Test 2 Results

Remember course grade is based on number of points including review questions, tests, extra credit

400+ A

325-399 B

250-324 C

200-149 D

- Lowest test score (out of 4) will be dropped
- Test 1 results average = 73 #exams approximate grade
  78-107 A 8

  64-77 B 8

  52-63 C 3

  41-50 D 1

Planetary Atmospheres

- Composition of a planet's atmosphere depends on
  - Surface Gravity
  - Temperature
- Light atoms/molecules move faster than heavy molecules
- If velocity >= escape velocity gas leaves planet
- Mercury, Moon: all escape
- Earth: lightest (H,He) escape
- Jupiter: none escape

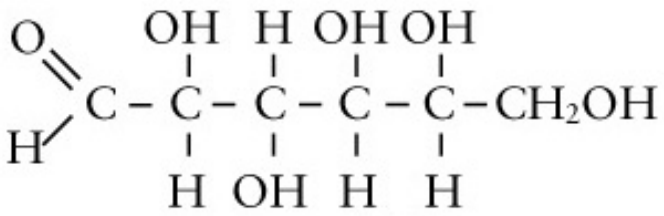
Life in the Universe

- 1 example of Life - Carbon-water based
- 1 example of "intelligence" → able to communicate with other "intelligent" life for about 75 years
- Intelligence = use Radio to send/receive messages
- Chemical building blocks (amino acids, water) plentiful in interstellar space
- Somehow about 1 billion years after Earth formed, bacteria appeared. All other life are probably descendants
- MACC's question: How **unique** is DNA as a replicating mechanism?

Life – Carbon+Water based?

Carbon vs Silicon? NO

Water vs other liquid or gas? Not sure but water seems to be the best medium



Glucose

"Ammonia! Ammonia!"

@R. Grossman 1962 New Yorker

Carbon or Silicon?

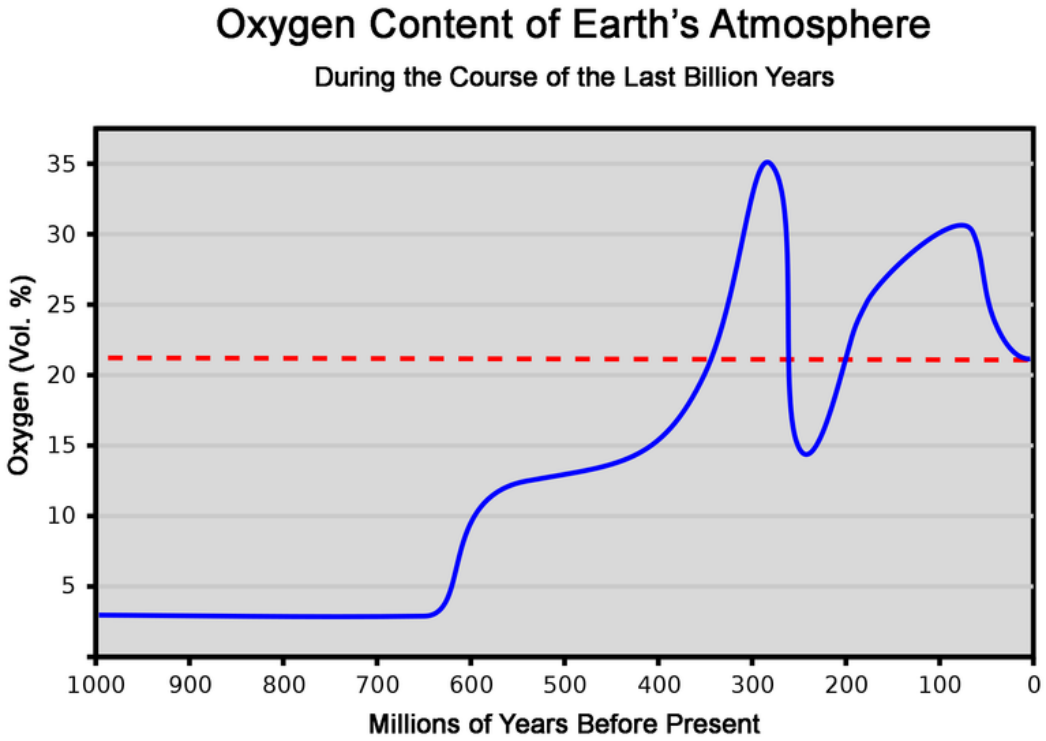
- **Mass:** silicon atom 2 X carbon atom → 20% of the mass of human body, weigh 20% more if carbon replaced with silicon. Slower, less agile bodies.
- **Size:** Silicon is bigger, less flexible. Carbon easily forms long, complicated organ molecules and flexible → myriad shapes needed to support a living body.
- **Radioactivity**: In carbon is not a problem: the radioactive isotopes have half lives in the thousands of years → no significant loss of body parts due to carbon decay.
- **Carbon chemistry** works with little more than C, H, O, and N, some of the most abundant elements in the universe, easy to combine in many different ways
- **Silicon chemistry:** primary form of silicon on earth, silicon dioxide, is immensely stable. Hard to break bonds → e.g. sand, carbon dioxide, is also stable, but less so…
- **Breakdown:** A few clever enzymes in plants can break down CO2 at room temp., electrons activated by sunshine; breaking down SiO2 needs concentrated energy ~ lightning (rare) - sunshine is all day long.

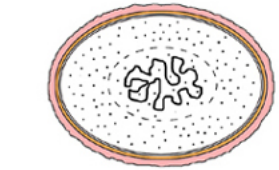
Minimal life form capable of self-reproduction is vastly more complicated with silicon than the simplest carbon-enzyme-based replicator.

Life on Earth

- 4.5 billion years ago Earth formed. About 1.5 billion years after that simple bacteria (prokaryote) appeared
- About 2 billion years after, complex life (eukaryote) appeared including algae which though photosynthesis started releasing oxygen
- Atmosphere changed, probably keeping warm enough so end of "iceball Earth"??

→ **Takes billions of years for complex life to develop**




Prokaryotic Cell


Animal (Eukaryotic) Cell

Other Life in Solar System?

- There is, or has been, liquid water on Mars and various moons of Jupiter (Europa, Ganymede, Callisto) and Saturn (Titan, Enceladus)→ look for signs of life.
- If ever find, is it of different origin then Earth's?
- More info about Mars then anywhere else: meteors from Mars and landings on the surface

Extra Terrestrial Intelligence

- Is there intelligent life on other planets?

  Drake equation estimates possibility in our galaxy

- Can we try to communicate?

  SETI = Search for Extra Terrestrial Intelligence

Drake Equation

$$N = R * f_p n_e f_l f_i f_c L$$

- N = number of "intelligent" civilizations in the Galaxy
- R* = rate at which solar type stars are formed
- f_p = fraction of stars which have planets
- n_e = number of planets suitable for life
- f_l = fraction of planets where life arises
- f_i = fraction of life that develops intelligence
- f_c = fraction of intelligent life that communicates
- L = lifetime of communicating intelligence

Possible Stars + Planets

Stars can't be

- Too large. Need lifetime more than 2 billion years
- Too small. habitable region not too close to star
- Too old. Need heavy elements C,O,N in "young" stars
- In binary system. Planet's temperature varies

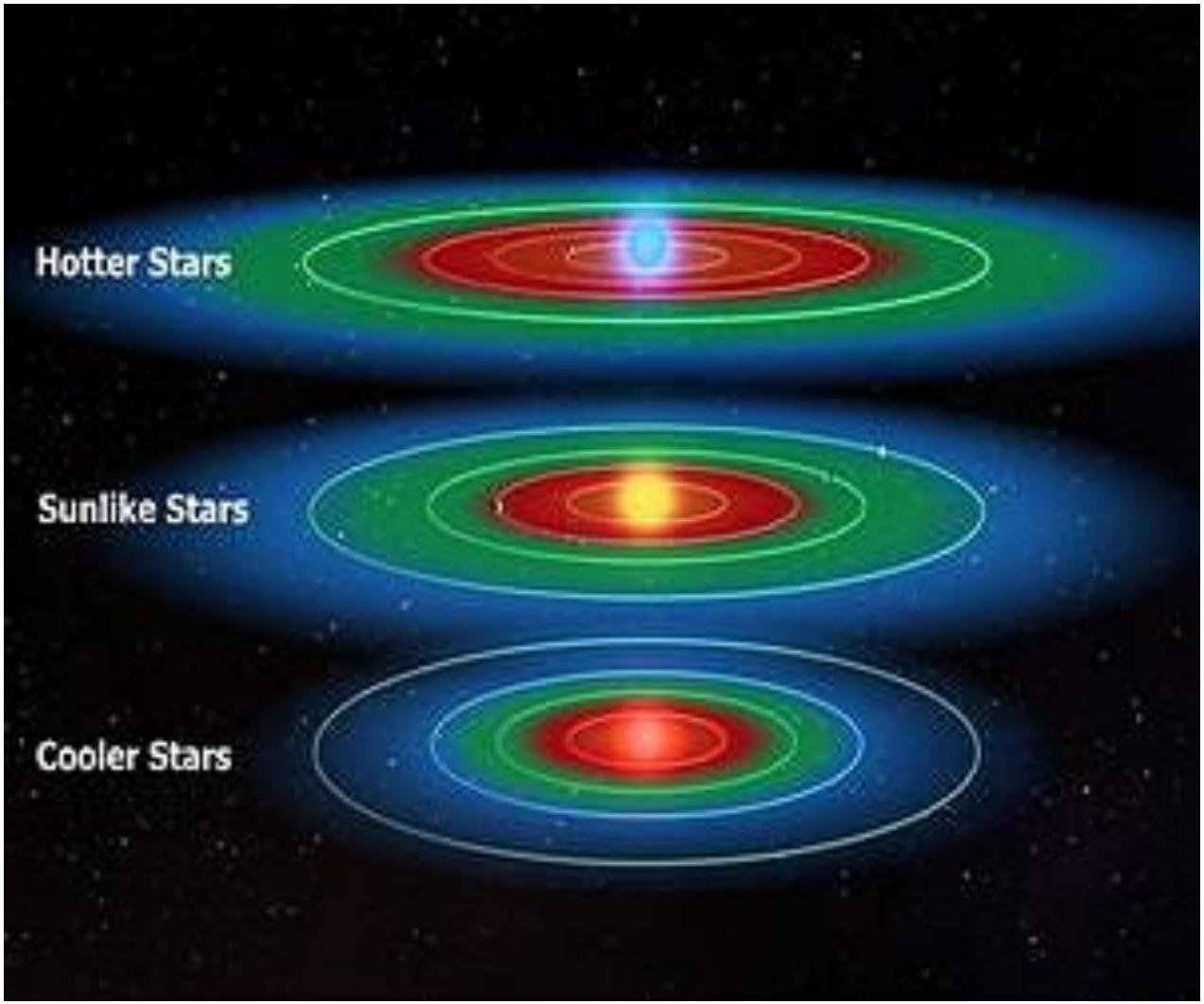
Planets can't be

too large or too small. want right atmosphere

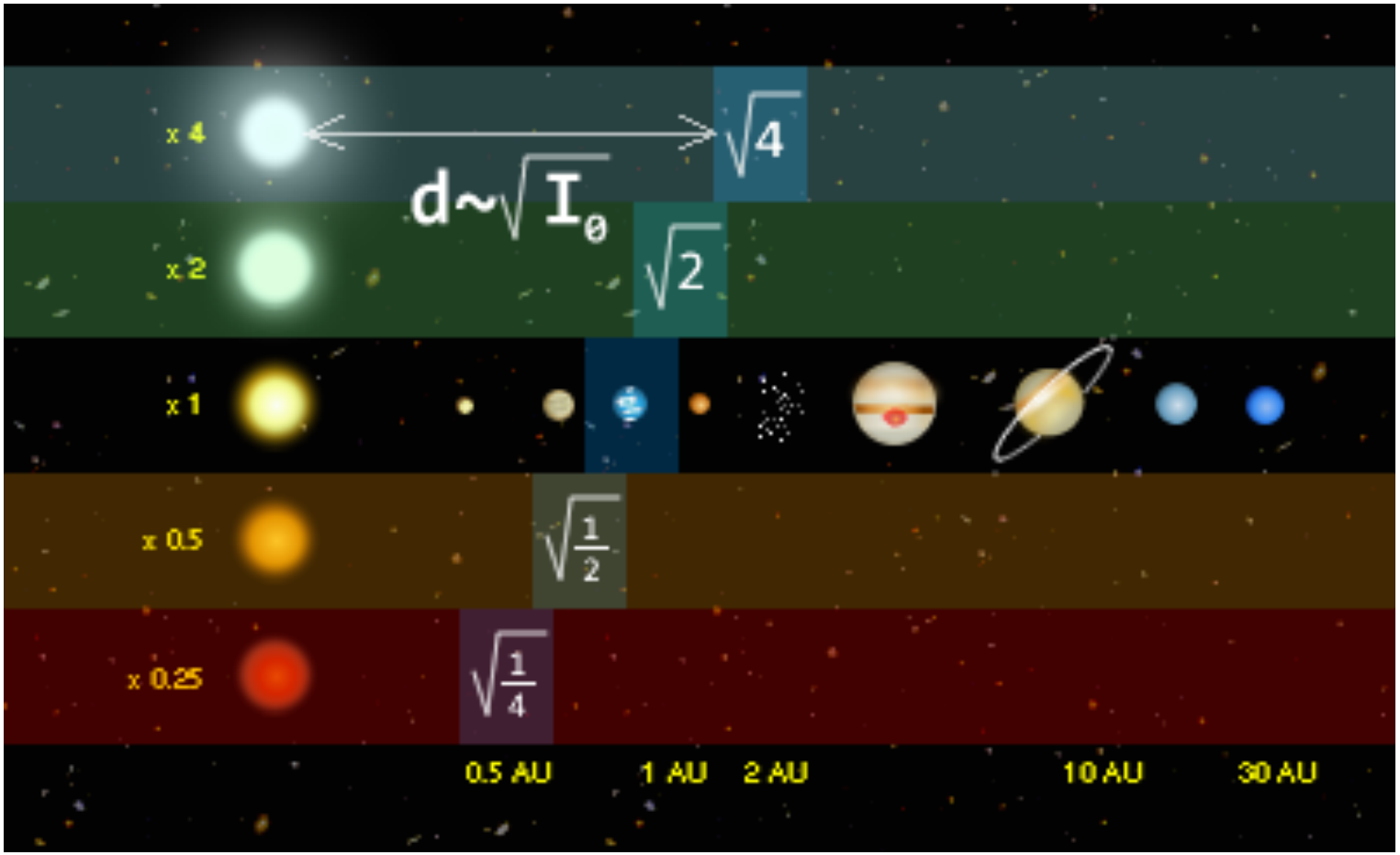
too hot or too cold. want temperature so liquid water

→ habitable zone about a star. For larger/hotter stars this will be further away

Habitable Zone



Habitable Zone



Evolution of Intelligence+ Technology

- Probability of evolution: simple to complicated to intelligent life?
- How probable is the development of technology?

  Me, DH:NOT VERY Carl Sagan: VERY
- Dolphins do not need technology
- How did humans evolve?

  opposable thumb

  communication

  slow and weak - did this necessitate brains? Tools?

tools → technology in some cultures but not in others

Length of Survival of "Intelligence"

- For human culture, anyone's guess. 100 to 100,000,000 years
- Large asteroid: 1 of 5 mass extinctions
- Large volcano: 4 of 5 mass extinctions
- Environmental catastrophes (global warming, ozone, insecticides)
- Nuclear/biological war
- Plague
- Humans could also become uninterested in SETI

Length of Survival of "Intelligence"

DH's ideas about this: **Most species are extinct**

Let's review recent history (since your grandparents have been alive)

1. Nuclear War (Diverted… for now)
2. Pesticides (Government intervened)
3. Ozone layer depleted (Government intervened)
4. Global Warming (Governments unable to intervene)
5. GMO's (Some governments have limited)

→ Jimmy Carter started clean technology

→ Ronald Reagan cancelled Carter's programs

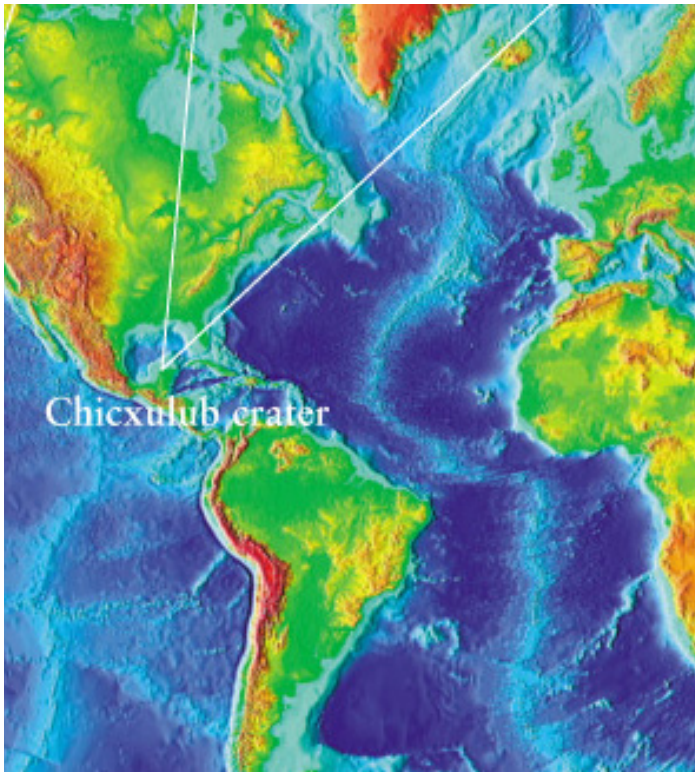
→ Fracking, coal, tar sands oil, increase emissions…

→ Very few number of unwise individuals making decisions for the entire planet…

We will need to reverse recent history in a profound and global manner – not likely

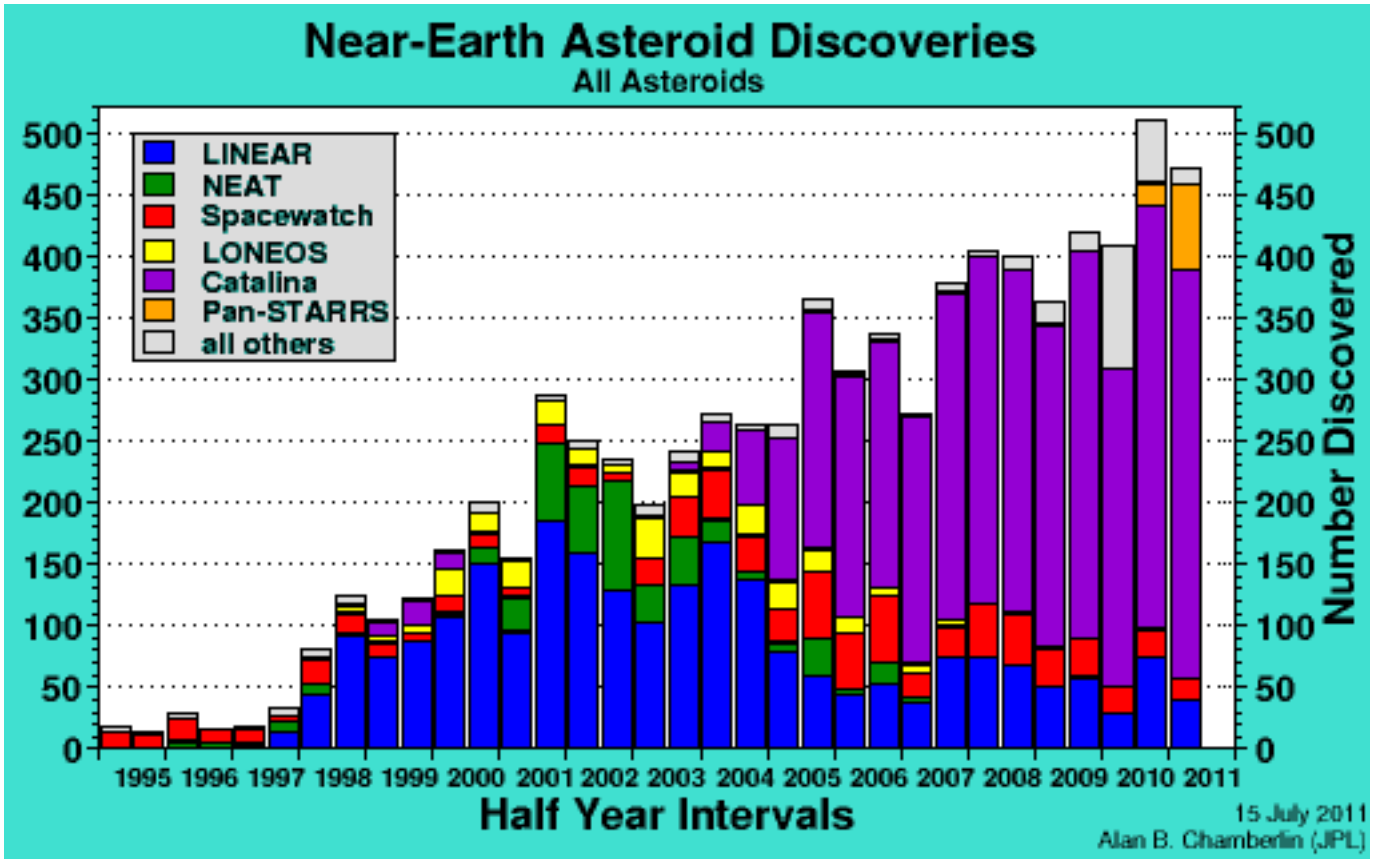
Asteroids, Comets and Meteors

Meteor crater in Arizona, from 50,000 years ago



Meteor crater in Yucatan, from 65,000,000 years ago

Near Earth Asteroid Tracking NEAT

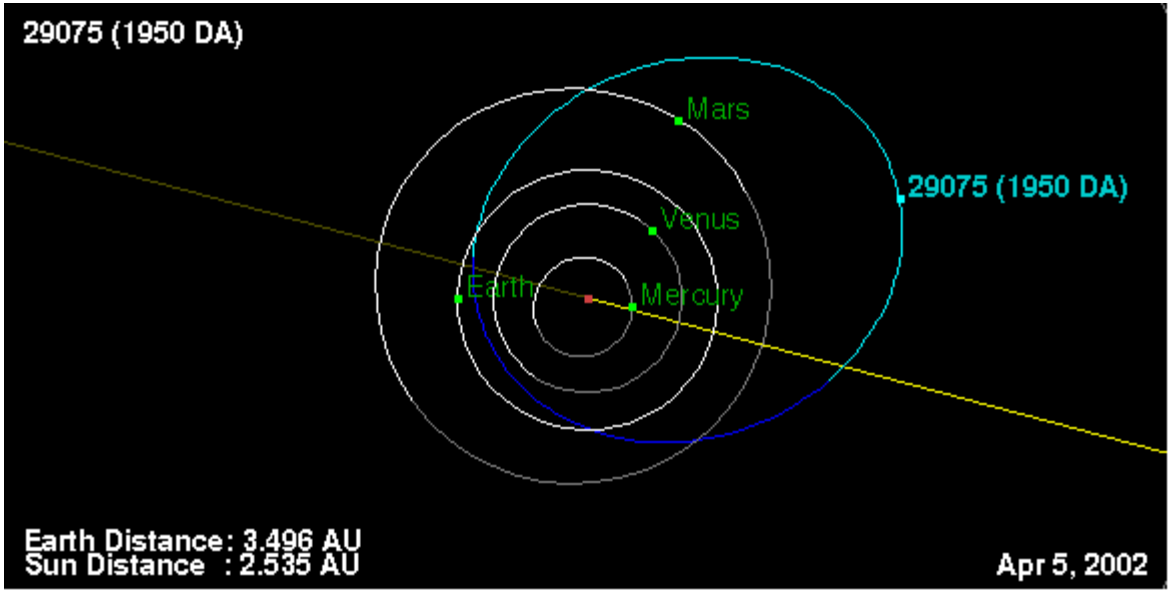


Look for and track all objects > 1 km in diameter, close to Earth. ~1200 are "potentially hazardous"

Near Earth Asteroids

(29075) 1950 DA is notable for having the highest known probability of impacting Earth (between 0 and 0.33%). Would happen on March 16, 2880. But orbit can change with time....

mass about 3 billion tons



Drake Equation

– Guess at values (better as more planets known) – get number of CURRENT civilizations

- R* = rate at which solar type stars are formed 1 per year
- f_p = fraction of stars which have planets 1
- n_e = number of planets suitable for life 0.01 - 0.1 ??
- f_l = fraction of planets where life arises 0.001 - 0.1 ?????
- f_i = fraction of life that develops intelligence 0.0001 - 0.5 ???????
- f_c = fraction of intelligent life that communicates 0.0001- 0.9 ??????
- L = lifetime of communicating intelligence 100 - 250,000 years ???
- N = # of "intelligent" civilizations in the Galaxy = 1000 (optimistic)

  OR = 1 (us possibly realistic)

Communicating with ET

- Send a spaceship

  Too slow. velocity is at most .001 times light speed so more than 3000 years to nearest star

- Send a radio/TV message (and listen for them)

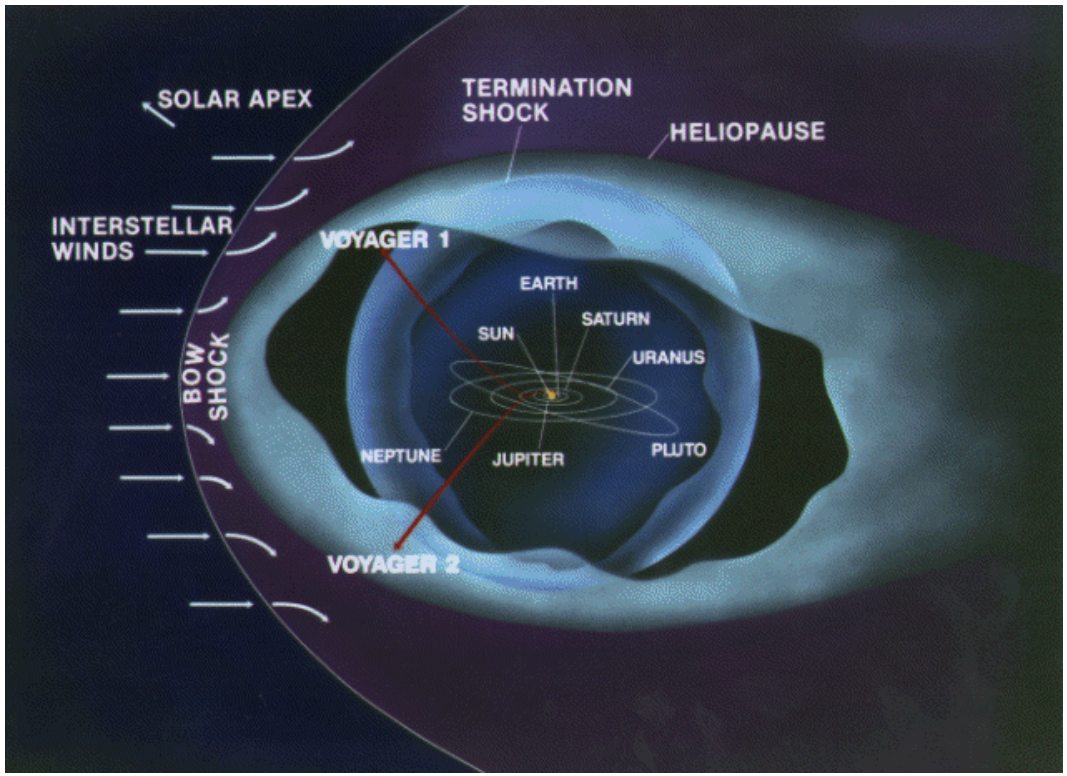
  Travels at speed of light over a wide area

  What frequency?

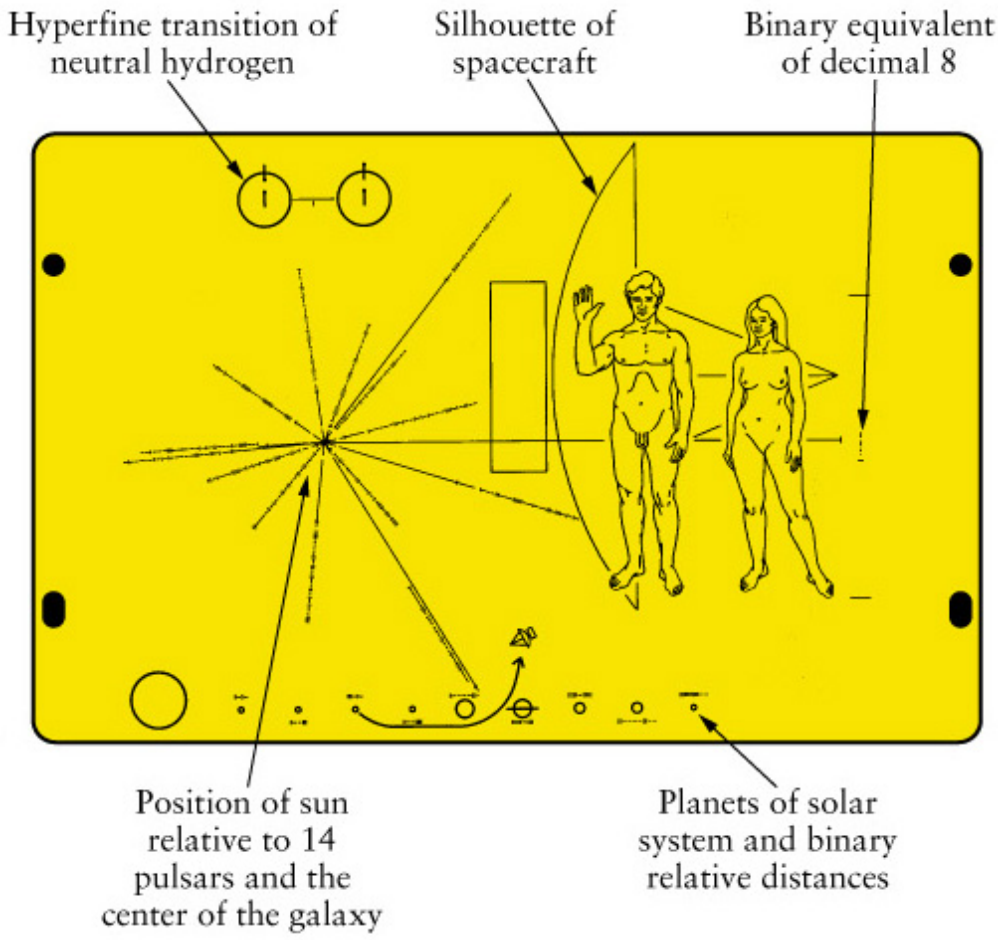
  What message?

  What direction? maybe in time have a list of found Earth-like exoplanets, improve probabilities

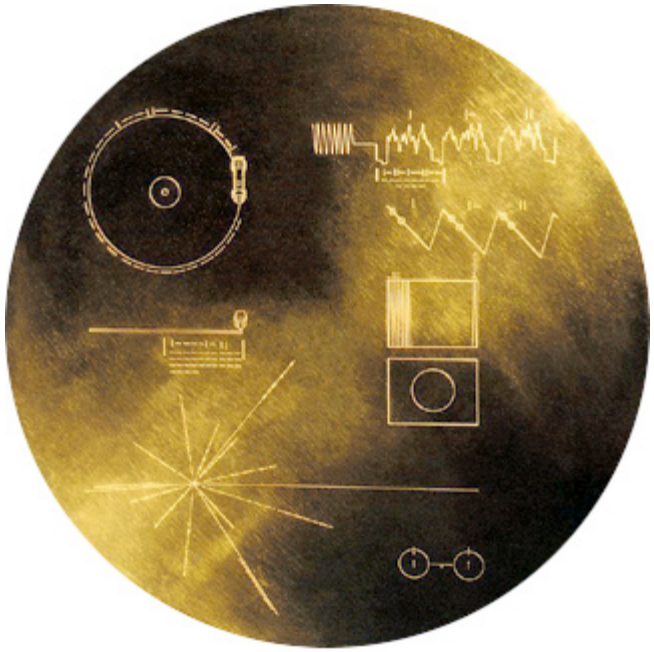
Communicating with ET: spacecraft



- Pioneer 10+11 and Voyager I+II launched in 1973+1977
- Now "outside" solar system. Can still communicate with the Voyager crafts at 117 AU from Sun
- Contain plaques and records for ET to find



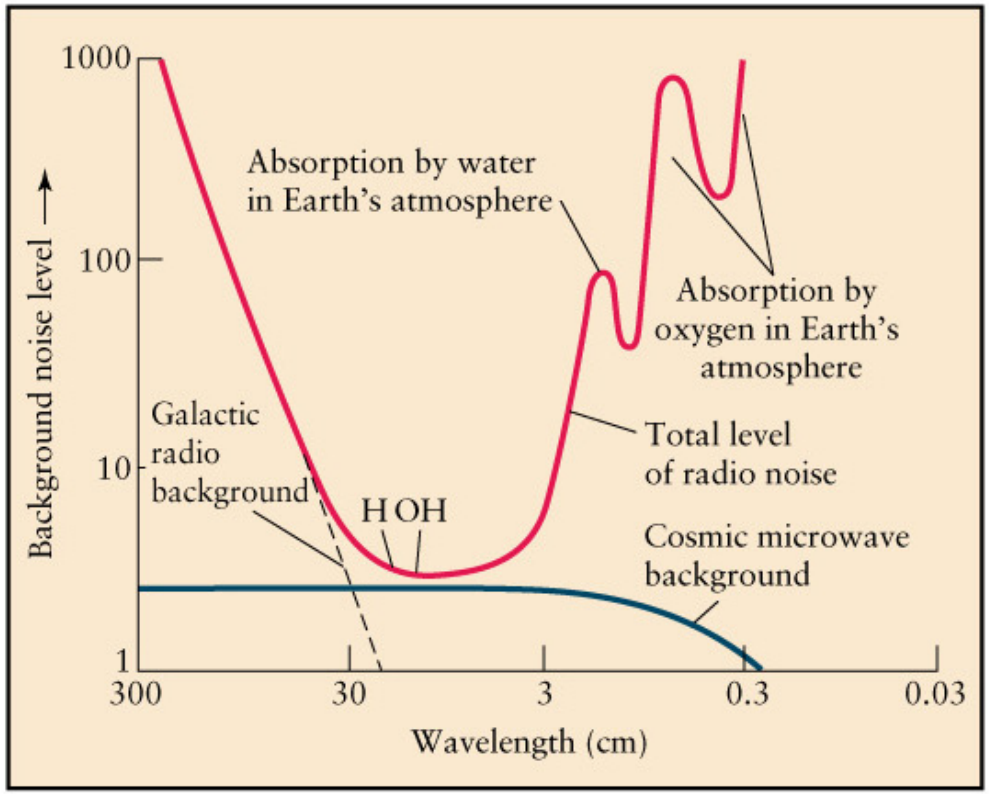
- Pioneer plaque



- Voyager record includes "Hello" in many languages, Richard Nixon, and 90 minutes of music from Javanese to Bach to Chuck Berry
- SNL joke. first message from aliens "send more Chuck Berry"

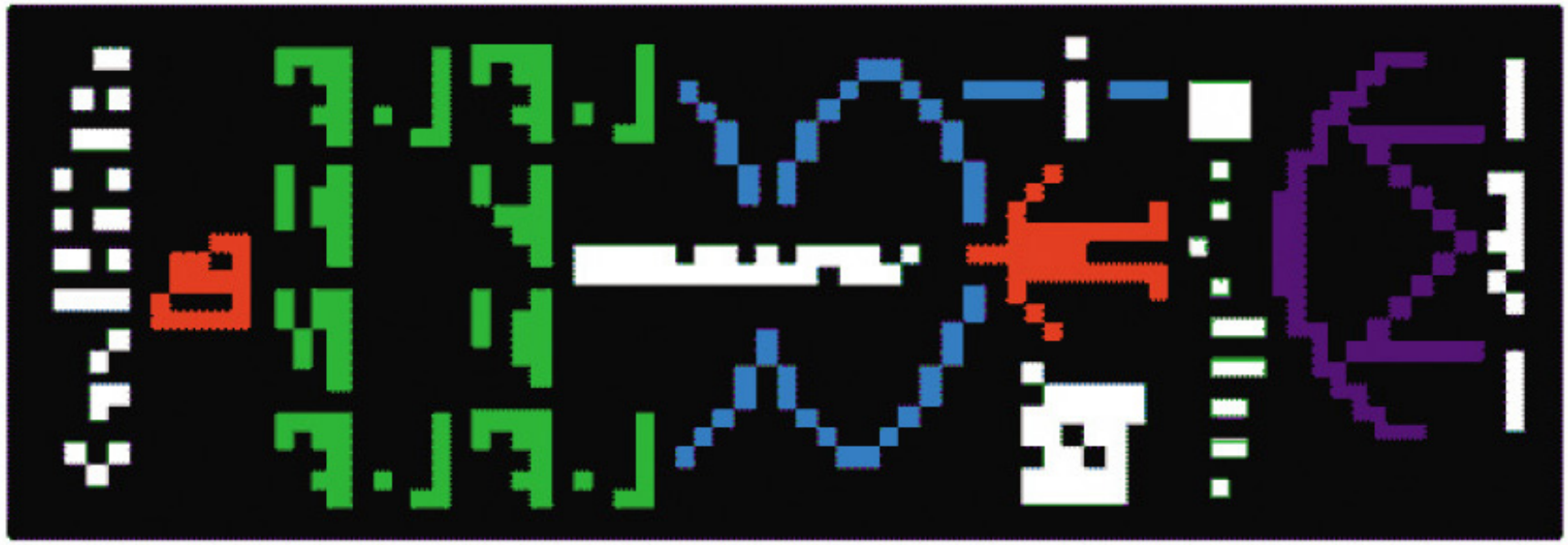
Communicating with ET: Radio

What frequency? Microwave is most quiet.
One of water's frequencies?

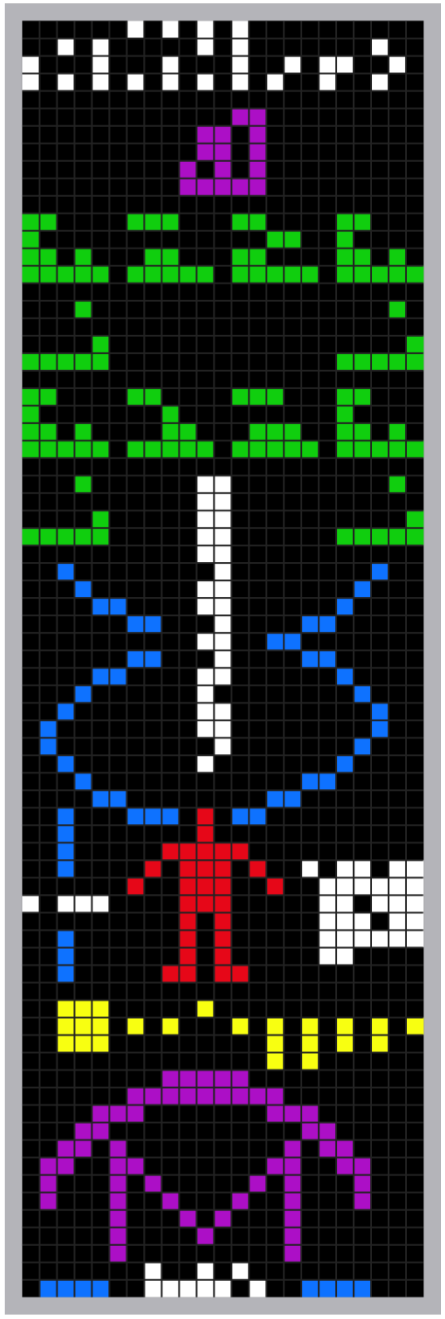


Communicating with ET: Radio

What message? See movie Contact (from Carl Sagan's book). Signal sent in 1974



23 columns by 73 rows = 1679 bits (either 0 or 1)



Numbers 1 to 10

Elements H (1) C(6) N(7) O(8) P(15)

Nucleotides (like phosphate and adenine)

DNA double helix including the number of base pairs in human genome

Human with height (left) and population (right)

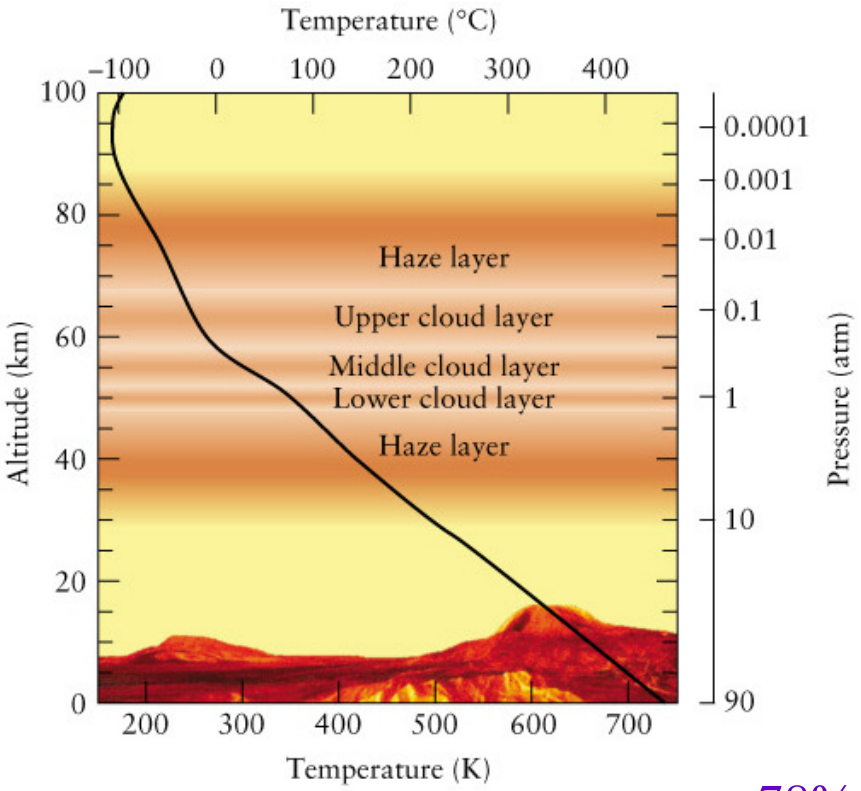
9 planets plus Sun with Earth shifted

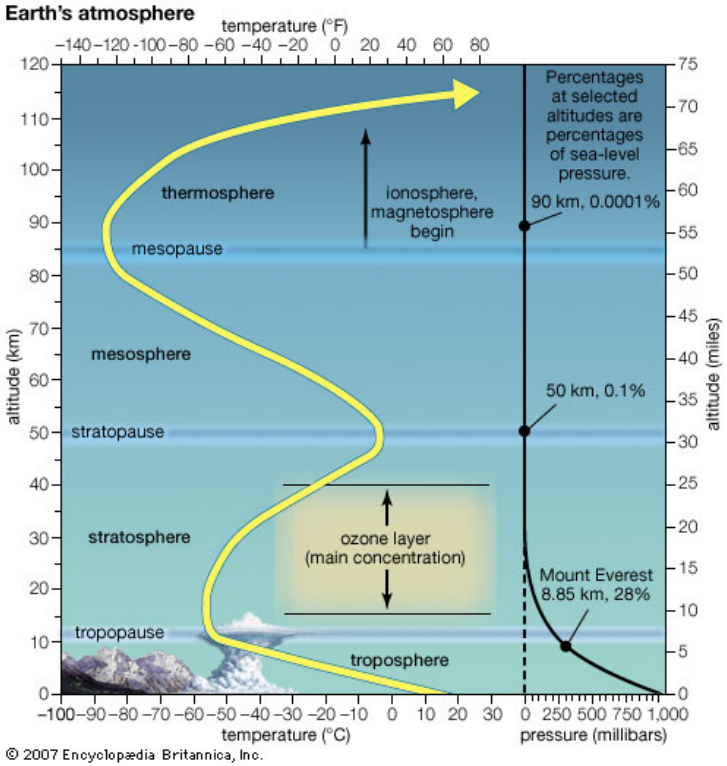
Arecibo telescope with diameter noted on bottom

Familiar Molecules

molecule	mass
H_2 hydrogen	2
He helium	4
CH4 methane	16
NH3 ammonia	17
H20 water	18
N2 nitrogen	28
O2 oxygen	32
CO carbon monoxide	28
CO2 carbon dioxide	44

Atmosphere of Venus vs Earth





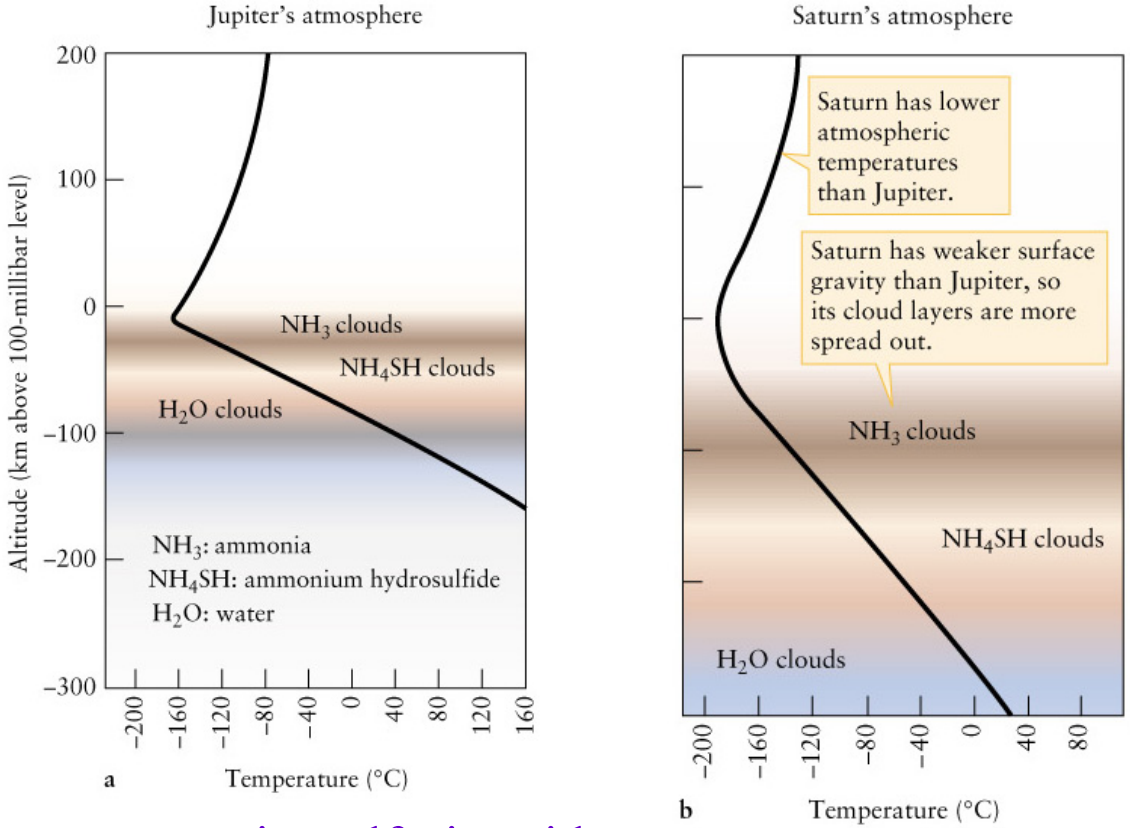
96.5% CO2, 3% N2

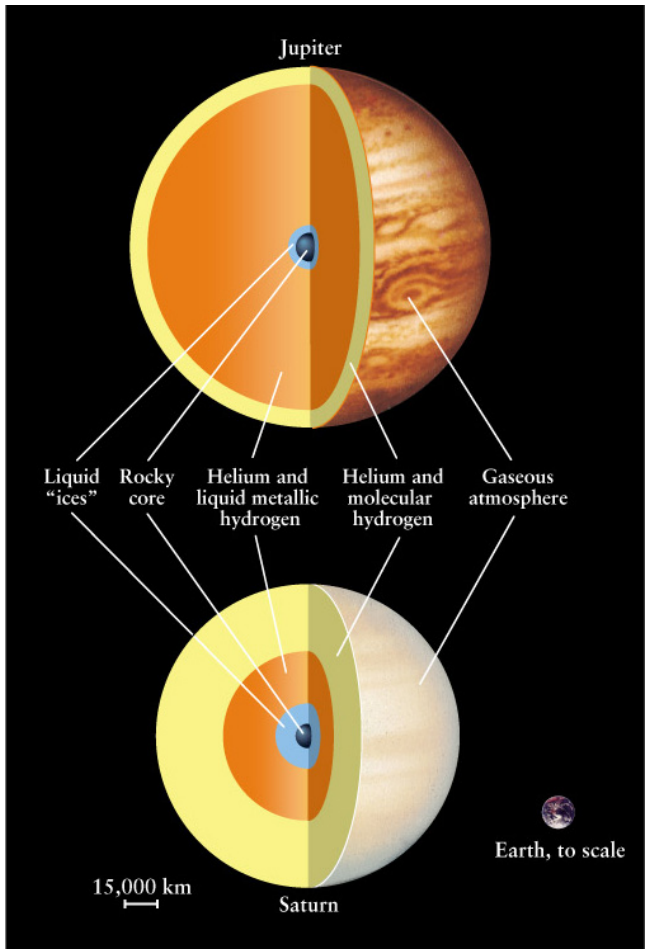
runaway greenhouse effect

78% N2, 21% O2, 0.04% CO2, ~1% H20. most CO2 absorbed by oceans

Titan, moon of Saturn, has ~90% nitrogen rest mostly methane and argon; pressure similar to Earth

Atmosphere of Jupiter and Saturn





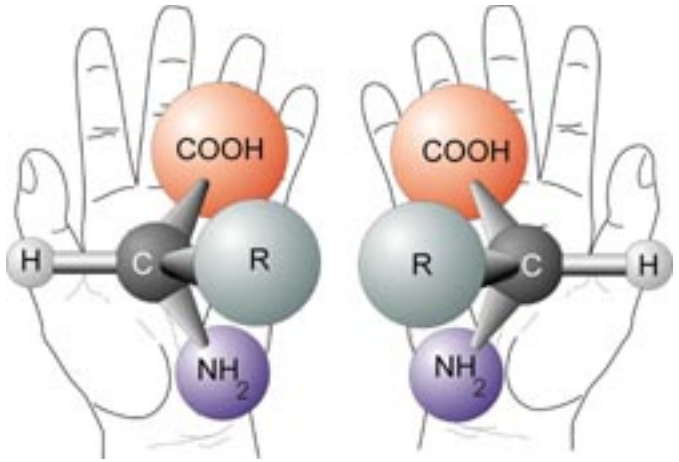
ammonia, sulfuric acid, water

interiors are helium and hydrogen, core of ice/rock

Titan, moon of Saturn, has ~90% nitrogen rest mostly methane and argon; pressure similar to Earth

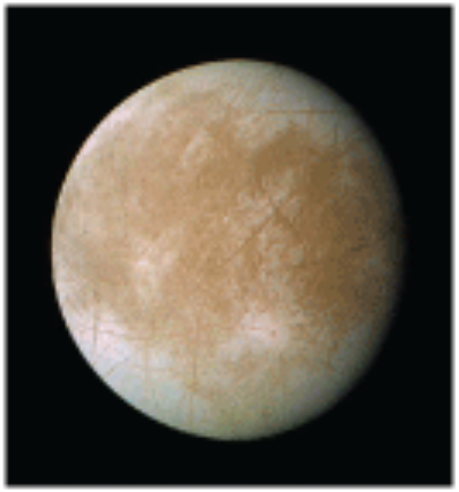
Life on Earth

- Appears all current life descended from same ancestor
- All use DNA and RNA and amino acids
- All use ATP for storing/using energy
- Amino acids come in both left-handed and right-handed versions. All life uses left-handed exclusively



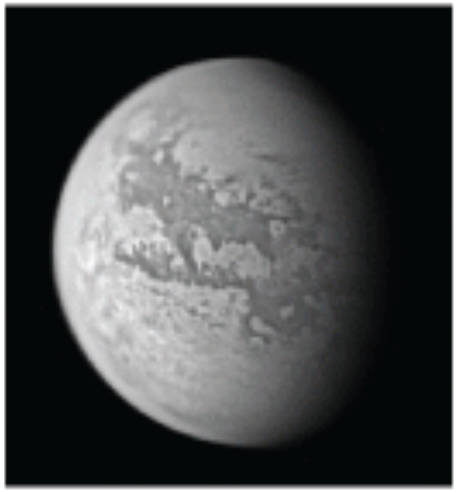
Best Bet: Moons of Jupiter and Saturn

●WATER ●ORGANICS ●NITROGEN ●ENERGY



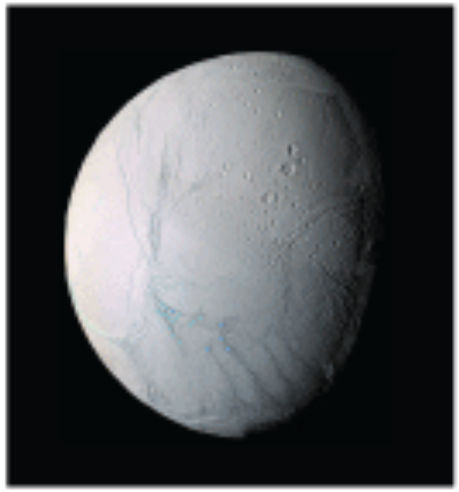
Europa ●

Water is abundant on Europa in the form of an ocean sloshing beneath the icy crust. Scientists don't yet know whether nitrogen or organics are present, but some think hydrothermal vents might erupt from the seafloor and power life.



Titan ●●●

The surface of Titan sits beneath a thick, nitrogen-containing atmosphere and is soaked in organic hydrocarbons, which could serve as an energy source. Whether a water ocean lurks deep underground is not yet known.



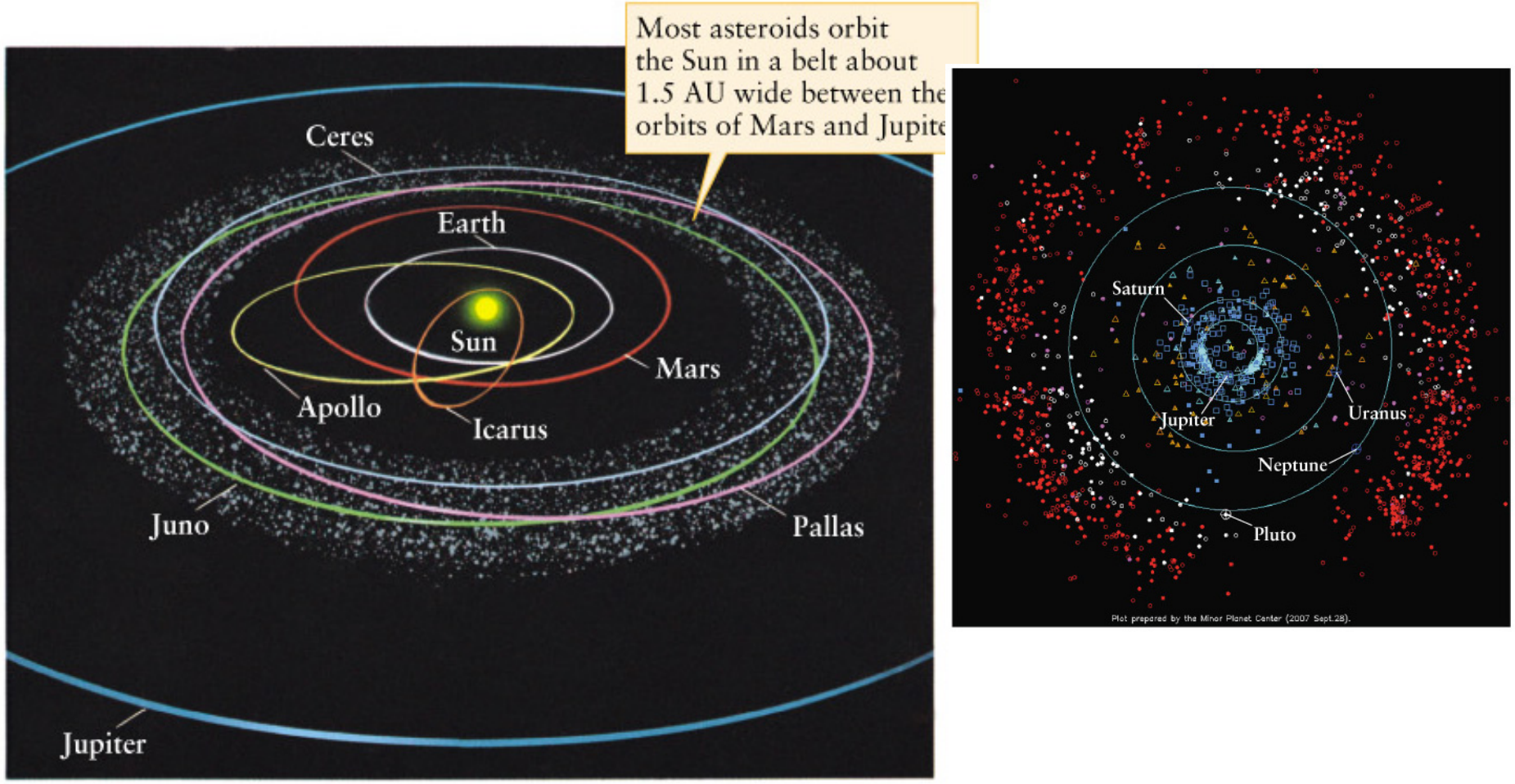
Enceladus ●●●●

Water, organics and nitrogen pour into space from the satellite's geysers, which require an energy source for fuel. Still, scientists aren't sure whether liquid water has been around long enough for life to evolve on the tiny moon.

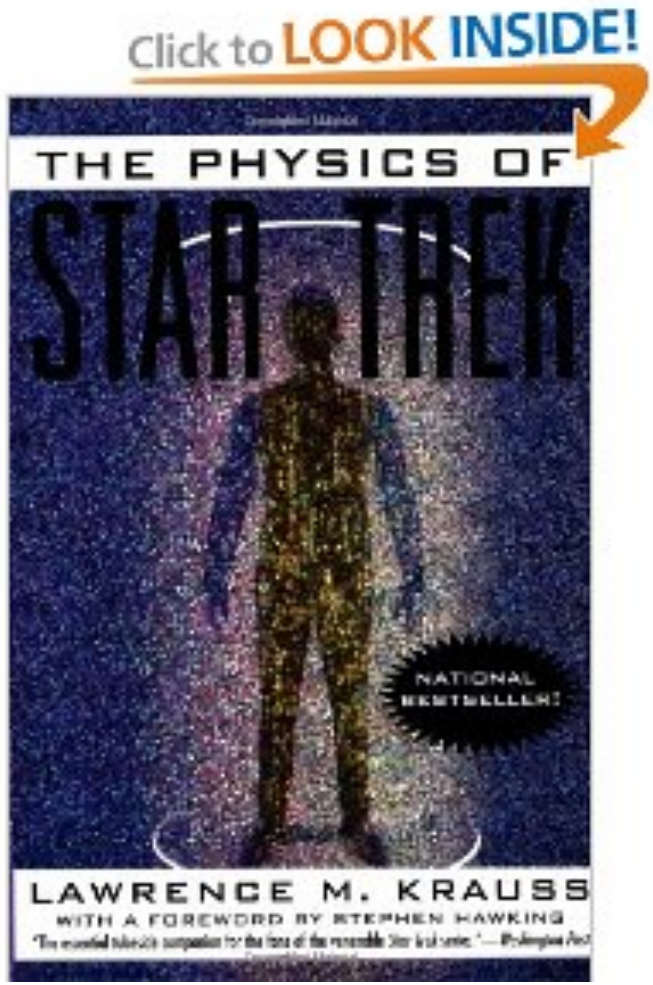
Life on Mars?

- Landings on the surface have not shown any evidence
- BUT 16 million years ago, an asteroid slammed into Mars, Mars rock thrown into space, drifted, and landed in Antarctica 13,000 years ago, results in 1996
- Tell from Mars by chemical and gas composition
- Possible indications (tubelike objects, hydrocarbons) of bacteria fossils from 3.6 billion years ago
- No agreement among experts (in Chapter 5)

Asteroids, Comets and Meteors

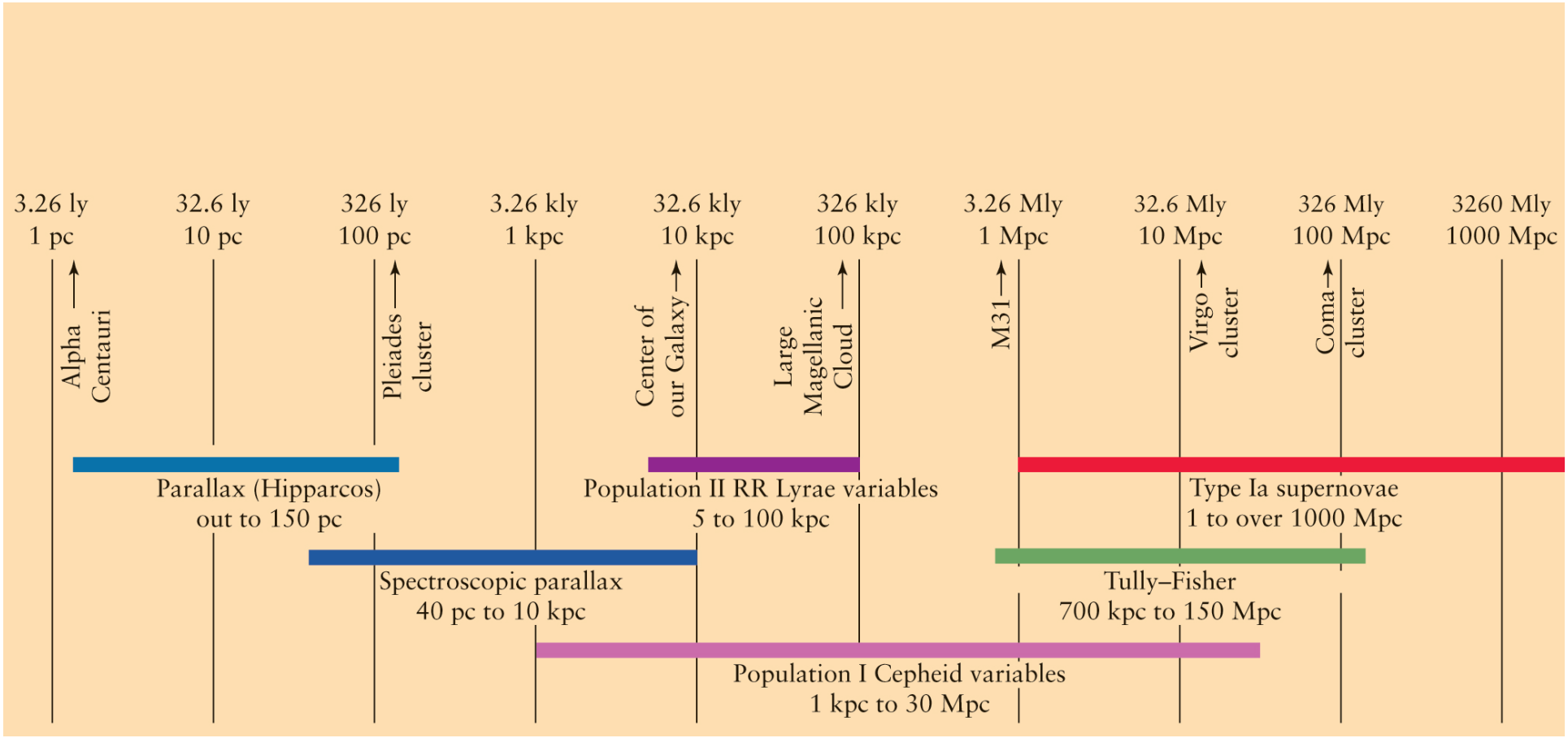


Communicating with ET spacecraft



- covers why space travel will always be "slow"

Measuring Distances – summary



- Type Ia supernovas (white dwarves which hit the Chandrashekar limit) are best for distant objects as always about the same absolute luminosity