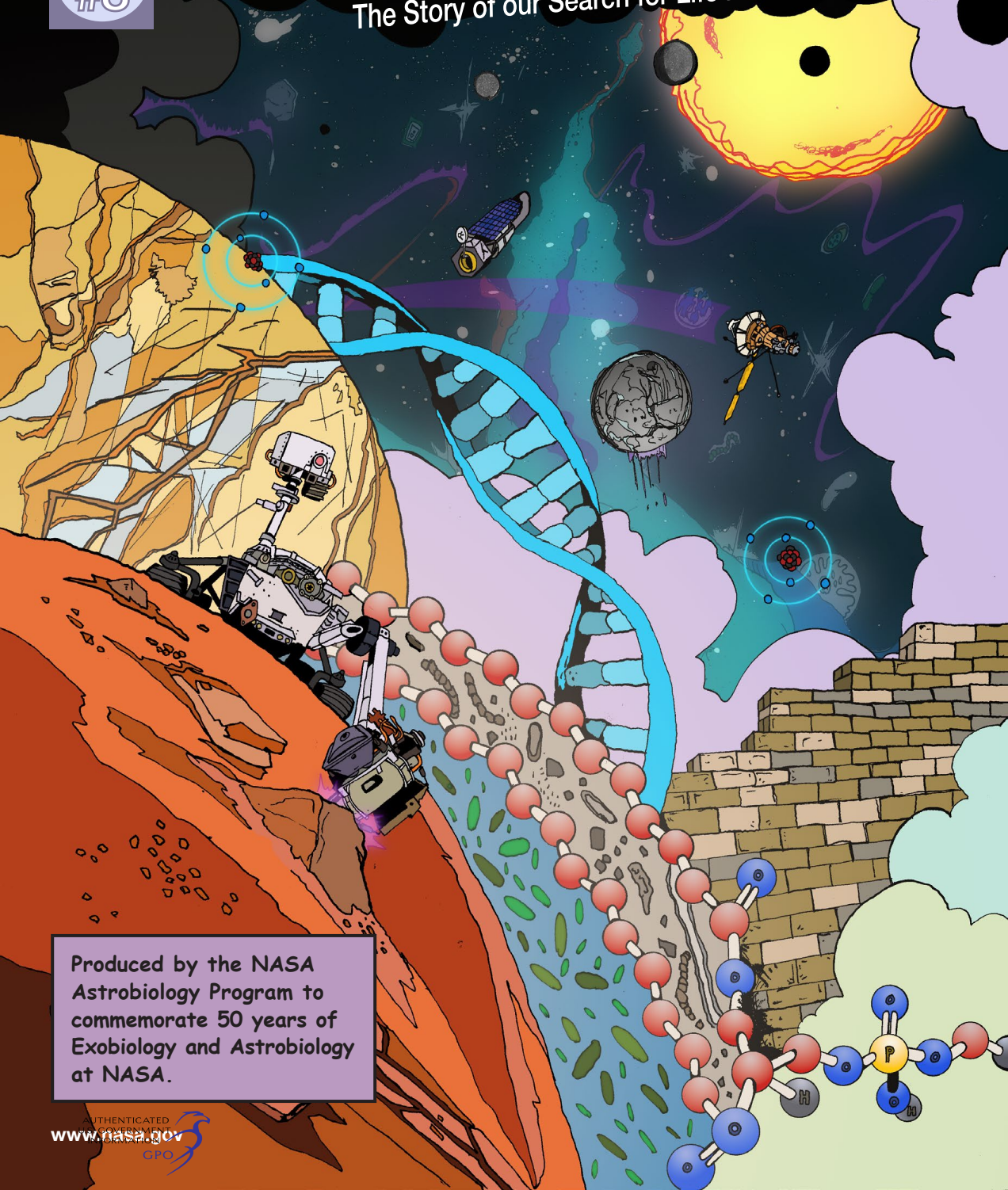


Issue
#8

ASTROBIOLOGY

The Story of our Search for Life in the Universe



Produced by the NASA
Astrobiology Program to
commemorate 50 years of
Exobiology and Astrobiology
at NASA.

Astrobiology

A History of Exobiology and Astrobiology at NASA

This is the story of life in the Universe—or at least the story as we know it so far. As scientists, we strive to understand the environment in which we live and how life relates to this environment. As astrobiologists, we study an environment that includes not just the Earth, but the entire Universe in which we live.

The year 2010 marked 50 years of Exobiology and Astrobiology research at the National Aeronautics and Space Administration (NASA). To celebrate, the Astrobiology Program commissioned this graphic history. It tells the story of some of the most important people and events that have shaped the science of Exobiology and Astrobiology. At now over 60 years old, this field is still relatively young. However, as you will see, the questions that astrobiologists are trying to answer are as old as humankind.

Concept & Story

Mary Voytek
Linda Billings
Aaron L. Gronstal

Artwork

Aaron L. Gronstal

Script

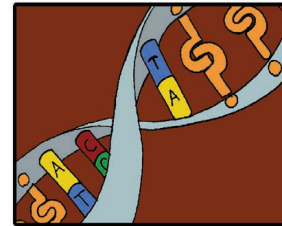
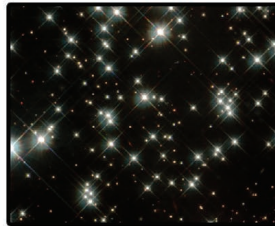
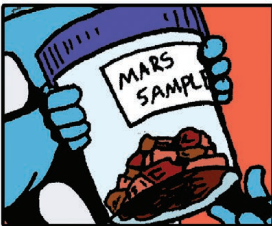
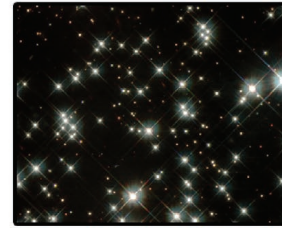
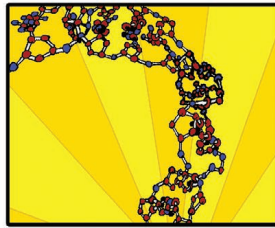
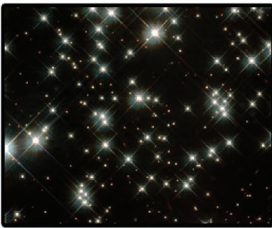
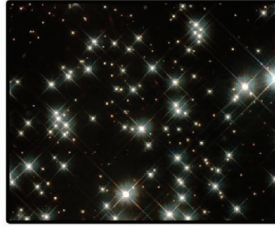
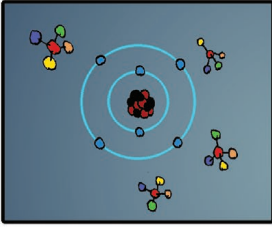
Aaron L. Gronstal and Lindsay Hays

Editor

Linda Billings

Special thanks to Heather Graham and Daniella Scalice

Issue #8—Biosignatures



The year 2010 marked the 50th anniversary of NASA's Exobiology Program, established in 1960 and expanded into a broader Astrobiology Program in the 1990s. To commemorate the past half century of research, we are telling the story of how this field developed and how the search for life elsewhere became a key component of NASA's science strategy for exploring space. This issue is the eighth in what we intend to be a series of graphic history books. Though not comprehensive, the series has been conceived to highlight key moments and key people in the field as it explains how Astrobiology came to be.

-Linda Billings, Editor

Astrobiology is the study of the origin of life on Earth and the potential for life in the Universe.

The search for life among the stars is as old as humankind.*

People were questioning life's potential beyond our planet even when they still thought the Earth was flat.

"to suppose that the Earth is the only populated world in infinite space is as absurd as to believe that in an entire field sown with millet, only one grain will grow." (1)

Astrobiology underlies our understanding of how life on Earth fits into the Universe, and astrobiology research is the key to NASA's search for life amongst the stars.

But when astrobiologists look for evidence of life in the Universe, what are they looking for?

Lindsay Hays
(NASA HQ)

Mary Voytek
(NASA HQ)

Issue 8: Biosignatures

Metrodorus of Chios
(Greek School of Atomism,
4th century B.C.)

* See Issue 1

There have been times in history when people thought they'd found something.



VIKING MARS MISSION (Issue 2)

Heather Graham (NASA Goddard)

This telescope thing is great!*

Galileo Galilei (1564-1642)

Clouds on Venus... that means rain right? There must be plants. Astrobotany!***

Gavriil Adria-novich Tikhov (1875-1960)

Yes, use radio to contact the Martians!

No... canali.

Canali!***

Ooo... canals could mean people!

Civilization! We could use my tech to contact them!****

Nikola Tesla (1856-1943)

Lord Kelvin (1824-1907)

Guglielmo Marconi (1874-1937)

Percival Lowell (1855-1916)

Viking 1 (1976)

Mars Global Surveyor (1998)

*Translated from Italian

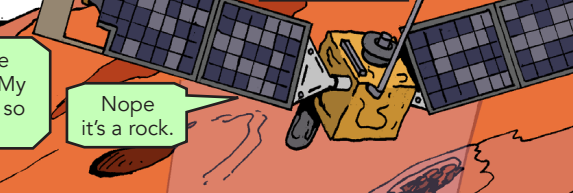
**Translated from Russian

***Actual Italian

****Translated from Serbian



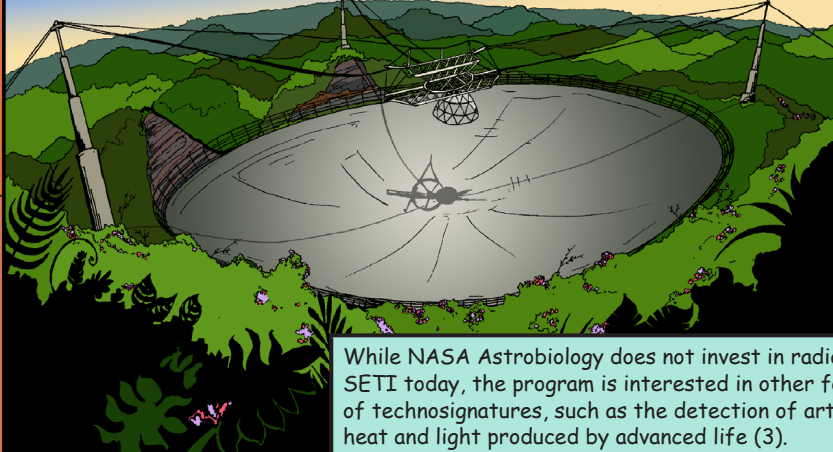
Is that a face down there? My eyesight isn't so great.



Nope it's a rock.

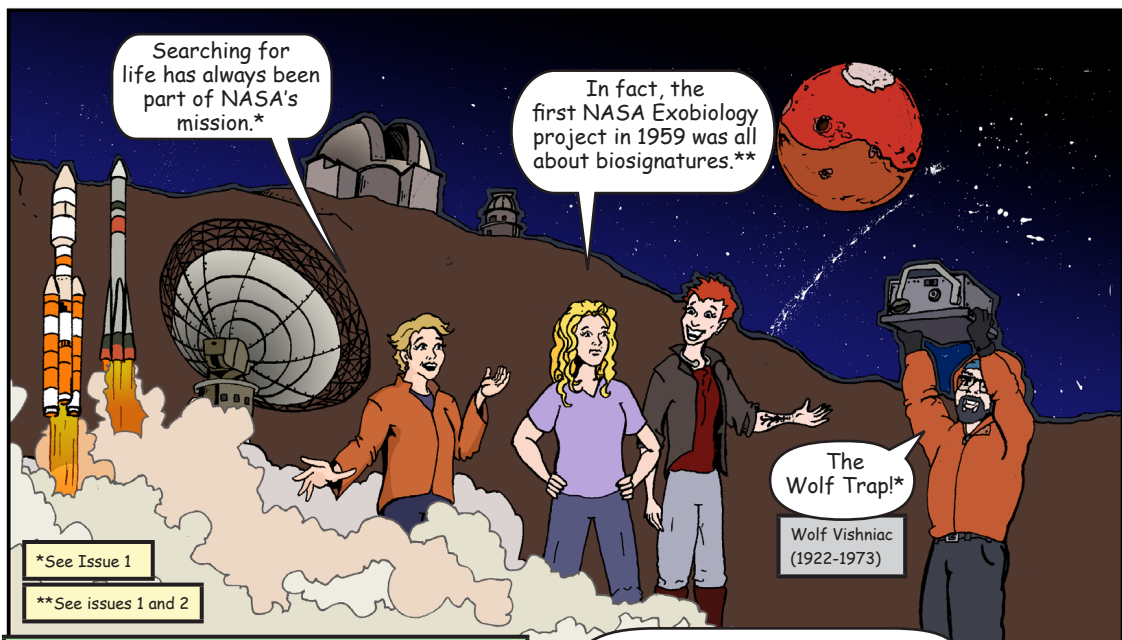
Ofentimes, the search for life beyond Earth conjures images of big telescopes listening for signals from distant civilizations, such as Ohio State University's Big Ear telescope and the Search for Extraterrestrial Intelligence (SETI). (2)

Arecibo Telescope, Puerto Rico.

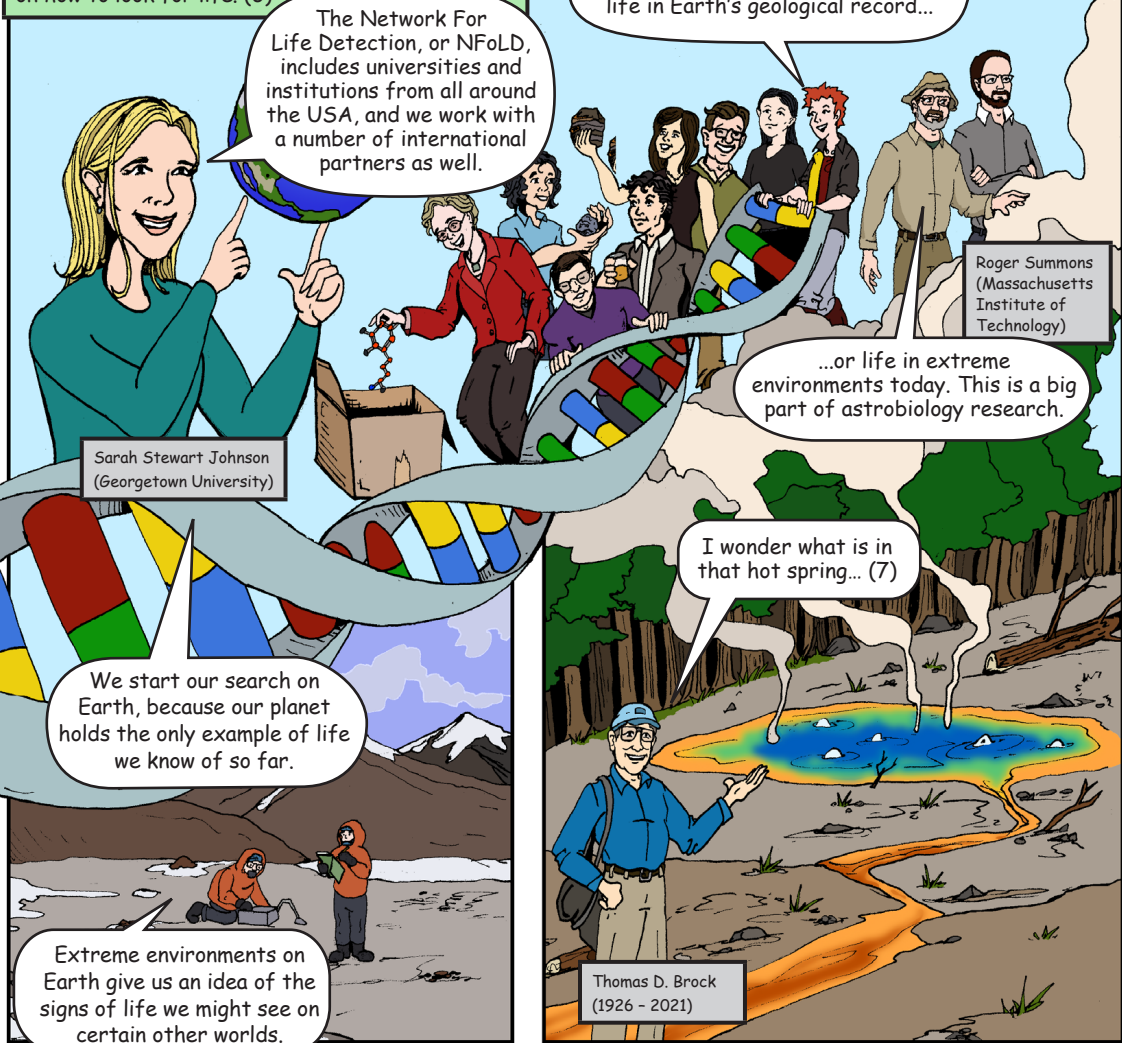


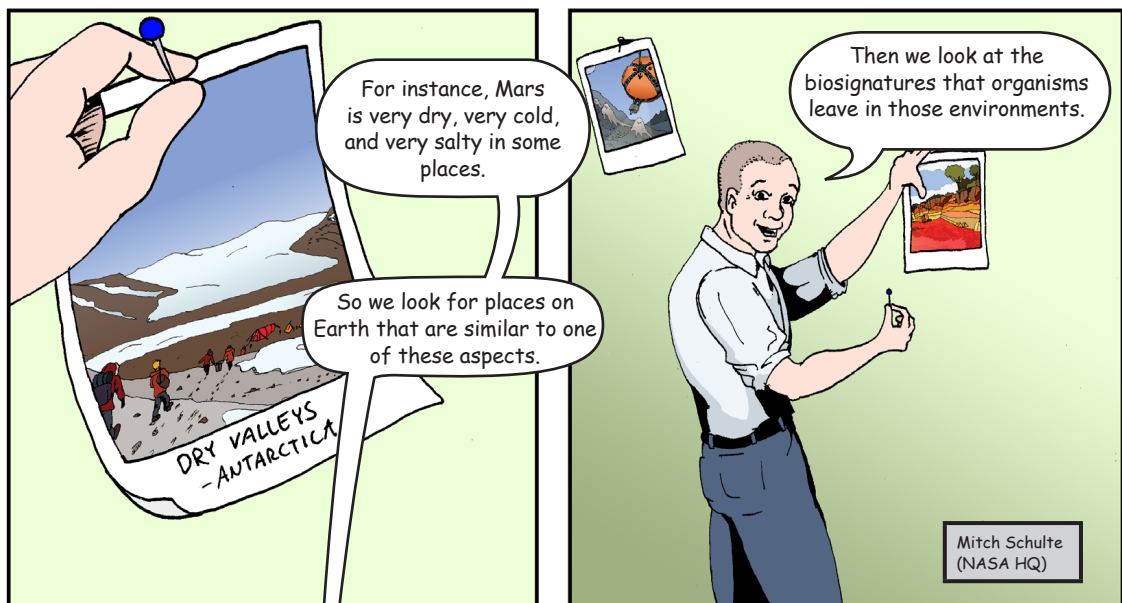
While NASA Astrobiology does not invest in radio SETI today, the program is interested in other forms of technosignatures, such as the detection of artificial heat and light produced by advanced life (3).

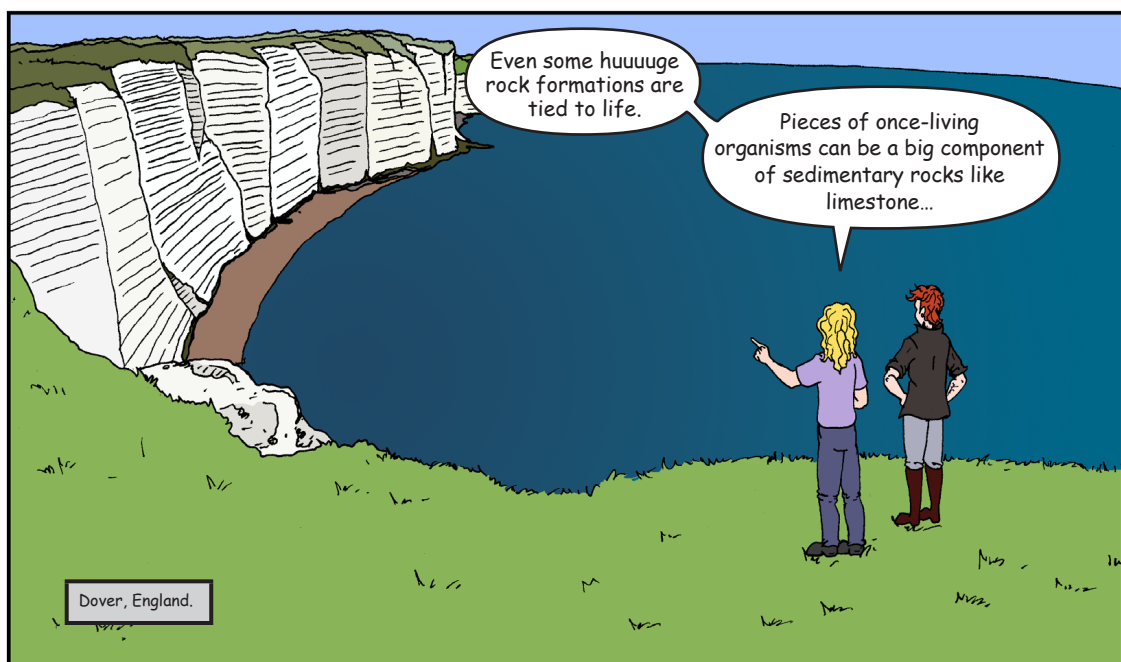
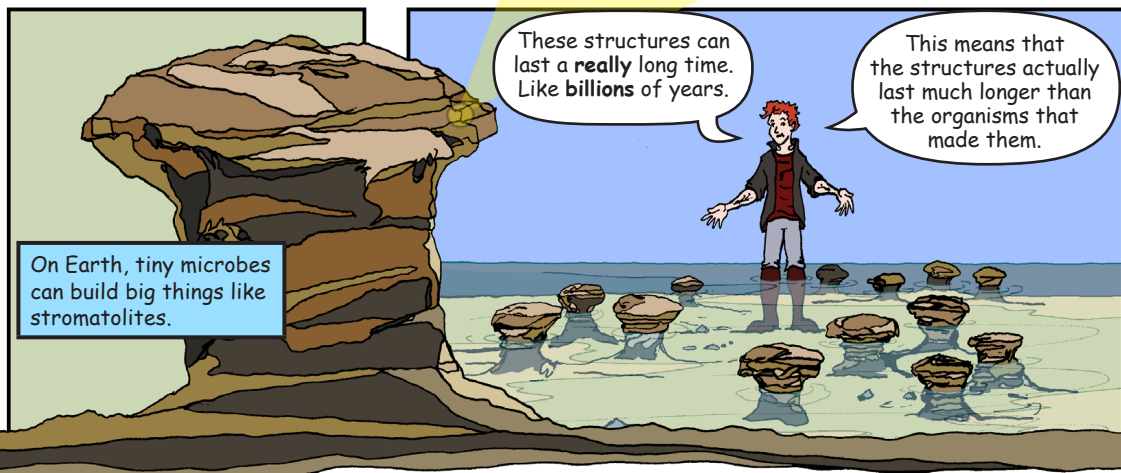
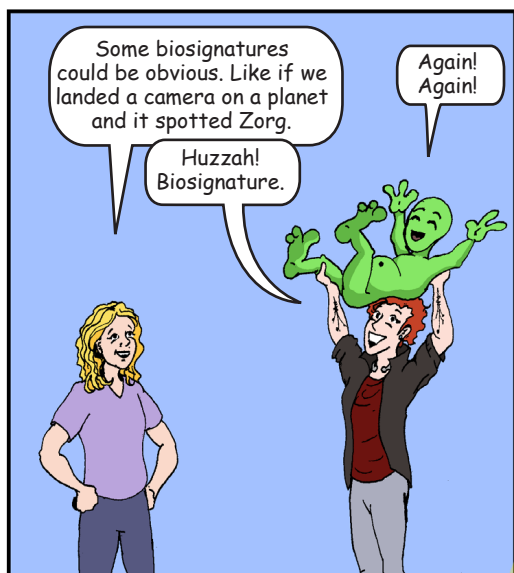


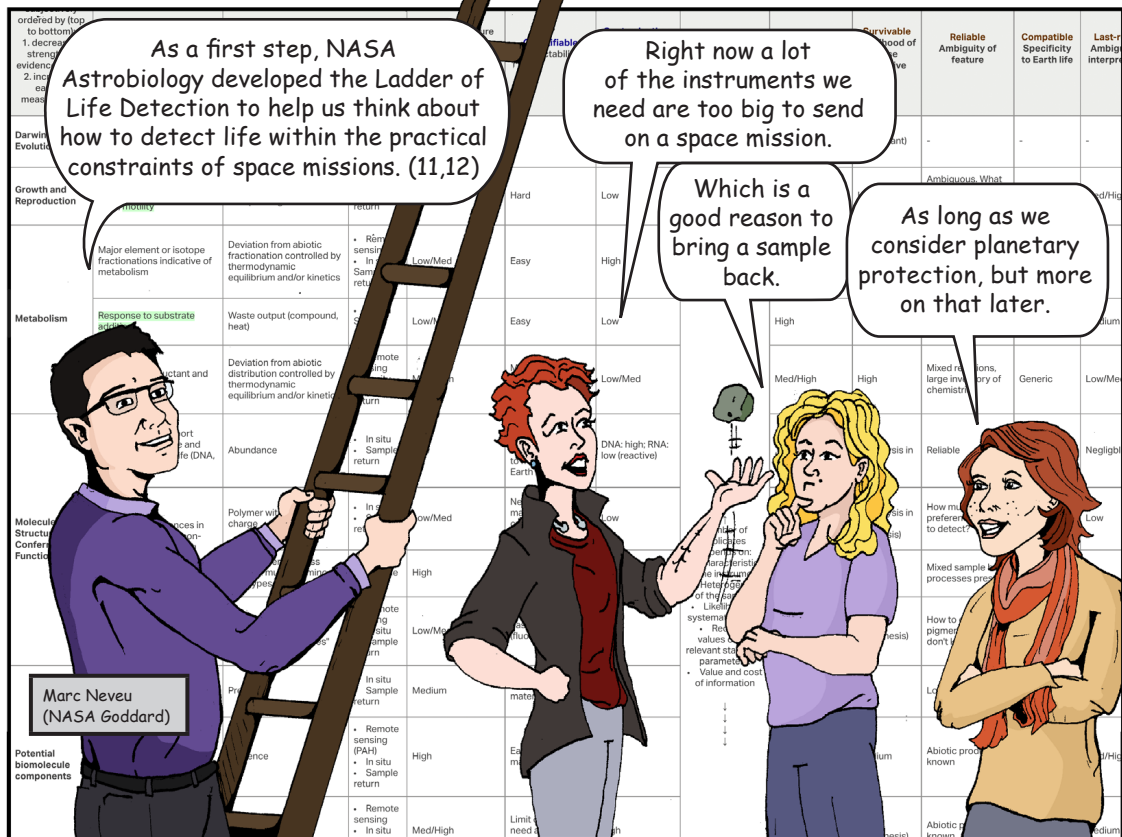
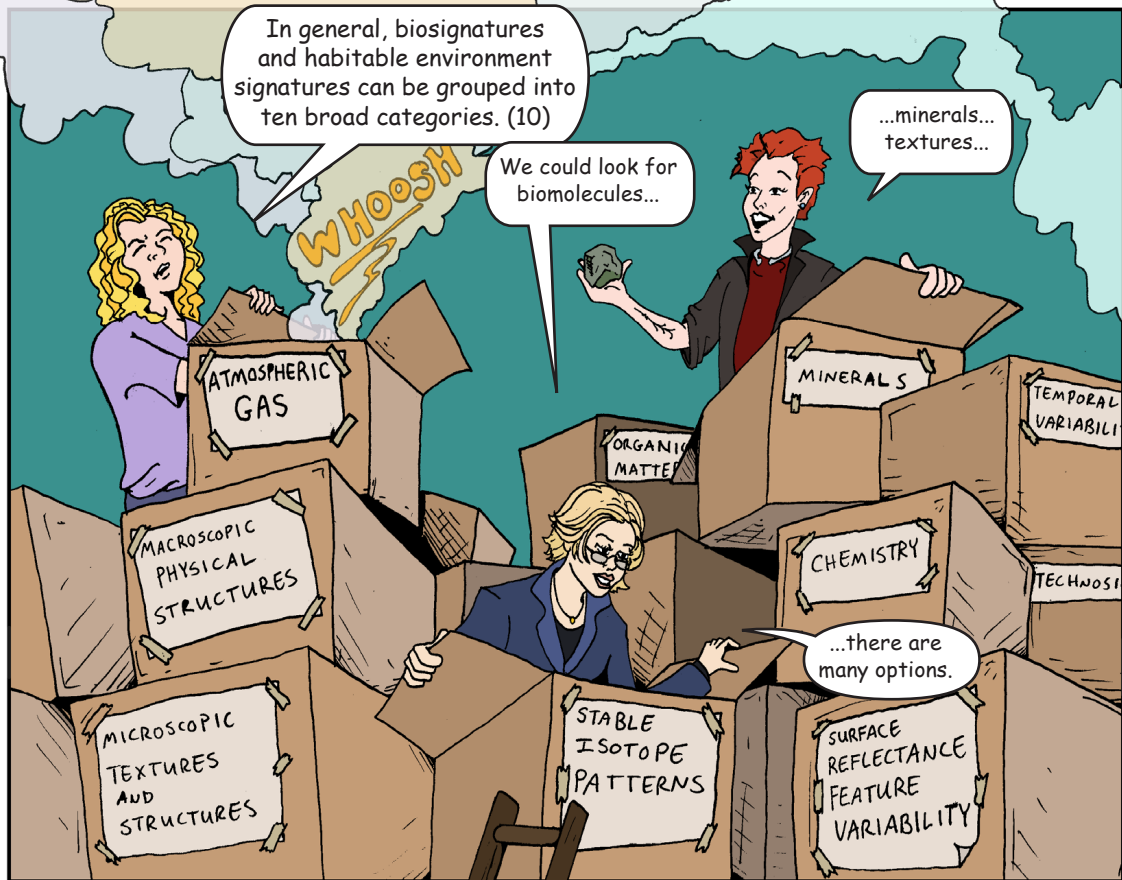


More recently, NASA formed an entire Research Coordination Network (RCN) specifically focused on how to look for life. (6)









When the space age began, there were big hopes for finding life on planets in the Solar System.

We quickly found out that it wouldn't be so easy.

Well. Viking was right. Just rocks

Yay rocks!

The search for life beyond Earth relies on data from probes in our solar system, or astronomical observations.

Nyet. No Plants.

Mars Pathfinder (NASA)*

NASA hasn't sent a dedicated life detection instrument to space since Viking.*

Hey, there is some sort of liquid on Titan! Craaazzy!

Venera (USSR)**

Don't see any life... but what is under Europa's icy shell?

Cassini-Huygens***

Galileo (NASA)**

Hey, Pluto has mountains!

New Horizons (NASA)***

Can anyone still hear me?

Voyager (NASA)***

So far, there isn't macroscopic life - or life we can see with the naked eye - on the surfaces of worlds in our system.

But there are still places we haven't looked. And microscopic life is still a possibility.

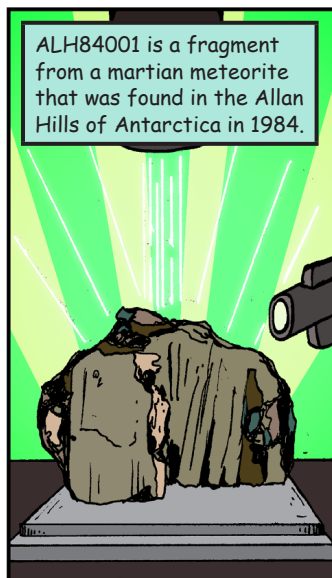
And rocks could still contain biosignatures of ancient life.

In the 90's, a big thing happened with a little 'rock' from Mars.

*See Issue 2

**See Issue 3

***See Issue 4

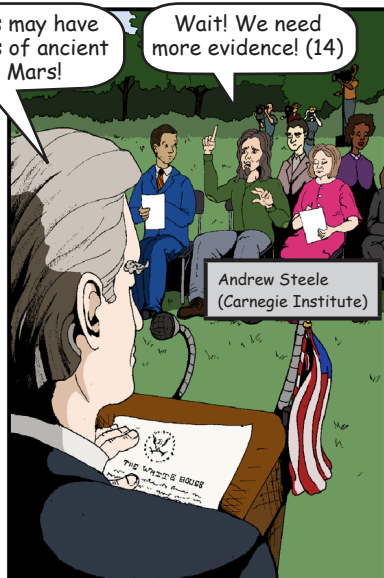


ALH84001 is a fragment from a martian meteorite that was found in the Allan Hills of Antarctica in 1984.



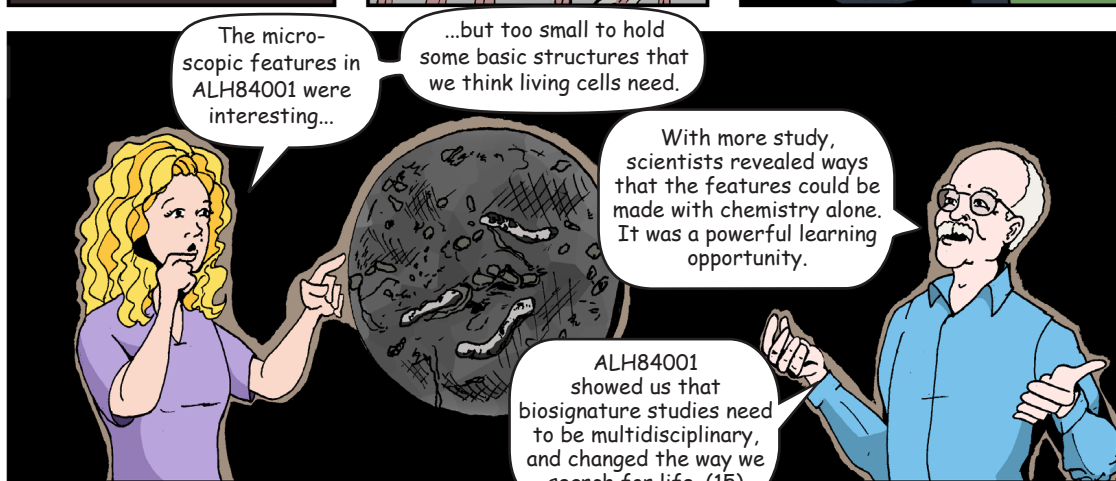
Are those microfossils in this meteorite? (13)

David S. McKay (1936-2013)
(NASA Johnson Space Center)



Wait! We need more evidence! (14)

Andrew Steele
(Carnegie Institute)

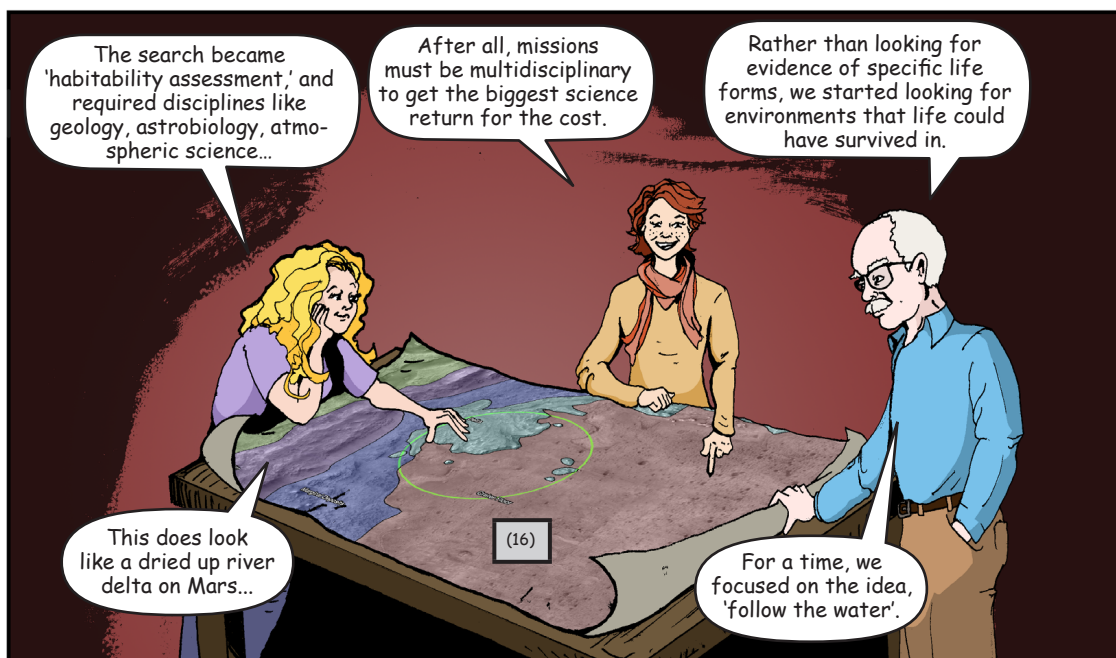


The microscopic features in ALH84001 were interesting...

...but too small to hold some basic structures that we think living cells need.

With more study, scientists revealed ways that the features could be made with chemistry alone. It was a powerful learning opportunity.

ALH84001 showed us that biosignature studies need to be multidisciplinary, and changed the way we search for life. (15)



The search became 'habitability assessment,' and required disciplines like geology, astrobiology, atmospheric science...

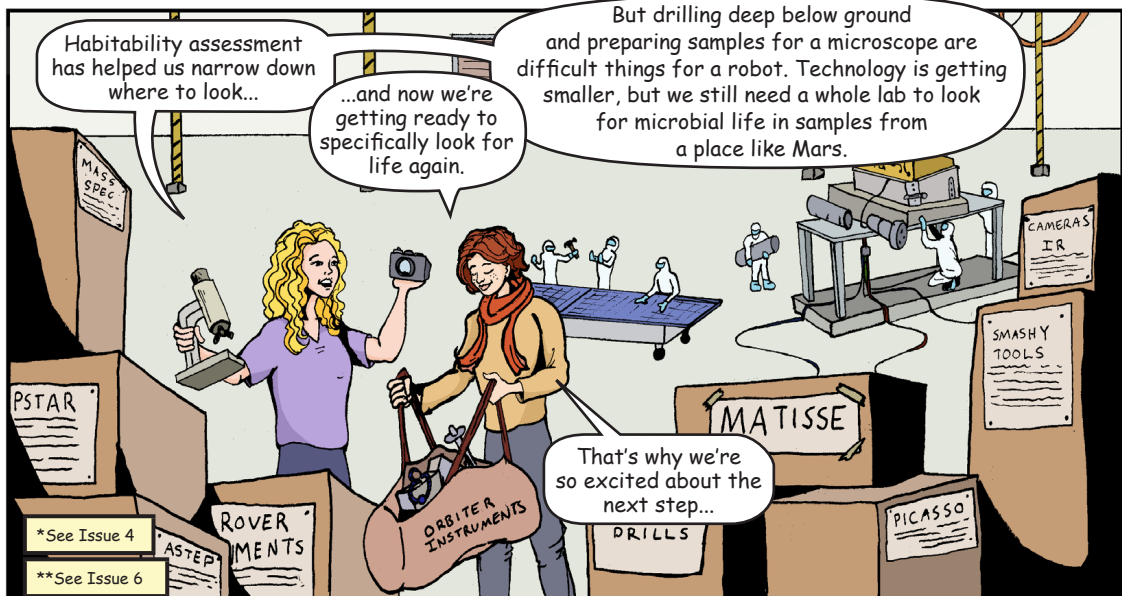
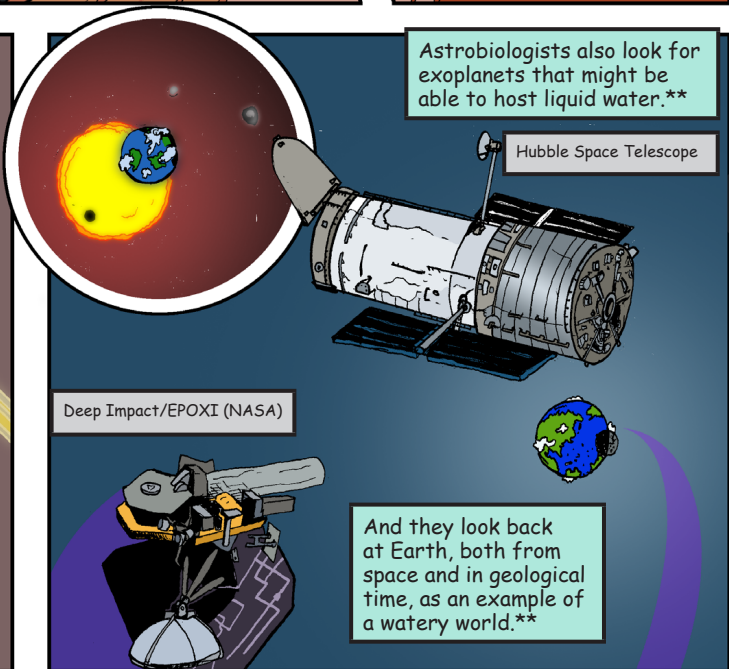
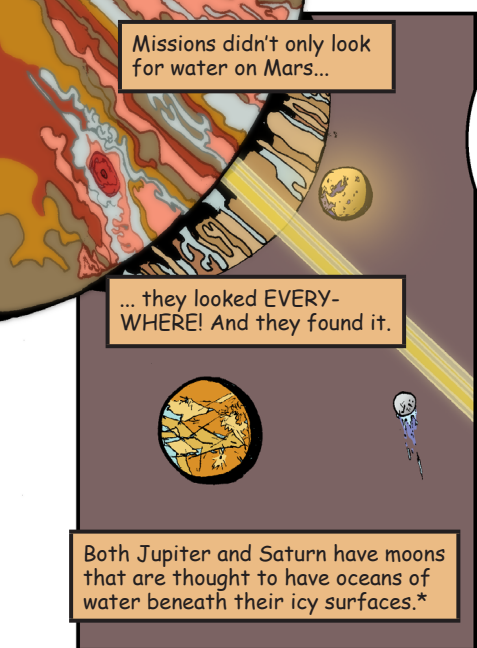
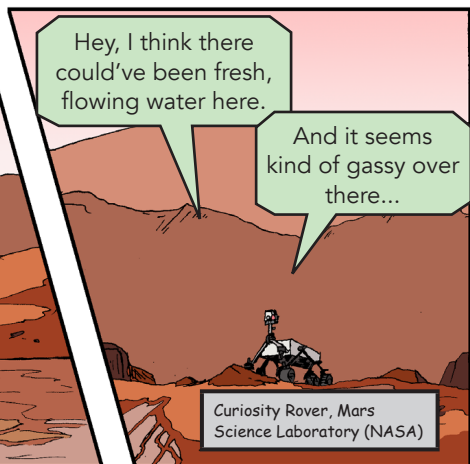
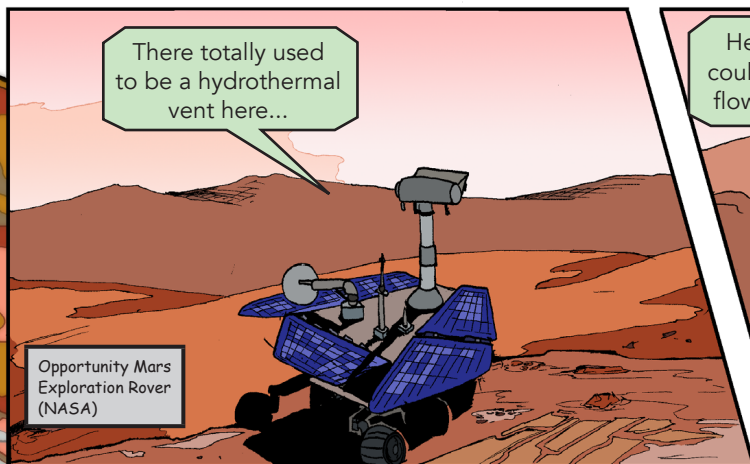
After all, missions must be multidisciplinary to get the biggest science return for the cost.

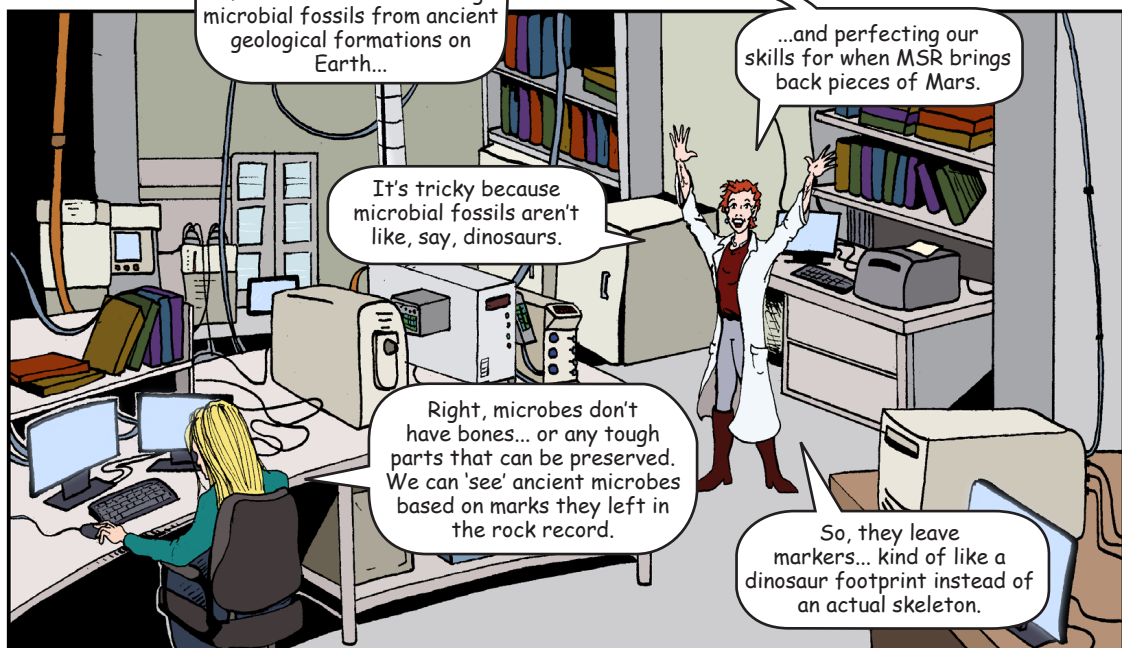
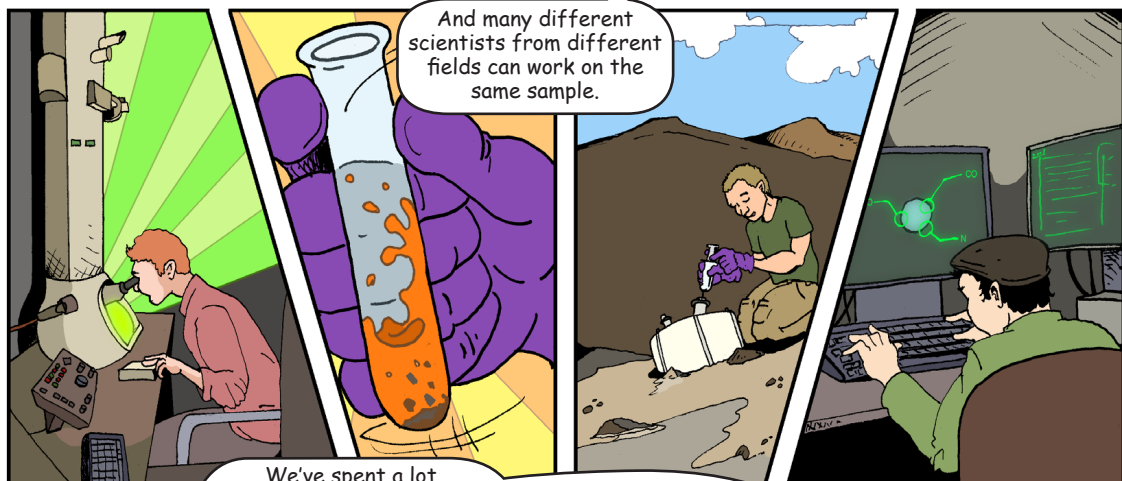
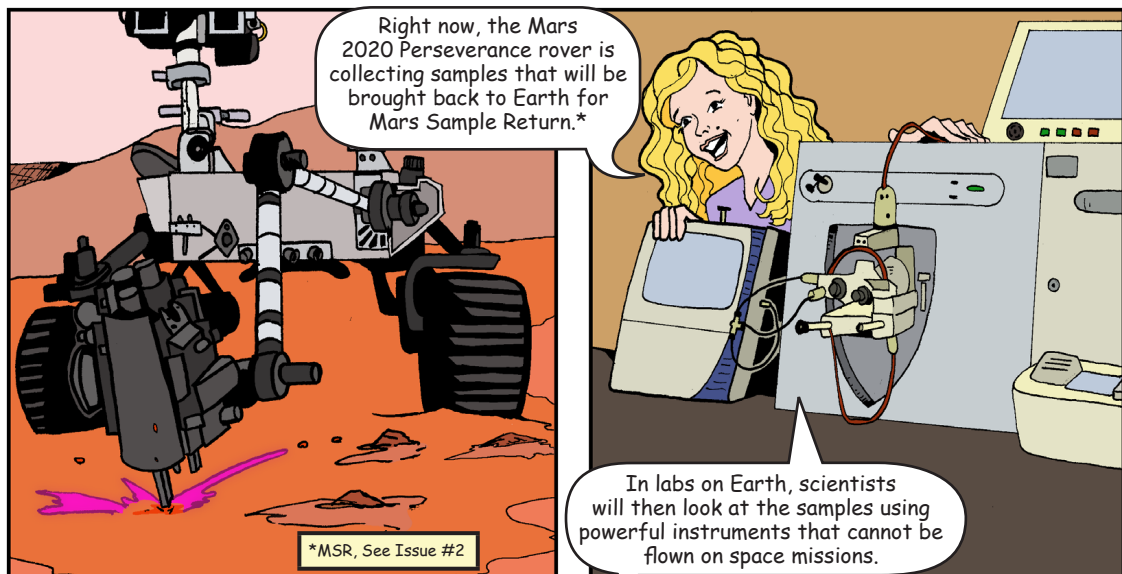
Rather than looking for evidence of specific life forms, we started looking for environments that life could have survived in.

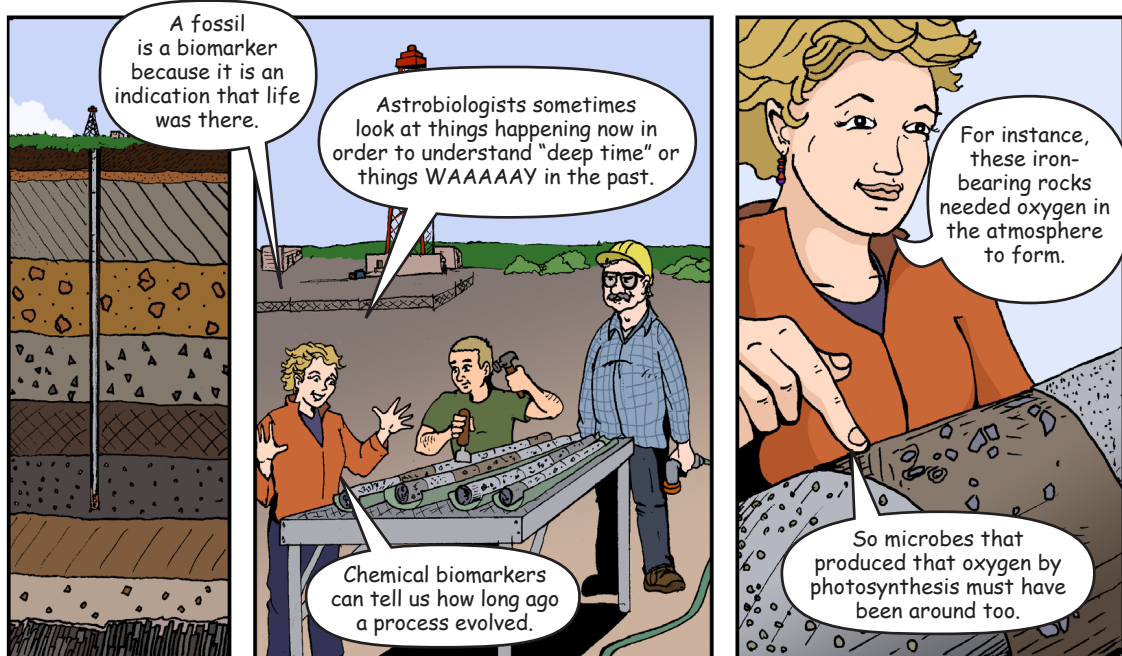
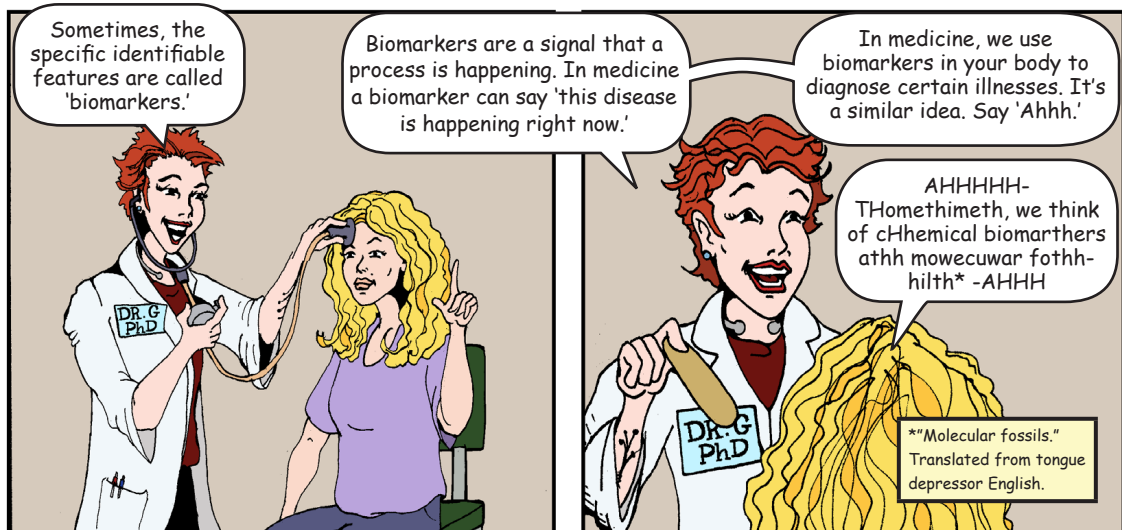
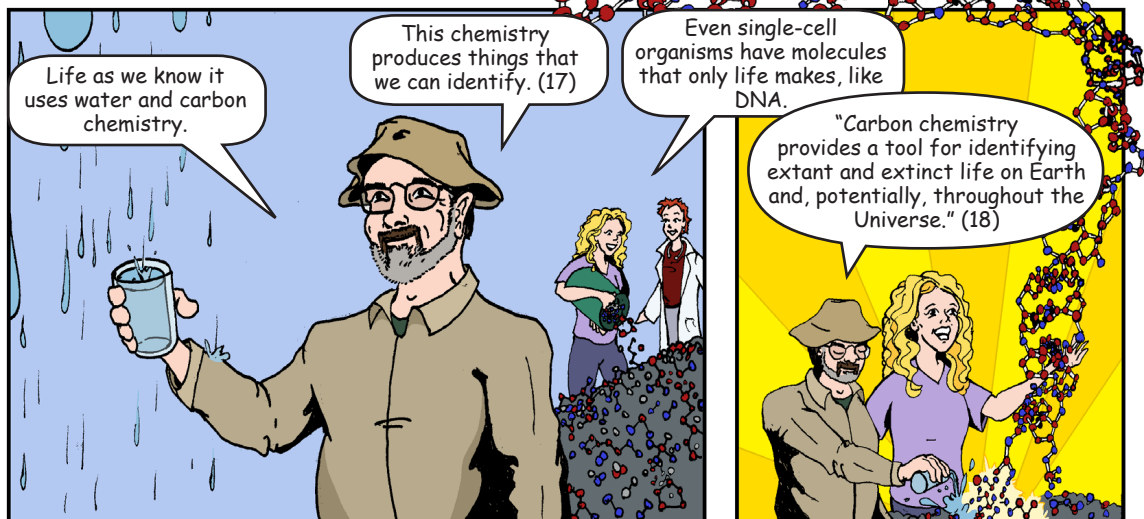
This does look like a dried up river delta on Mars...

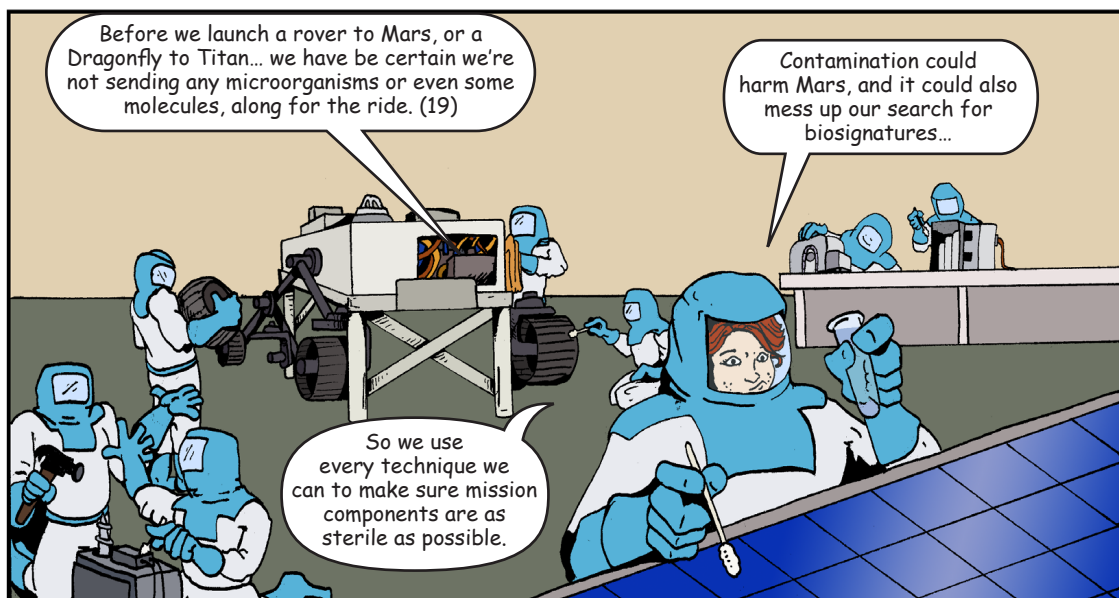
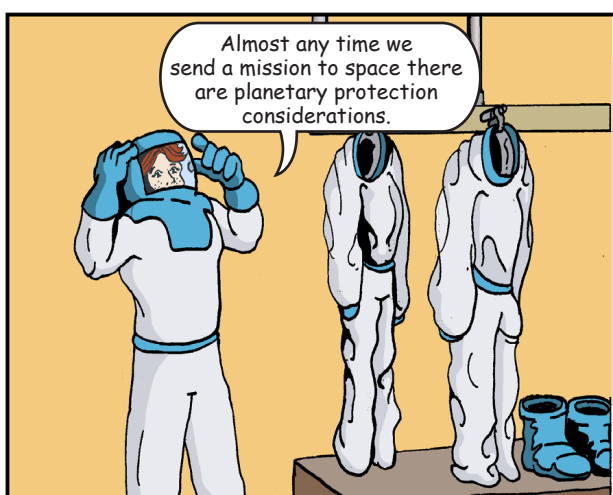
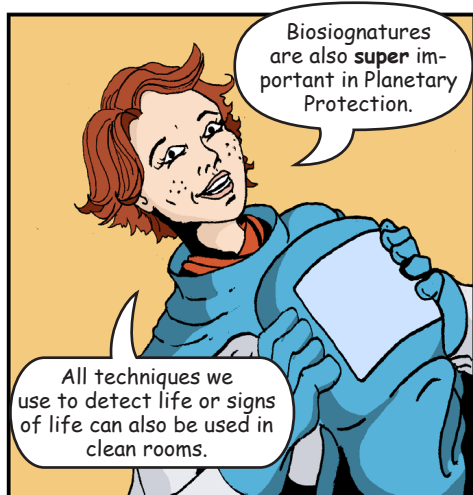
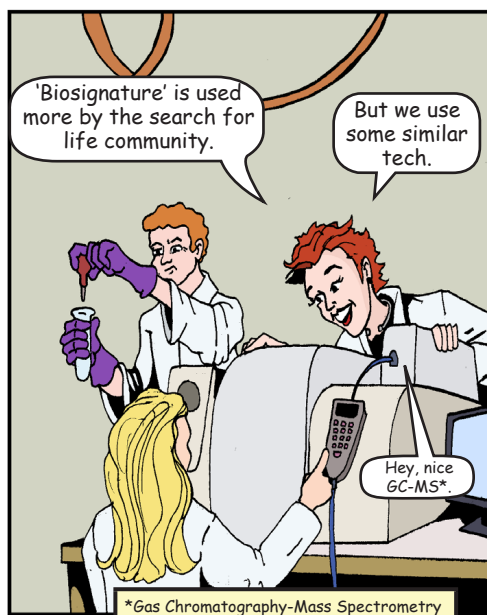
(16)

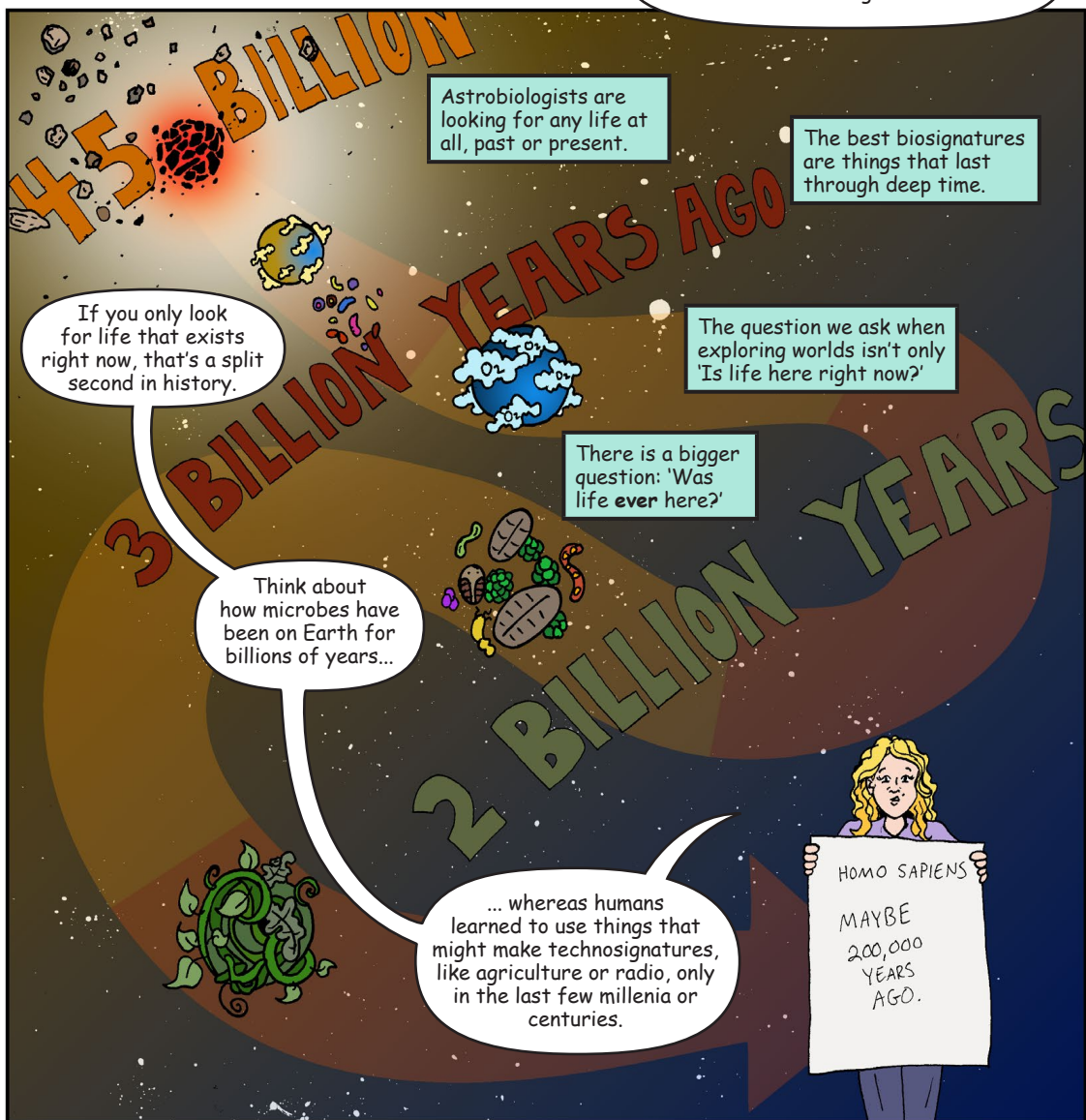
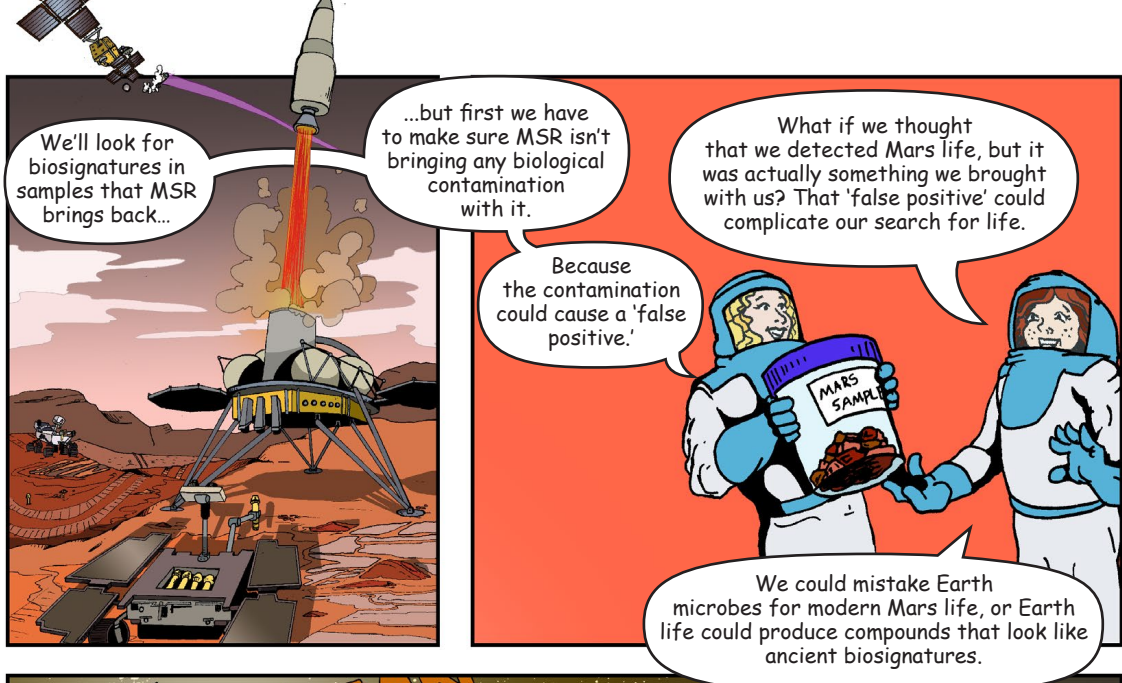
For a time, we focused on the idea, 'follow the water'.

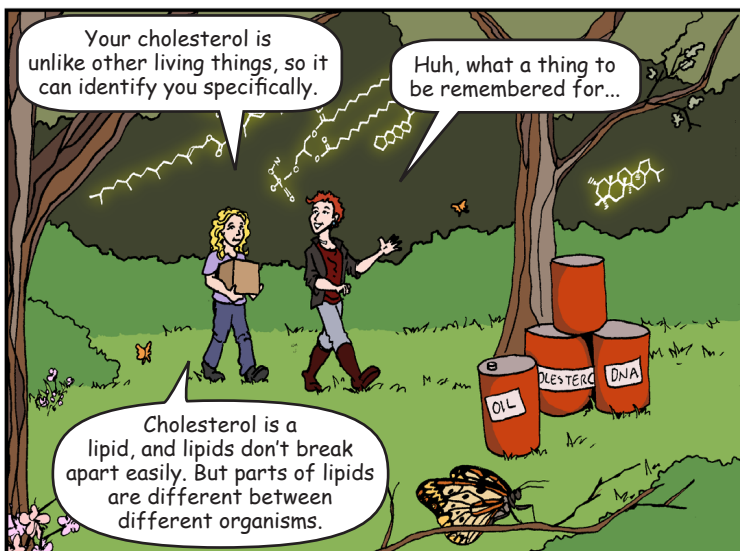
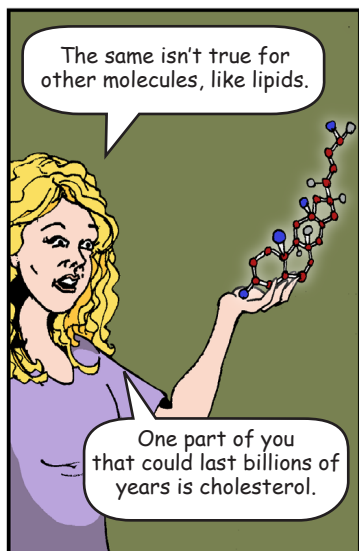
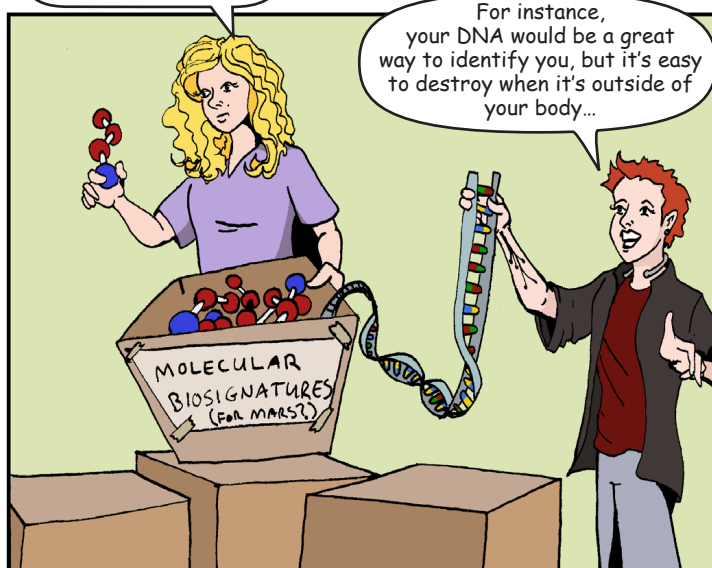
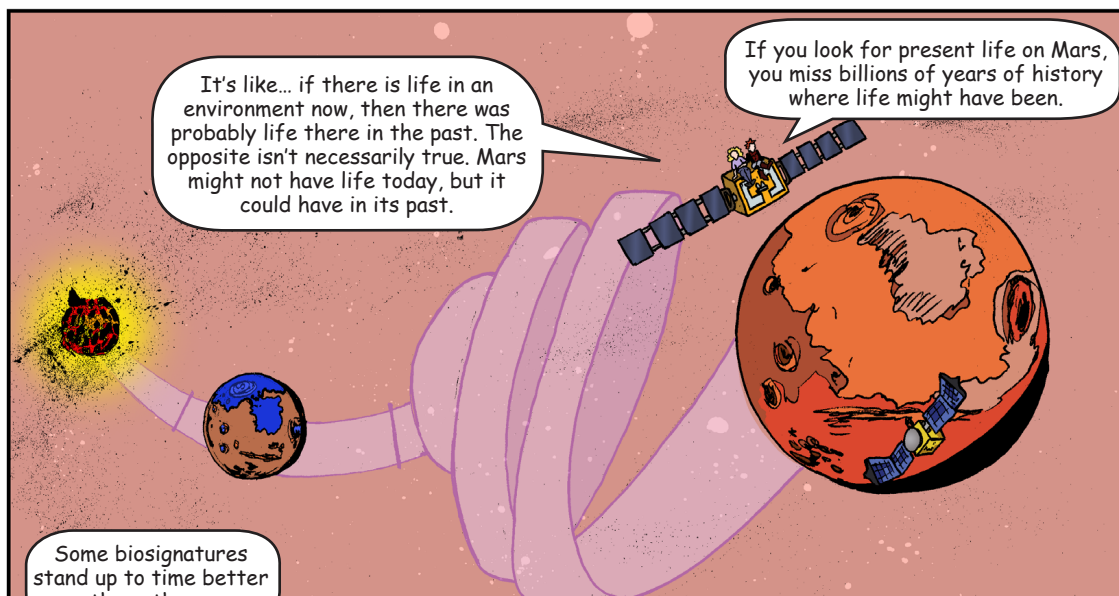


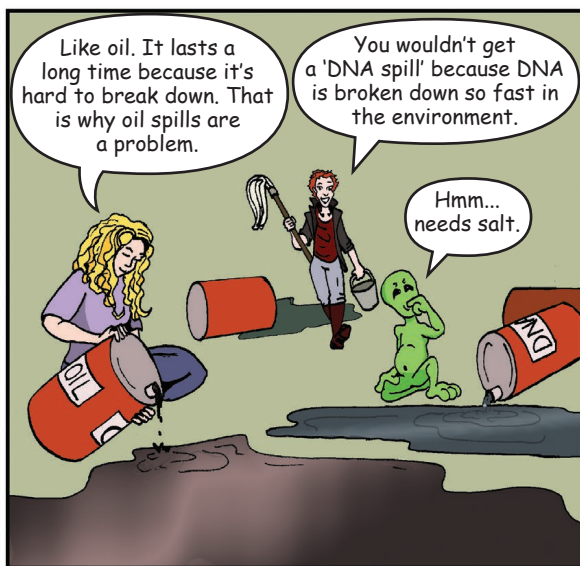
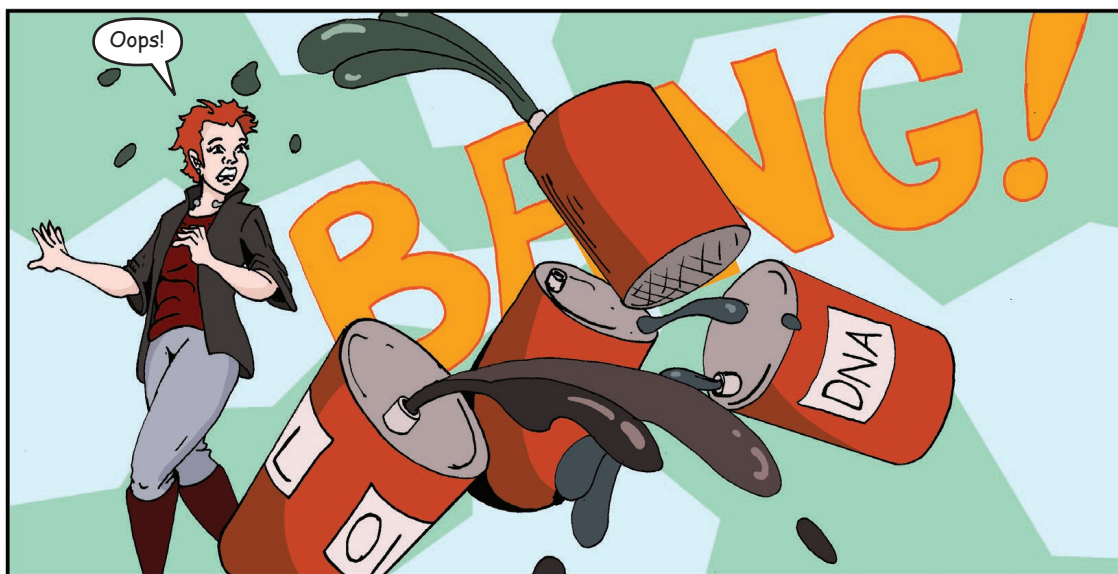


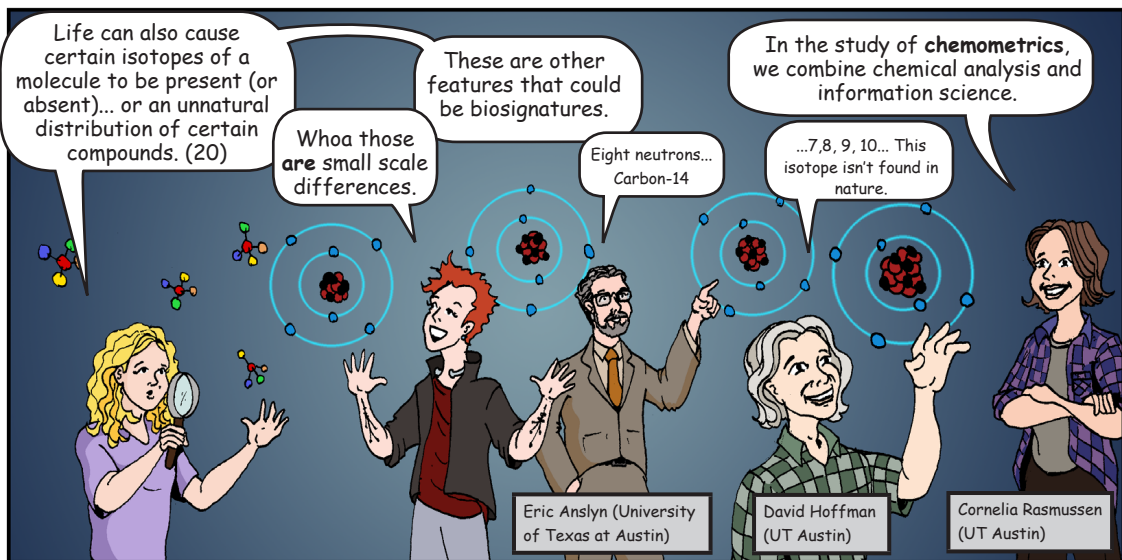
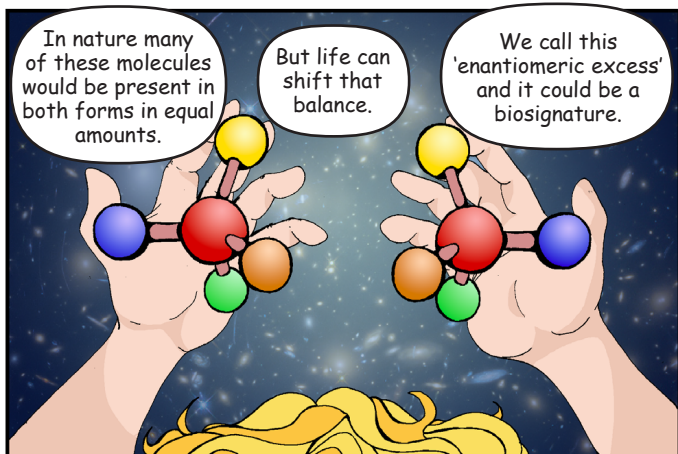
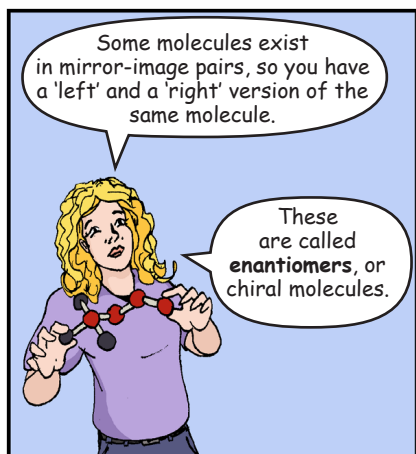


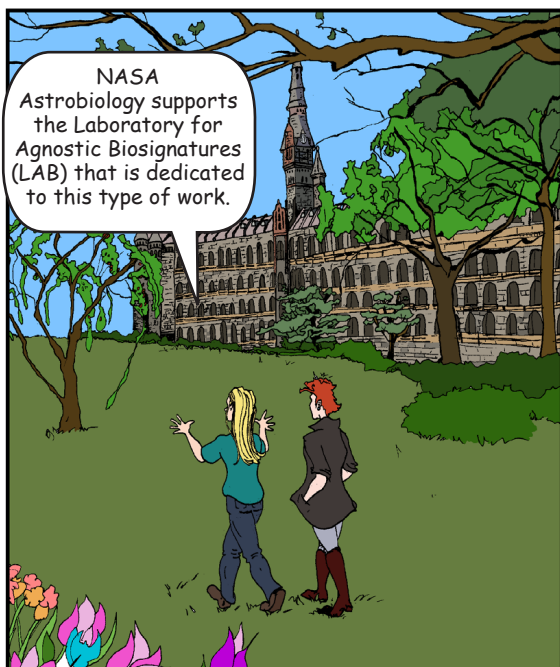
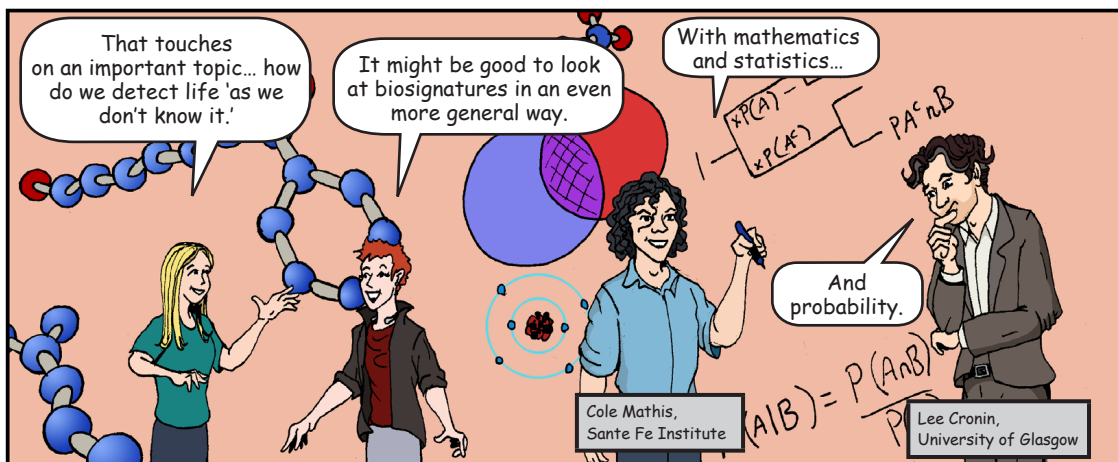
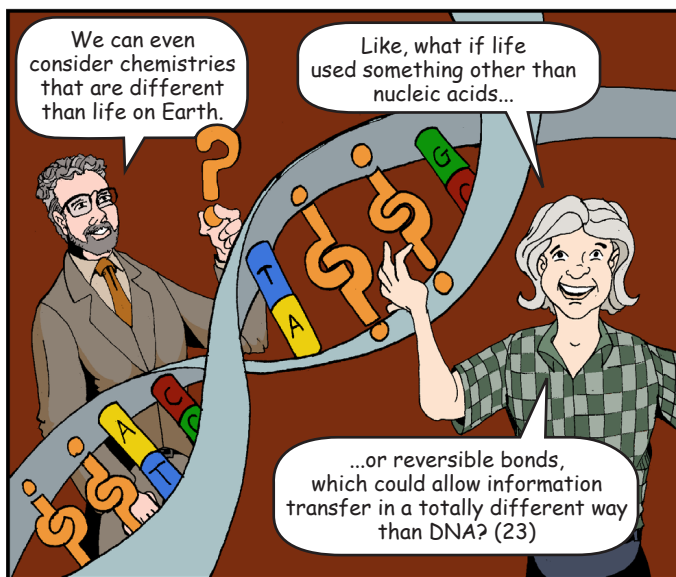
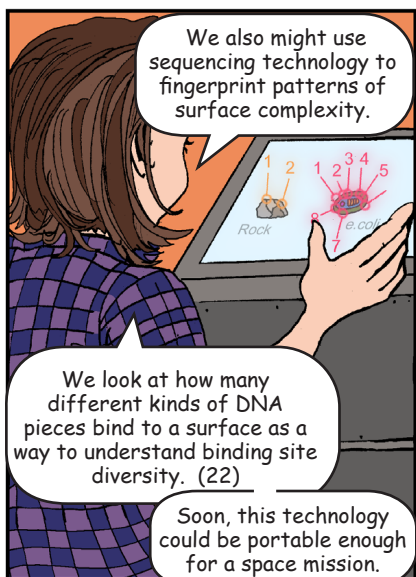


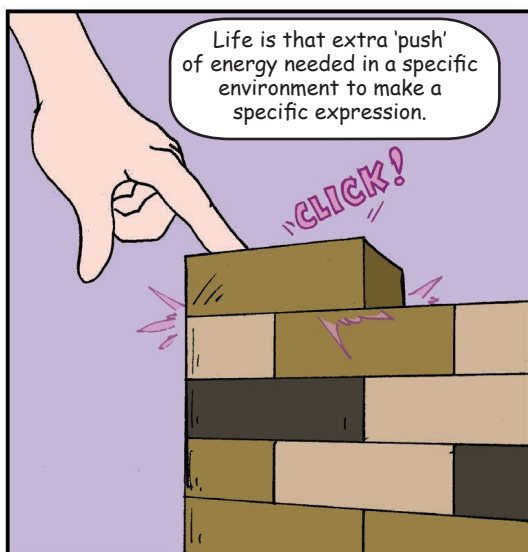
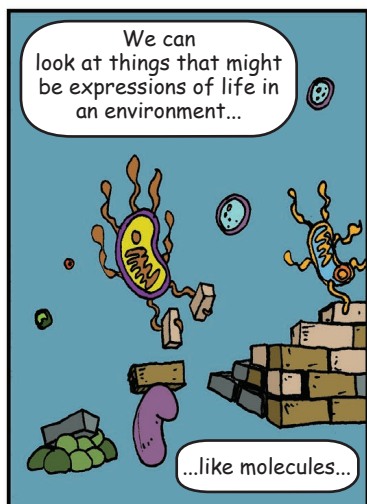
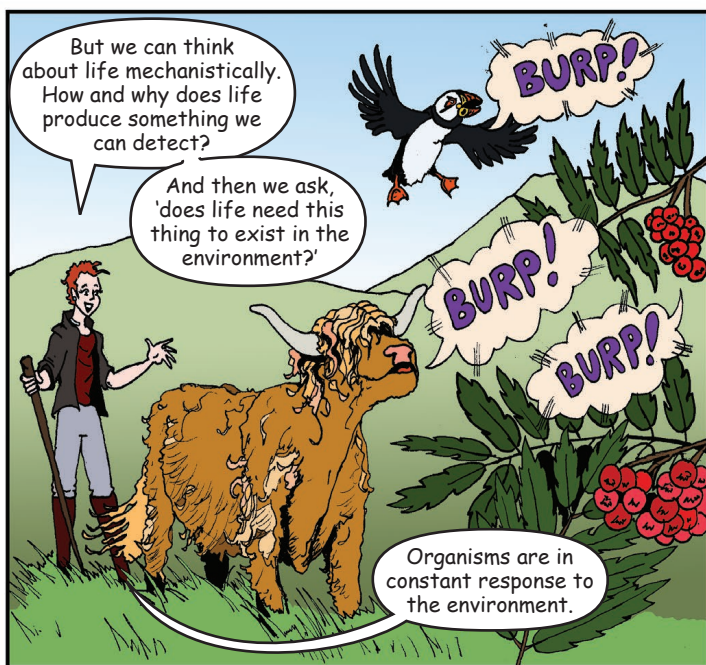












Glasgow, Scotland.

We've been developing a framework for looking for life based on probability.

What is the probability of a signature being made with and without life?

We need a signature that is exclusively associated with all life.

And we need a detection system for it. (24)

Stuart Marshall (U of Glasgow)

So we thought...

...can we distinguish between non-living and living systems through complex molecules?

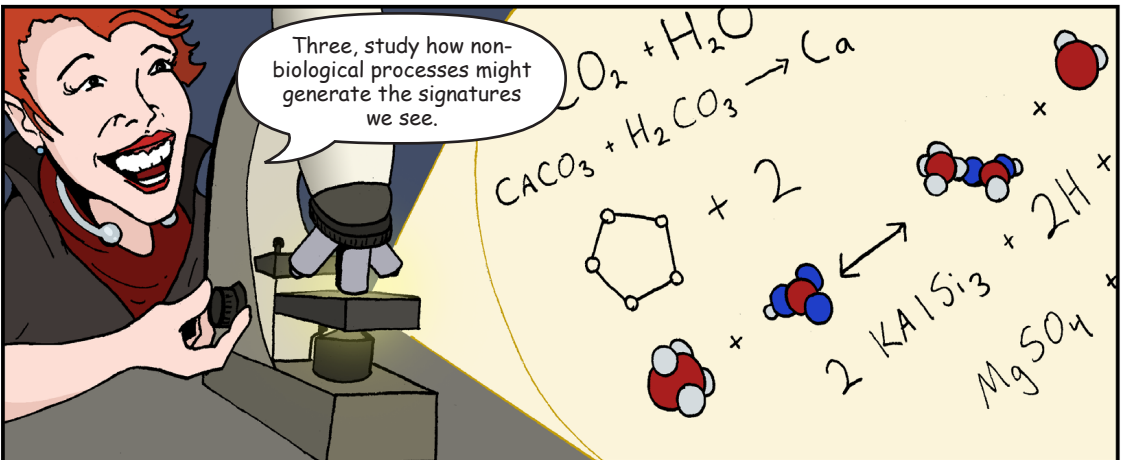
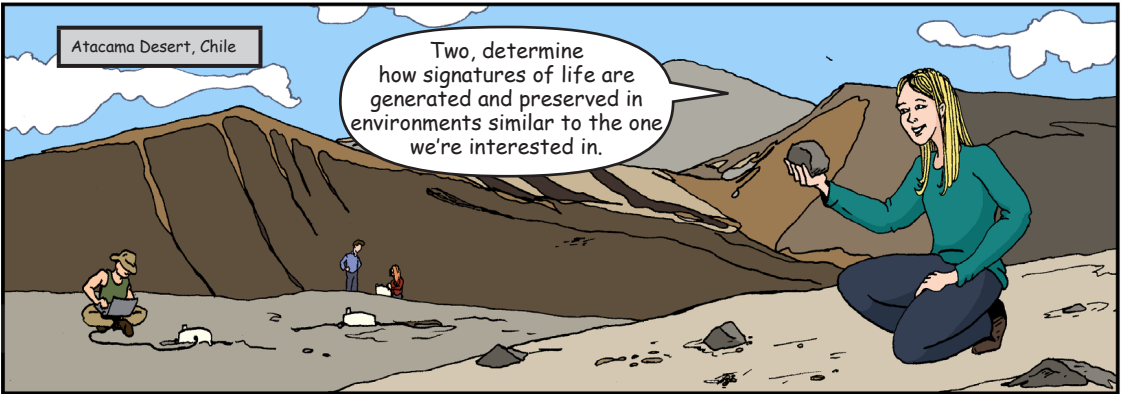
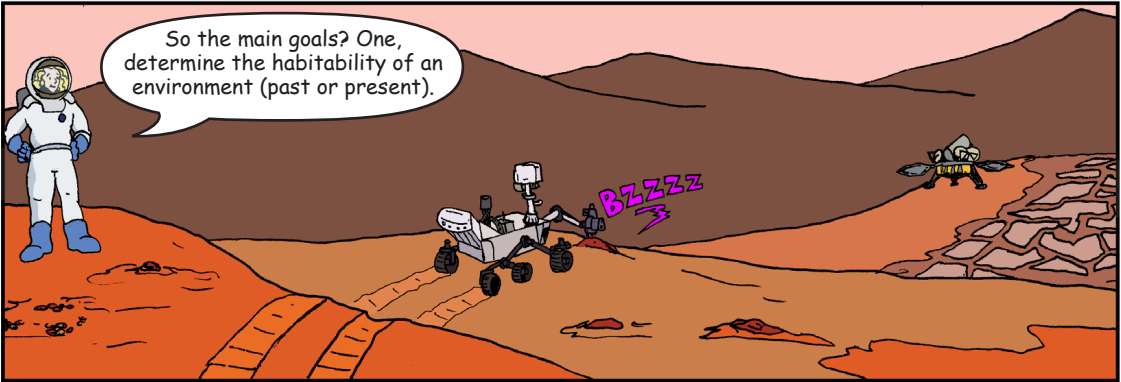
Life produces complex molecules that cannot form randomly.

So we developed a molecular complexity index, where we can identify molecules that are too complex to exist in a **certain environment** without life.

Environmental context is essential in determining the complexity threshold.

And we figured out how to test our ideas of complexity in the lab.

Environment	Complexity Index
TOTAL FORMOSE SOUP	✗
UNILABY PEPTIDES	✓
SANDSTONE	✗
DIPETIDE	✓
MILLER-UREY SOUP	✗
E. coli	✓
YEAST	✓
MID-MIOCENE PALEOMAT	✓
ANGONNE	✗



We are moving from the strategy of 'follow the water' to a true strategy of 'search for life.'

But we need to be careful.

Nancy Grace Roman Space Telescope (NASA) (25)

We want to avoid 'false positives' so that we don't have another Viking or ALH84001.*

We need everyone participating to build up the evidence. (26)

It's not only about good science, it's also about being a good colleague. We have to work together.

We need cooperation across disciplines so that we can agree when we do find something. For a definitive detection of life we will need multiple lines of evidence from multiple scientific disciplines. (27)

Studying biosignatures is an entirely interdisciplinary endeavor that needs physical scientists, modelers, biologists, and many other disciplines.

Okay who's ready?

James Green
(NASA HQ)

*See Page 10

Astrobiology

A History of Exobiology and Astrobiology at NASA

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