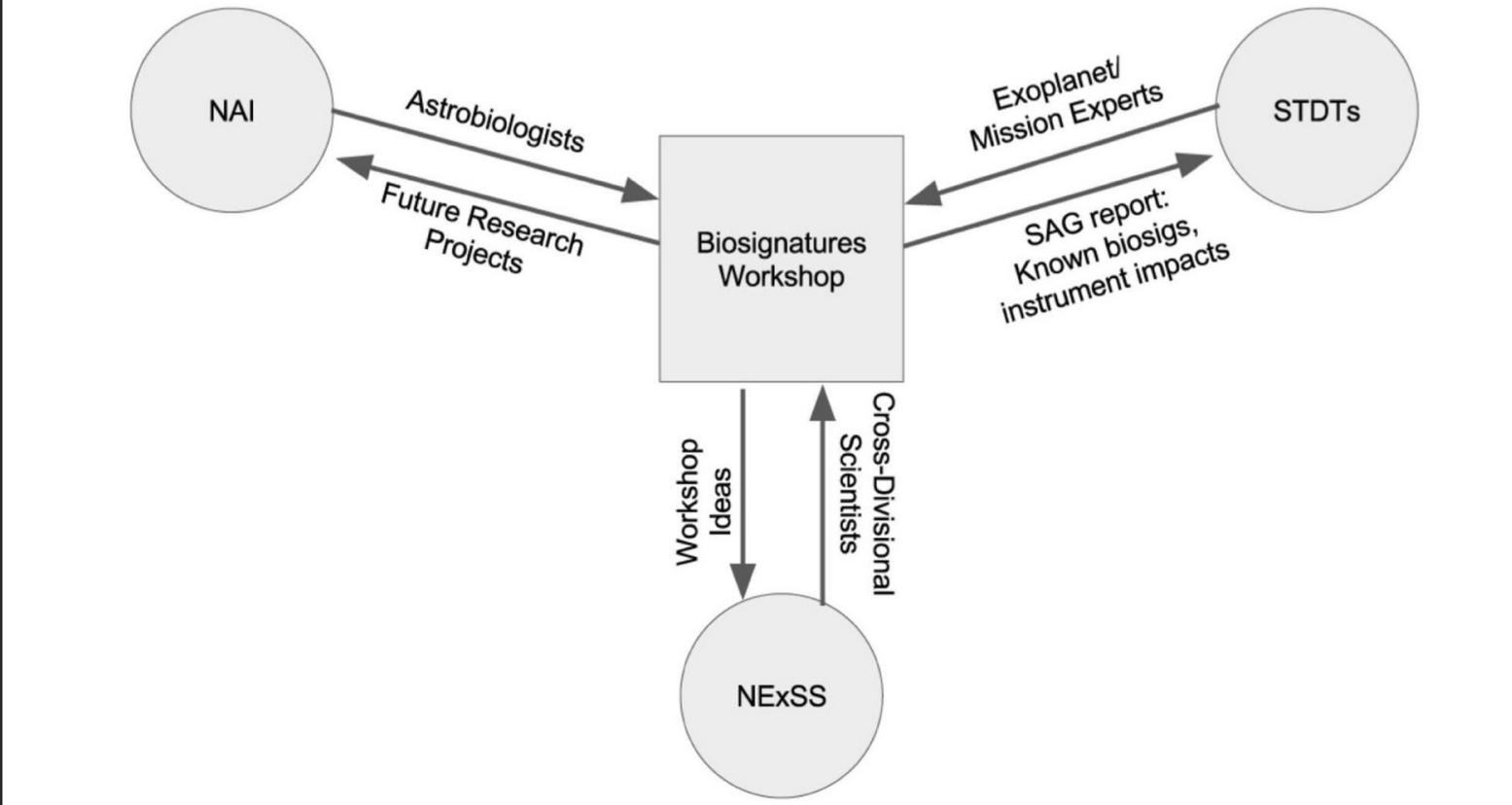


# Exoplanet Biosignatures Workshop Without Walls (aka ExoPAG SAG 16) Update

Organizers: Shawn Domagal-Goldman, Nancy Kiang, Niki Parenteau

Chapter leads: Eddie Schwieterman, Hillairy Hartnett, Victoria Meadows,  
Chris Reinhard, David Catling, Sara Walker, Bill Moore, Yuma Fujii



Video (3) Start [Camera Icon] [Microphone Icon] [Fullscreen Icon]

Nikole [Video Icon]

David Des Marais [Video Icon]

Shawn Domagal-gol... [Video Icon]

Telecon Number

11 [Font Size Icon] [Text Color Icon] [List Icon]

Inside the US: 1-844-467-4685  
 Passcode: 5947549553#  
 Outside the US: Give your country to Michael Toillion for number/passcode.

Chat (Everyone)

The chat history has been cleared

MARY PARENTEAU: <http://online.liebertpub.com/doi/pdfplus/10.1089/15311070260192246>

MARY PARENTEAU: Free download of Des Marais et al., 2002

Sonny Harman: yup!

Don Hood: yup!

Everyone [Text Input] [Send Icon]

Attendees (27)

Audio Bridge

Participants (20)

- Alternative Earths ...
- Andrew Rushby
- Andrew Rushby 2
- Debajyoti
- Don Hood
- Eddie Schwieterman
- Karl Stapelfeldt
- LSU - Nicki Button,...
- Maggie
- Maria
- Markus Rabus
- Norio Narita 2
- Renyu Hu

Lobby

Presentation

Questio...

Worksh...

big text

# ExoPAG SAG16 will submit 5(+1) manuscripts:

1. EB I: Exoplanet Biosignatures: A Review of Remotely Detectable Signs of Life. Schwieterman et al.
  2. Exoplanet Biosignatures: Understanding Oxygen as a Biosignature in the Context of Its Environment. Meadows et al.
  3. Exoplanet Biosignatures: A Framework for Their Assessment. Catling et al.
  4. Exoplanet Biosignatures: Future Directions. Walker et al.
  5. Exoplanet Biosignatures: Observational Prospects. Fujii et al.
- +1. Executive Summary of 1-5 above.

# Exoplanet Biosignatures: A Review of Remotely Detectable Signs of Life

1. Requirements for life, biosignature definitions and types
2. Evaluating planetary habitability
3. an overview of terrestrial exoplanet modeling studies,
4. Gaseous biosignatures
5. Surface biosignatures
6. Temporal Biosignatures
7. Methods of assessing biosignature plausibility
8. Cryptic biospheres and “false negatives” for life
9. Prospects for detecting exoplanet biosignatures
10. Summary of our review

# Planetary Biosignatures Reviewed

## Atmospheric Gases

e.g.,  $O_2$ ,  $O_3$ ,  $CH_4$ ,  $N_2O$ , DMS, DMDS,  $CH_3Cl$ ,  $CH_3SH$ ,  $CS_2$ ,  $C_2H_6$ , organic haze, etc.

## Surface Features

e.g., Vegetation Red Edge (VRE), Other Reflectance features

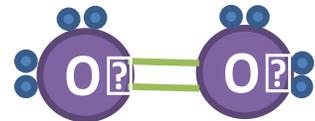
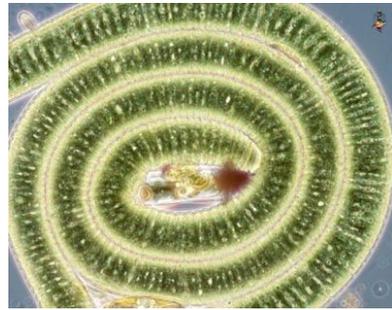
## Temporal Changes

e.g., Seasonal Change in Gas (e.g., "Keeling Curve") or Pigments

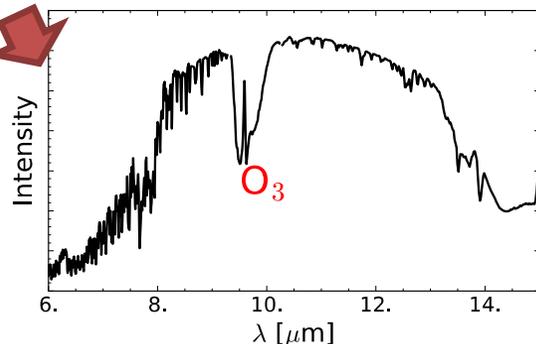
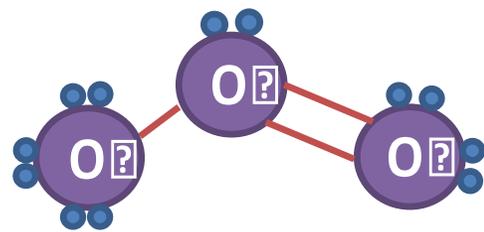
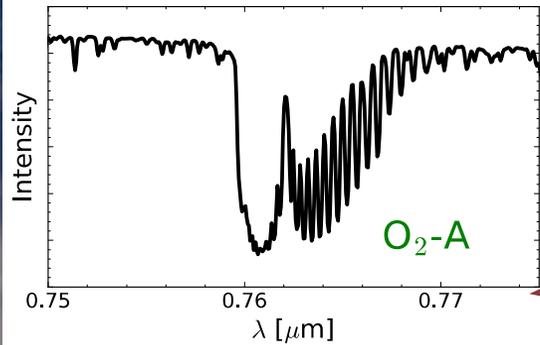
# EXOPLANET BIOSIGNATURES: REVIEW

## Gaseous

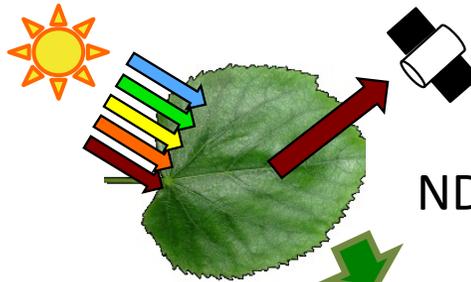
Ex: **Oxygenic Photosynthesis**



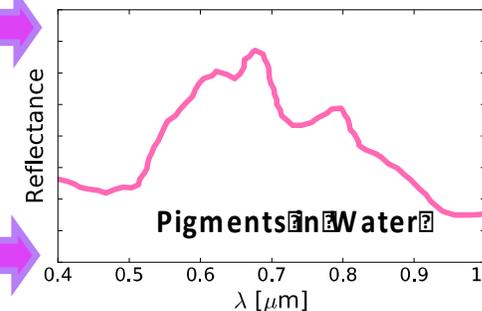
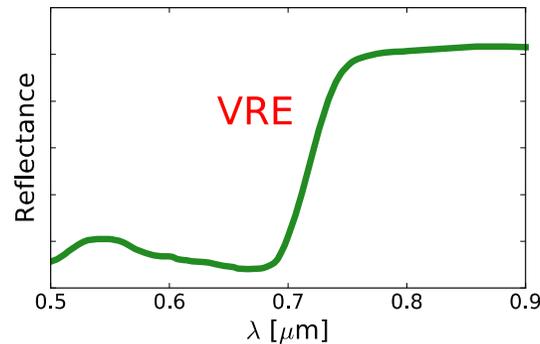
**Photolytic Byproduct**



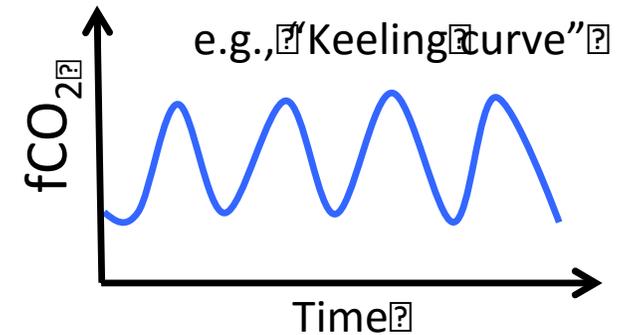
## Surface



$$\text{NDVI} = \frac{\text{IR} - \text{VIS}}{\text{IR} + \text{VIS}}$$



## Temporal



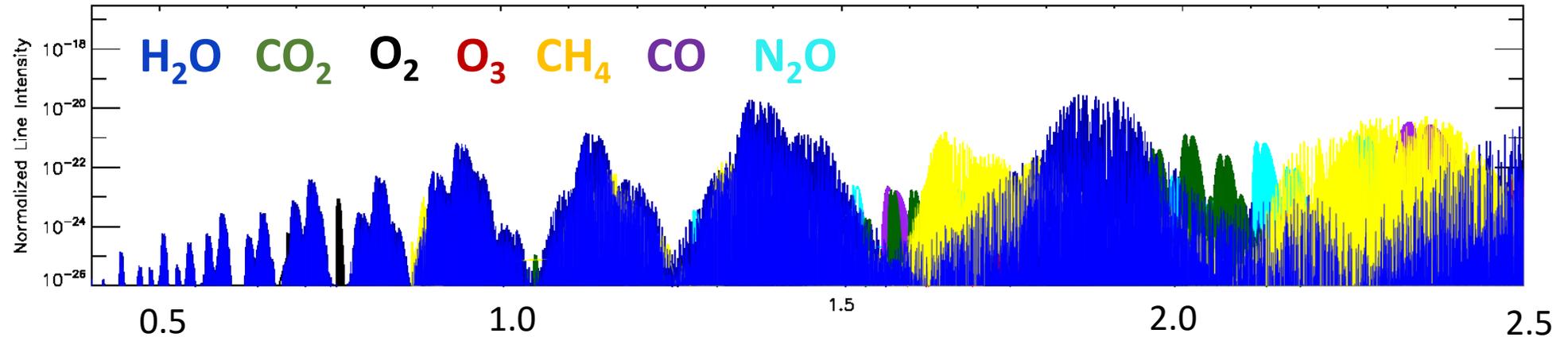
Seasonal Changes in Gases in Surface



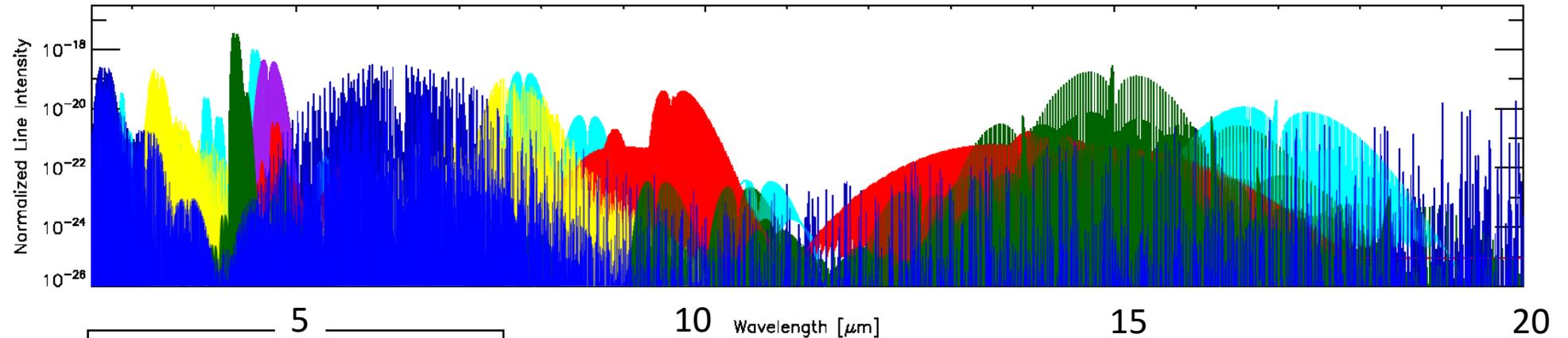
Schwieterman (2016)

# Line Intensities for Major Gases in Atmosphere

VIS to NIR: 0.4 – 2.5  $\mu\text{m}$

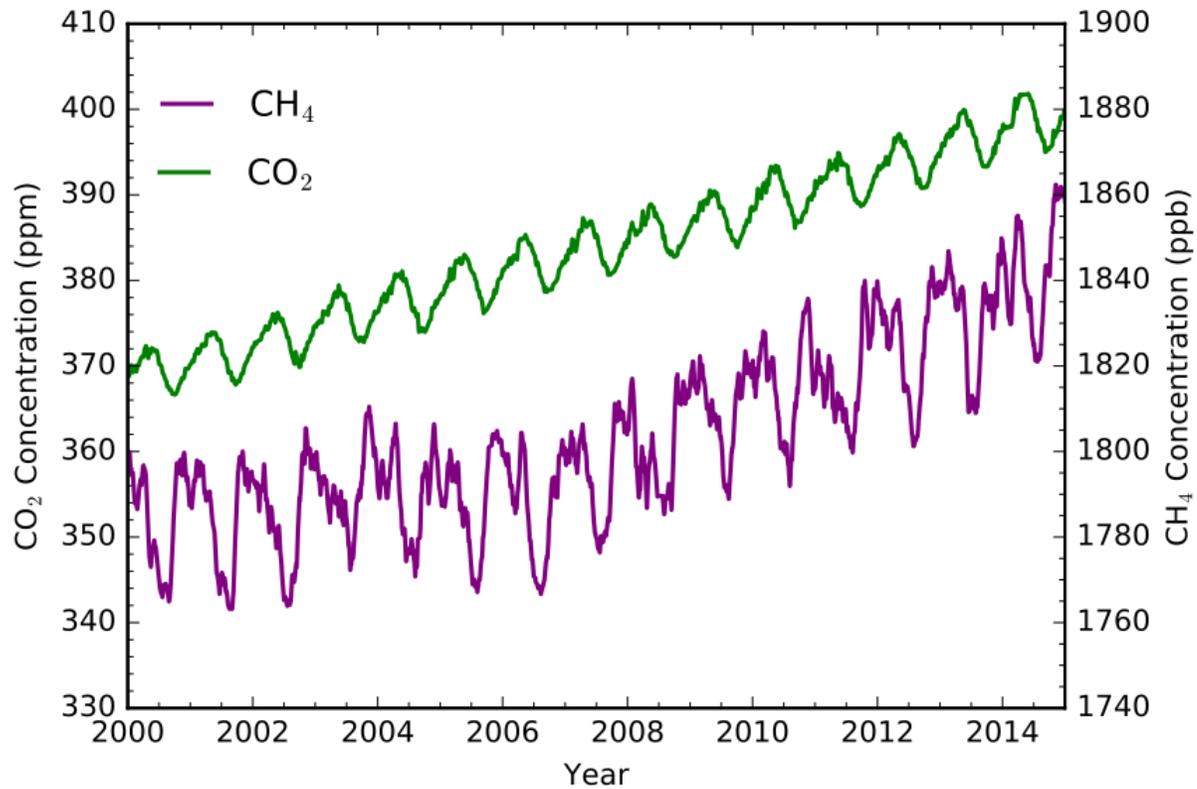


NIR to MIR: 2.5 – 20  $\mu\text{m}$

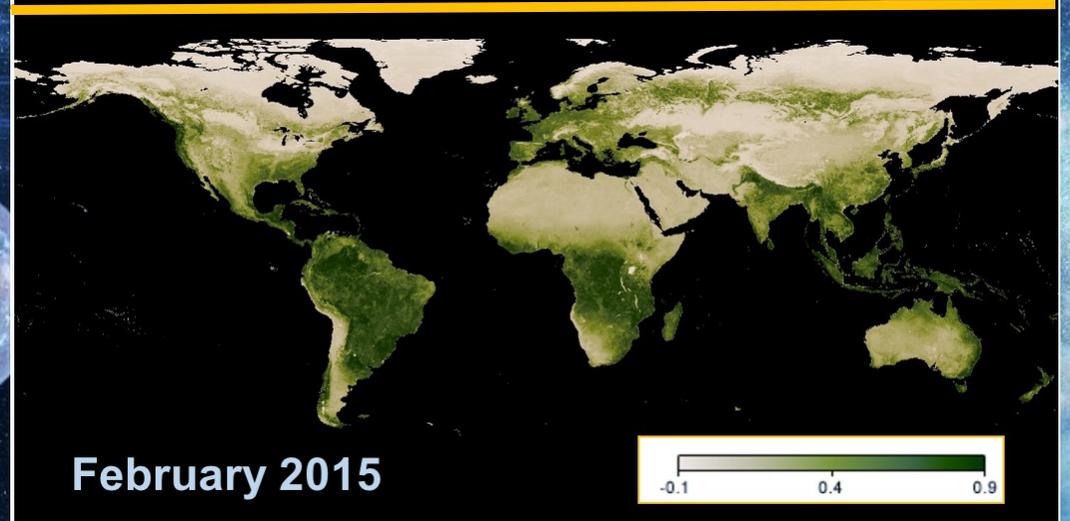
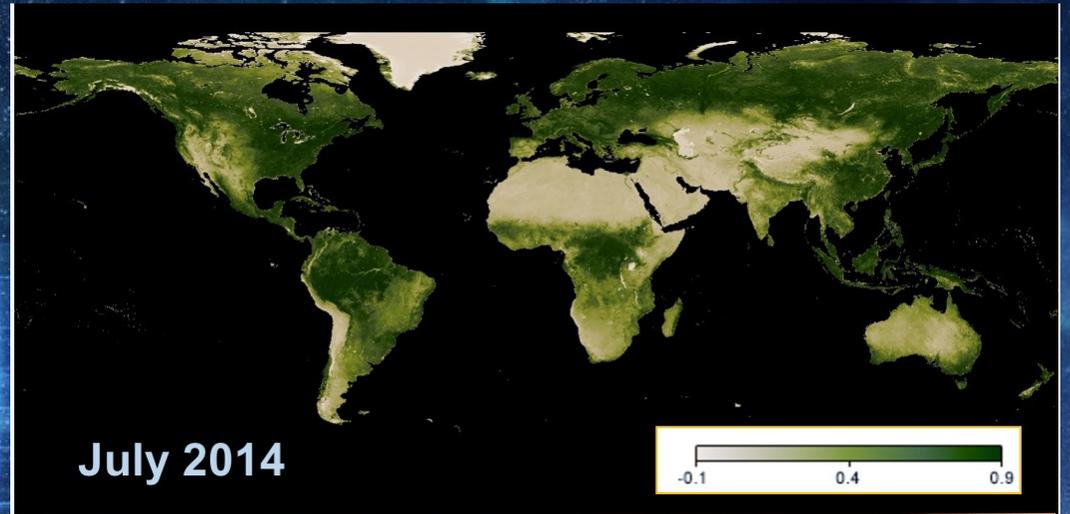


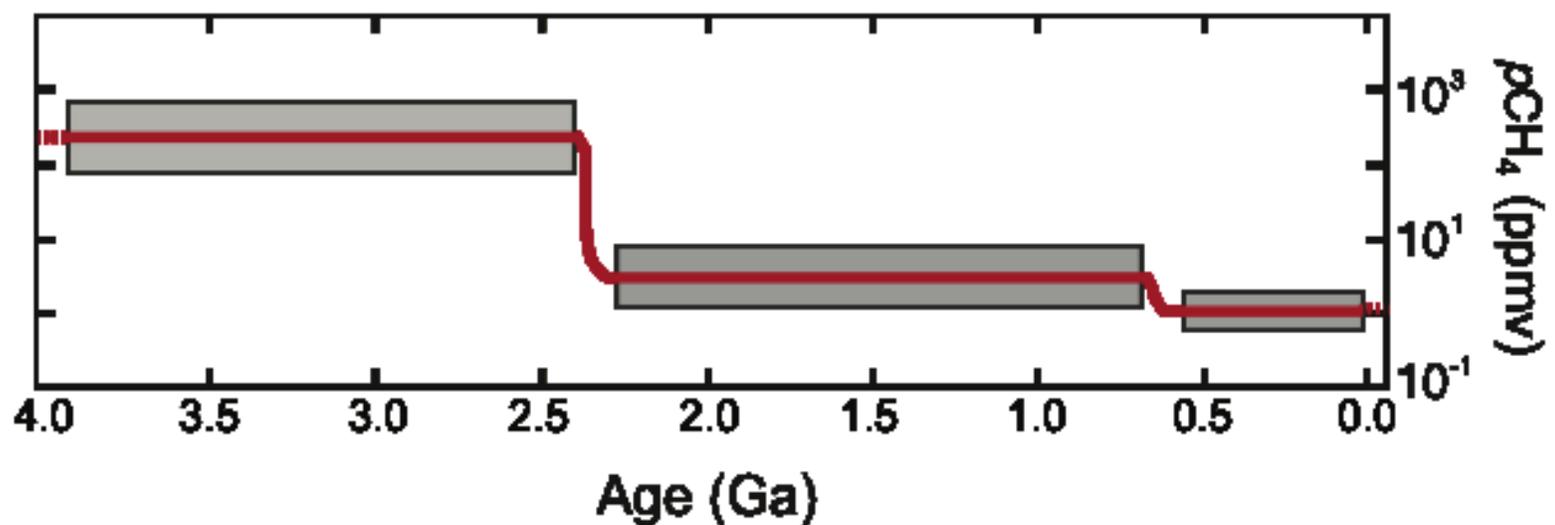
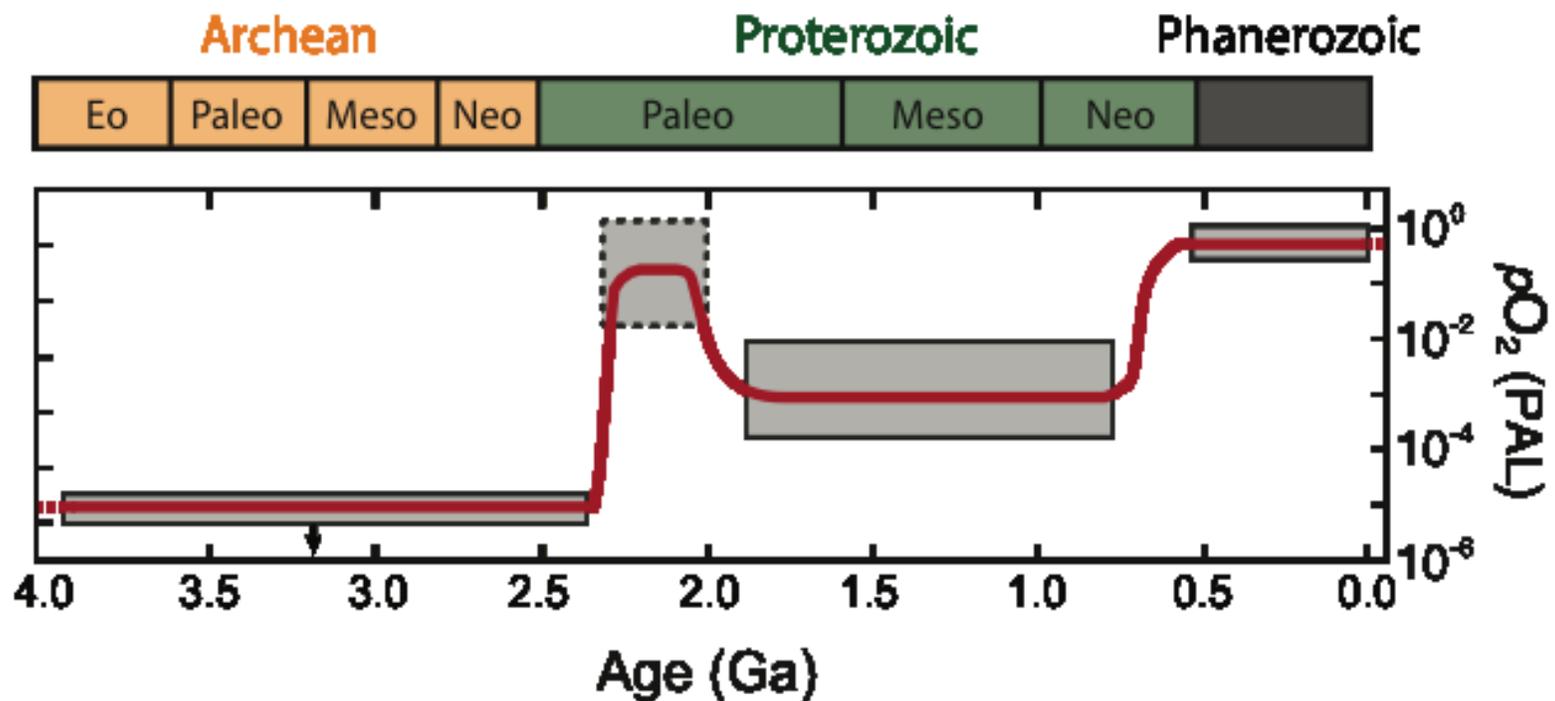
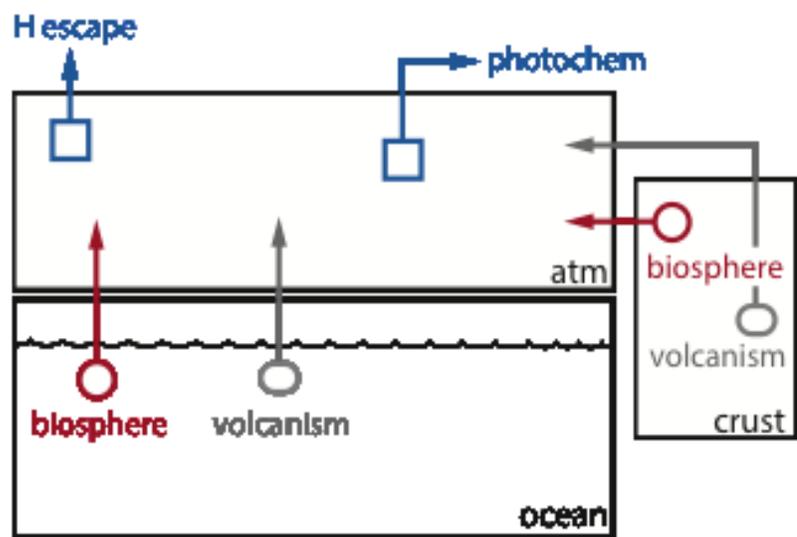
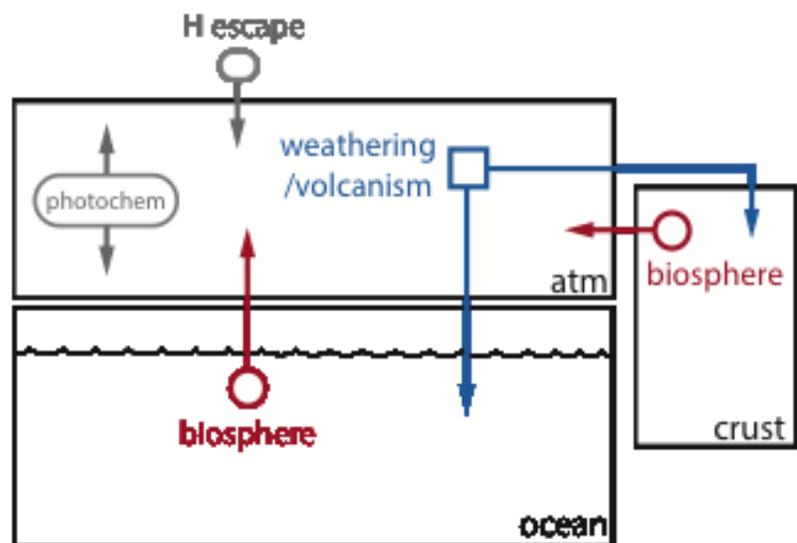
More Absorption

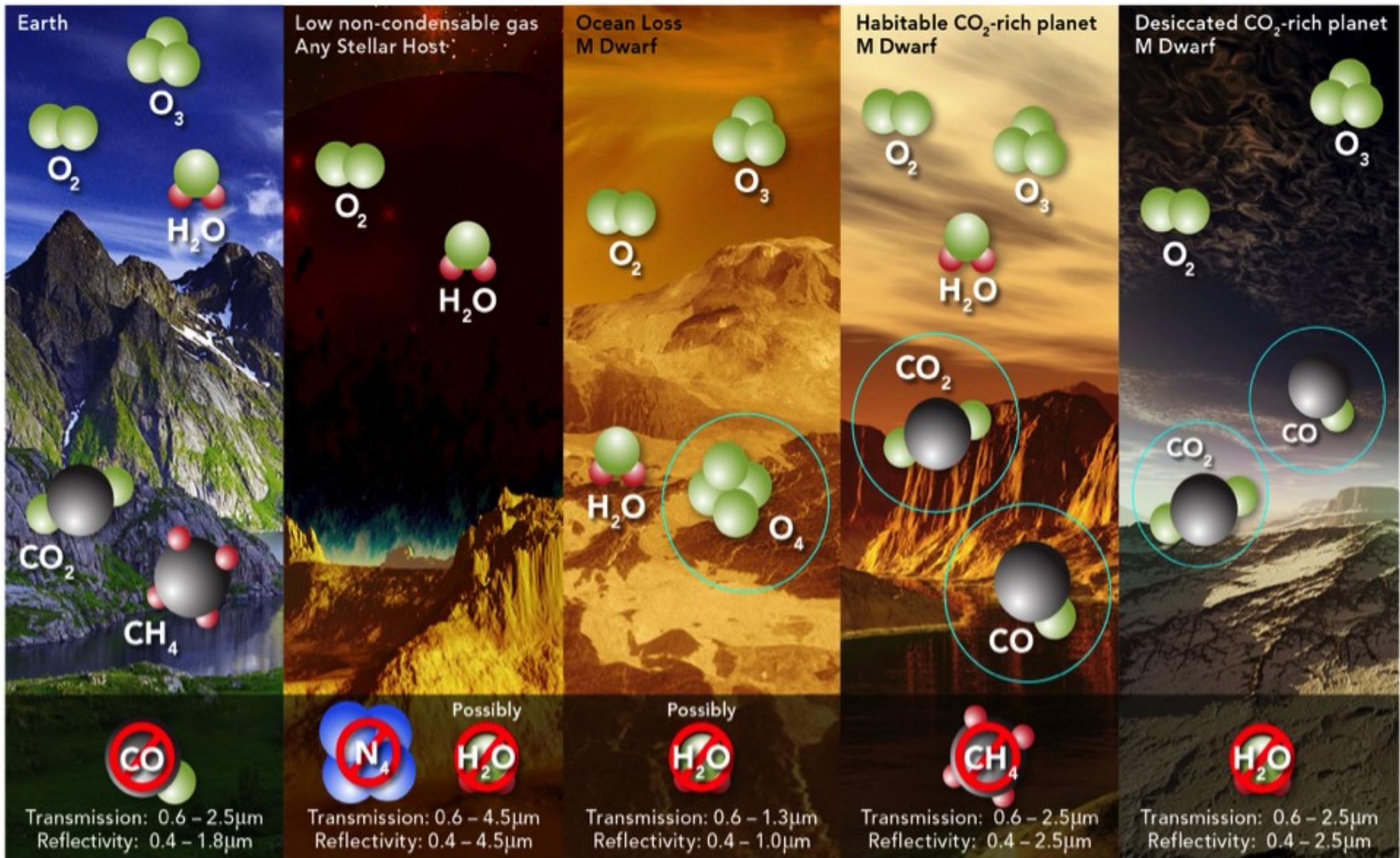
*Gas abundance oscillations as a possible temporal biosignature*



**Seasonal change in global NDVI**

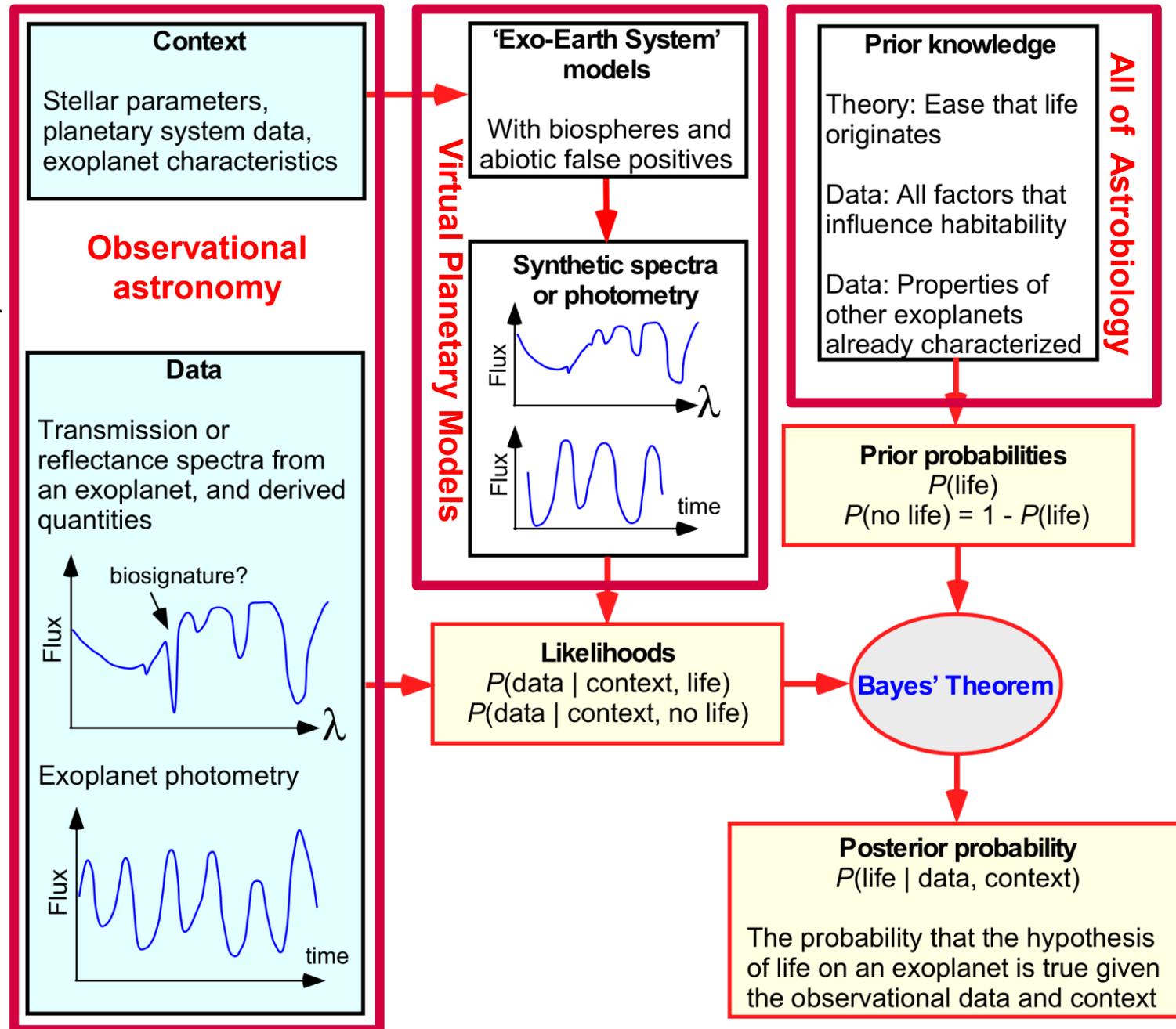






A framework for exoplanet biosignature assessment

(Catling+ 2017, *Astrobiol.* in prep.)



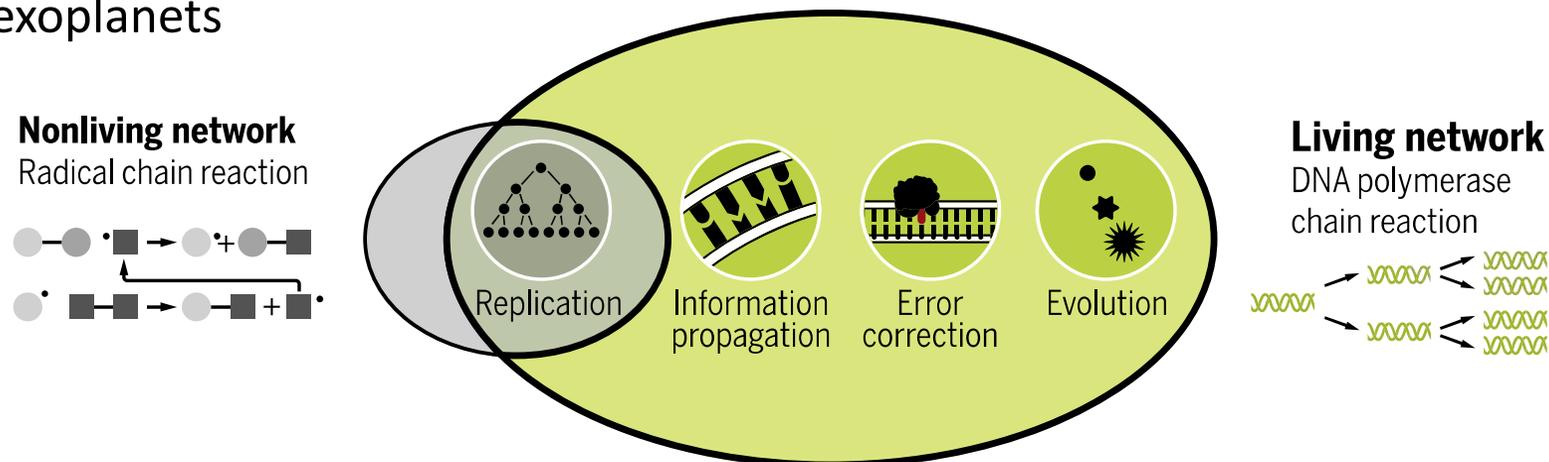
# Exoplanet Biosignatures 4: Future Directions

## **Moving from *product-based* to *process-based* approaches**

- Question in a process-based approach:
  - What fundamental life processes underlie the chemistry we can detect on exoplanets?
  - How do we detect these processes?
  - And how can understanding the processes of life in turn inform new ways to identify and interpret the chemical signatures of life?

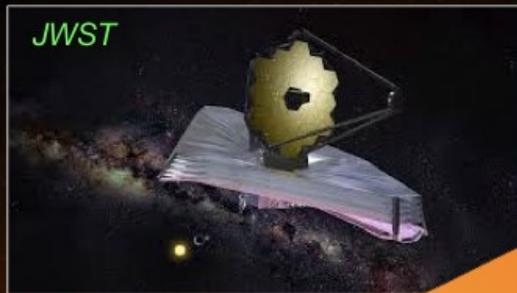
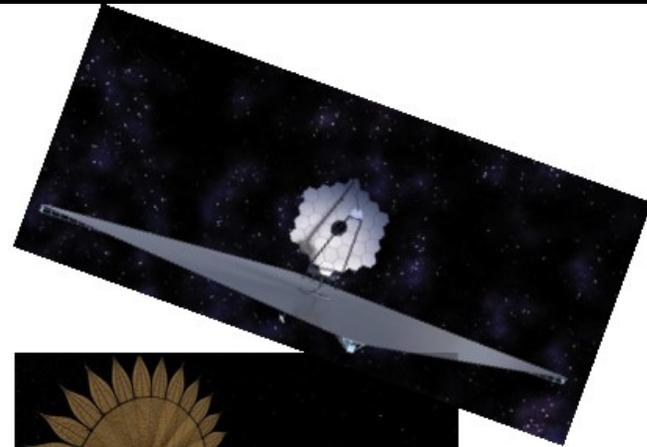
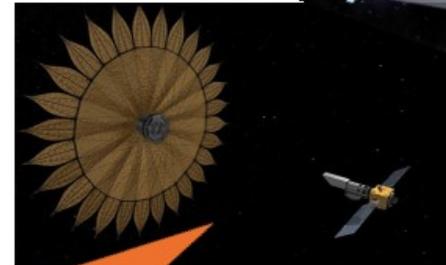
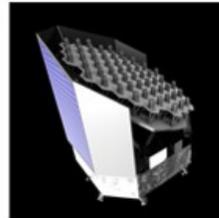
# What remote biosignatures will work when environmental context and biology are different than Earth?

- Characterizing environmental contexts for life:  **$P(\text{data} | \text{no life})$** 
  - Stellar environment, climate, geochemistry
- Characterizing living processes:  **$P(\text{data} | \text{life})$** 
  - Black-box approaches considering inputs/outputs of biological processes
  - Information and energetics of living networks
  - Laboratory and theoretical validation outside of Earth-like conditions
  - Coupled evolution of planets and life
- Advancing Bayesian and statistical approaches to the search for life on exoplanets





FLATO



2030

discovery  
characterization

2020

Existing Telescopes

*K2, HST, Spitzer, ...*  
*VLT, Keck, Subaru, ...*



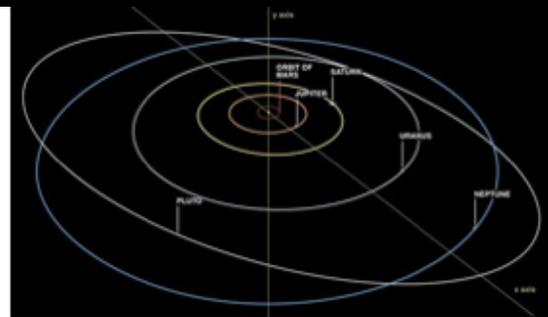
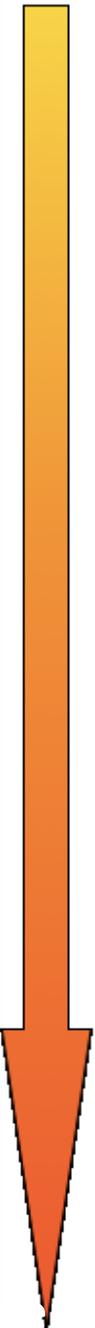
TMT



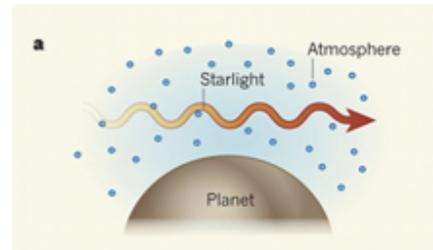
E-ELT



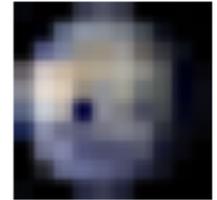
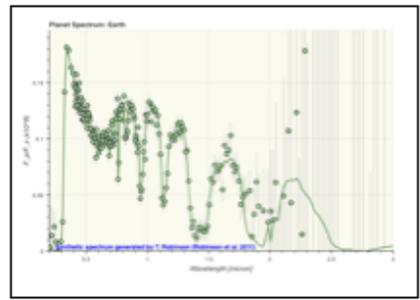
Extremely Large Telescopes

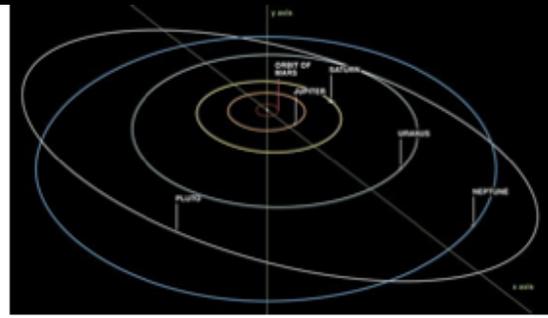
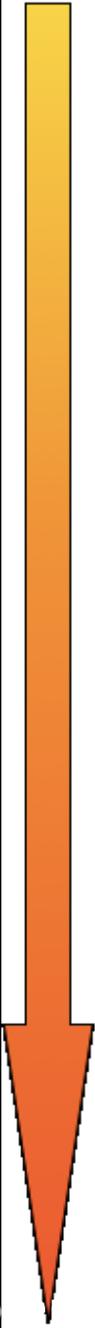


biosignatures?

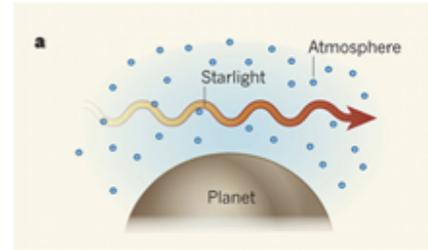


biosignatures?

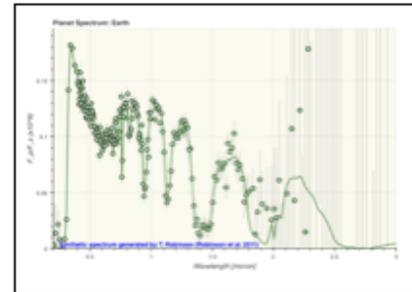




biosignatures?



biosignatures?





### The Team

ject is overseen by representatives from NASA HQ, , and a Steering Committee composed of the PIs of sal teams selected to be the founding members of NExSS.

Meet the Team



### Many Worlds

Many Worlds is a website for everyone interested in the burgeoning field of exoplanet detection and research. It presents columns, news stories and in-depth features, as well as the work of guest writers.

Visit Many Worlds



### EB Discussions

Community commenting is now open for the Exoplanet Biosignatures Workshop Without Walls output. You may manuscripts from May 16 - June 9, 2017.

Follow the Discussion

ie Web

#### When a brown dwarf is actually a planetary mass object

as a brown dwarf is actually a planet—or planet-like anyway. A team led by Carnegie's Jonathan Gagné, and researchers from the Institute for Research on Exoplanets (iREx) at Université de Montréal, University of

NExSS Events Calendar

Event	Date	Location
Exoplanet Biosignatures Workshop Without Walls	May 16 - June 9, 2017	Virtual
...	...	...

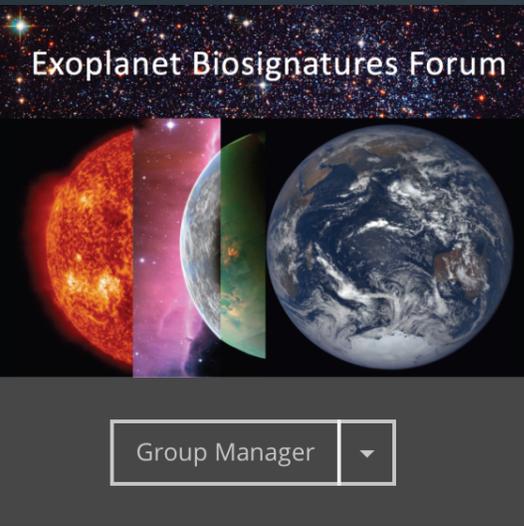


# Exoplanet Biosignatures Workshop-Without-Walls Review Papers - Discussion Forum

Discoverability: Visible

Join Policy: Closed

Created: 19 Apr 2017



Overview

Members 19

Announcements 2

## Overview

Welcome to the community discussion forum for the the [NExSS Exoplanet Biosignatures Workshop-Without-Walls!](#)

The workshop was held as a series of online participatory state-of-the-science review sessions during June 13-July 15, 2016, and an in-person meeting including video-conferencing participation in Seattle, WA, July 27-29, 2017. The culmination of these meetings is a set of 5 review papers on the science and technology of remote searches for signs of life on exoplanets. To ensure broad interdisciplinary input, the international scientific community was widely solicited to participate in the writing of these papers, which review the state of the science, probe emerging ideas and challenges, and project observational capabilities for the near and far future. These papers will be published as products of the Exoplanet Exploration Program Analysis Group (ExoPAG) Study Analysis Group 16 (SAG16). It is intended that they will serve as in-depth references to inspire students to senior researchers in research topics to further the search for life outside the Solar System.

Before final publication, we now post the drafts here for a 3-week community comment period, May 8-26, 2017. You can view the drafts and comments on the forum once the comment period opens. For the ability to post comments, please register [here](#).

### Conference contacts:

Shawn Domagal-Goldman, shawn.goldman \*at\* nasa.gov

Nancy Y. Kiang, nancy.y.kiang \*at\* nasa.gov

# Community Feedback

- 9 comments on the first manuscript
  - 7 comments on second
  - 8 comments on the third
  - 3 comments on the fourth
  - 11 comments on the fifth
- 
- 38 total posted comments – this does not count one “post” with multiple “comments”
  - Additional comments/feedback delivered privately via email

# Timeline

- April 25 – presented progress update to astrobiology community @ AbSciCon2017
- May 15-21 – posted papers on arXiv, open community commenting period
- May 15-June 8 – open community commenting period
  - We are still taking comments, but do not guarantee they will be incorporated
- July 14 – Submit papers, including executive summary to *Astrobiology* for publication
  - We will send the executive summary to the ExoPAG EC for review/comment