Microorganisms suitable for studying biomarkers within the atmosphere in a test tube project

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**AIMS** Study the metabolism, vitality and gaseous production of photosynthetic organisms when forced to live in a different environment, miming an earth-like planet orbiting around the HZ of an M type star.

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**Timeline of experiments**

First step:  
- M starlight simulator and Incubator build-up  
- Choice of organisms

Second step:  
- Irradiation of selected organisms with terrestrial conditions,  
- Optimization of physiological analyses for the selected organisms

Third step:  
- Irradiation of the samples with M star radiation,  
- Analysis of photosynthetic performances.

Fourth step:  
- Irradiation of organisms with M star radiation at terrestrial temperature and extrasolar planet gaseous mixture.  
- Analysis of photosynthetic performances.
Sensitive to the FR and NIR radiation

Photosynthetically active in low light conditions

No day-night cycle: continuous irradiation

Resistant to harsh environments

Able to live in modified atmosphere
The high plasticity of cyanobacteria
Recent findings

Gan et al., 2014 SCIENCE (September)
Extensive remodeling of a cyanobacterial photosynthetic apparatus in far-red light

Gan et al., 2015 LIFE
Occurrence of Far-Red Light Photoacclimation (FaRLiP) in diverse cyanobacteria

Gan e Bryant., 2015 Environmental Microbiology
Olsen et al., 2015 Frontiers in Microbiology
Adaptive and acclimative responses of cyanobacteria to far-red light (FaRLiP) and low light (LoLiP)
Which kind of environments?

Gan and Bryant., 2015

http://www.nhm.ac.uk/
After only **24h of FarRed light** (720nm, 15 µmol photons m\(^{-2}\) s\(^{-1}\)) reorganize the photosynthetic apparatus reaching a **photosynthetic activity up to 40% faster** than in Red light.

They have a special cluster of **21 genes**:

- coding for a FR light photoreceptor and protein and pigment components of the major three complexes of the photosynthetic apparatus: PSI, PSII and phycobilisomes.
<table>
<thead>
<tr>
<th>Strain</th>
<th>Section</th>
<th>FaRLIpc</th>
<th>Chls</th>
<th>PEc</th>
<th>PECa</th>
<th>CCAc</th>
<th>Isolation habitat</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Synechococcus</em> sp. PCC 7335</td>
<td>I</td>
<td>+</td>
<td>a, d, f</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Type III, Snail shell, intertidal zone, Puerto Penasco, Mexico</td>
<td>Rippka et al., 1979; Gan et al., 2015</td>
</tr>
<tr>
<td><em>Chroococcidiopsis thermalis</em> PCC 7203</td>
<td>II</td>
<td>+</td>
<td>a, d, f</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Soil sample, near Greifswald, Germany</td>
<td>Rippka et al., 1979; Gan et al., 2015</td>
</tr>
<tr>
<td><em>Pleurocapsa</em> sp. PCC 7327</td>
<td>II</td>
<td>(+)</td>
<td>N.D.1</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Type I, Hunters Hot Spring, Oregon, USA</td>
<td>Rippka et al., 1979</td>
</tr>
<tr>
<td><em>Leptolyngbya</em> sp. JSC-1</td>
<td>III</td>
<td>+</td>
<td>a, d, f</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Type III, Microbial mat, La Duke Hot Spring, Gardiner, Montana, USA</td>
<td>Brown et al., 2010; Gan et al., 2014</td>
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<tr>
<td><em>Oscillatoriales</em> sp. JSC-12</td>
<td>III</td>
<td>(+)</td>
<td>N.D.1</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Microbial mat, La Duke Hot Spring, Gardiner, Montana, USA</td>
<td>Rippka et al., 1979; Gan et al., 2015</td>
</tr>
<tr>
<td><em>Calothrix</em> sp. PCC 7507</td>
<td>IV</td>
<td>+</td>
<td>a, d, f</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Sphagnum bog, near Kastanienbaum, Vierwaldstättersee, Switzerland</td>
<td>Rippka et al., 1979; Gan et al., 2015</td>
</tr>
<tr>
<td><em>Chlorogloeopsis</em> sp. PCC 9212</td>
<td>V</td>
<td>+</td>
<td>a, d, f</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Thermal spring water, Orense, Spain</td>
<td>Gan et al., 2015</td>
</tr>
<tr>
<td><em>Chlorogloeopsis</em> sp. PCC 6912</td>
<td>V</td>
<td>(+)</td>
<td>a, d, f</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Soil sample, Allahabed, India</td>
<td>Rippka et al., 1979; Airs et al., 2014</td>
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<tr>
<td><em>Fischerella</em> sp. PCC 9605</td>
<td>V</td>
<td>(+)</td>
<td>N.D.1</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Freshwater, Israel</td>
<td>Rippka et al., 1979</td>
</tr>
<tr>
<td><em>Fischerella</em> sp. JSC-11</td>
<td>V</td>
<td>(+)</td>
<td>N.D.1</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Microbial mat, La Duke Hot Spring, Gardiner, Montana, USA</td>
<td>Rippka et al., 1979</td>
</tr>
<tr>
<td><em>Fischerella musicola</em> PCC 7414</td>
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<td>(+)</td>
<td>N.D.1</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Hot spring, New Zealand</td>
<td>Rippka et al., 1979</td>
</tr>
<tr>
<td><em>Fischerella thermals</em> PCC 7521</td>
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<td>a, d, f</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>Hot spring Sinkhole II, Mammoth Hot Springs area, Yellowstone National Park, Wyoming, USA</td>
<td>Rippka et al., 1979; Gan et al., 2015</td>
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<tr>
<td><em>Mastigocoleus</em> testarum BC008</td>
<td>V</td>
<td>(+)</td>
<td>N.D.1</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Type III, Marine snail shell, Cabo Rojo, Puerto Rico</td>
<td>Ramirez-Reinat and Garcia-Pichel, 2012</td>
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<tr>
<td><em>Halomicronema</em> hongdechloris</td>
<td>III</td>
<td>(+)</td>
<td>a, f</td>
<td>-</td>
<td>n.a.2</td>
<td>-</td>
<td>Stromatolites, Shark Bay, Hamelin Pool, Western Australia</td>
<td>Chen et al., 2012</td>
</tr>
<tr>
<td>KC1</td>
<td>I</td>
<td>(+)</td>
<td>a, f</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Type III, Lake Biwa, Japan</td>
<td>Akutsu et al., 2011; Miyashita et al., 2014</td>
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<tr>
<td>KC1-likeb</td>
<td>I</td>
<td>(+)</td>
<td>a, f</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>Green-clackish biofilm, outside Jenolan Caves, NSW, Australia</td>
<td>Behrendt et al., 2015</td>
</tr>
</tbody>
</table>
First described for shaded *Synechococcus* sp. ecotypes of Thermal Spring, Yellowstone National Park

*Are characterized by peculiar genes coding for light harvesting complexes components of the photosynthetic apparatus absorbing FR light:* photosystem-II CP43 protein homolog *isiX* / Allophycocyanin subunit *apcB3* / Allophycocyanin subunit *apcD4* / Hypothetical protein (putative low light photoreceptor)

*LoLiP cyanobacteria*

This discovery lead to enlarge the PAR radiation range

In vivo absorption spectra of photosynthetic organisms containing different chlorophylls and the quantum yield of photosynthesis using only chlorophylls $a$ and $b$ (grey line).

The selected organisms

**Acaryochloris marina**

**Chroococcidiopsis thermalis PCC7203**

**Chlorogloeopsis frischii PCC 6912**
Cyanobacteria from thermal springs
Cyanobacteria from caves
Growth analyses (OD, biomass, Fo)
Light and fluorescence microscopy

Pigment composition of extracts (spectrophotometer and HPLC)
In vivo absorbance, trasmittance and reflectance spectra

77K fluorescence spectra
FluorCam and dualPAM fluorescence analyses
Tunable Diode Laser Absorption Spectroscopy
Light and fluorescence microscopy

*Chlorogloeopsis frischii* PCC 6912
In vivo spectra by Cary 5000
(collaboration with Prof. Pellizzo)
Mesuring Chls levels and photosynthetic efficiency by Fluor Cam
The organisms in the MINI LISA incubator
Masuring CO₂ by Tunable Diode Laser Absorption Spectroscopy setup (TDLAS)

Accuracy: O₂ <1% ; CO₂, CH₄ = 0.1%
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