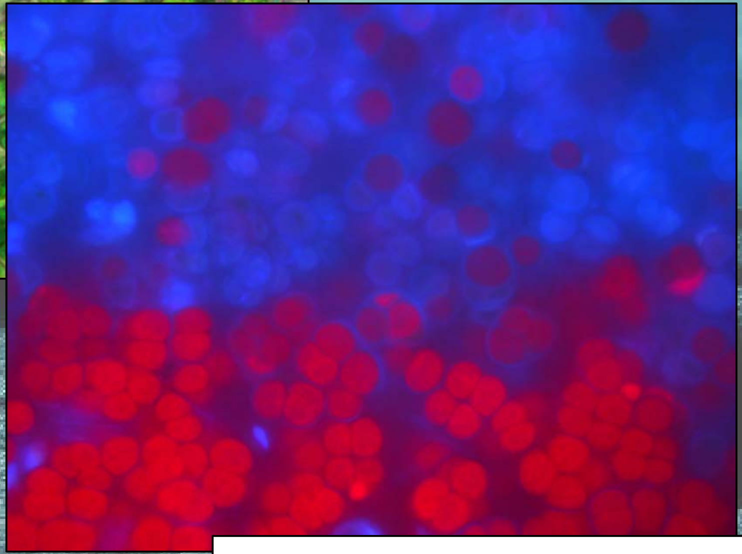
Tunable Diode Laser Absorption Spectroscope

Viability and cell growth

Optical Microscope



Chlorogloeopsis frischii **PCC 6912**



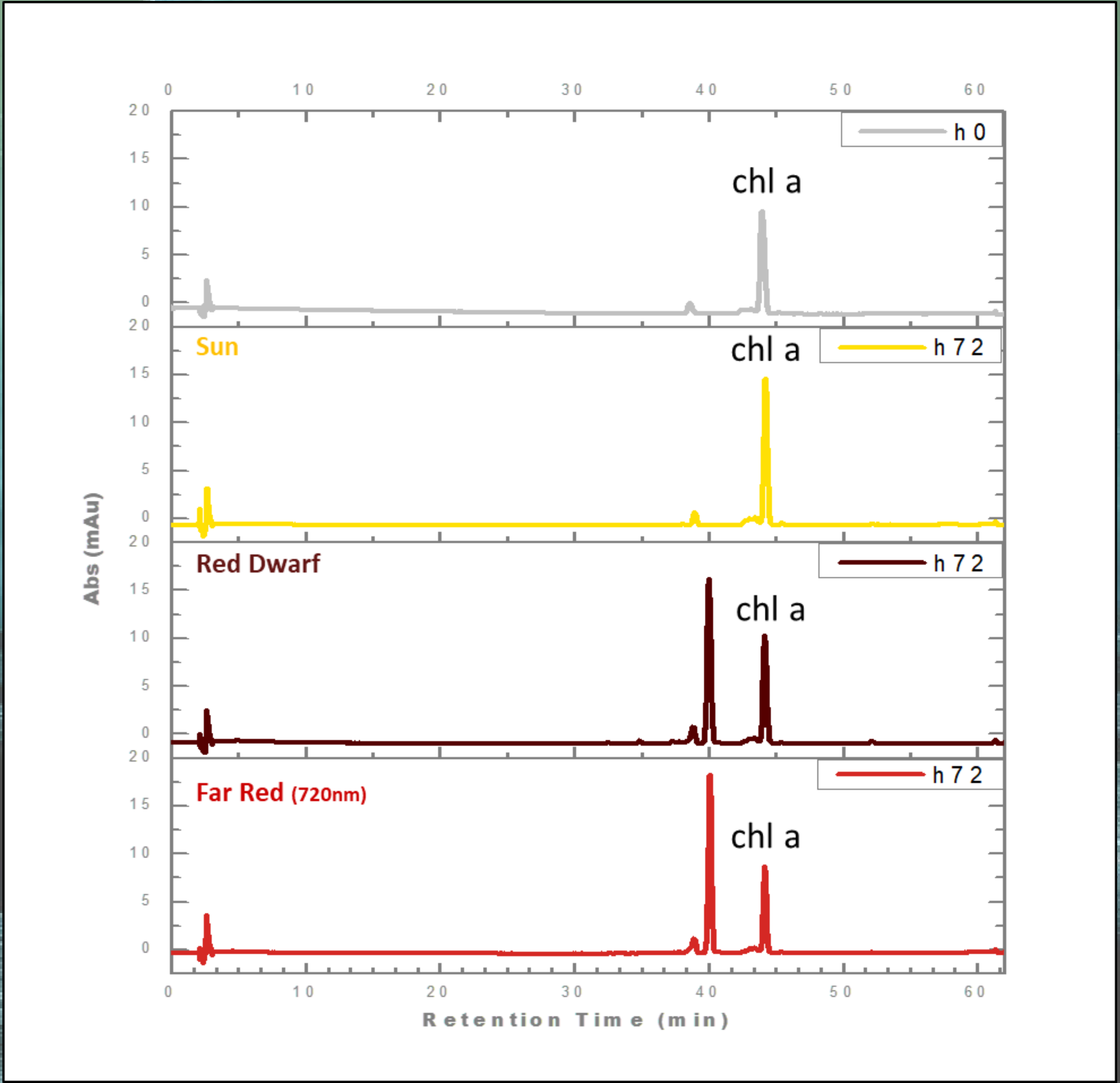
Fluorescence Microscope

Spectrophotometer

Differencial gene expression

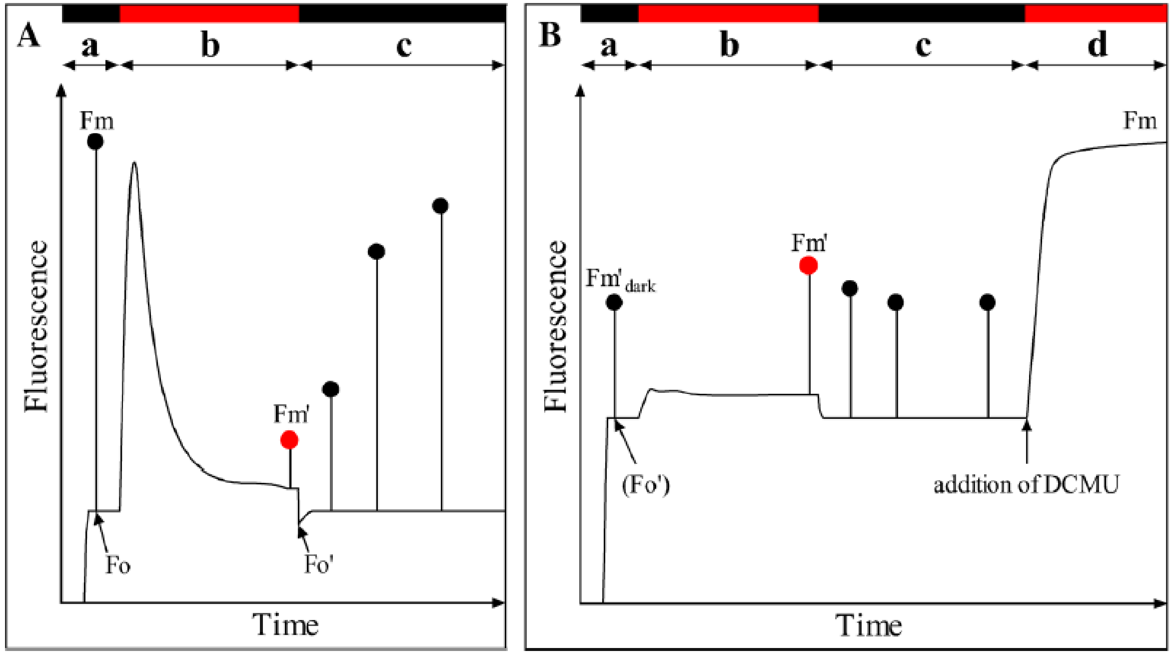
Pigment's synthesis and content

HPLC



Biochemical and biophysical characteristics of the photosynthetic apparatus

Fig. 1 Typical traces of chlorophyll fluorescence quenching analysis in land plants (**A**) and cyanobacteria (**B**). Measurements are conducted in four phases: dark-acclimated phase (*a*), light-acclimated phase (*b*), dark-recovery phase (*c*), and DCMU phase (*d*)



Ogawa, Misumi and Sonoike, 2017

Expected Results

1 – Gain of knowledge on biological responses to environmental parameters resembling those of extrasolar planets orbiting M-type stars

2 – Production of a Database of atmospheric biosignatures useful for future space mission observations

3 – Evaluation of the suitability of the tested organisms for long-term missions on ISS or to the Moon/Mars

Thanks For The Attention

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