

Astr 102: Introduction to Astronomy

Fall Quarter 2009, University of Washington, Željko Ivezić

Lecture 19:

Life in the Universe: Are we alone?

Outline

1. Life on Earth

- When did life arise on Earth?
- How did life arise on Earth?
- What are the necessities of life?

2. Life in the Solar System

- Where exactly?

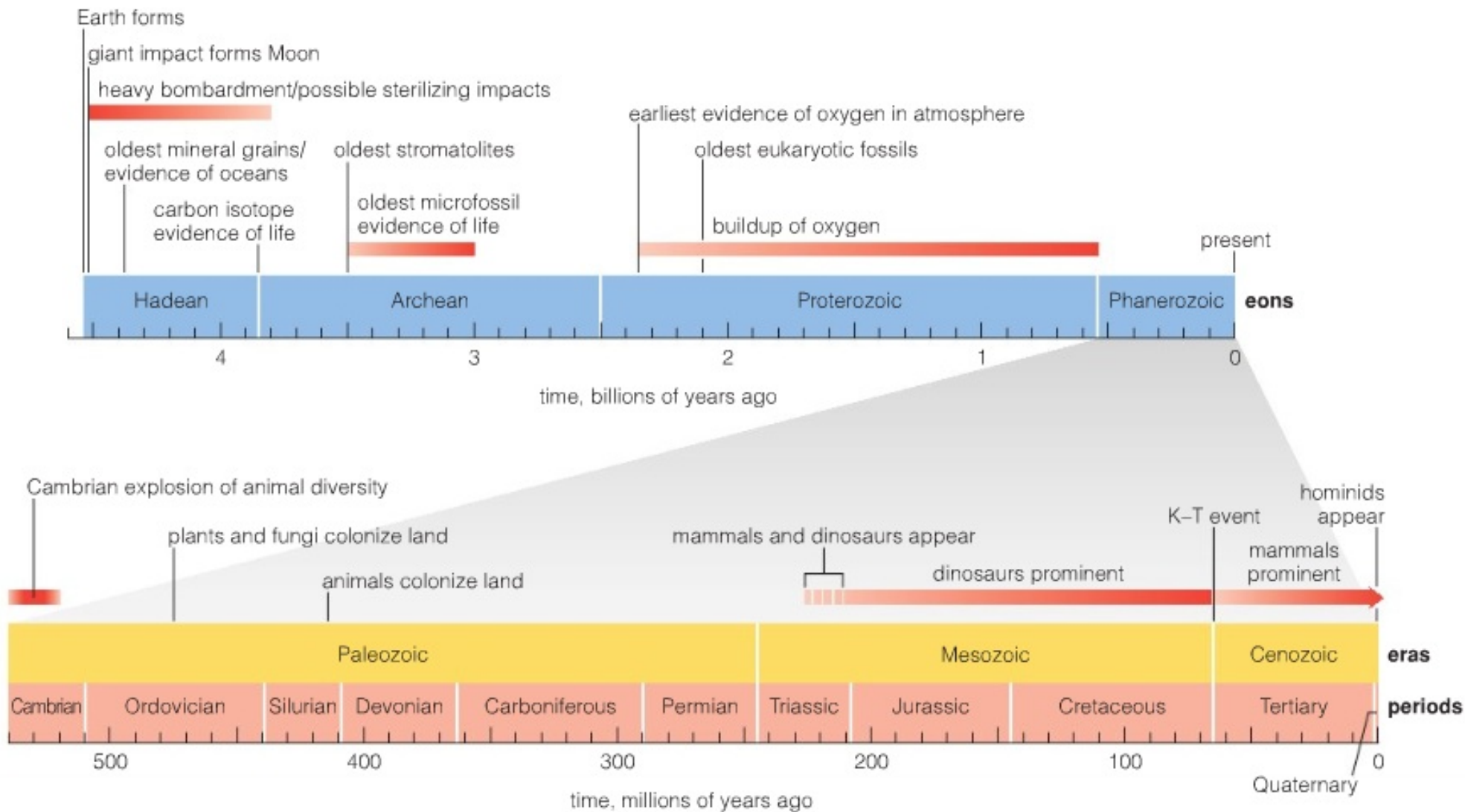
3. Life Around Other Stars

- How likely is it?

4. The Search for Extraterrestrial Intelligence

- From UFOs to Pioneer 10

The history of life development on Earth



The main point: life started soon after the conditions allowed it!

The history of life development on Earth

How do we know that life already existed about 4 billion years ago?



a These large mats at Shark Bay, Western Australia, are colonies of microbes known as "living stromatolites"; they stand about knee-high. Microbes near the top generate energy through photosynthesis.



b The bands visible in this section of a modern-day mat are formed by layers of sediment adhering to different types of microbes.



c This section of a 3.5-billion-year-old stromatolite shows a structure nearly identical to that of a living mat.

1. **Living stromatolites** are live colonies of microbes with very specific and easily recognizable structure.
2. Similar structure is found in rocks as old as 3.5 billion years
3. **Carbon dating:** the abundance ratio of two carbon isotopes, C^{12} and C^{13} , is higher in living organisms, and thus in fossils, too.

The life on Earth developed within a few hundred million years after the end of the "heavy bombardment" !

The tree of life on Earth

DNA studies show that all living organisms on Earth are related: the life on Earth shares common ancestry.

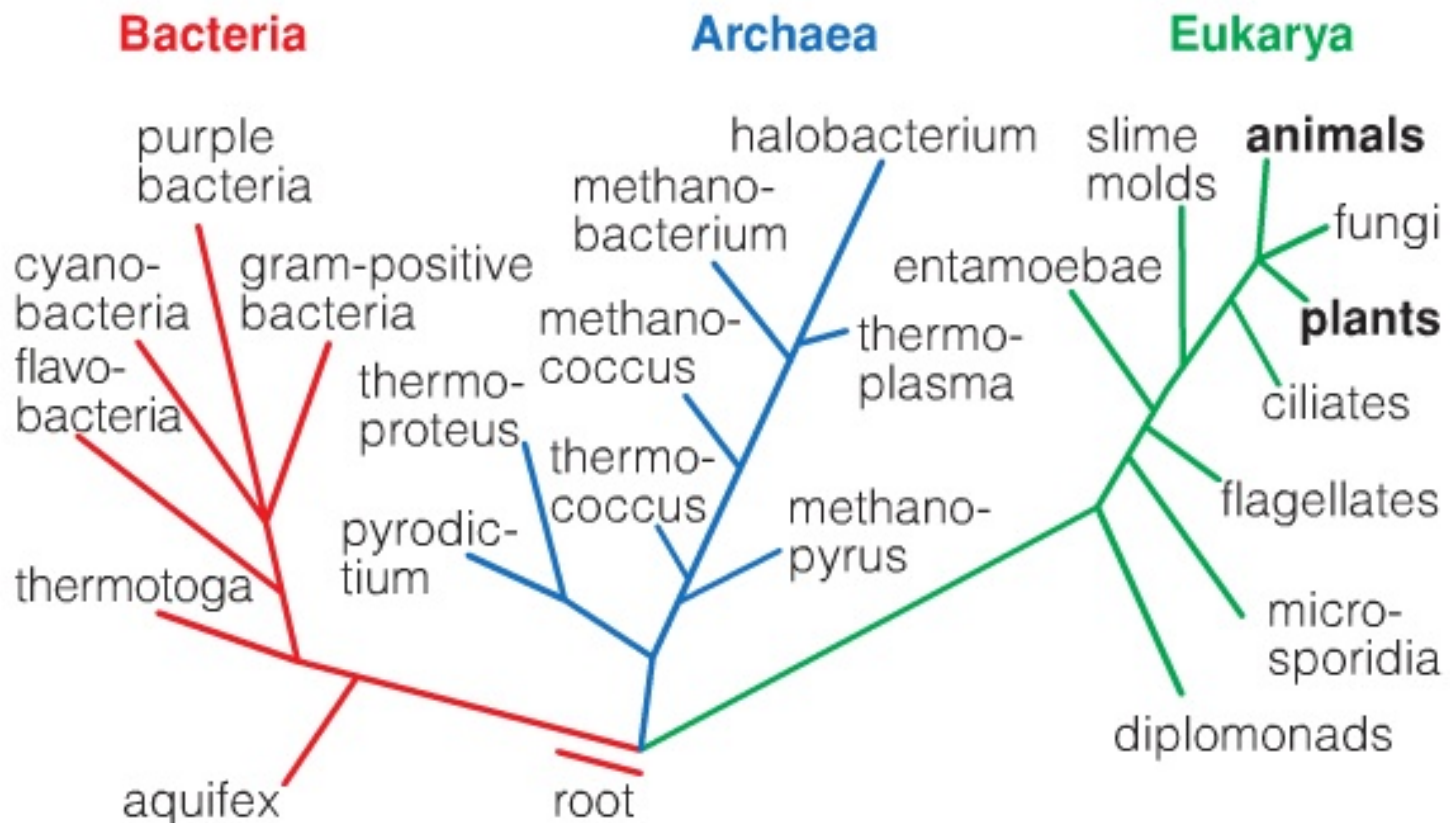


Figure 18.6

The tree of life, showing evolutionary relationships determined by comparison of DNA sequences in different organisms. Just two small branches represent *all* plant and animal species.

The necessities of life

Based on life on Earth, the three main requirements for life are:

1. **Material/nutrients for building the living cells**
2. **Energy source (sunlight for photosynthesis, but also from other chemical reactions, or from the heat of Earth)**
3. **Liquid water**

Note that oxygen is not listed!

The liquid water requirement is the most restrictive one:
liquid water is rare.

These requirements give us a basic road map for searching for life elsewhere.

Extra-terrestrial life?

Is there life beyond Earth? Are we special?

1. Other planets and moons in Solar System

- Venus, Mars?
- Jovian moons? (Europa in particular)

2. Around Other Stars

- Complex problem
- The first quantitative step: the Drake equation

$$\text{Number of civilizations} = N_{\text{planets}} \times f_{\text{life}} \times f_{\text{civ}} \times f_{\text{now}} \quad (1)$$

The Drake Equation

What is the number of civilizations in the Milky Way?

$$\text{Number of civilizations} = N_{planets} \times f_{life} \times f_{civ} \times f_{now} \quad (2)$$

1. $N_{planets}$: the number of habitable planets in the Galaxy; equal to the number of stars (which we know fairly well) times the probability that a star has a habitable planet (which we don't know accurately, but we do know that it's not negligible)
2. f_{life} : the fraction of habitable planets that develop life
3. f_{civ} : the fraction of planets with life that develop civilizations capable of interstellar communication
4. f_{now} : the fraction of advanced civilizations that exist now (the ratio of the time advanced civilizations "last" to and the age of the Galaxy)

We do not know precisely what is the result.

It could be just one civilization (i.e. us), or many.



May 11, 1950 - MtMinville, Oregon - credit: STUDIOVNI

SELECTED UFO CASES

Catalog of selected and good quality UFO cases and reports, including famous and classic cases.

"We have, on one hand, the facts -- thousands of unexplained observations by reliable witnesses. They stand as a monument to the limitations of our understanding." -- [Jacques Vallee](#)

(This is a new section of the UFO Evidence website, and is currently under development. Many classic and famous cases have been added.)

Total number of cases & reports: (564)

Physical Effects & Evidence

Physical Trace Cases (51)
Artifacts / Fragments (10)
Physiological Effects (41)
EM (electro-magnetic) Effects (33)
Vehicle Interference (23)
Animal Reaction (36)
Radar Cases (24)
Photographic Cases (64)

Special Types of Witnesses

Pilot Sightings (49)
Military Sightings (51)
Police Sightings (32)
Scientist / Engineer Sightings (13)
Astronomer Sightings (3)
Astronaut / Space Sightings (4)
Famous People Sightings (13)
Children & Youth (37)
Clergy (Priests, Ministers) (5)
Multiple Witness Cases (266)
Group Sighting (37)
Mass Witness Sightings (10)
Polygraph (Lie-Detector Test) (9)
Photo of Witness(es) (98)

Humanoid / Occupant & Abduction

Humanoid / Occupant / "Alien" (81)
Missing Time (15)
Abduction (18)
Communication (9)
Contact Cases (11)
"Dyad Scout Craft" (8)
"Alien" Photographs (7)

Other Special Types of Sightings

Near Nuclear Facilities (11)
Water Sightings (28)
Vehicle Encounter / Pacing (18)
Pilot / Aircrew Sightings (49)
Military Sightings (51)
Astronaut / Space Sightings (4)
Interaction / Awareness (19)
Human-Initiated Contact (5)
UFO Crash / Retrieval (12)
UFO Landings (47)
Multiple UFOs (41)
Polygraph (Lie-Detector Test) (9)
Witness Sketches (154)
Photo of Witness(es) (98)
Mass Witness Sightings (10)

Hynek Classification

NL - Nocturnal Lights (10)
ND - Nocturnal Discs (modified Hynek) (115)
DD - Daylight Discs / Objects (115)
RV - Radar-Visual Cases (6)
CE1 - Close Encounter - 1st Kind (77)
CE2 - Close Encounter - 2nd Kind (35)
CE3 - Close Encounter - 3rd Kind (53)

Common Shapes or Types of UFOs

Disc / Saucer Shape (165)
Cigar Shape (25)
Triangle Shape (49)
Multiple UFOs (41)
"Dyad Scout Craft" (8)

Special Features & Patterns

Portholes / Windows (66)
Smell / Odor (6)
Sound / Noise (15)
Humming Sound (34)
Silent UFOs (48)
Light Beams (12)
Body Lights (46)
Rotary Motion (Spinning) (8)

Despite these claims, most scientists agree that there is no reliable evidence that the UFO phenomenon is related to extra-terrestrial visitors. Most are optical illusions, atmospheric effects, sightings of Venus, or just plain intentional hoax.

Fermi's Paradox: Where are They?

It seems plausible that within a few million years, an advanced civilization could colonize a significant fraction of the Milky Way.

If advanced civilizations are common, someone should already have colonized the Milky Way. Indeed, long time ago!

But we have no evidence yet of such a civilization. Why?

1. **We are alone.** Advanced civilizations are very rare and we may be the first one in the Milky Way.
2. **Colonization has not happened yet.** Three possible reasons:
i) it ain't that easy, ii) others are not as curious as we are, iii) civilizations disappear before they develop space travel (oopsy!)
3. **There is such a civilization, but has not yet revealed its existence to us.**

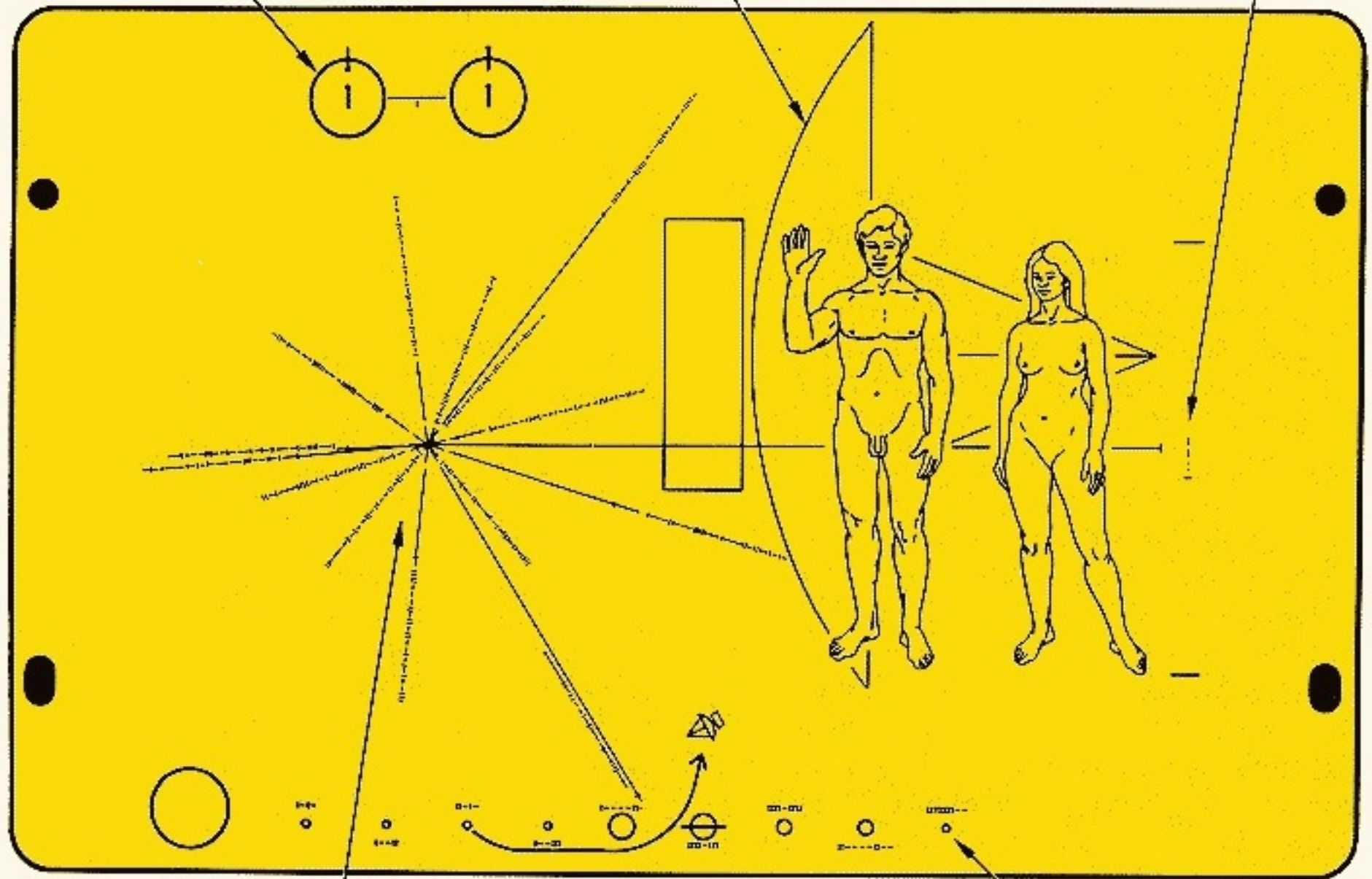
SETI: the Search for Extraterrestrial Intelligence

1. **SETI Institute:** a serious scientific organization, see <http://www.seti.org> (as opposed to numerous non-scientific “institutes”, for a neighborhood example see <http://www.discovery.org>). SETI has many interesting initiatives, including “Adopt a Scientist” program, and the largest distributed computing effort with over 3 million users (see <http://setiathome.berkeley.edu>).
2. **Pioneer 10:** one of the first major attempts to establish a “contact” with other civilization. How can we communicate? (no, they wouldn’t speak English)

HYPERFINE TRANSITION OF
NEUTRAL HYDROGEN

SILHOUETTE OF
SPACECRAFT

BINARY EQUIVALENT
OF DECIMAL 8



POSITION OF SUN
RELATIVE TO 14
PULSARS AND THE
CENTER OF THE GALAXY

PLANETS OF SOLAR
SYSTEM AND BINARY
RELATIVE DISTANCES 13



We must dream,
or we'll never get to "where no man has gone before".

