



# Science of the Springs

Astrobiology in Yellowstone National Park



# What is Astrobiology?

## **Astro:**

stars, universe

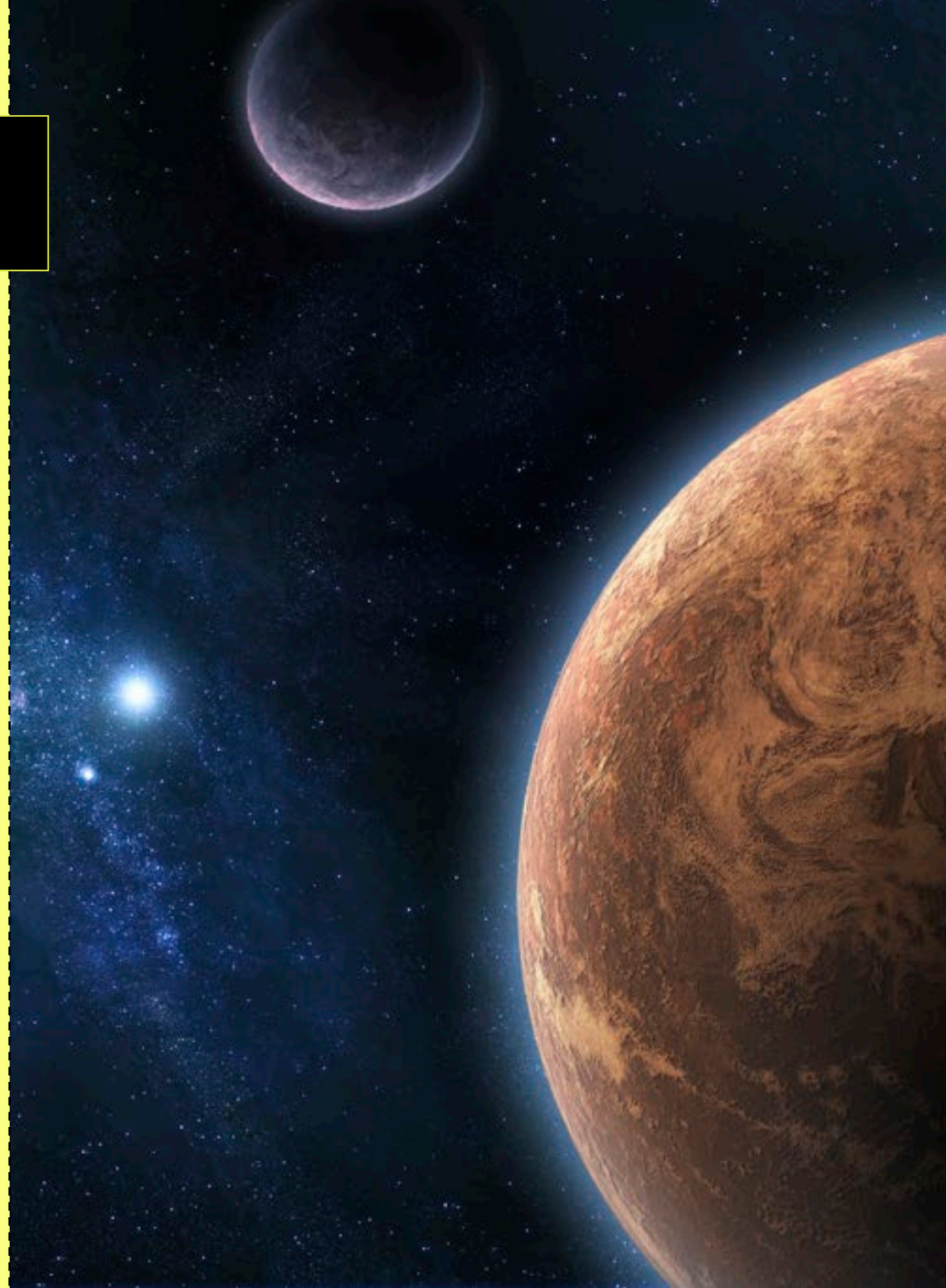
## **+ Biology:**

the study of life

- New field of science: combines geology, biology, chemistry, astronomy

## **3 main questions**

- How did life begin?
- Are we alone?
- What is the future of life on Earth and beyond?



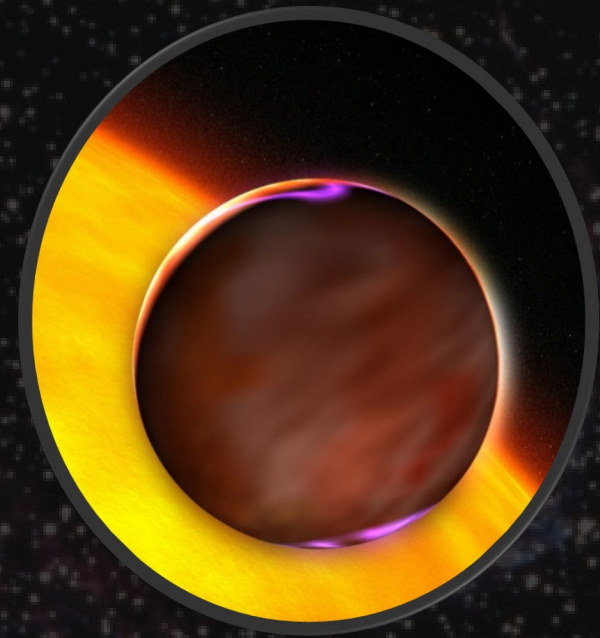
# Yellowstone Hot Springs and Extraterrestrial Life: What's the connection?

## Environments as analogs

- Early Earth
- Extrasolar planets

## Limits of life

- Habitability
- Extremophiles

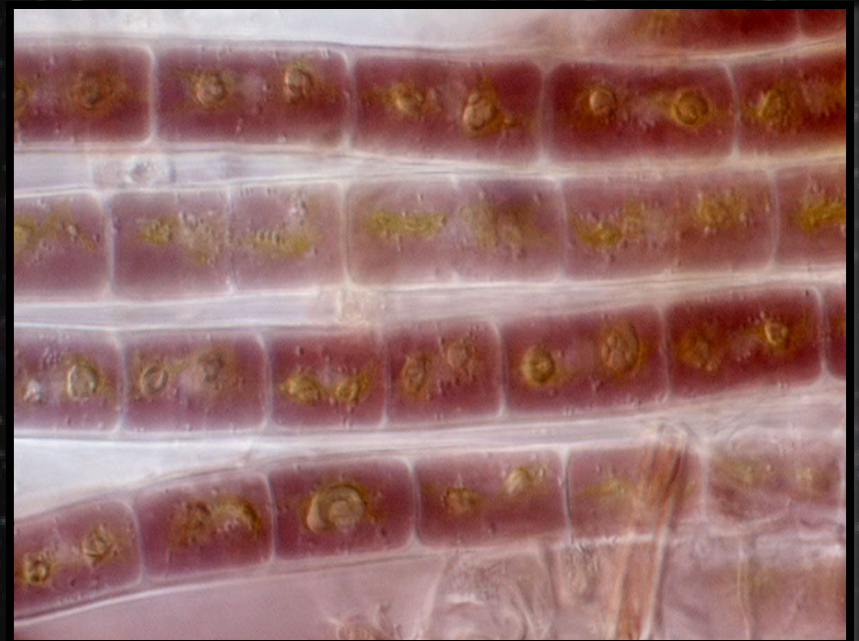




# Extremophiles

## Tiny, extreme-loving microbes

- Bacteria & Archaea
- Microbes are found EVERYWHERE on Earth.
- Extremophiles when extreme!
- Yellowstone is one of the best places to study extremophiles.
- Variety and accessible



# Where can we find life?

- exceedingly hot
- in below-freezing temperatures
- dry deserts
- very acidic
- deep underground
- at the bottom of the ocean
- other planets?





# How is Yellowstone like early Earth?

- Around 3.5 billion years ago: only rocks, gases, water, and HOT temperatures
- First life to emerge: microbes
- Iron-sulfur compounds



# Where in Yellowstone are scientists doing research?

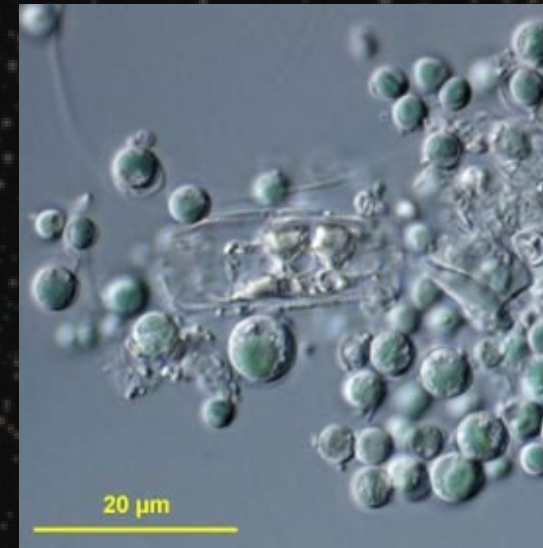
- **Norris Hot Springs:**  
Acidic and Toxic Metals Similar to early Earth
- **Old Faithful:** No Oxygen or Light Methanogens
- **Grand Prismatic:**  
Photosynthetic Microbes  
Microbial Mats
- **Mammoth Hot Springs:** Limestone Biosignatures



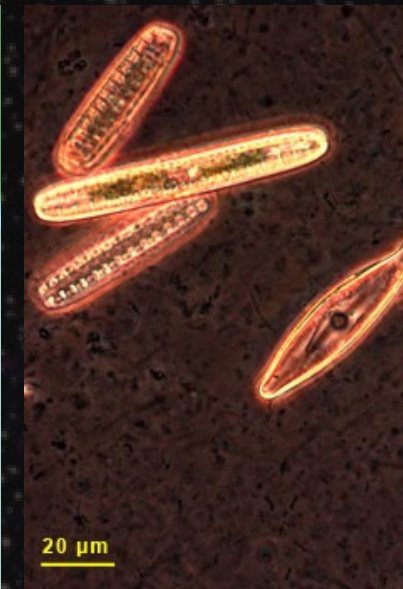
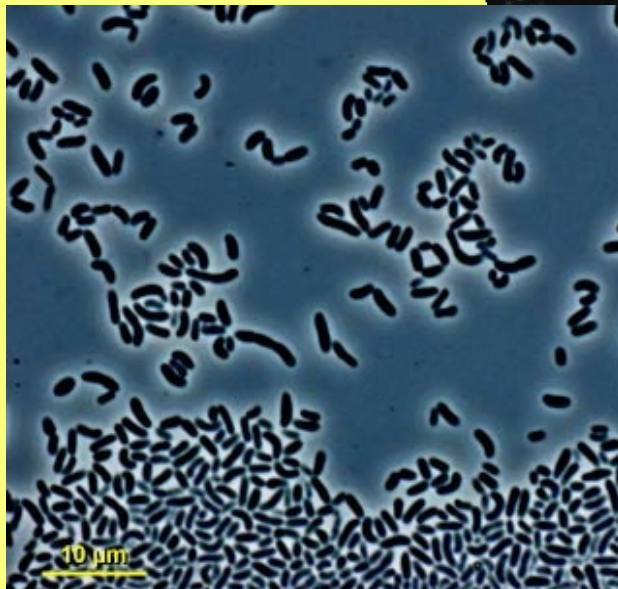


# Why are microbes so important to astrobiology?

- First life on Earth
- Relatively simple
- Very hardy



Microbial Mat





# What is habitability?

## Where can life live?

- Habitability is the potential for an environment to develop and sustain life.
- Extremophiles broaden our definition of habitable.
- Determining habitability in the solar system and universe

