EXOBIOLOGY AND THE SEARCH FOR LIFE ELSEWHERE

FROM MARS TO THE MOONS OF JUPITER AND SATURN TO THE NEWLY-DISCOVERED TRAPPIST-1 EXOPLANETS
Are we alone?

What is life anyway?

What’s special about our home planet?

How do we go about searching for life out there?
“I, for one, am not so immensely impressed by the success we are making of our civilization here that I am prepared to think we are the only spot in this immense universe which contains living, thinking creatures, or that we are the highest type of mental and physical development which has ever appeared in the vast compass of space and time.”

Winston Churchill, 1939 (unpublished)
“I believe alien life is quite common in the universe, although intelligent life is less so. Some say it has yet to appear on planet Earth.”

Stephen Hawking, 2010
Percival Lowell’s Martian “Canali,” 1893
Popular Mars drawing from 1890’s vs. Recent Hubble Telescope Photo
MARS

• 1976: Vikings 1 & 2 land, after being sterilized to avoid contaminating Mars with Earth microbes

• 2004: Spirit & Opportunity Rovers

• 2012: Curiosity (Mars Science Lab)

• Today – almost no atmosphere, but some water ice just below the surface, carbon dioxide (dry) ice caps at the poles that shrink and grow seasonally

• Conclusive evidence for water ice just below the surface
MARS

• Water, water, once was everywhere
• Huge river valleys in many areas on the planet
• Streamlined islands show evidence of large floods
• Mineral deposits (gypsum) left behind by water
• Meteor strikes have often produced mud ejecta and mud flows, evidence of ice just below the surface
MARS

- Jezero Crater
- Ancient river delta
- Minerals and clay deposits
- Possible site to explore for organic sediments
Are we alone?
METEORITE

- Found in Antarctica in 1984
- Billion year-old Martian rock
- Blasted off Mars 17 million years ago
- Controversial analysis suggested microscopic fossils – probably not
What is life anyway?

- Organization (cells)
- Chemical reactions
- Homeostasis / self-regulation
- Regulated growth
- Reproduction
- Responds to stimuli
- Subject to evolution
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Viruses?
Computer Viruses?
Robots?
Earth in 1968
What’s special about our home planet?

- Goldilocks Zone
- Water on surface
- Atmosphere protected by magnetic poles
- All the right chemical building blocks
  - Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorus, Potassium, Sulphur, Calcium, Iron, Magnesium, Sodium, Chlorine
- Earth has somehow avoided catastrophe
How do we go about searching for life out there?

SETI – let’s simply cut to the chase

Follow the water in our solar system

• Mars
• Planet-sized moons
• Comets and asteroids

Exoplanets – search nearby star systems

Find biosignatures that are solid evidence for life
GANYMEDÉ

- Galileo 1610
- Larger than Mercury
- Metallic core, aurora from permanent magnetic moment
- May contain more water than all of Earth’s oceans
- Tenuous atmosphere with small amounts of oxygen
• Galileo 1610
• Volcanic plumes
• Tidal heating
• Very little water
EUROPA

- Galileo 1610
- Subsurface water likely
- Water vapor geysers
- Icy tectonic plates
CALLISTO

- Galileo 1610
- Surface ice and dry ice (CO2) and condensed oxygen
- Subsurface ocean 100 miles below surface?
- Thin atmosphere with oxygen and carbon dioxide
- Radioactive heating only
ENCELADUS

- Saturn 6th largest moon
- Cryovolcanoes near the pole
- Tidal heating
- Tectonic plates
- Water vapor geysers
So, let's look outside our solar system
Kepler Space Telescope
2009-2013

Continuously monitored brightness of 145,000 stars

Discovered over 1000 planets
Spitzer Space Telescope (Infrared) 2003

Directly measures heat from large planets and young stars

Discovered the TRAPPIST-1 planets
What’s the big deal about TRAPPIST-1?

• Seven planets!
• Close @ 40 light years away
• Some could be in the Goldilocks Zone
• More than 3500 exoplanets found so far
• Likely that we’ll discover many more
So, how do we know we found life?

- **Biosignatures include** oxygen, methane
- **Isotopic abundances of methane**
- **Other byproducts of life processes?**
- **Is the surface green?**
Spectral Signatures of Atmospheric Gases

Critical to remotely measure the composition of distant atmospheres

Also explains why it’s necessary to put telescopes in space
Chlorophyll has a very distinctive signature

Absorbs reds and blues

Appears green
James Webb
2018

Cross your fingers!