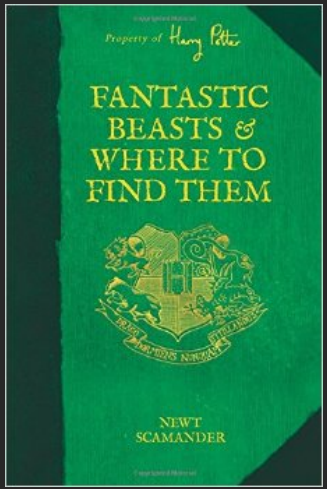
Announcements

- Check your lab scores. 0's went in and some things probably fell between cracks.
- You have a final!
  - Written to be around 1.5-2 times as long ($\approx$ 30 questions)
  - Have 3 hours to complete
  - Wednesday at 8am here
  - Study materials and old test posted
  - Should also consider studying from this semester's tests and polling questions
  - I'll be around pretty much all day Monday and Tuesday next week for questions
  - Email me if you'd like to try to reserve one of my spare calculators for test day!
- I'm serving breakfast Monday night! Come say hi!

What is Life? (Baby don't hurt me?)

In beginning our search for life, we need to pin down a rather fundamental detail:

- What constitutes life?
  - Is fire alive?
  - Are viruses alive?
  - Are there differences between organisms versus life-forms?



Life's Variety

- Erwin Schrodinger:
  - Matter which avoids decay into equilibrium
  - Something which uses energy to maintain an ordered state
- NASA:
  - Self-sustaining chemical system capable of Darwinian evolution
  - Ability for reproduction with transferable mutations

Classic Textbook Requirements

- Order: Molecules are arranged in orderly patterns that form cell structures
- Reproduction: Living organisms are capable of reproducing (or some members are)
- Growth: Living organisms grow and develop in patterns partially determined by heredity
- Energy: Living organisms use energy to fuel their activities
- Environmental Response: Living organisms actively respond to changes in their surroundings
- Adaptation: Life evolves through some form of natural selection

More a set of guidelines really. . .

Looking back at viruses:

- Viruses cannot reproduce by themselves
  - They need a host to take over their cell machinery
- They have a form of structure, but not actual cell structure
- They don't grow, they just replicate
  - But they DO evolve

Life

Things get fuzzy real fast, so think of our rules of life more like general rules of thumb (rules of thumbs?)

Copernican Principle

- We've always found ourselves wrong when assuming Earth to be special
  - Earth not center of solar system
  - Sun not center of galaxy
  - Nothing special about Milky Way either
- Would be surprising for life to have developed here but nowhere else
- The numbers by themselves would imply life developing somewhere, even if incredibly rare
  - Seem to be billions of stars in our galaxy that could have 1 or more planets
  - Should be billions in other galaxies as well

Fermi Paradox

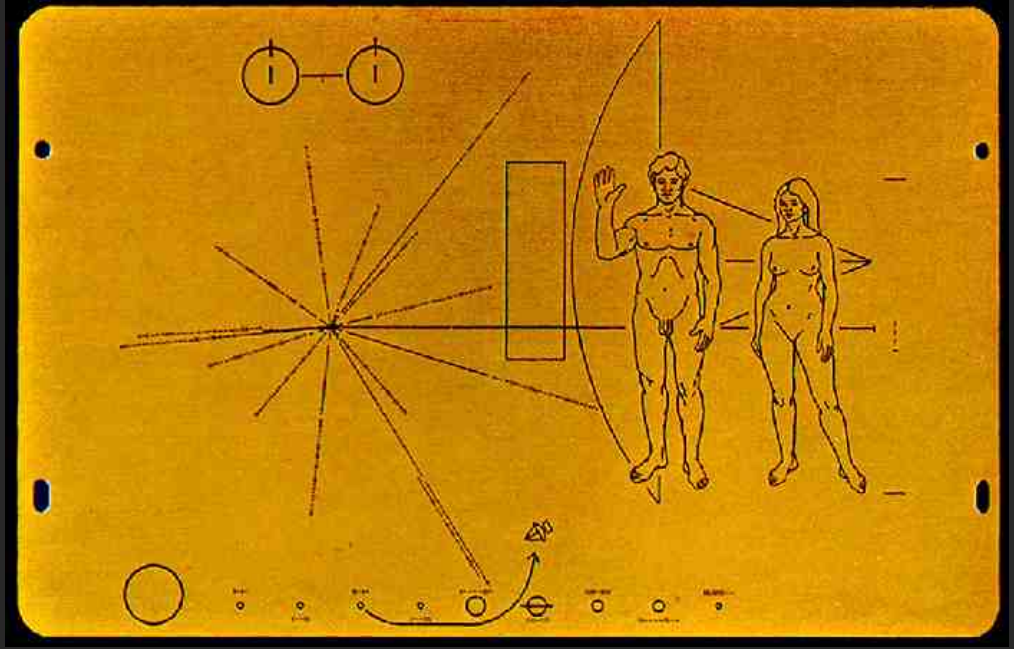
- Intelligent life has the ability to progress through technology
- If intelligent life is common, where is it?
  - Life is common but intelligence is not?
  - Data flowing past us that we can not yet detect?
  - Advanced species don't interfer? (Prime Directive?)
  - Civilizations self destruct past a certain technology threshold?
  - The Dark Forest?

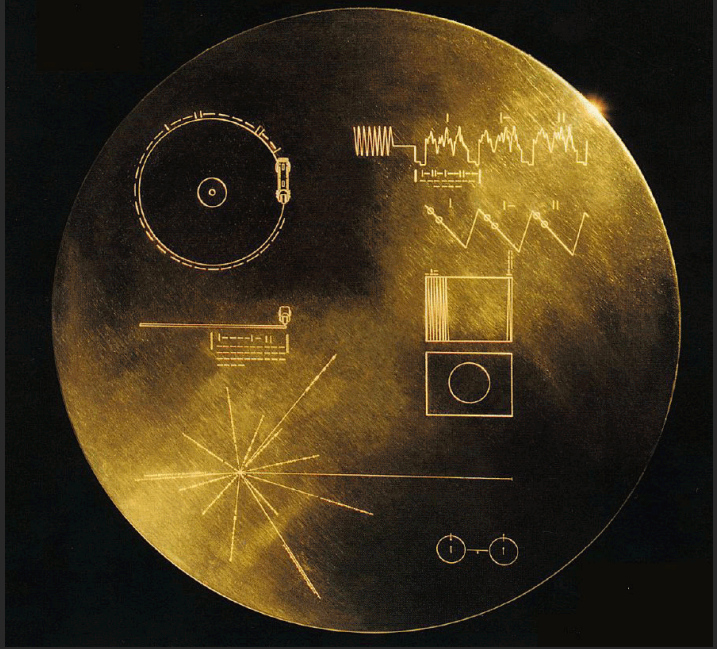
How could we detect life?

- Atmospheric Gases:
  - Large amounts of oxygen may be a good indicator, but not foolproof
  - Likely would need evidence of oxygen along with several other key gases (methane?)
  - What other events could cause similar signatures?
  - Earth's atmosphere only hit the needed level of oxygen 2 billion years ago. Could life have been detected the 1.5 billions years it was around before that?
- Direct observation
  - Picking up stray radio signals?
  - Laser communications?
  - Evidence of Dyson Sphere's?!

SETI

- SETI: Search for ExtraTerrestrial Intelligence
  - Looks for signals from extraterrestrial civilizations
  - Generally looking in both radio and optical
- METI: Messaging to ExtraTerrestrial Intelligence
  - Sends OUT information into the void, hoping to initialize a reply





Except from Voyager Record

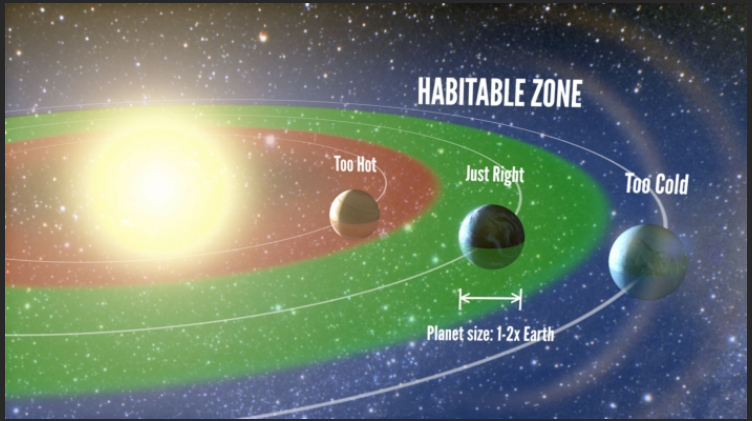
We cast this message into the cosmos. It is likely to survive a billion years into our future, when our civilization is profoundly altered... If another civilization intercepts Voyager and can understand these recorded contents, here is our message:

This is a present from a small, distant world, a token of our sounds, our science, our images, our music, our thoughts, and our feelings. We are attempting to survive our time so we may live into yours. We hope, someday, having solved the problems we face, to join a community of galactic civilizations. This record represents our hope and our determination, and our goodwill in a vast and awesome universe.

Light is so slow!

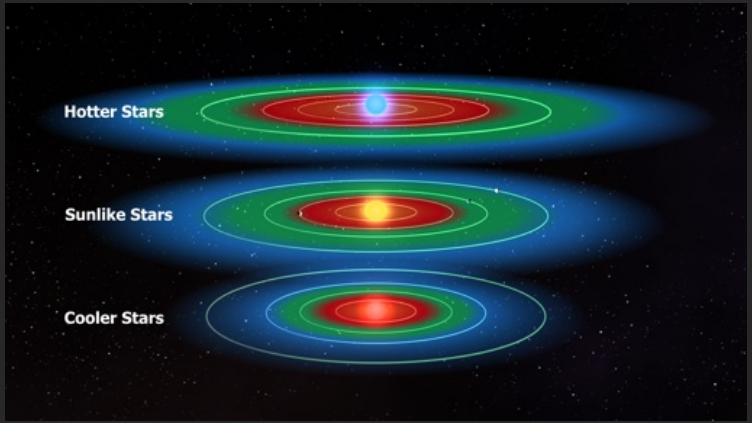
Where COULD life be living?

- Most life thought to be contingent on temperature
- Need planets that lie in the habitable zone



Gotta be juuuuust riggggght. . .

- Region where liquid water is possible
- Recent calculations suggest maybe 1 in 5 stars has an Earth-like planet that may be habitable!



The  Equation

- The Drake equation attempts to estimate the number of advanced civilizations currently existing in the galaxy!

$$\text{Number of Civs} = N_{HP} \times f_{life} \times f_{civ} \times f_{now}$$

  - N_{HP}: number of habitable planets
  - f_{life}: fraction of habitable planets with life
  - f_{civ}: fraction of life-bearing planets with adv communication species
  - f_{now}: fraction of civilization-bearing planets that exist now
- The only number we have any IDEA of at the moment is N_{HP}

Class Picture Time!

I need a class picture! (This is also your attendance for the day, so make sure I can see you!)

Teacher Evaluations

- Only an X to mark a bubble
- Fill in the bubble if you made a mistake and want to choose something else
- Comments are most useful to me, and much appreciated!
  - Feelings about homework, tests, or labs? What was good? What was bad? Suggestions?

- Volunteer?
  - Collect all forms upon completion
  - Place all forms, including blanks, into the envelope and seal it
  - Deliver promptly to Smullin 108
  - Thank you so much!!