What I know today about the Final

- Tuesday, December 10, 8 – 11 am, same place
- Around 90 multiple choice questions
- Closed book and closed note
- No smartphones allowed
- Calculators of any kind are permitted, but the math can be readily done without them
- Equation Sheet Provided
- Around 40% old stuff, 60% new stuff
- **Bring a #2 pencil!**
- **Know your Student ID**

What I know today about the Final

- Chris and Emily will proctor the Exam
- It is 35% of your quarter grade
- Review Sessions with Chris and Emily
  - Thursday Night, 7:30 pm, Phys Sci 114
  - Sunday Afternoon, 4 pm, Phys Sci 114
- Office Hours Monday, 12/9 from 12-2 pm in the Center for Adaptive Optics Atrium
- Study Guide done
- We will provide Scantrons….
- I will be at a conference on Monday/Tuesday

Grades so far

- All HWs have been turned in
- Clicker questions very nearly done
- I made a tentative grade breakdown on Mastering Astronomy based on the HWs, midterms, and clickers, posted last night
    - You can see where you stand, pre-final
    - Grade breakdown is in the “Announcements” on the main page

Note: Only assignments past the due date are counted towards each category subtotal.

DATE DUE	CATEGORY/TITLE	RAW SCORE	WEIGHT	WEIGHTED SCORE	NOTES
	CLICKER QUIZ				Current Weight: 15.38% Assigned Weight: 15.38%
12/04/13	Clicker attendance	10.00 / 10.00			
	CLICKER QUIZ SUBTOTAL	10.00 / 10.00		15.38%	
	HOMEWORK				Current Weight: 38.46% Assigned Weight: 38.46%
10/03/13	HW#1	19.31 / 27.00	12.50%	8.94%	
10/10/13	HW#2	29.80 / 34.00	12.50%	10.96%	
10/17/13	HW#3	25.78 / 32.00	12.50%	10.07%	
10/24/13	HW#4	25.30 / 27.00	12.50%	11.72%	
11/07/13	HW#5	27.02 / 32.00	12.50%	10.55%	
11/14/13	HW#6	22.71 / 32.00	12.50%	8.87%	
11/21/13	HW#7	23.99 / 30.00	12.50%	10.00%	
12/03/13	HW#8	14.72 / 23.00	12.50%	8.00%	
	HOMEWORK SUBTOTAL	189 / 237			
	WEIGHTED HOMEWORK SUBTOTAL	187 / 237		30.43%	
	MIDTERM EXAM				Current Weight: 46.15% Assigned Weight: 46.15%
11/04/13	Midterm	34.00 / 75.00	100%	45.33%	
	MIDTERM EXAM SUBTOTAL	34.00 / 75.00			
	WEIGHTED MIDTERM EXAM SUBTOTAL	34.00 / 75.00		20.92%	
	TOTAL SCORE	233 / 322		215 / 322	
	WEIGHTED TOTAL SCORE (to date)			66.73%	

Maximum total points: 322 points

Average is 232 points (72%)

The rough breakdown, pre-final is:
high A: 277+
low A: 268+
high B: 243+
low B: 225+
high C: 213+
low C: 196+
D/F: below 196

Average on midterm was 62%

Online course evaluations

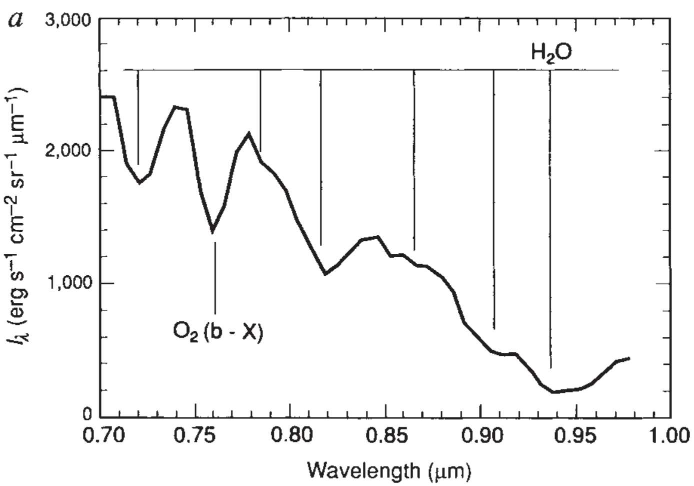
- Please do them before the final exam
- They are important to me, Chris, and Emily for feedback on how the class and discussion sections were run and structured
- Will help to improve the class next time
- When I come up for review, I get judged both on the quality of my teaching (via the evaluations) and the fraction of the evals that actually get filled out

A search for life on Earth from the Galileo spacecraft

Carl Sagan[*], W. Reid Thompson[*], Robert Carlson[†], Donald Gurnett[‡] & Charles Hord[§]

[*] Laboratory for Planetary Studies, Cornell University, Ithaca, New York 14853, USA
[†] Atmospheric and Cometary Sciences Section, Jet Propulsion Laboratory, Pasadena, California 91109, USA
[‡] Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242-1479, USA
[§] Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado 80309, USA

In its December 1990 fly-by of Earth, the Galileo spacecraft found evidence of abundant gaseous oxygen, a widely distributed surface pigment with a sharp absorption edge in the red part of the visible spectrum, and atmospheric methane in extreme thermodynamic disequilibrium; together, these are strongly suggestive of life on Earth. Moreover, the presence of narrow-band, pulsed, amplitude-modulated radio transmission seems uniquely attributable to intelligence. These observations constitute a control experiment for the search for extraterrestrial life by modern interplanetary spacecraft.



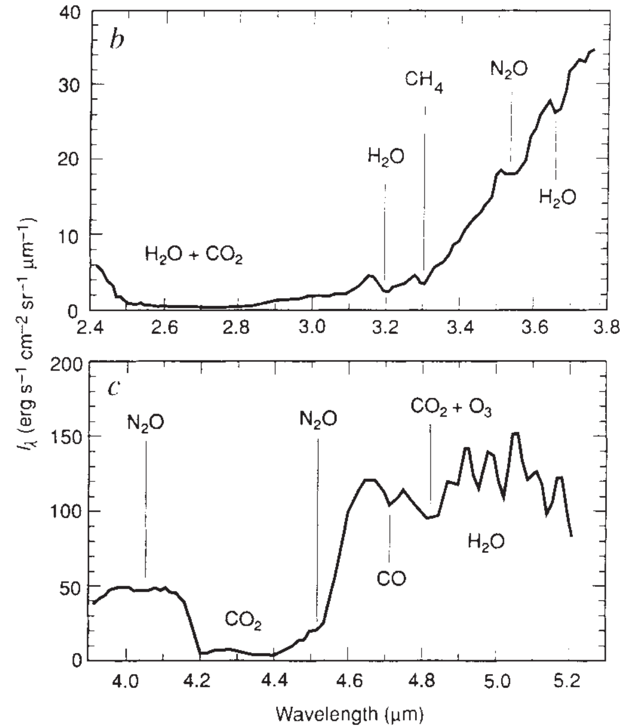


FIG. 1 *a*, Galileo long-wavelength-visible and near-infrared spectra of the Earth over a relatively cloud-free region of the Pacific Ocean, north of Borneo. The incidence and emission angles are 77° and 57° respectively. The $(b'\sum_g^+ - X^3\sum_g^-)$ 0–0 band of O_2 at 0.76 µm is evident, along with a number of H_2O features. Using several cloud-free regions of varying airmass, we estimate an O_2 vertical column density of 1.5 km-amagat ± 25%. *b* and *c*, Infrared spectra of the Earth in the 2.4–5.2 µm region. The strong υ_3 CO_2 band is seen at the 4.3 µm, and water vapour bands are found, but not indicated, in the 3.0 µm region. The υ_3 band of nitrous oxide, N_2O, is apparent at the edge of the CO_2 band near 4.5 µm, and N_2O combination bands are also seen near 4.0 µm. The methane (0010) vibrational transition is evident at 3.31 µm. A crude estimate[10] of the CH_4 and N_2O column abundances is, for both species, of the order of 1 cm-amagate (≡1 cm path at STP).

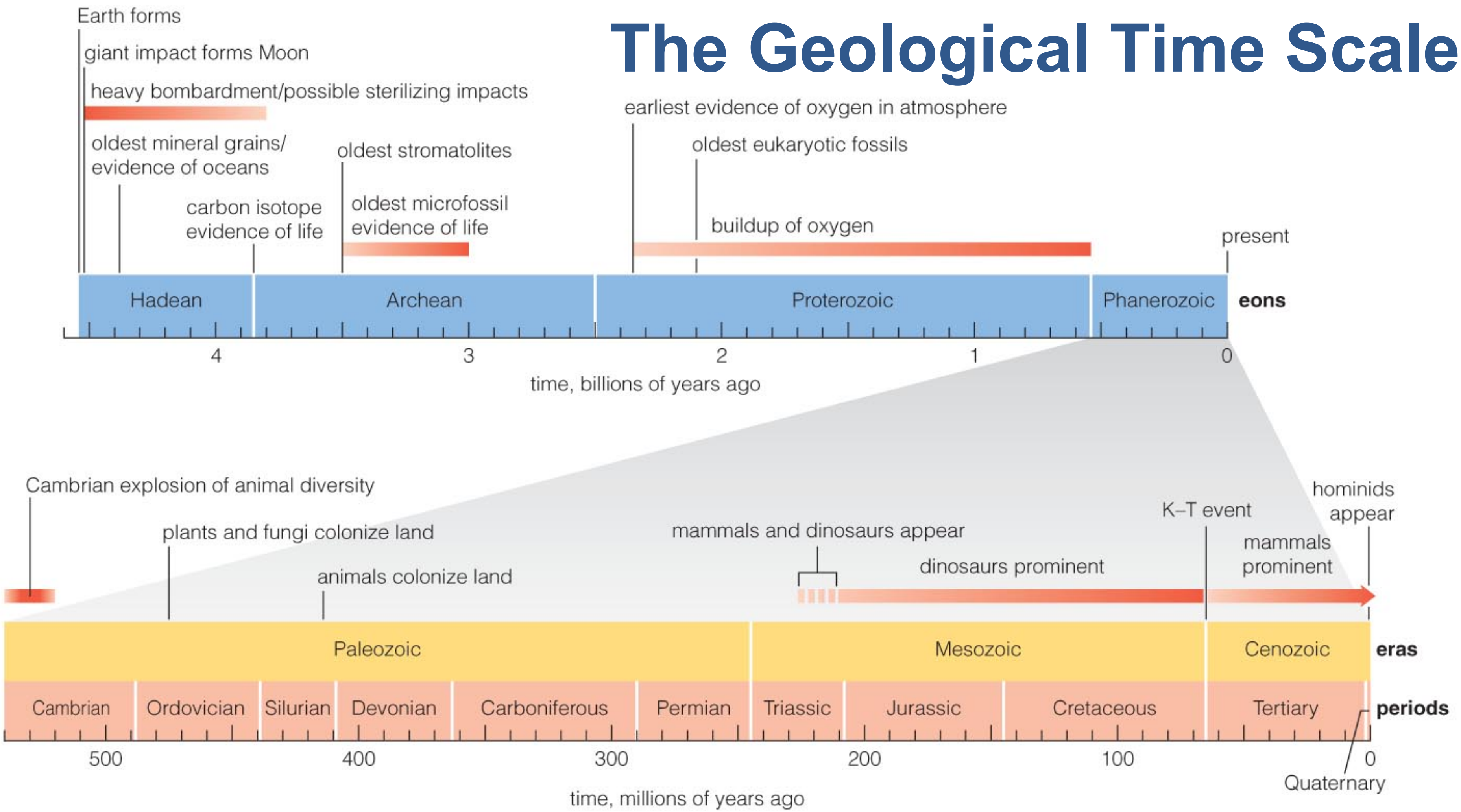
Several spacecraft have now been used to look back on Earth

Life in the Universe

24.1 Life on Earth

- Our goals for learning:
  - **When did life arise on Earth?**
  - **How did life arise on Earth?**
  - **What are the necessities of life?**

The Geological Time Scale



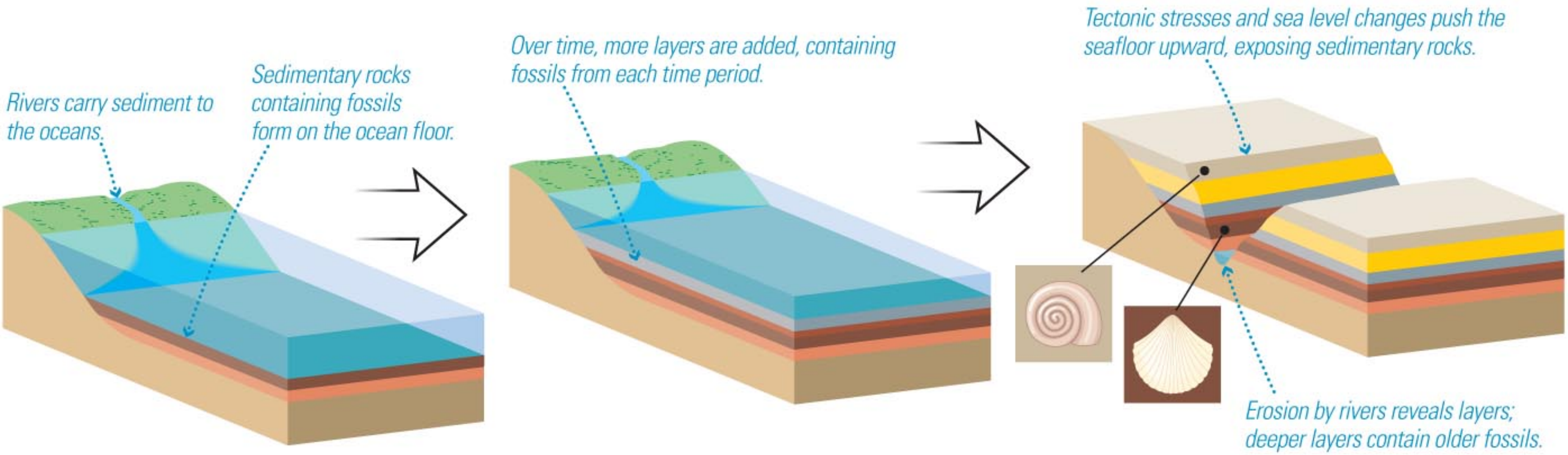
- For the first billion years of Earth, only single-cell organisms
- It took nearly a billion years for life to start making oxygen
- It took another 1.5 billion years for oxygen to build up
- First hominids: 99.9% of Earth history already passed

Earliest Life Forms

- Life probably arose on Earth more than 3.85 billion years ago, shortly after the end of heavy bombardment.
  - It could have arisen even earlier, and survived in deep oceans or deep in the crust, where giant impacts wouldn't harm it

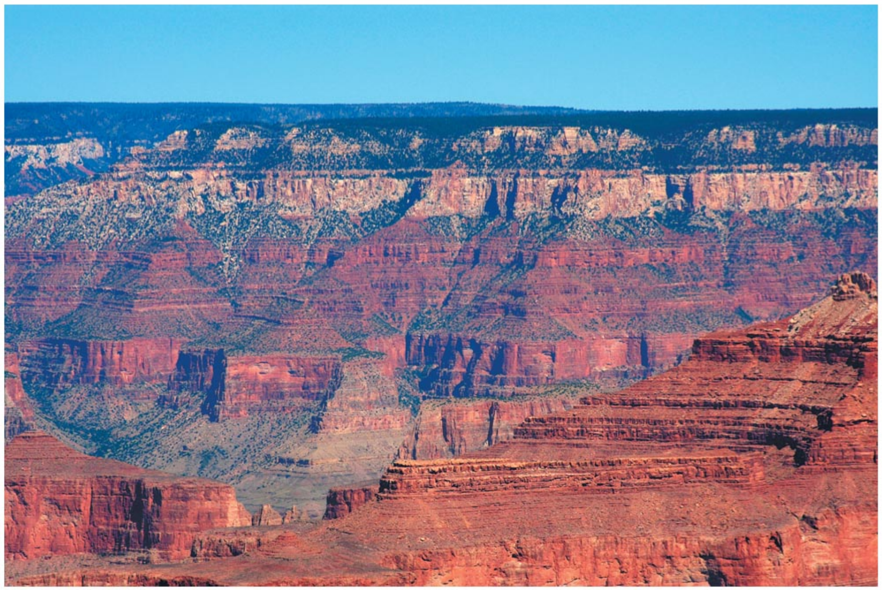
- Evidence comes from carbon isotopes.
  - "Chemistry of life" slightly prefers C-12 to C-13, since it is lighter and easier to move around. All data indicate similar C12/C13 ratio for life
  - Evidence for altered C ratio, different from rocks, back to 3.85 billion years
- Microfossils at 3.5 billion years ago as well

Fossils in Sedimentary Rock



- Relative ages: deeper layers formed earlier
- Absolute ages: radiometric dating
- For instance, Grand Canyon shows about 2 billion years of exposed rock

Fossils in Sedimentary Rock



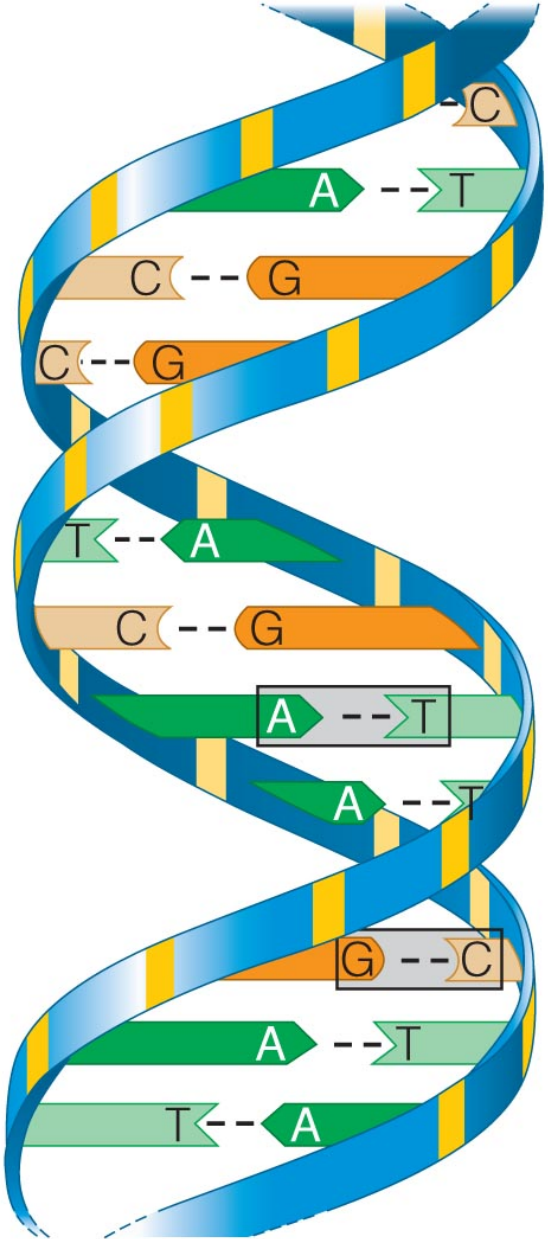
- Rock layers of the Grand Canyon record 2 billion years of Earth's history.

Earliest Fossils

a These knee-high mats at Shark Bay, Western Australia, are colonies of microbes known as “living stromatolites.”

- The oldest fossils show that bacteria-like organisms were present over 3.5 billion years ago.
- Carbon isotope evidence dates the origin of life to more than 3.85 billion years ago.

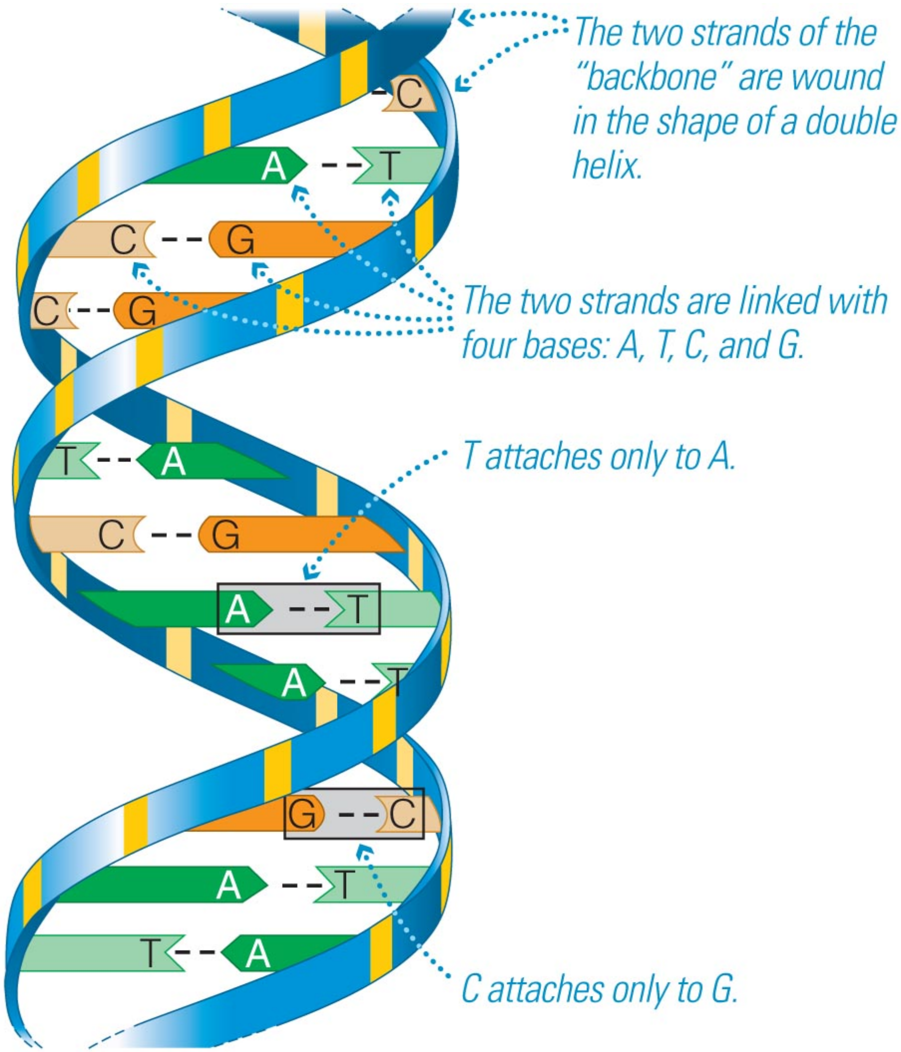
How did life arise on Earth?



Origin of Life on Earth

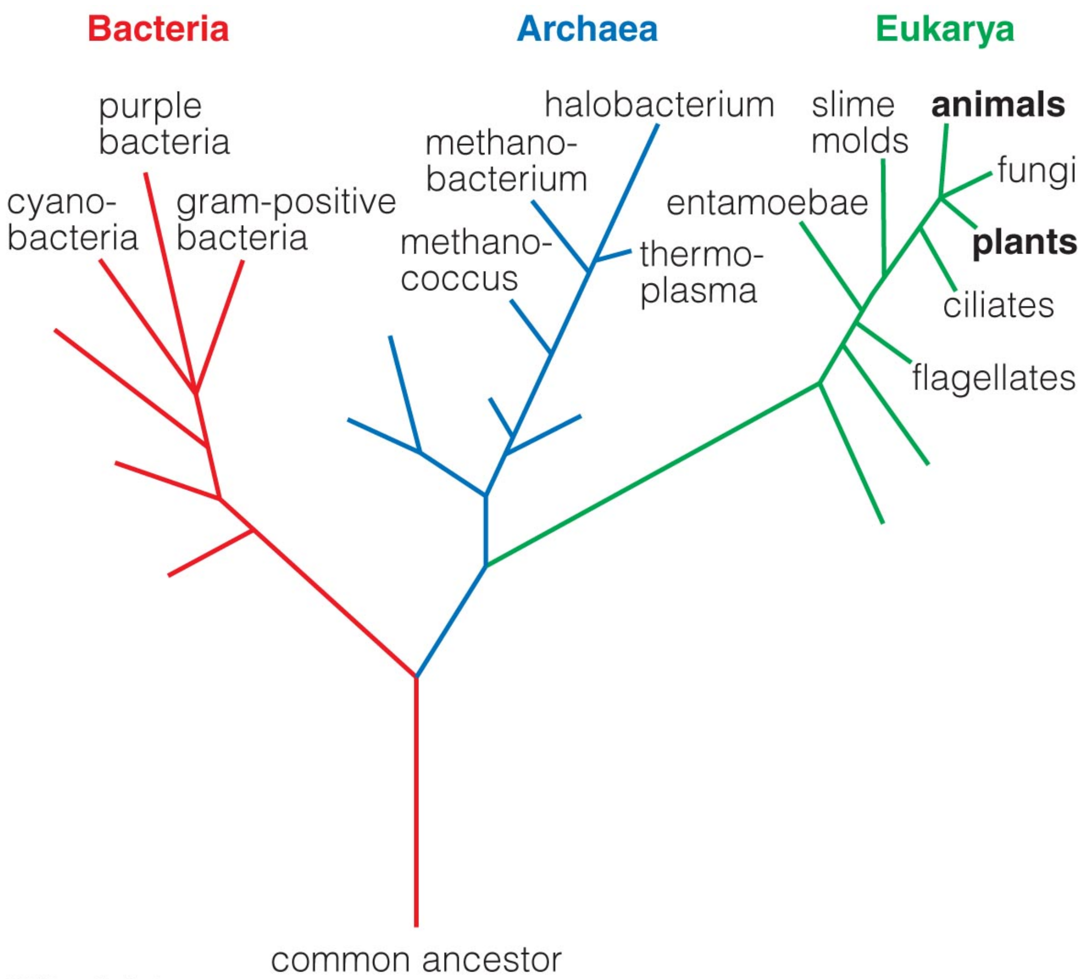
- Life evolves through time.
- All life has DNA
- All life on Earth shares a common ancestry.
- We may never know exactly how the first organism arose, but laboratory experiments suggest plausible scenarios.

The Theory of Evolution

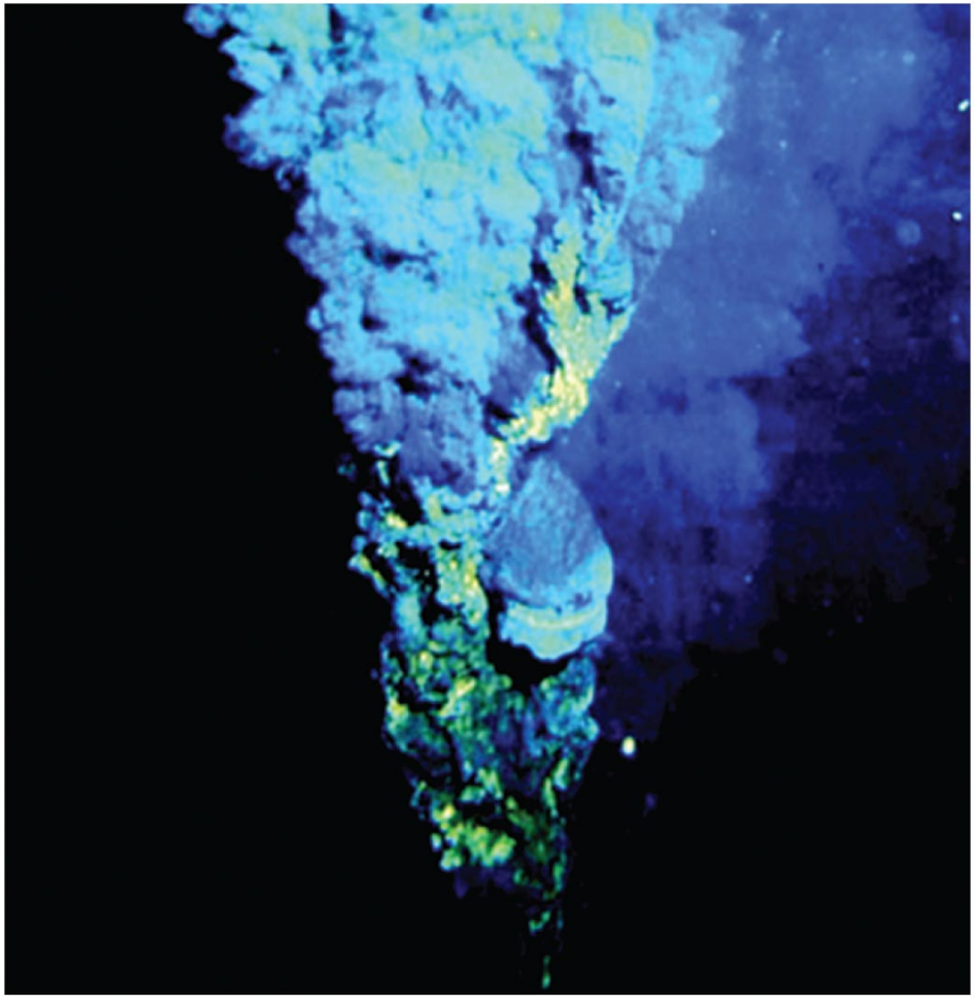


- The fossil record shows that evolution has occurred through time.
- Darwin's theory tells us HOW evolution occurs: through **natural selection.**
- Theory supported by discovery of DNA: evolution proceeds through **mutations.**

Tree of Life

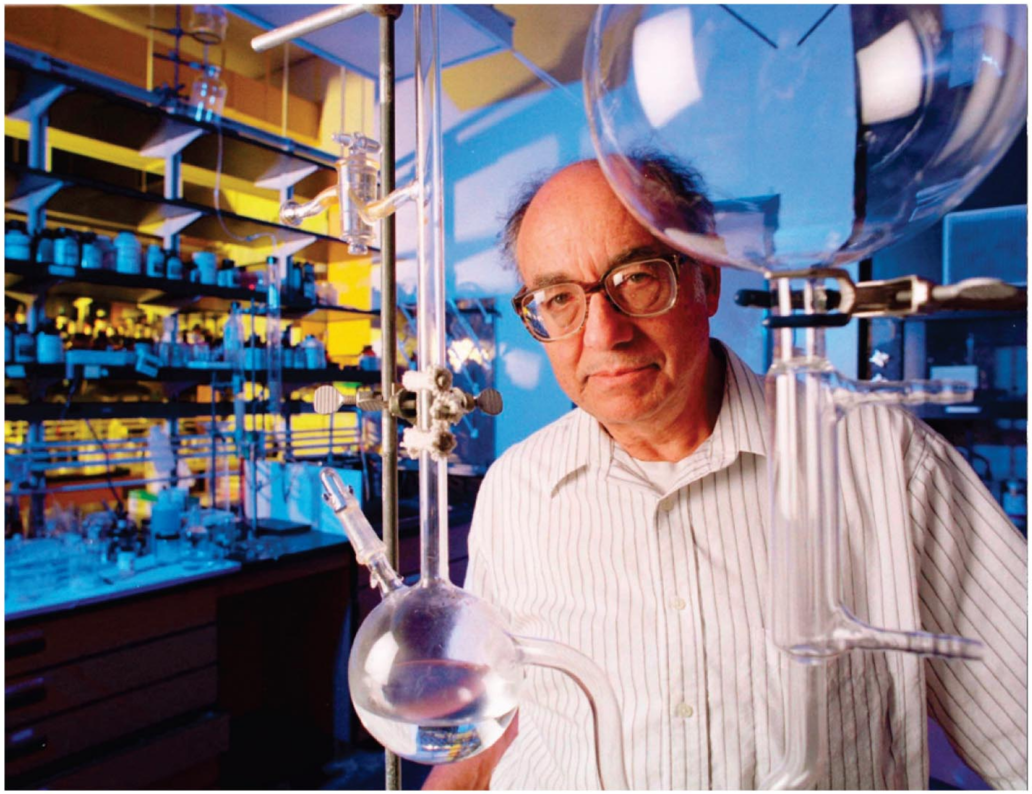


- Mapping genetic relationships has led biologists to discover this new "tree of life."
- Plants and animals are a small part of the tree.
- Suggests likely characteristics of common ancestor

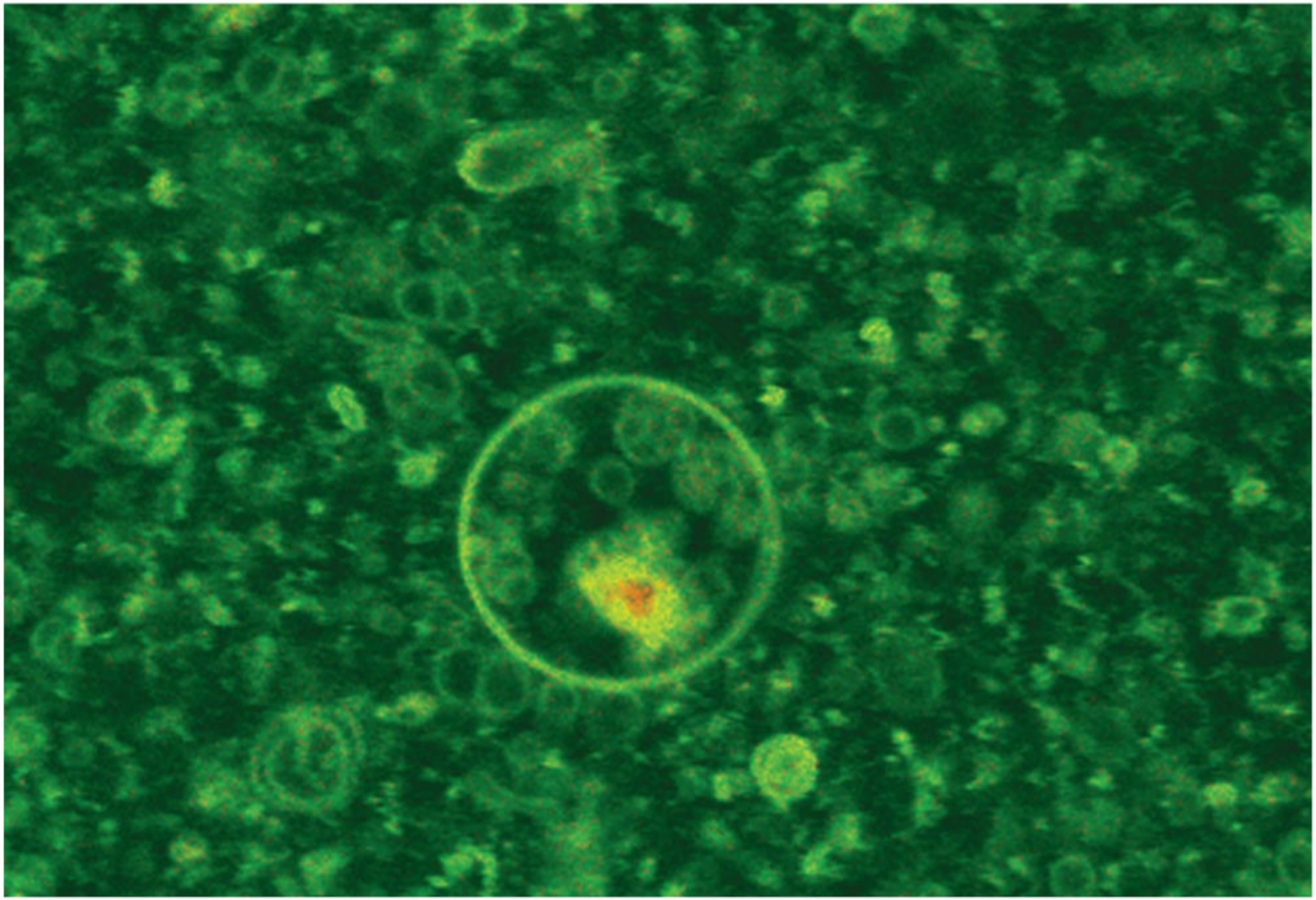


- These genetic studies suggest that the earliest life on Earth may have resembled the bacteria today found near deep ocean volcanic vents (*black smokers*).
- The nice thing about hot salty water is that there is an energy source (heat from the Earth), a source of atoms/ molecules, in a protected environment

Laboratory Experiments

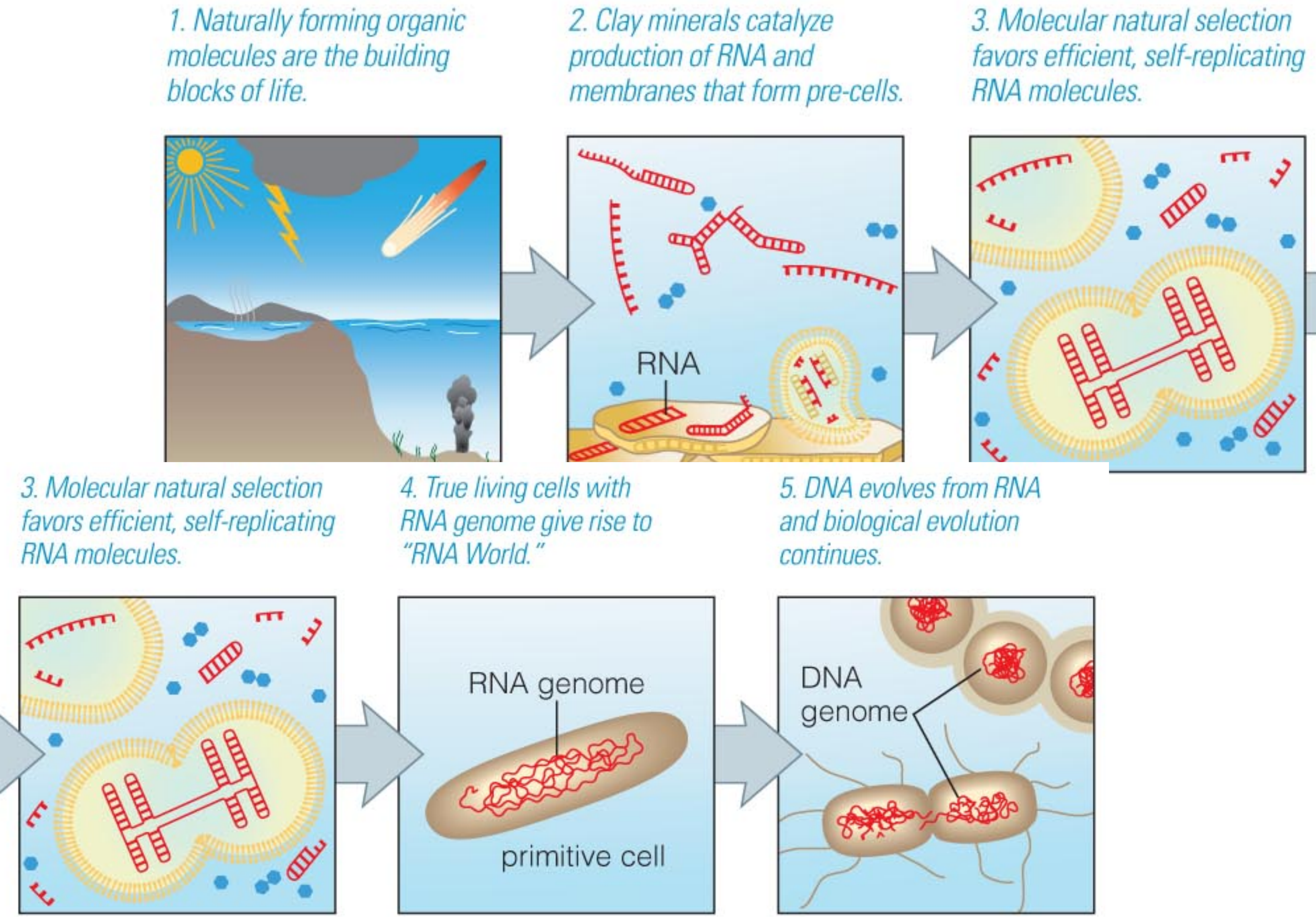


- The Miller-Urey experiment (and more recent experiments) show that the building blocks of life form easily and spontaneously under the conditions of early Earth.
- Take a mixture of atmospheric gases and surface liquids and rocks put in some energy (electricity, etc) and see what happens



- Microscopic, enclosed membranes or "pre-cells" have been created in the lab.

Chemicals to Life?



Could life have migrated to Earth?

- Venus, Earth, Mars have exchanged tons of rock (blasted into orbit by impacts).
- Some microbes can survive years in space.
- “Panspermeria”

Some have suggested that early Earth may have been too inhospitable to life, and that life came instead from Mars or from distant solar systems

Brief History of Life

- 4.4 billion years - early oceans form
- 3.5 billion years - cyanobacteria start releasing oxygen
- 2.0 billion years - oxygen begins building up in atmosphere
- 540–500 million years - Cambrian Explosion
- 225–65 million years - dinosaurs and small mammals (dinosaurs ruled)
- Few million years - earliest hominids

Thought Question

You have a time machine with a dial that you can spin to send you randomly to any time in Earth's history. If you spin the dial, travel through time, and walk out, what is most likely to happen to you?

A. You'll be eaten by dinosaurs.
B. You'll suffocate because you'll be unable to breathe the air.
C. You'll be consumed by toxic bacteria.
D. Nothing. You'll probably be just fine.

Thought Question

You have a time machine with a dial that you can spin to send you randomly to any time in Earth's history. If you spin the dial, travel through time, and walk out, what is most likely to happen to you?

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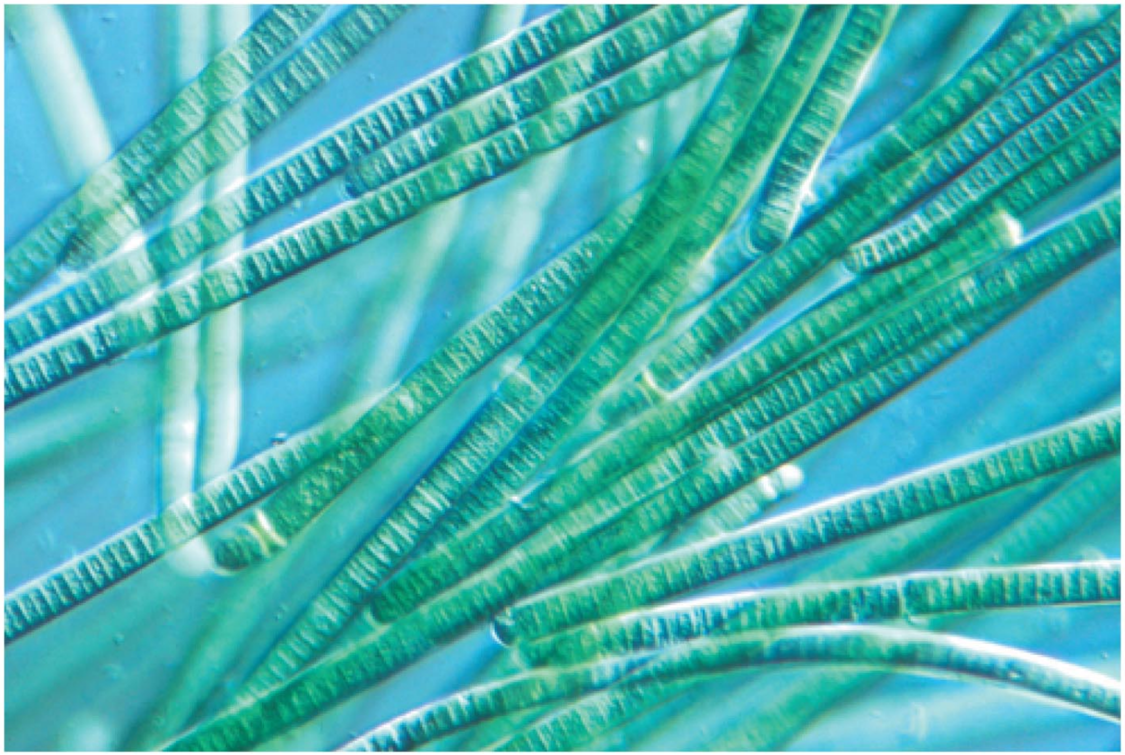
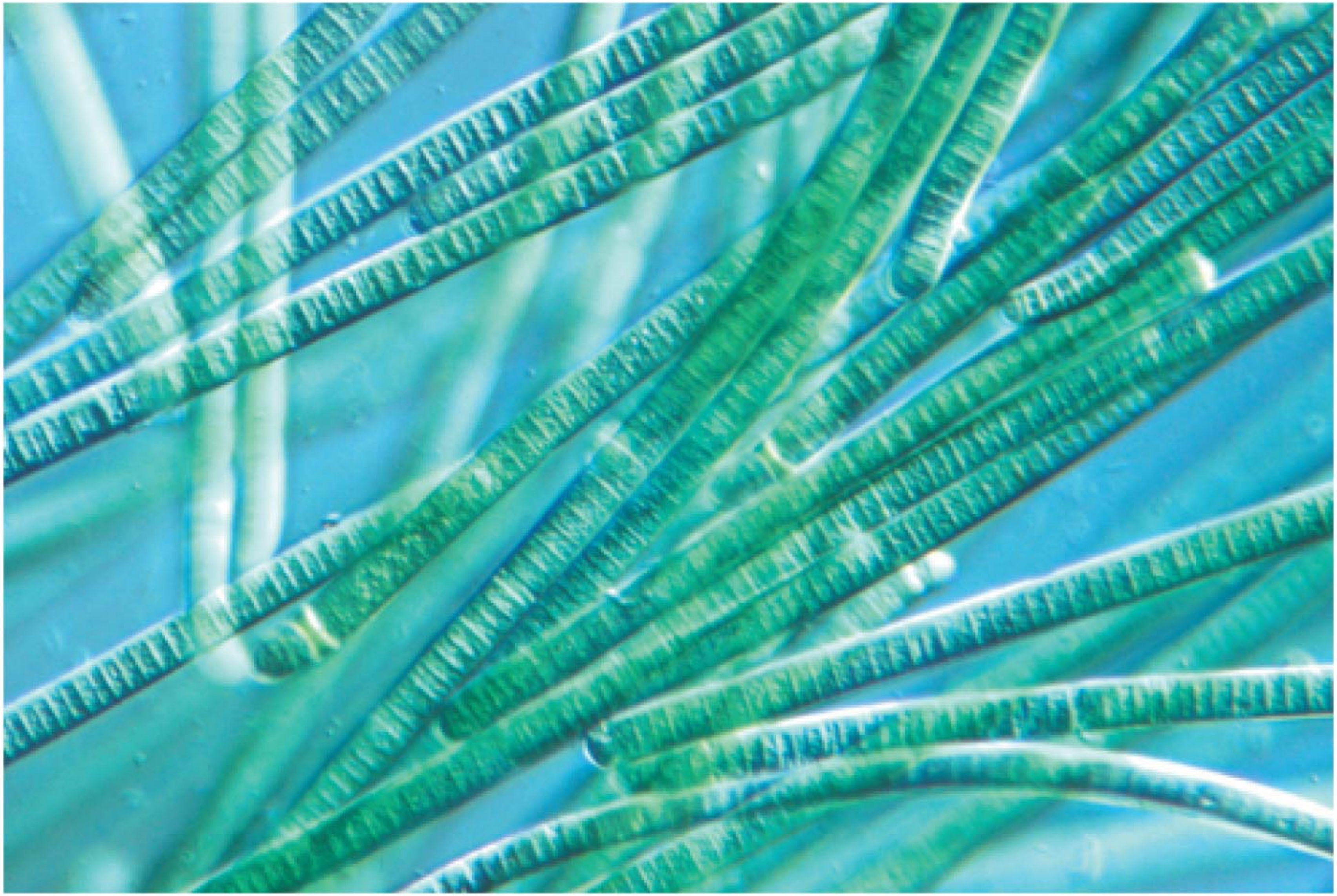
D. Nothing. You'll probably be just fine.

Origin of Oxygen



- Cyanobacteria paved the way for more complicated life forms by releasing oxygen into atmosphere via photosynthesis.

What are the necessities of life?



Necessities for Life

- A nutrient source
- Energy (sunlight, chemical reactions, internal heat)
- Liquid water (or possibly some other liquid)

Hardest to find on other planets

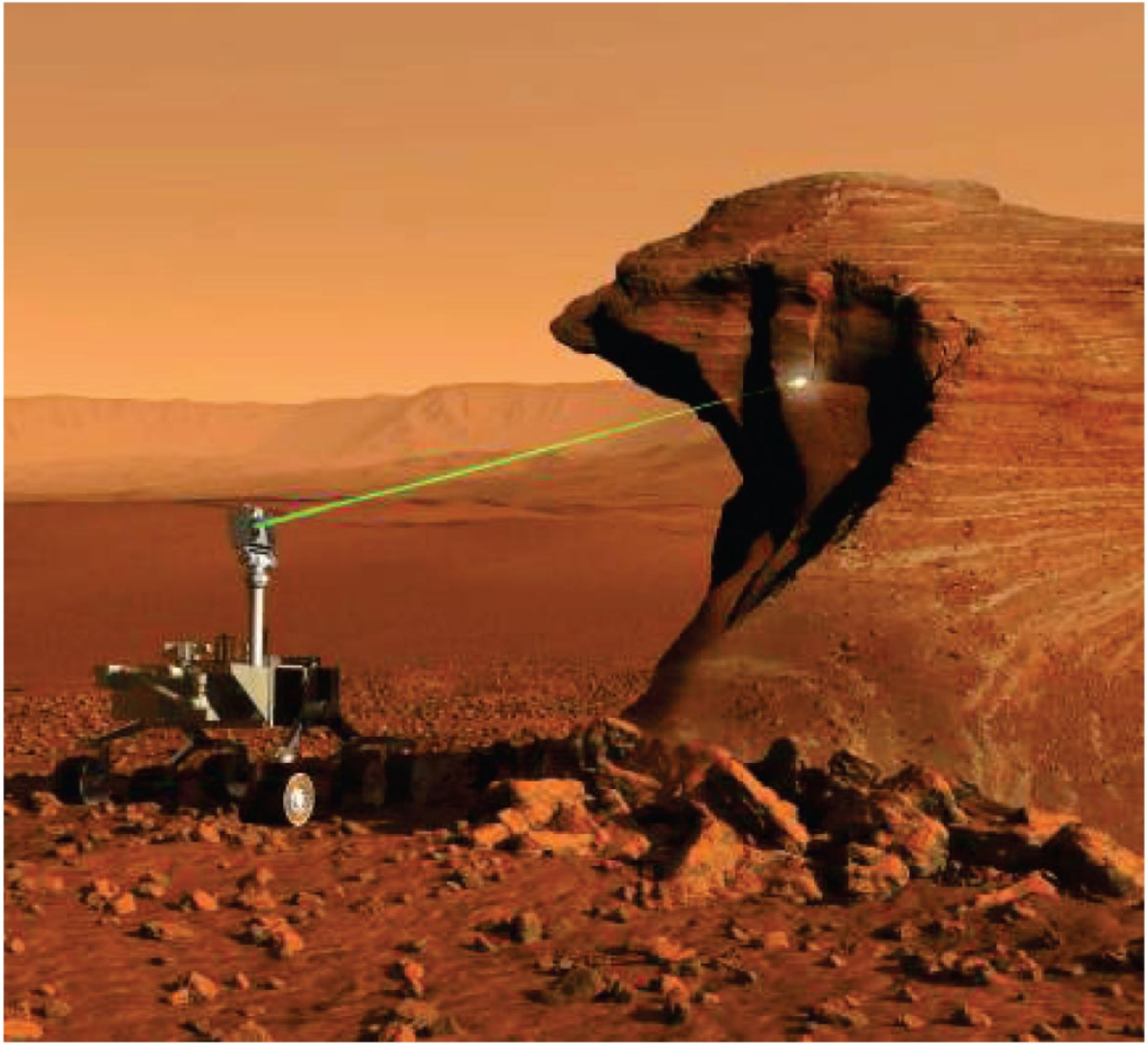
What have we learned?

- **When did life arise on Earth?**
  - Life arose at least 3.85 billion years ago, shortly after end of heavy bombardment.
- **How did life arise on Earth?**
  - Life evolved from a common organism through natural selection, but we do not yet know the origin of the first organism.
- **What are the necessities of life?**
  - Nutrients, energy, and liquid water.

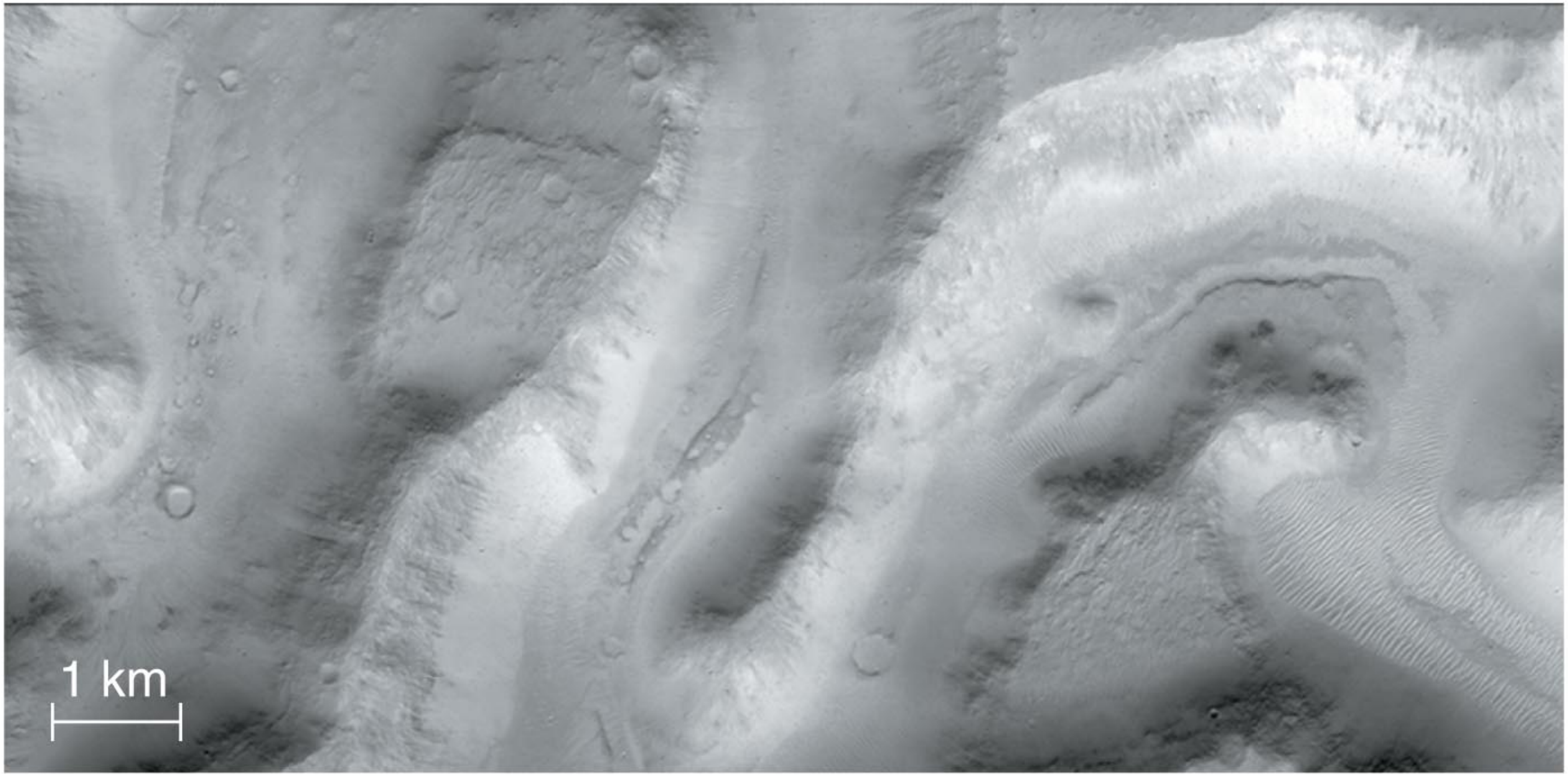
24.2 Life in the Solar System

- Our goals for learning
  - **Could there be life on Mars?**
  - **Could there be life on Europa or other jovian moons?**

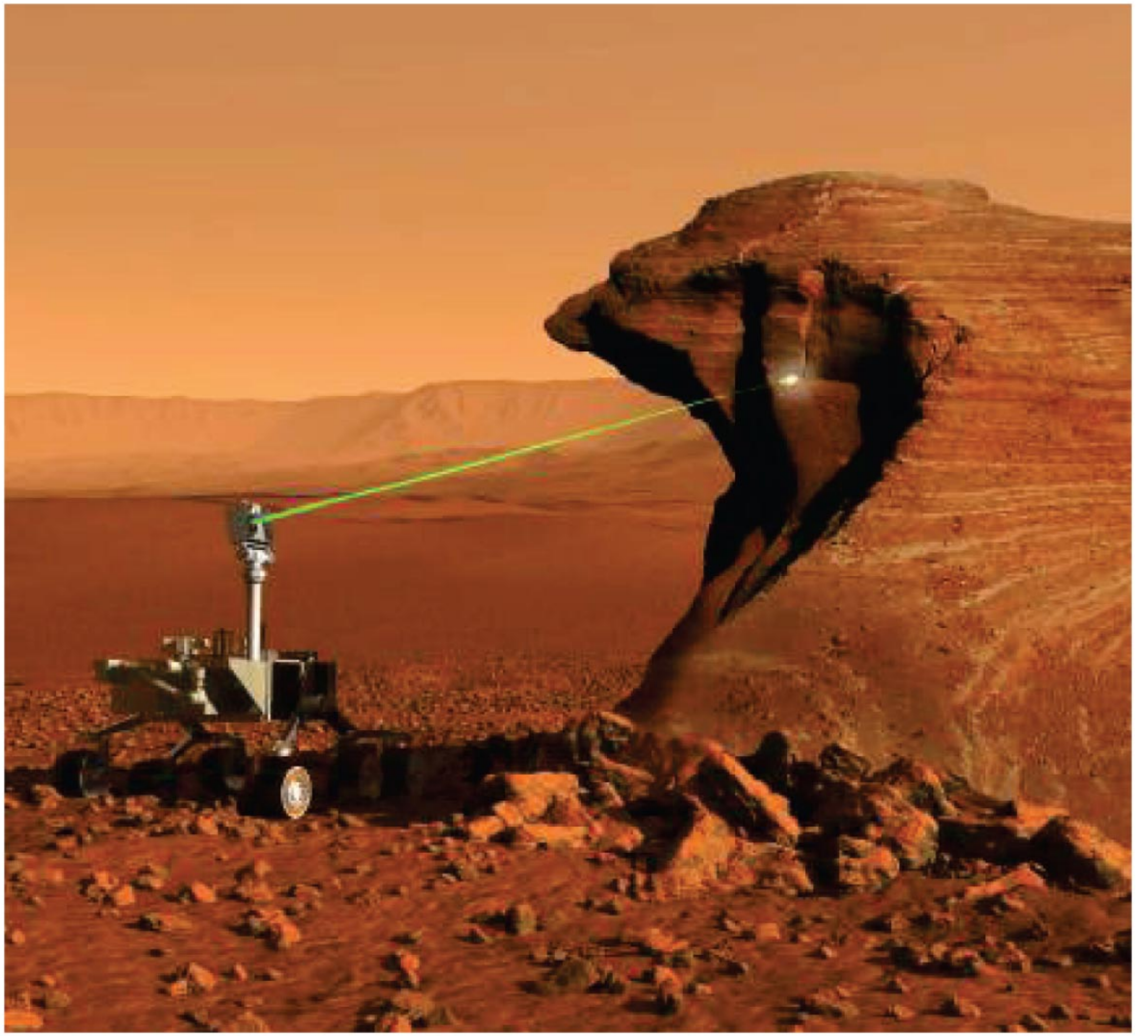
Could there be life on Mars?



Searches for Life on Mars

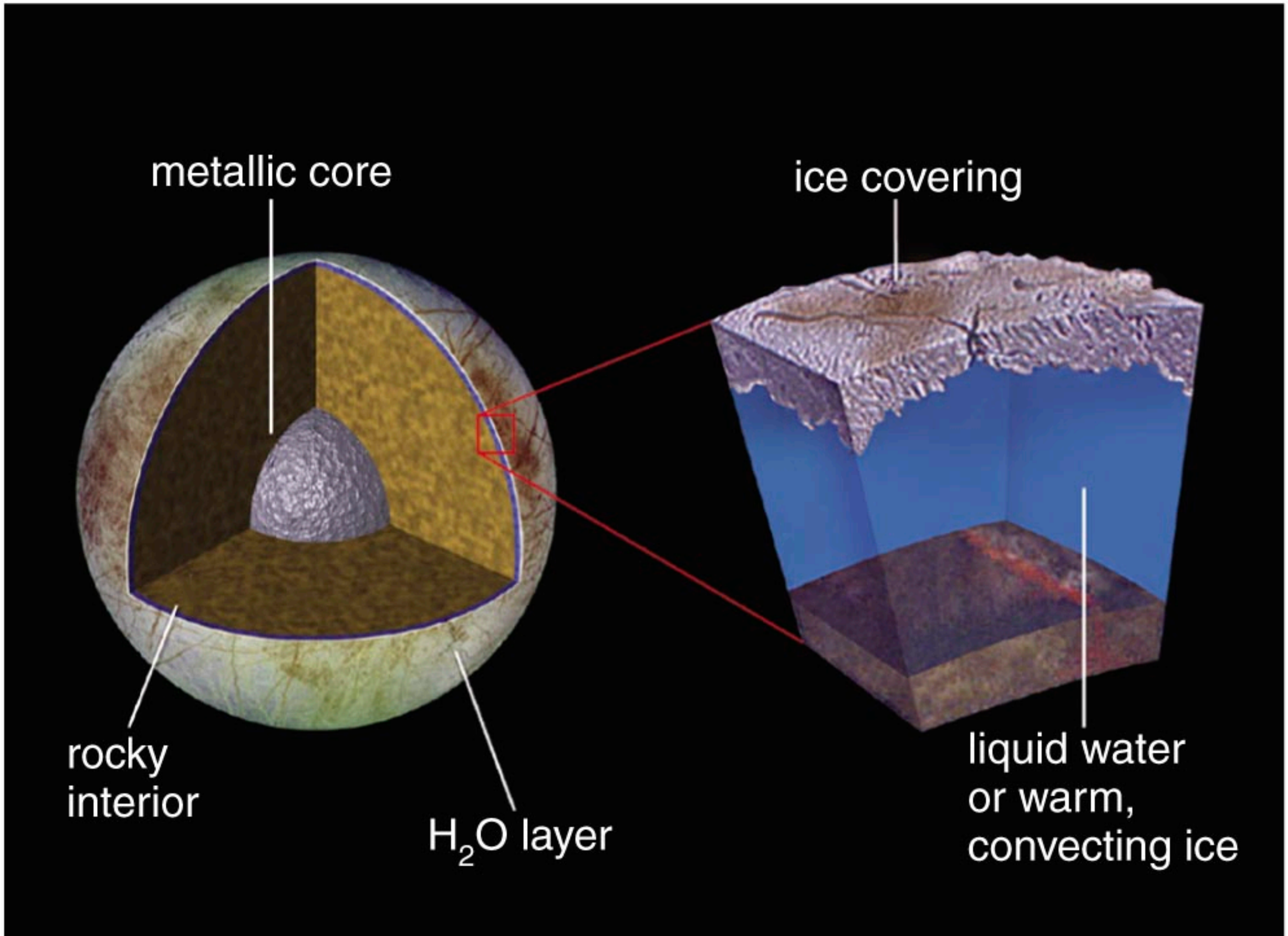


- Mars had liquid water in the distant past.
- Still has subsurface ice; possibly subsurface water near sources of volcanic heat

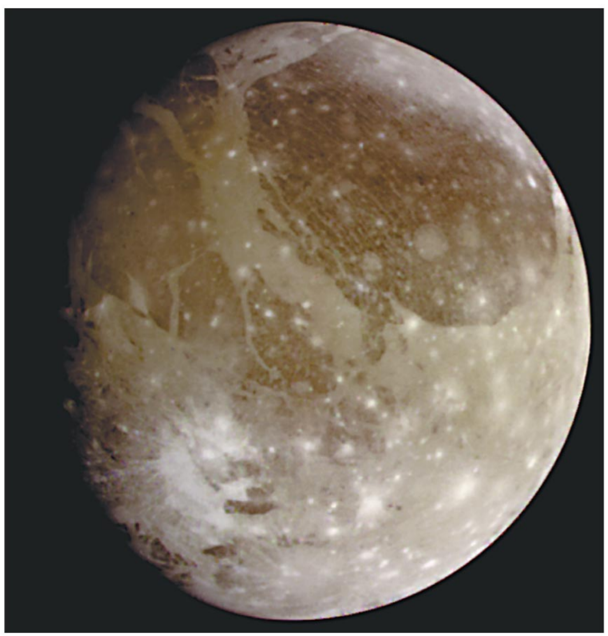


- The *Curiosity* rover landed on Mars in 2012. It carries many instruments designed to explore the habitability of the planet.
- In 2004, NASA *Spirit* and *Opportunity* rovers sent home new mineral evidence of past liquid water on Mars.
- The joke is what water has been discovered on Mars about 20 times

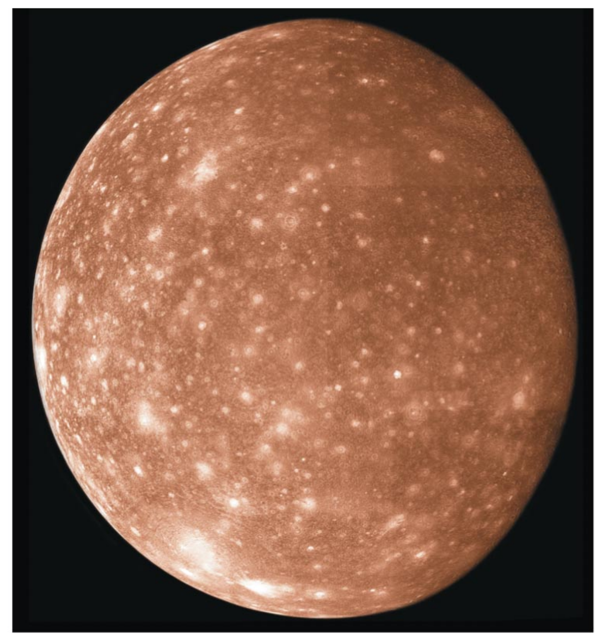
Could there be life on Europa or other jovian moons?



- Ganymede, Callisto also show some evidence for subsurface oceans.
- Relatively little energy available for life, but there still may be enough.
- Intriguing prospect of THREE potential homes for life around Jupiter alone.

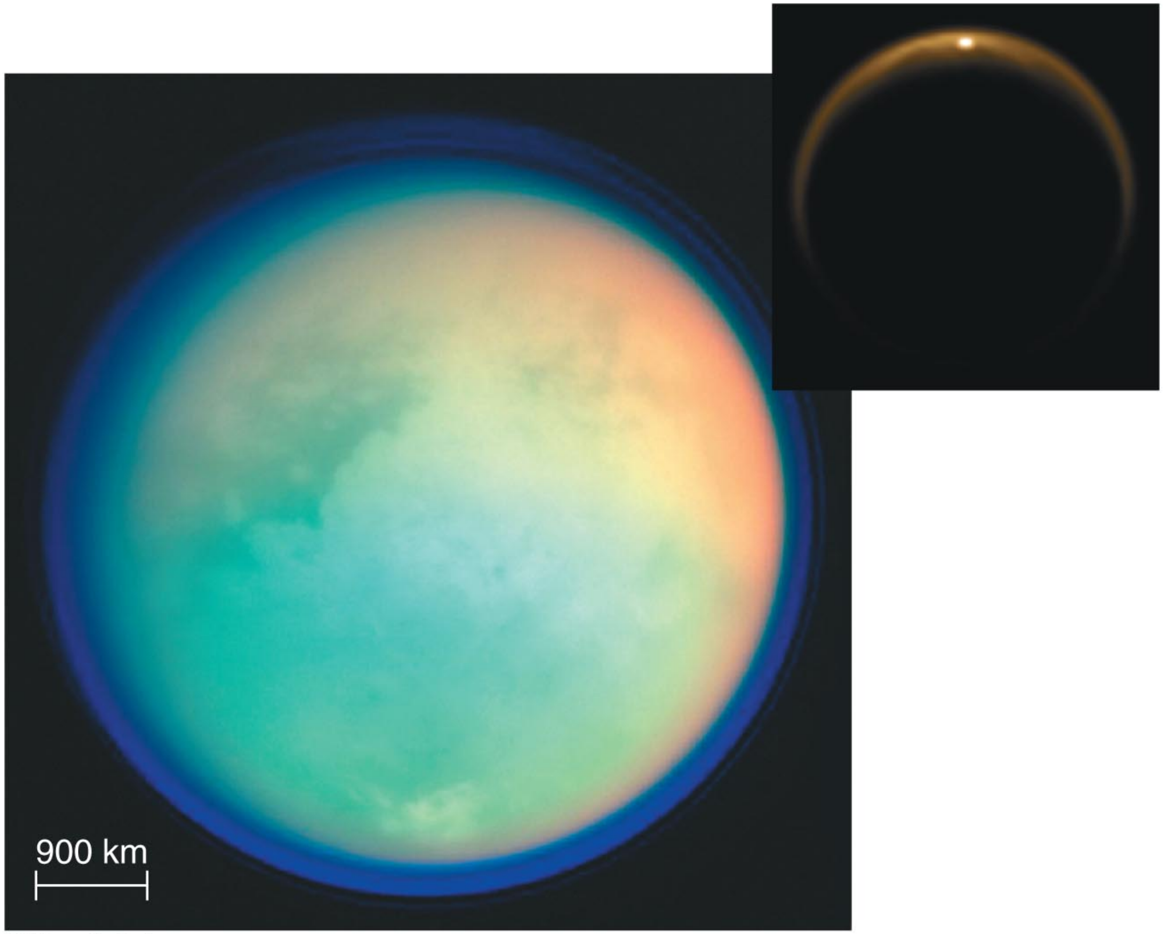


Ganymede



Callisto

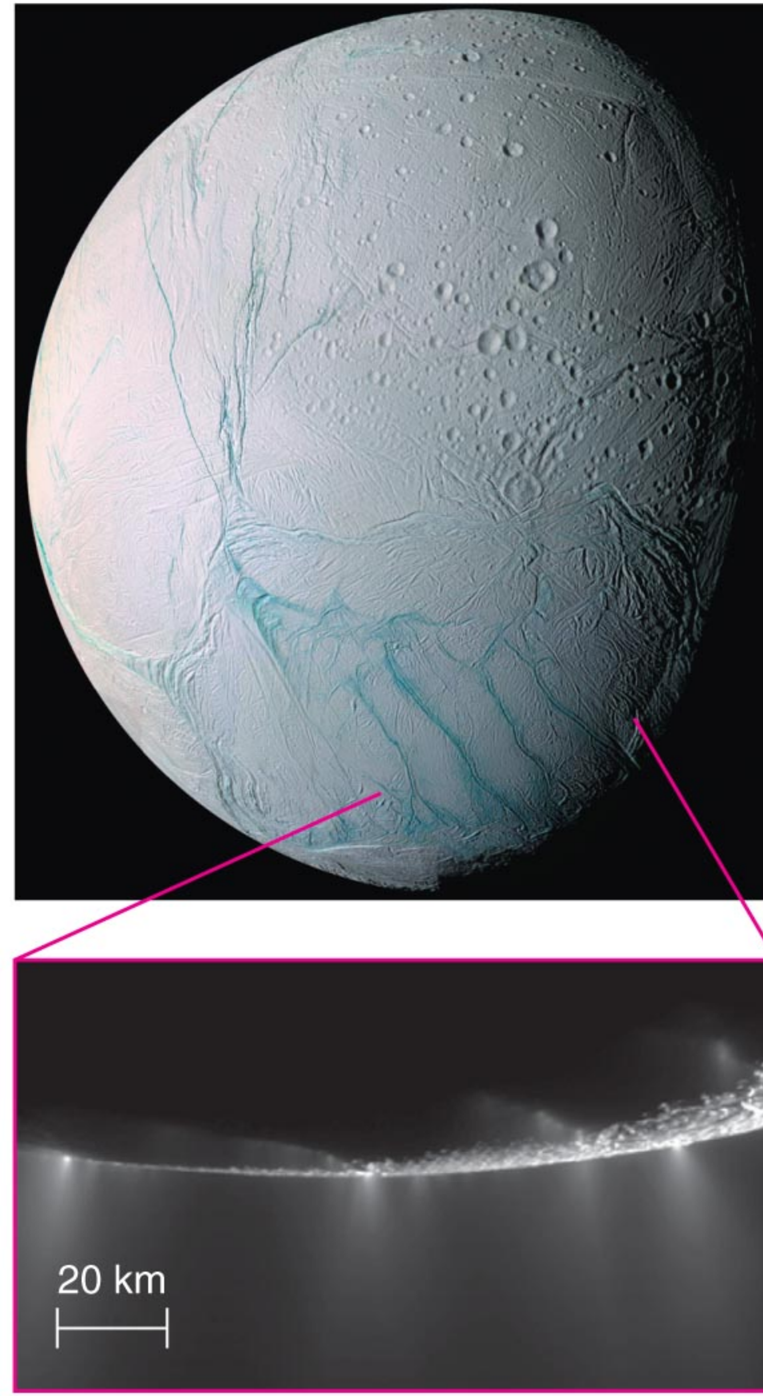
Titan



- The surface is too cold for liquid water (but there may be some deep underground).
- Has lakes of liquid ethane/methane on its surface.
- Most biologists think ethane/methane is a poor substitute for water

Enceladus

- Ice fountains suggest that Enceladus may have a subsurface ocean.
- Landing in an ice fountain + sample return would be far easier than drilling down below tens of km of Europa crust



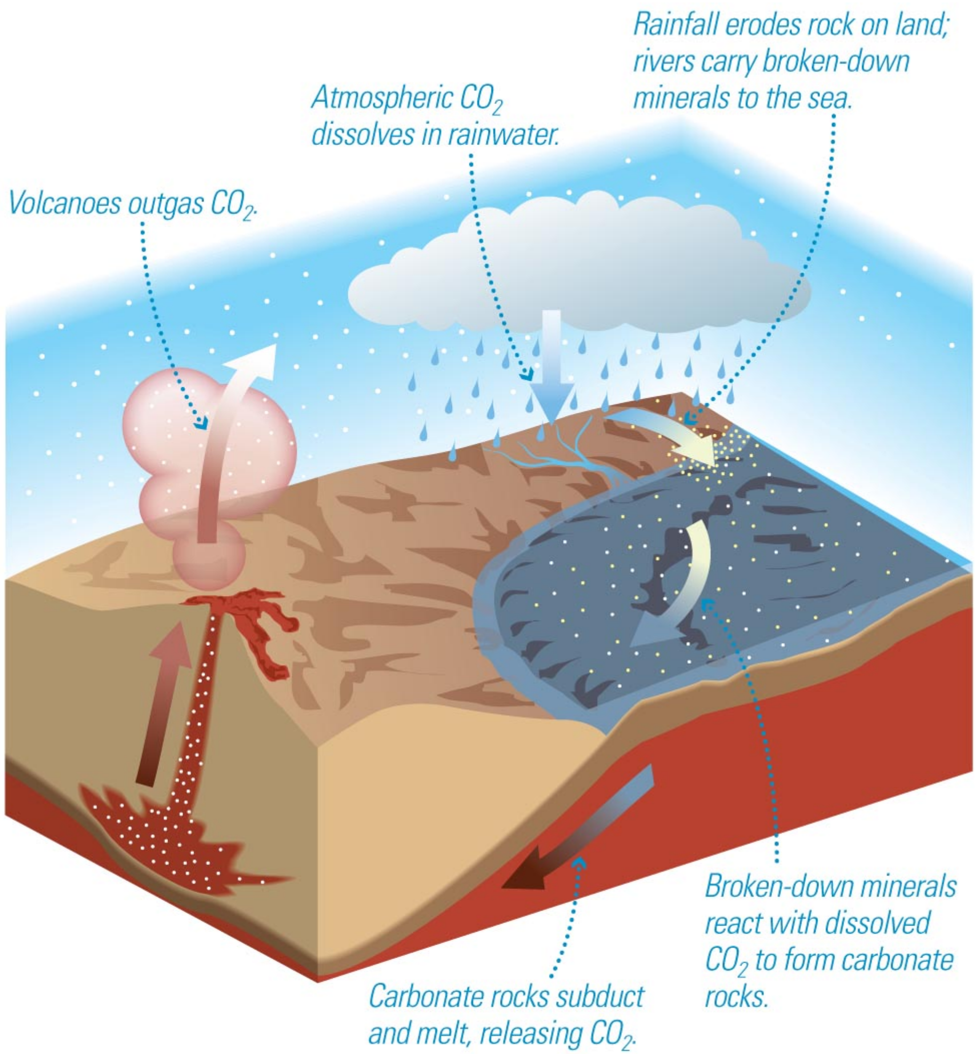
What have we learned?

- **Could there be life on Mars?**
  - Evidence for liquid water in past suggests that life was once possible on Mars.
- **Could there be life on Europa or other jovian moons?**
  - Jovian moons are cold but some show evidence for subsurface water and other liquids.

Impacts and Habitability

- Some scientists argue that Jupiter-like planets are necessary to reduce rate of impacts.
- If so, then Earth-like planets are restricted to star systems with Jupiter-like planets.

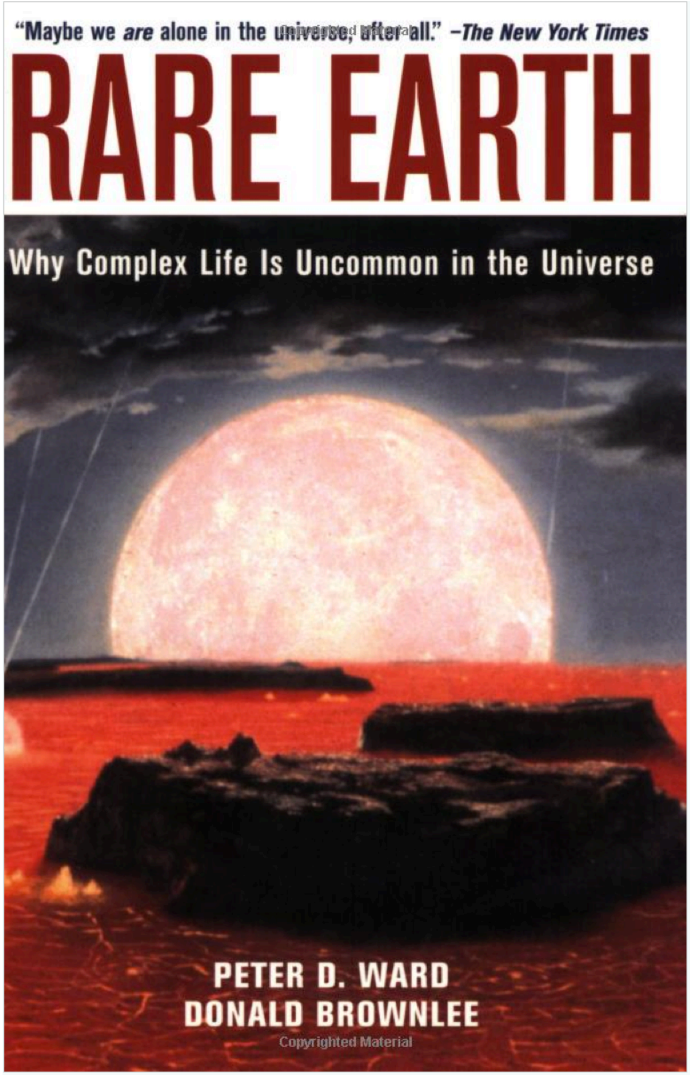
Climate and Habitability

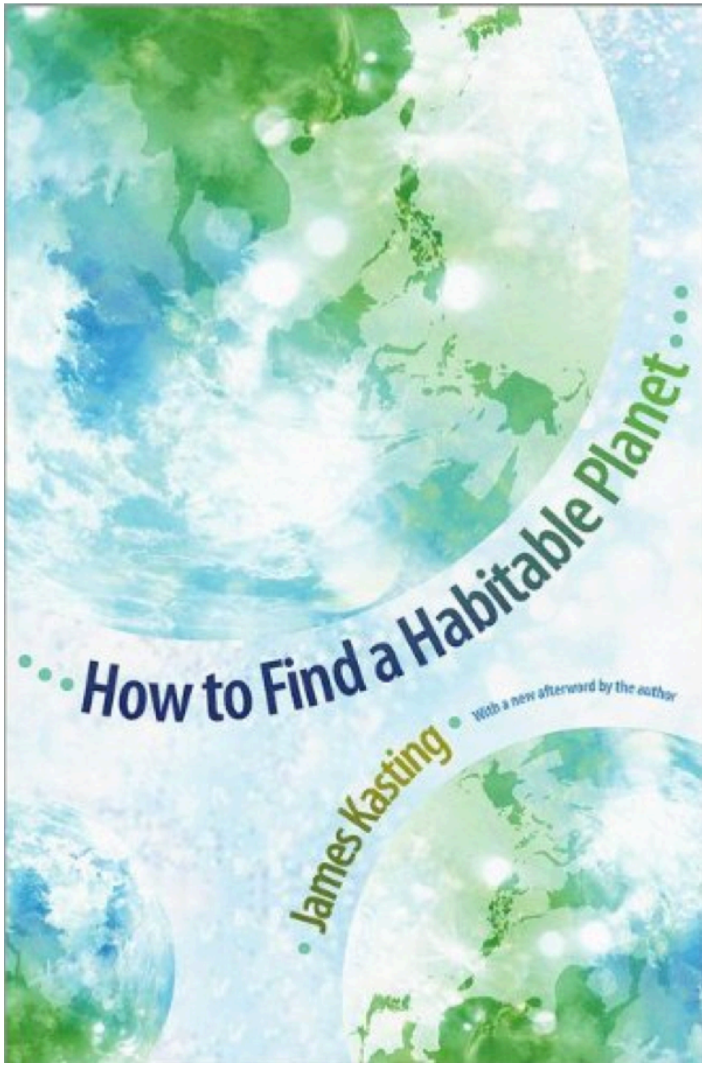


- Some scientists argue that plate tectonics and/or a large moon are necessary to keep the climate of an Earth-like planet stable enough for life.

The Bottom Line

We don't yet know how important or negligible these concerns are.

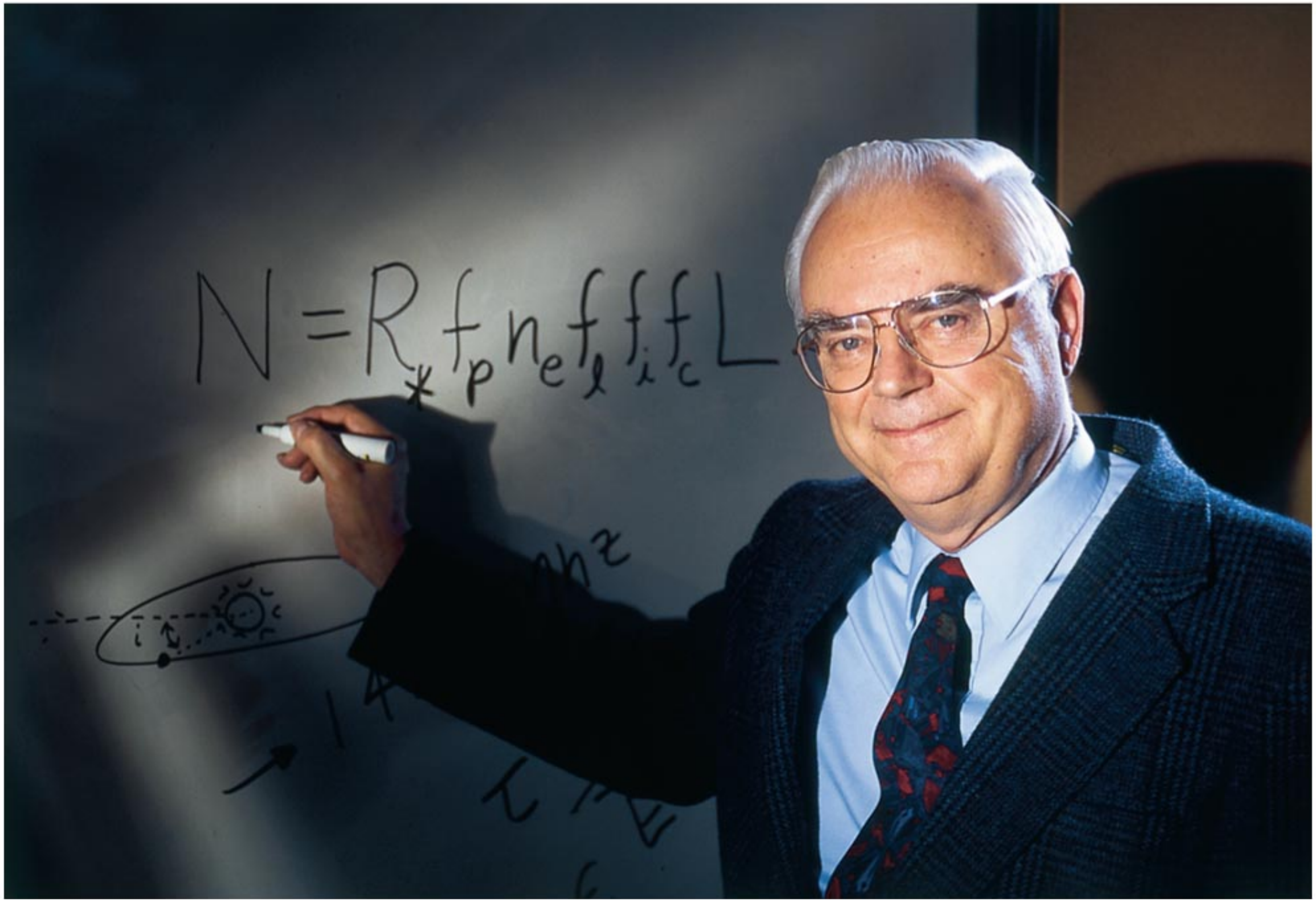




24.4 The Search for Extraterrestrial Intelligence

- Our goals for learning:
  - **How many civilizations are out there?**
  - **How does SETI work?**

How many civilizations are out there?



Frank Drake, long-time UCSC professor

The Drake Equation

- Number of civilizations with whom we could potentially communicate

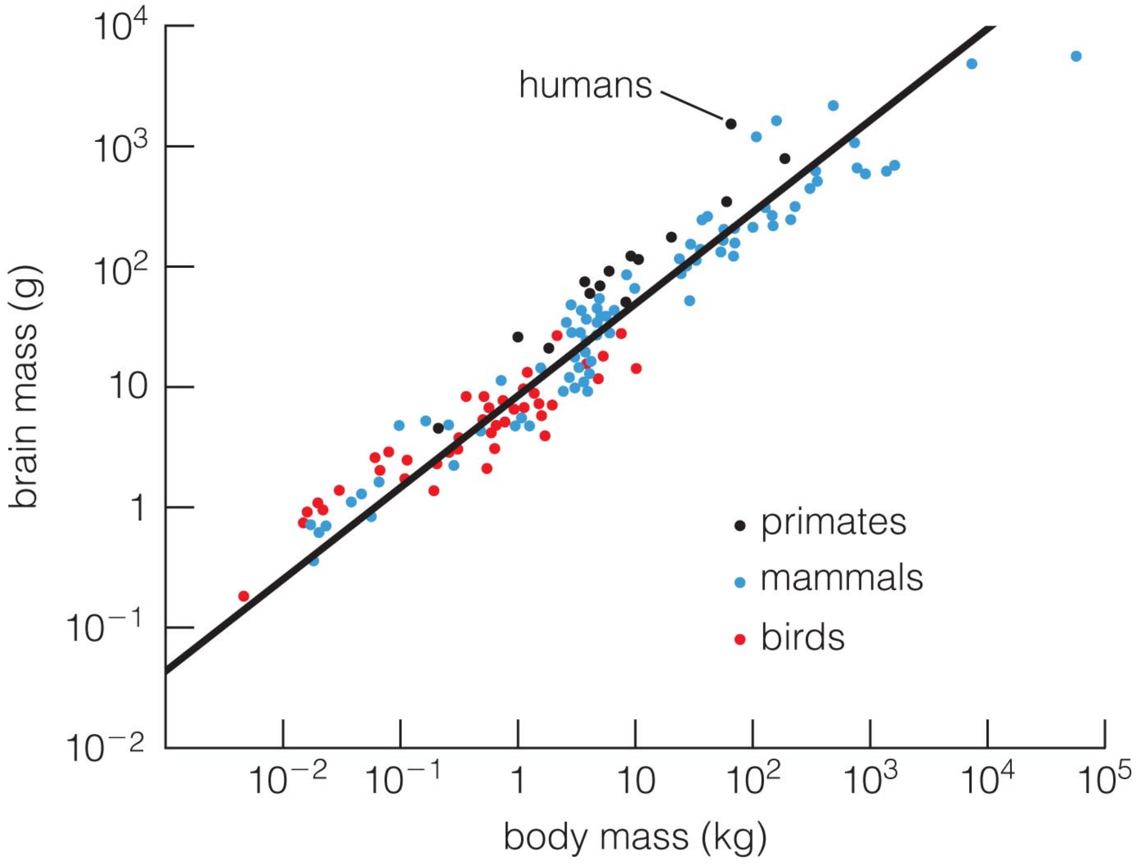
$$= \boldsymbol{N}_{\mathbf{HP}} \times \boldsymbol{f}_{\mathbf{life}} \times \boldsymbol{f}_{\mathbf{civ}} \times \boldsymbol{f}_{\mathbf{now}}$$

- N_{HP} = total number of habitable planets in galaxy
- f_{life} = fraction of habitable planets with life
- f_{civ} = fraction of life-bearing planets with civilization at some time
- f_{now} = fraction of civilizations around *now*

- We do not know the values for the Drake equation.

- N_{HP} : probably billions
- f_{life} : ??? hard to say (near 0 or near 1)
- f_{civ} : ??? took 4 billion years on Earth
- f_{now} : ??? depends on whether civilizations can survive long-term

Are we "off the chart" smart?



- Humans have comparatively large brains.
- Does that mean our level of intelligence is improbably high?

- SETI experiments look for **deliberate** signals from extraterrestrials

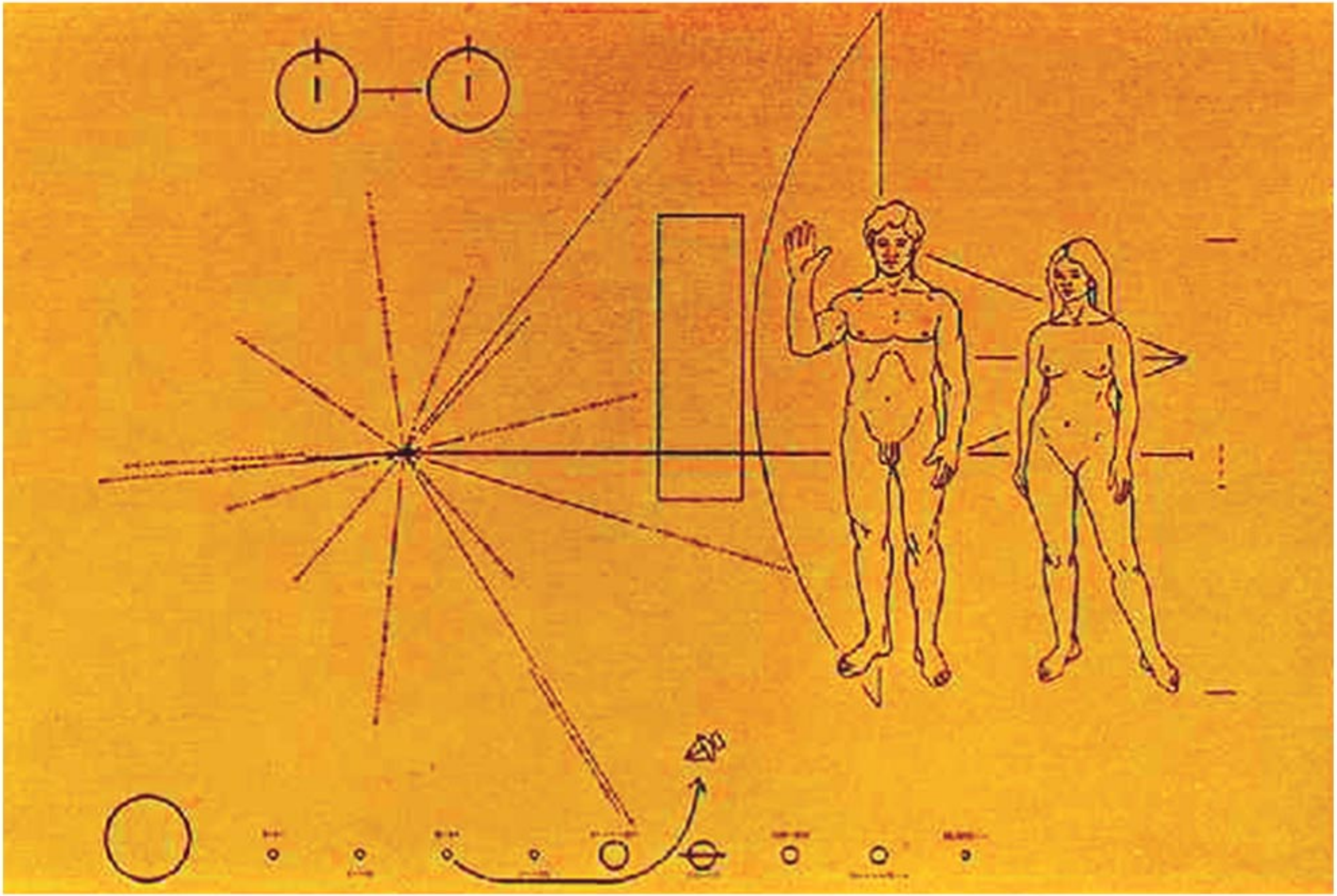
- We've even sent a few signals ourselves…

- Earth to globular cluster M13: Hoping we'll hear back in about 42,000 years!

What have we learned?

- **How many civilizations are out there?**
  - We don't know, but the Drake equation gives us a framework for thinking about the question.
- **How does SETI work?**
  - Some telescopes are looking for deliberate communications from other worlds.

Where are the aliens?

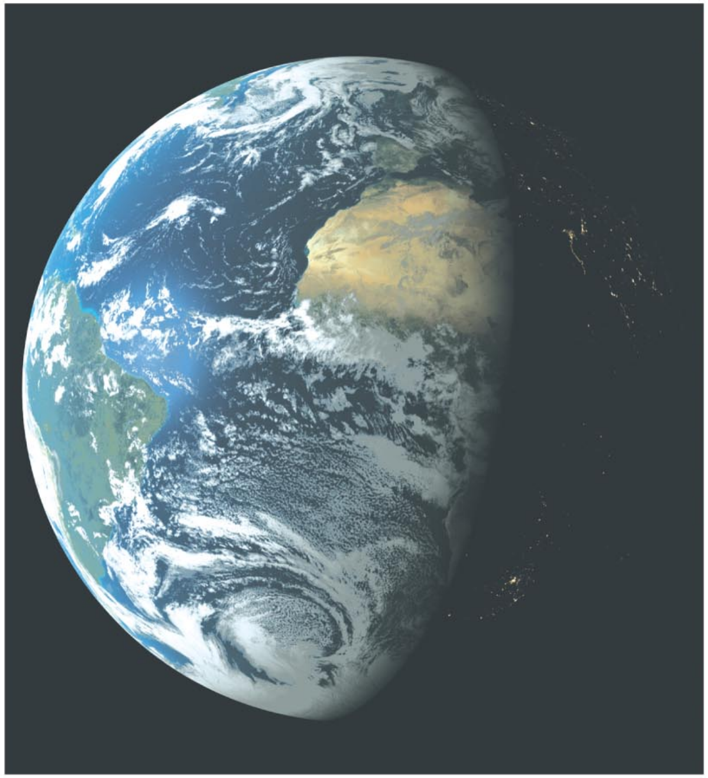


Fermi's Paradox

- Plausible arguments suggest that civilizations should be common. For example, even if only 1 in 1 million stars gets a civilization at some time $\Rightarrow$ 100,000 civilizations
- So why we haven't we detected them?

Possible solutions to the paradox

1) We are alone: life/civilization is much rarer than we might have guessed.
   – Our own planet/civilization looks all the more precious…



Possible solutions to the paradox

2) Civilizations are common, but interstellar travel is not because:
   - interstellar travel is more difficult than we think.
   - the desire to explore is rare.
   - civilizations destroy themselves before achieving interstellar travel.

- These are all possibilities, but not very appealing…

Possible solutions to the paradox

3) There IS a galactic civilization…
   … and some day we'll meet them.

What have we learned?

- **How difficult is interstellar travel?**
  - Interstellar travel remains well beyond our current capabilities and poses enormous difficulties.
- **Where are the aliens?**
  - Plausible arguments suggest that if interstellar civilizations are common then at least one of them should have colonized the rest of the galaxy.
  - Are we alone? Has there been no colonization? Are the colonists hiding? We don't know yet.

NATURE | NEWS

NASA funding shuffle alarms planetary scientists

Agency restructuring will postpone a major grants programme for one year.

Alexandra Witze

04 December 2013

Back in February 2000, the newly rebuilt Hayden Planetarium featured a space show called "Passport to the Universe," which took visitors on a virtual zoom from New York City to the edge of the cosmos. En route the audience saw Earth, then the solar system, then the 100 billion stars of the Milky Way galaxy shrink to barely visible dots on the planetarium dome.

I soon received a letter from an Ivy League professor of psychology who wanted to administer a questionnaire to visitors, assessing the depth of their depression after viewing the show. Our show, he wrote, elicited the most dramatic feelings of smallness he had ever experienced.

How could that be? Every time I see the show, I feel alive and spirited and connected. I also feel large, knowing that the goings-on within the three-pound human brain are what enabled us to figure out our place in the universe.

Allow me to suggest that it's the professor, not I, who has misread nature. His ego was too big to begin with, inflated by delusions of significance and fed by cultural assumptions that human beings are more important than everything else in the universe.

In all fairness to the fellow, powerful forces in society leave most of us susceptible. As was I . . . until the day I learned in biology class that more bacteria live and work in one centimeter of my colon than the number of people who have ever existed in the world. That kind of information makes you think twice about who—or what—is actually in charge.

From that day on, I began to think of people not as the masters of space and time but as participants in a great cosmic chain of being, with a direct genetic link across species both living and extinct, extending back nearly 4 billion years to the earliest single-celled organisms on Earth.