



# Searching for ancient life on Mars with the Curiosity and Perseverance Mars rovers

Dr. Nina Lanza | 29 July 2025

Science, Technology, &  
Telecommunications Committee

Searching for ancient life on Mars

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# Life on Mars: Not a new idea

Part Four  
Seventh Magazine Section

The New York Times.

SUNDAY, DECEMBER 9, 1906

Music—Drama—Art  
Society—Sailors

## THERE IS LIFE ON THE PLANET MARS

*Prof. Percival Lowell, recognised as the greatest authority on the subject, declares there can be no doubt that living beings inhabit our neighbor world.*

By Lilian Whiting.

The Peaks at Flagstaff, Arizona.

THE regions of canals on Mars, forming a definite and a wisely planned system designed to irrigate the areas of the vast deserts which make up the surface of this planet, are an unanswerable argument for the existence of conscious, intelligent life. A thing made probable a maker. This truth, of course, was Piazzi's favorite assertion, but it is none the worse for that. Schiaparelli discovered 104 canals. Prof. Percival Lowell and his staff of the Lowell Observatory at Flagstaff, Arizona, have discovered over 300, and they regard the number as no limit. The larger and more obvious are, like the *Great Auroric*, discovered first; but in each region of the planet the trained sight and skill of the great astronomer who is now held to be the specialist on Mars—the Martian expert, as it were—discover new and smaller ones.

The observations of Mars present a series of paradoxes. Certain oppositions present the planet com-

ret safe to assume that the professional astronomer is no "dilettante." In fact, Prof. Lowell has emphasized the fact that the astronomer must see with his mind as well as with his eyes.

In consultation with Prof. W. H. Pickering and other eminent astronomers the site of the new observatory, whose supreme mission was to be the study of Mars, was selected in Arizona, on account of the cloudiness of the air. Flagstaff is on a plateau some 7,000 feet above sea level, with the purple peaks of the San Francisco mountains as a background, and to this new observatory the first observations of Mars

quickness to vegetable growth would produce the phenomena we see," says Prof. Lowell. "Set free from the winter looking on, the water accumulated in the cap starts vegetation, which produces the increased visibility of the canals. This started the

New York Times, 9 December 1906

THE NEW YORK TIMES, SUNDAY, AUGUST 27, 1911

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## MARTIANS BUILD TWO IMMENSE CANALS IN TWO YEARS

Vast Engineering Works Accomplished in an Incredibly Short Time by Our Planetary Neighbors— Wonders of the September Sky.

By Mary Prector.

ACCORDING to a telegram dated Aug. 11, from Flagstaff Observatory, Arizona, Dr. Percival Lowell announces the rediscovery of two new canals of Mars, which were seen for the first time at the last opposition in 1909. The canals are more conspicuous, and displaying more definite features, because of their starting significance. Measurements of their dimensions show each of them to be a thousand miles long and some twenty miles wide. In comparison, the canals of the Colorado River would be a secondary affair. What has been the cause of these vast channels which have suddenly opened on Mars, where the internal forces are far less than on our planet? Nothing like it has ever been seen or heard of before. To what is the amazing late existence on another world of a surface feature in the character of a great canal? It is the character of an event so far of unique occurrence.

That these vast channels have been opened by some internal disturbance of the planet, for the purpose of the first time, is a possibility which is being examined with the most intense interest. It is a possibility which is being examined with the most intense interest. It is a possibility which is being examined with the most intense interest.

These Two Drawings by Prof. Lowell and Prof. E. C. Sipher Show the New Canals Just Observed.

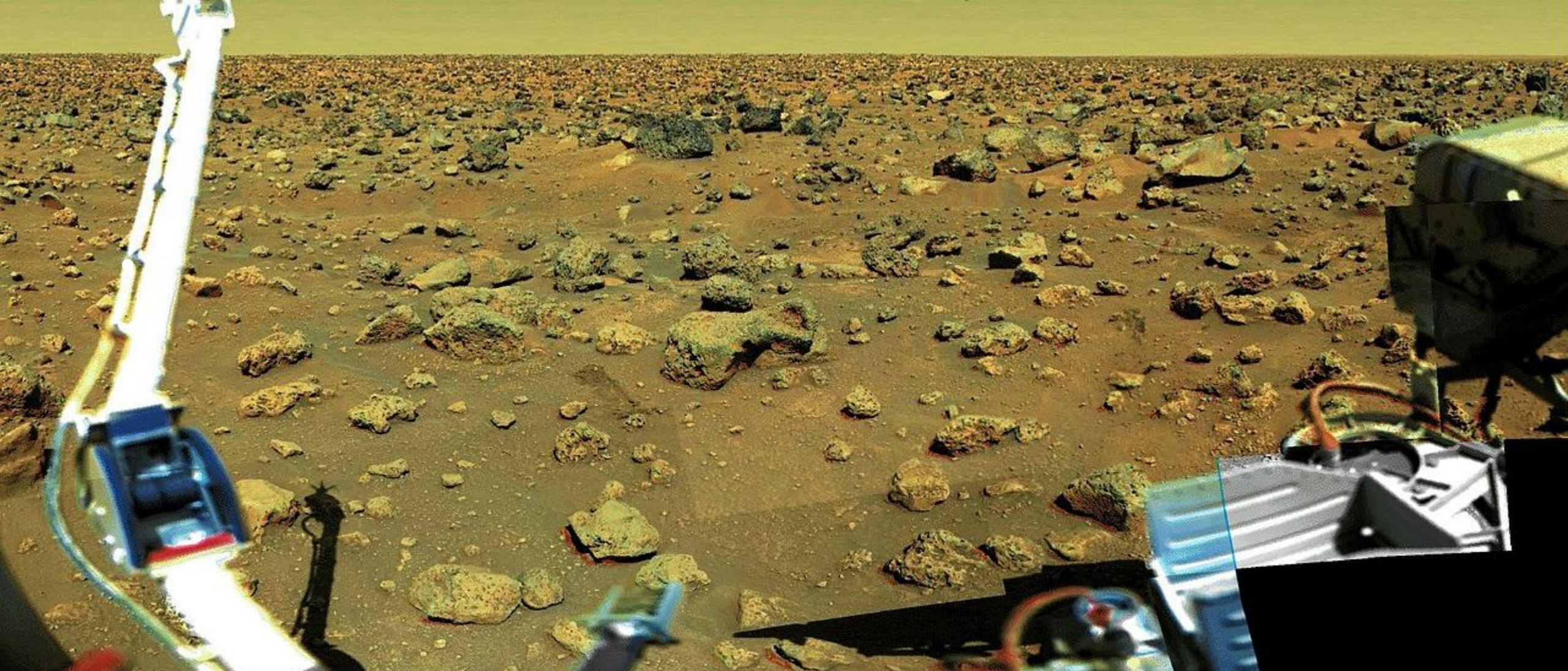
The record books were then examined, when it appeared that not a trace of them was to be found in the drawings of Mars, 1903, or August 1904, or any other of the planet's previous oppositions. That they had not been observed in previous years had not been observed in previous years had not been observed in previous years.

The record of canals seen at Flagstaff is registered at the Lowell Observatory after each opposition, or near approach of the planet, when it is well placed for observation. From these records a fresh map, including all new details observed, is made of the planet's surface. These maps are, therefore, of the greatest value in enabling us to trace any new features or changes on Mars, and they have so far shown only very slight variations in comparison with any alterations which may be taking place on that planet. What new revelations are in store for us, at the present opposition, we have not yet ascertained, but we have no doubt that the new discoveries will be of the greatest interest and importance.

Examining the Flagstaff records for the past eleven years, during which Mars has been kept under observation, no signs of any new features on Mars to escape their notice had been found in these canals.

The Great Telescope at Lowell Observatory.





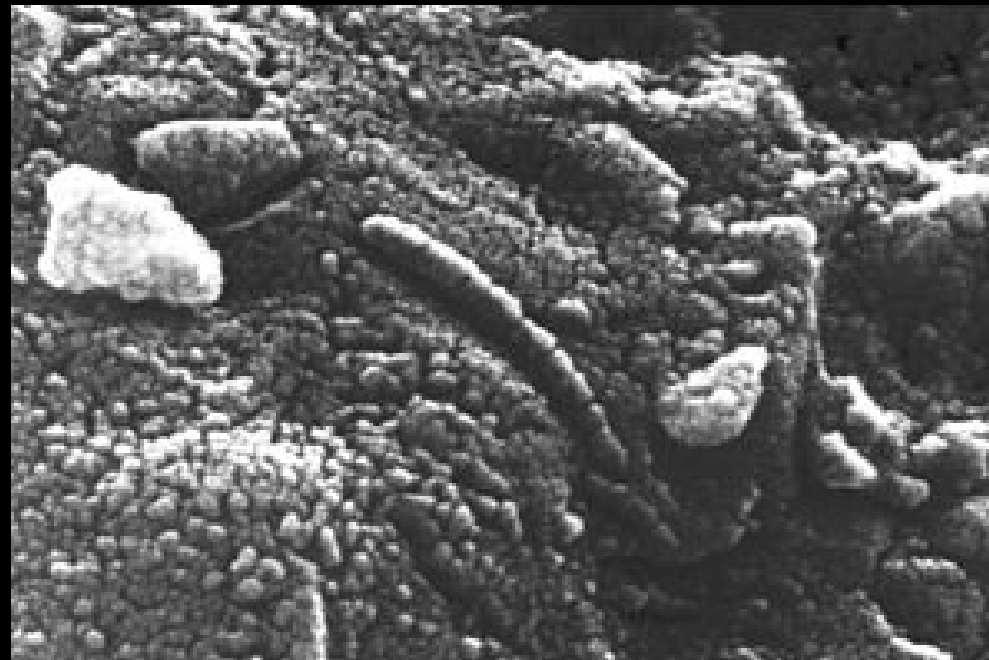
# View from Viking: A “dead” world



# 1996: Ancient martian life discovered in meteorite?

“Today, rock 84001...speaks of the possibility of life. If this discovery is confirmed, it will surely be one of the most stunning insights into our universe that science has ever uncovered.”

– President Bill Clinton, 1996





# Why do we care if there are/were Martians?

## Are we alone?

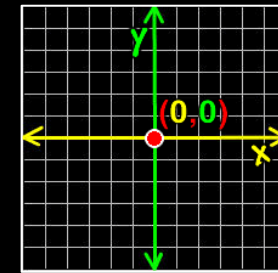
- Are we unique?
- Are we special?



Hello?

## Where did we come from?

- How does life develop?
- How conducive to life is Earth?

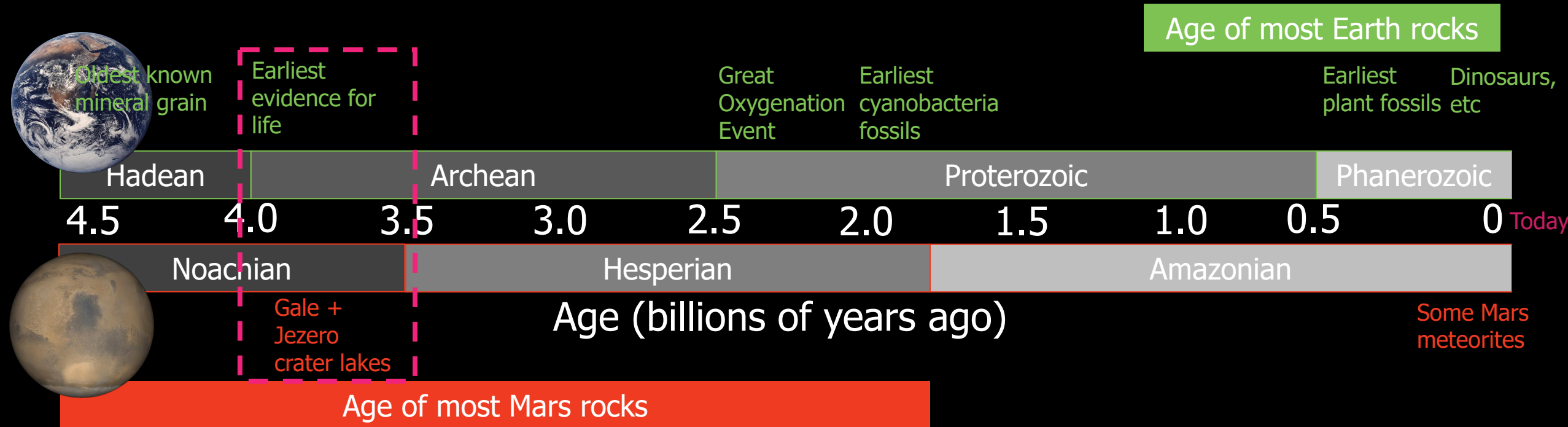


## We can test hypotheses on Mars

Most Earth-like of our neighbors  
Similar histories, compositions



# Mars was habitable at the right time—but was it ever inhabited?

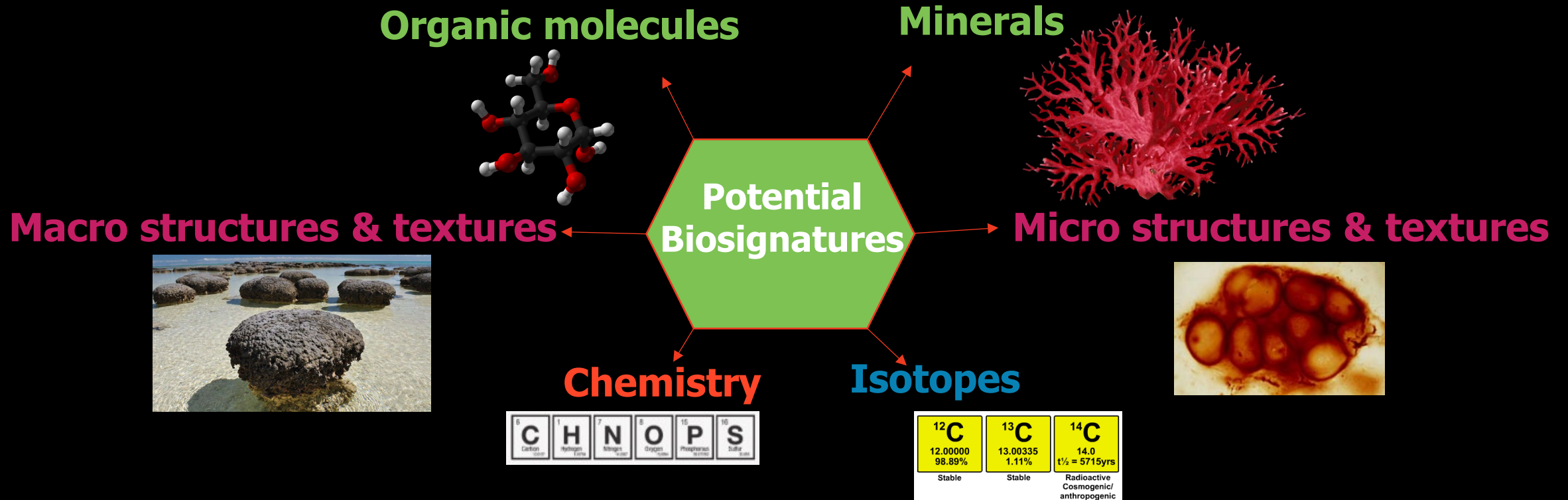


- Mars surface rocks are old compared to Earth's
- On Earth, microbial life developed early
- Mars was habitable when Earth life was abundant
  - Ancient rocks provide window into deep past

We can learn about our own origins by studying Mars



# How can we identify ancient life in rocks?



- Need **multiple lines of evidence**
- **Hard to assess remotely** with spacecraft instruments
- Samples in lab can be **repeatedly analyzed**, saved for **future analyses**

*After Carrier et al., 2020*



# Our Mars rover family

MSL (2011)  
Curiosity

MER (2003)  
Spirit and Opportunity

Mars 2020 (2020)  
Perseverance

Pathfinder (1996)  
Sojourner



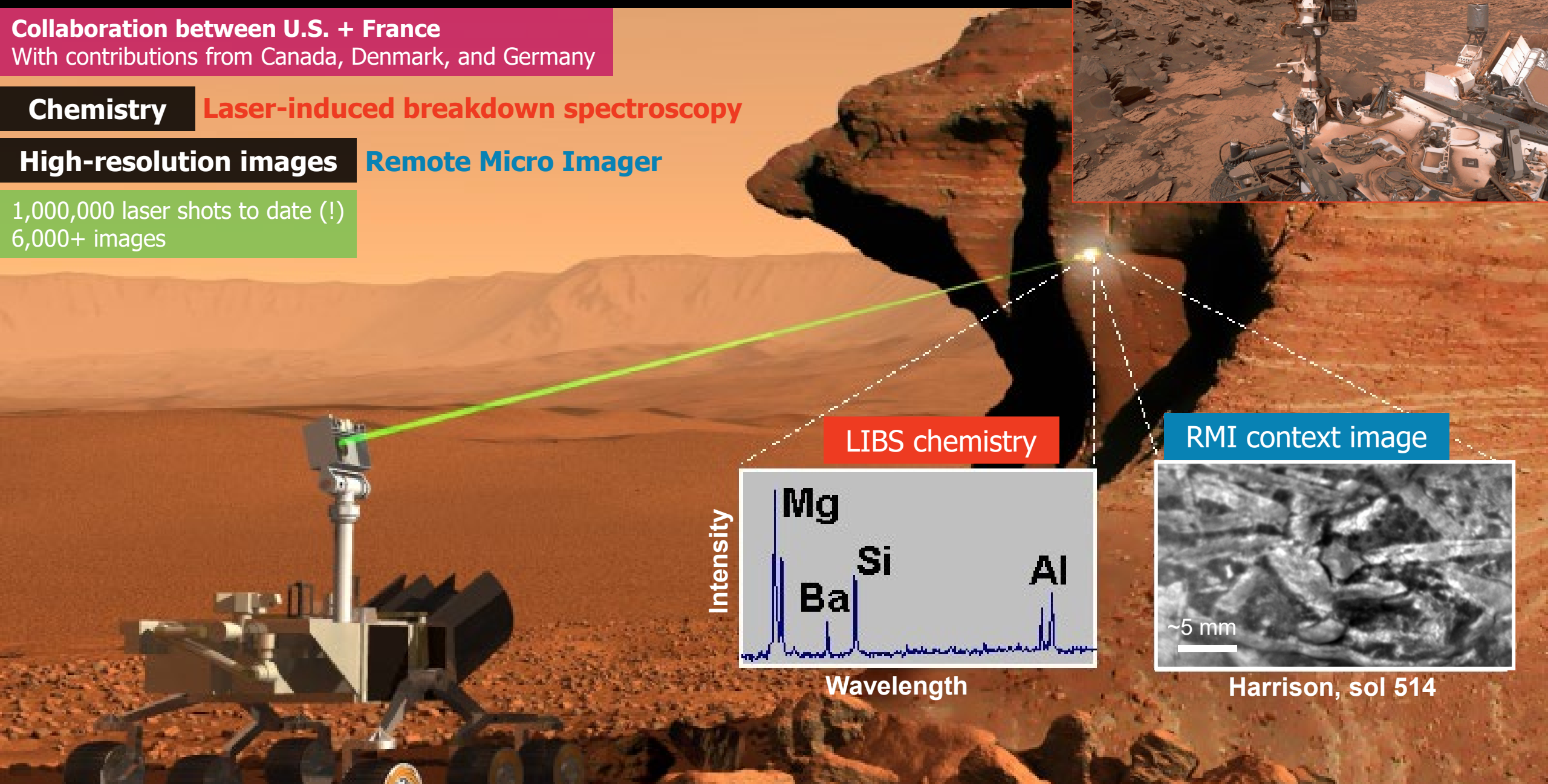
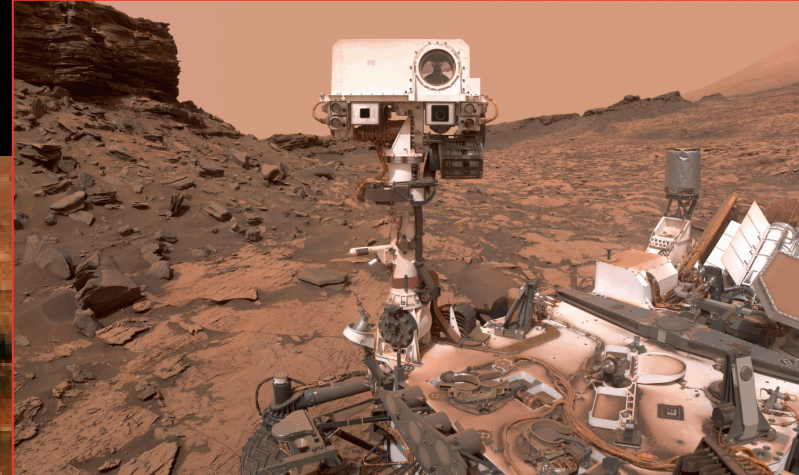
# The ChemCam instrument

Collaboration between U.S. + France  
With contributions from Canada, Denmark, and Germany

**Chemistry** Laser-induced breakdown spectroscopy

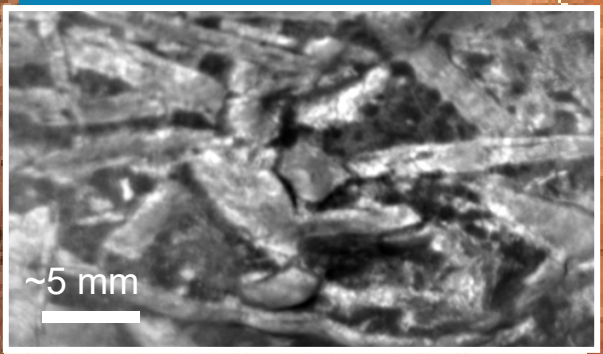
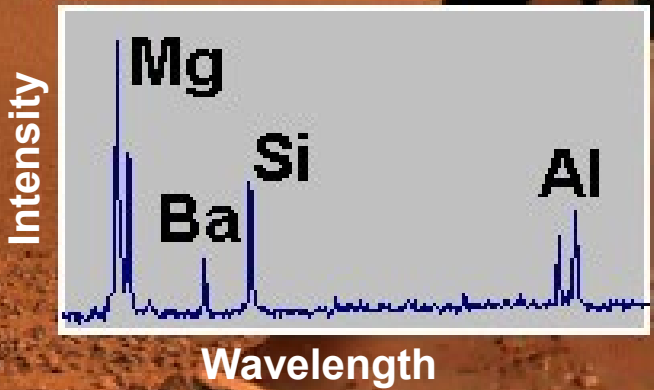
**High-resolution images** Remote Micro Imager

1,000,000 laser shots to date (!)  
6,000+ images



LIBS chemistry

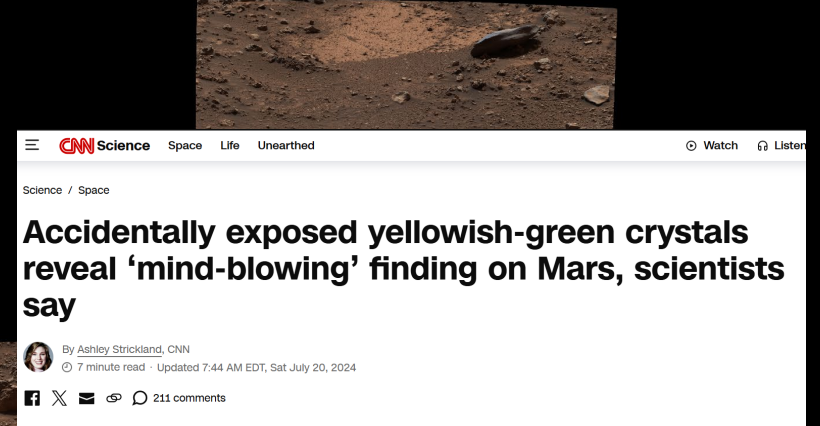
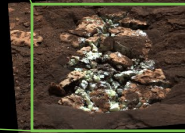
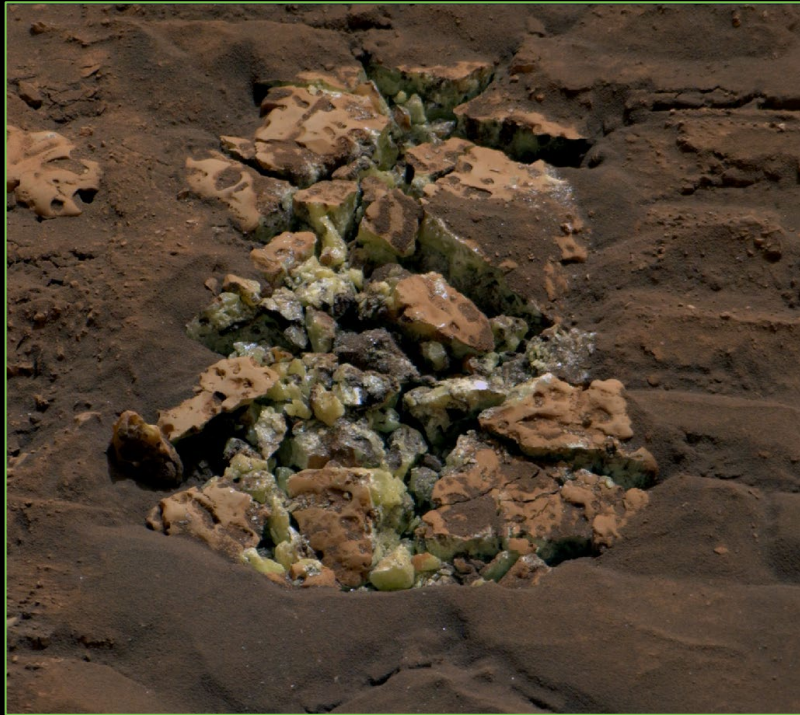
RMI context image



Harrison, sol 514

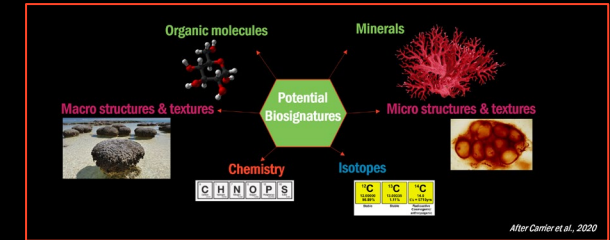


# Curiosity discovers elemental sulfur



- Drove over a rock "Convict Lake" and broke it
- Revealed bright yellow mineral
- Confirmed to be sulfur with chemistry measurements

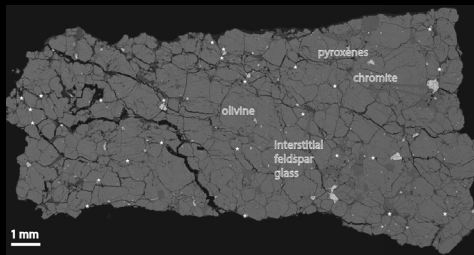
# What does all this sulfur mean?



Reduced

Oxidized

Lorand et al., 2018



Small amounts in meteorites + on Mars    First time observation

Abundant on the martian surface

- Reduced from surrounding environment → redox disequilibrium
- Multiple mechanisms of formation on Earth: volcanoes + organic material + microbes
- Opens up many intriguing possibilities!



# The SuperCam instrument

Collaboration between U.S., France, Spain

What can SuperCam do?

Chemistry

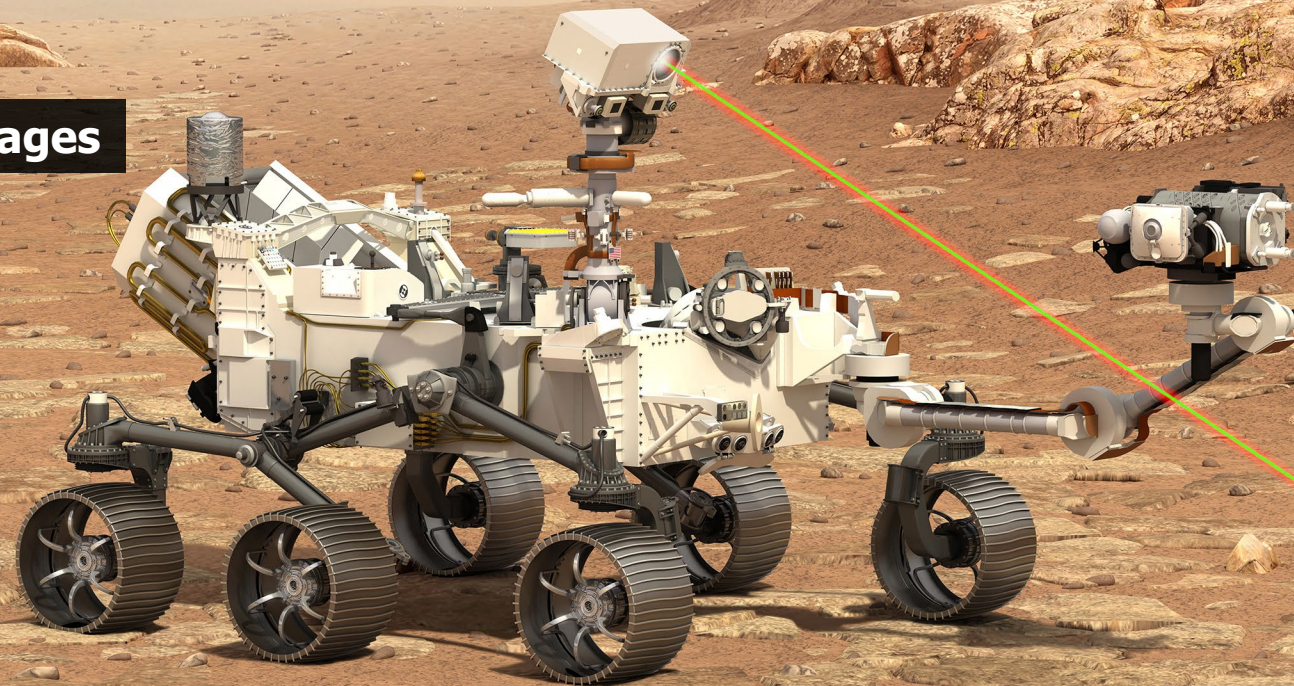
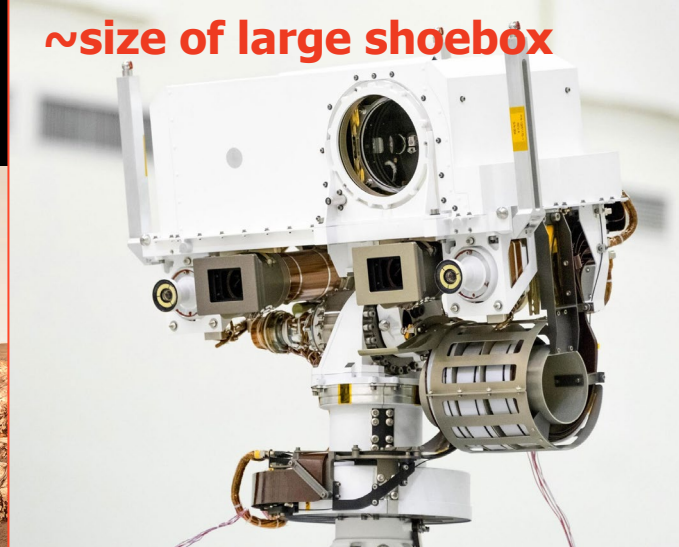
Laser-induced breakdown spectroscopy (LIBS)

Mineralogy

Raman spectroscopy

Microphone

High-resolution images





# A potential biosignature on Mars?

## Announced on July 25, 2024

New results from Perseverance!

Science / Space

### NASA's Perseverance rover may have just found what it was looking for on Mars

By Ashley Strickland, CNN  
6 minute read · Published 4:21 PM EDT, Fri July 26, 2024

68 comments

NASA's Perseverance rover discovered "leopard spots" on a rock nicknamed in Mars' Jezero Crater in July. NASA/JPL-Caltech/MSSS

Sign up for CNN's Wonder Theory science newsletter. Explore the universe on fascinating discoveries, scientific advancements and more.

(CNN) — The NASA Perseverance rover may have found a pivotal clue central to its mission on Mars: geological evidence that could suggest on the red planet billions of years ago.

### Mars rover discovers an ancient rock with a 'potential biosignature'

Scientists are intrigued, but caution this does not necessarily mean life on Mars because organic molecules have non-biological origins.

3 min

MARS 2020

### NASA Did Not Say It Found Life on Mars. But It's Very Excited About This Rock.

The rock, studied by NASA's Perseverance rover, has been closely analyzed by scientists on Earth who say that nonmicrobial processes could also explain its features.

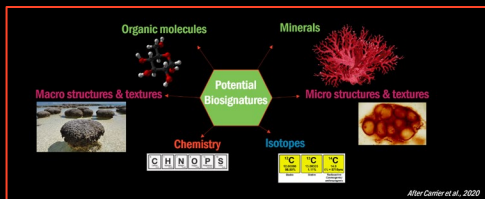
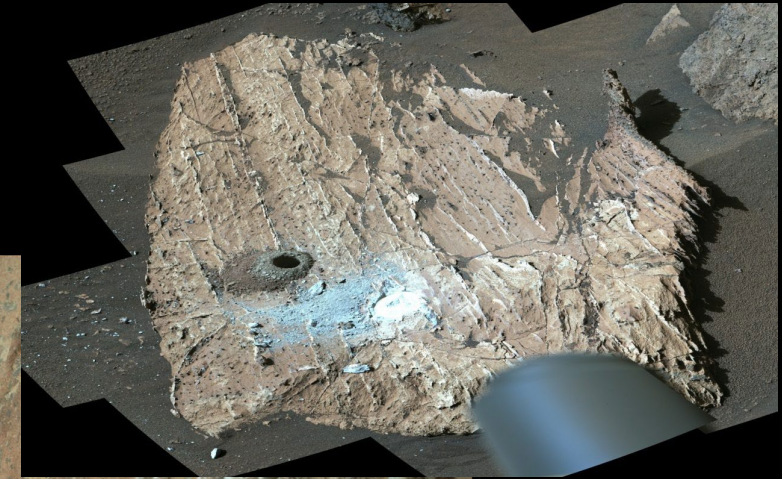
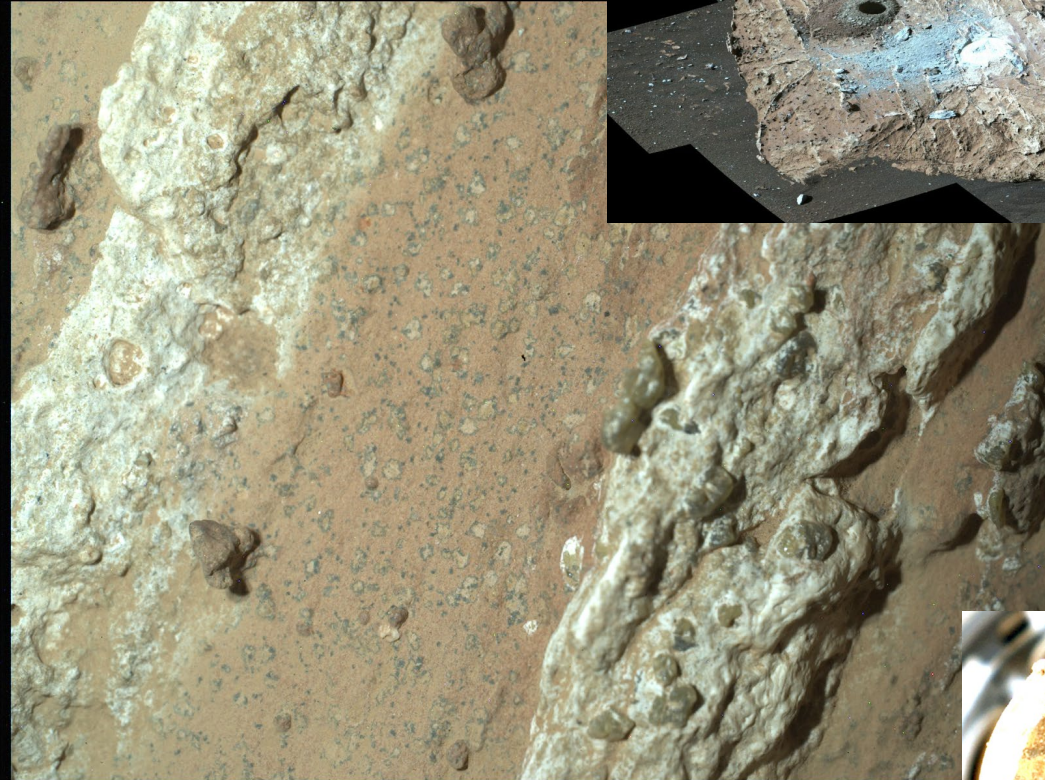
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# A rock named Cheyava Falls

- Contains
  - Organic molecules
  - Minerals
    - Formed in water
  - Micro structures & textures
    - “Leopard spots” → reduction?
    - Veins
  - Chemistry
    - Sulfur, Phosphorus (CHNOPS)

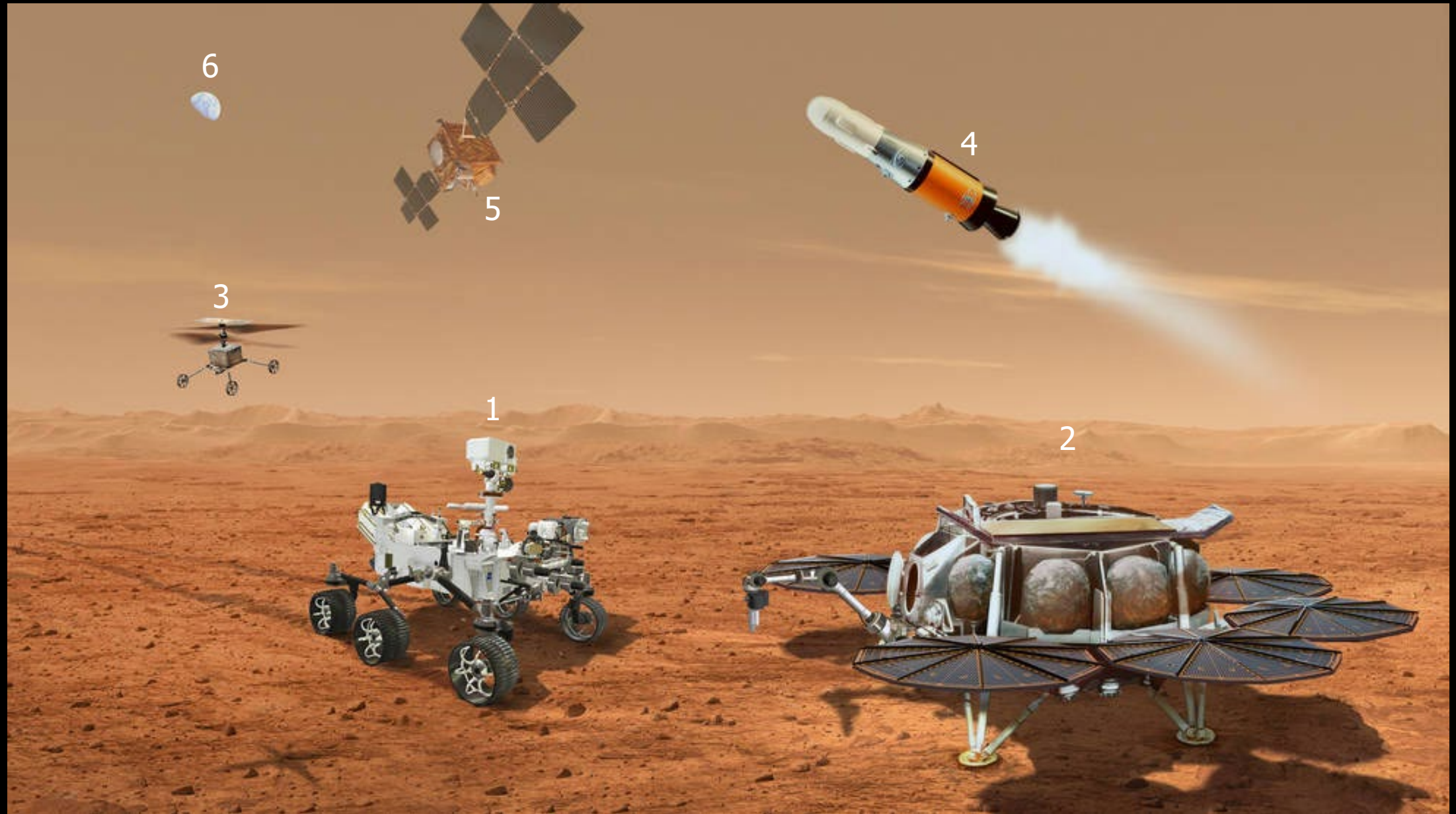


**Is this a sign of ancient life?**  
**We'll need to bring it back to Earth to be sure!**



# Mars Sample Return mission (TBD)

Perseverance is first of a three-part mission





# Backup

# Goals of the NASA Curiosity Mars rover

To assess the past and present habitability of Mars



## Looking for Habitability:

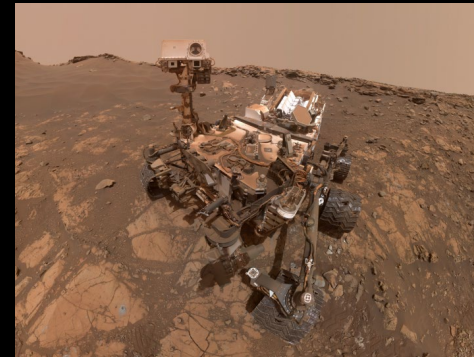
Identify past environments capable of supporting microbial life: H<sub>2</sub>O, organic materials

## Assessing Geology and Climate:

Determining processes that shaped the surface (past and present)

## Preparing for Humans:

Assess surface environmental conditions (radiation, temperature)

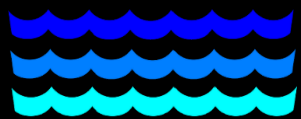
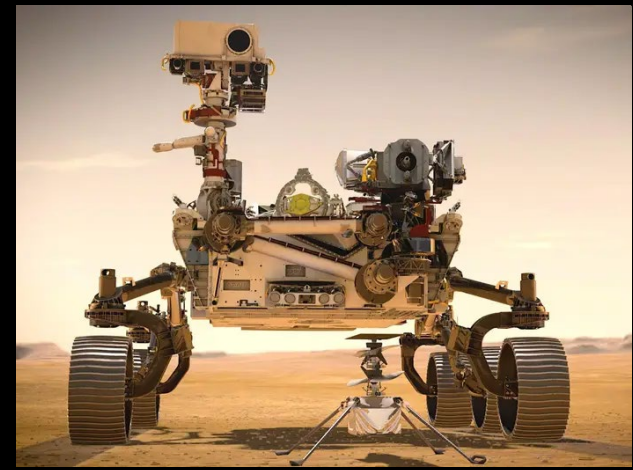


**Curiosity has been roving Mars for 13 (Earth) years!**



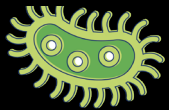
# Goals of Perseverance

To seek signs of ancient life on Mars + bring back samples



**Looking for  
Habitability:**

Identify past environments capable of supporting microbial life



**Seeking  
Biosignatures:**

Seek signs of possible past microbial life in those habitable environments, particularly in rocks known to preserve signs of life over time



**Caching  
Samples:**

Collect core rock and "soil" samples and store them on the martian surface for future return (planned 2033\*)



**Preparing for  
Humans:**

Test oxygen production from the martian atmosphere, assess environmental conditions



# Life in the past verses present

Where do we look and what do we look for?

- Current search focused on potential **past life**
  - What does life leave behind? Where?
  - How does it change over time?
- Mars **today is less habitable** than it has been in the past
- Must ask **different questions** about **potential present life**
  - **Where are present-day "oases"?**
    - Conditions are more hospitable than average



**We are looking for ancient life with our current Mars missions**

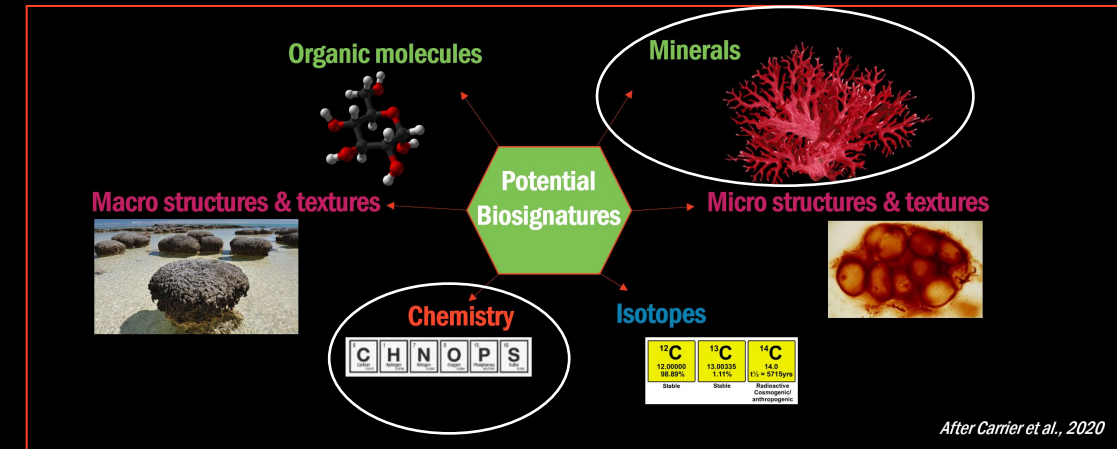
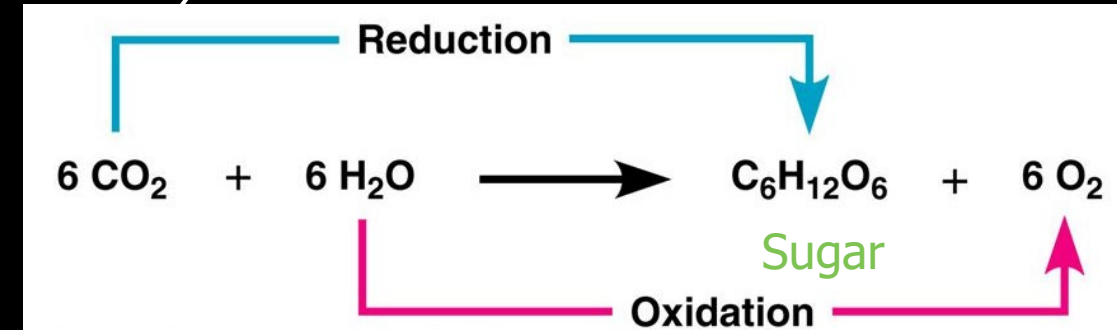


# What is redox chemistry?

## Reduction + oxidation

- Transfer of electrons between species
  - Oxidized = lose  $e^-$
  - Reduced = gain  $e^-$
- Requires energy
  - Photons (light) → photooxidation, photosynthesis
  - Reactive oxygen species → microbes
- Sensitive to environmental conditions
  - Eh (oxygen), pH
- Some elements have multiple oxidation states
  - $Fe^{2+}$  (reduced),  $Fe^{3+}$  (oxidized)
- Changes number of valence electrons available to form bonds
  - e.g.,  $FeO$  (wustite) vs  $Fe_2O_3$  (hematite)

Photosynthesis is a redox reaction



Redox state determines bond → mineralogy → tells us about environmental conditions

Microbes often produce redox disequilibria