

Extraterrestrial Life

Extraterrestrial Life

Extraterrestrial implies the Universe

But we only KNOW about life on Earth (will use as “model”)

Danger of “Earth Chauvinism”

Objectives:

Scientific Perspective

Understand connection between Universe and Life

Give you tools to make your own judgments

Controversial Issues:

Evolution

Visits by Aliens (UFO's)

Themes:

Cosmic Evolution

The Drake Equation

Contact

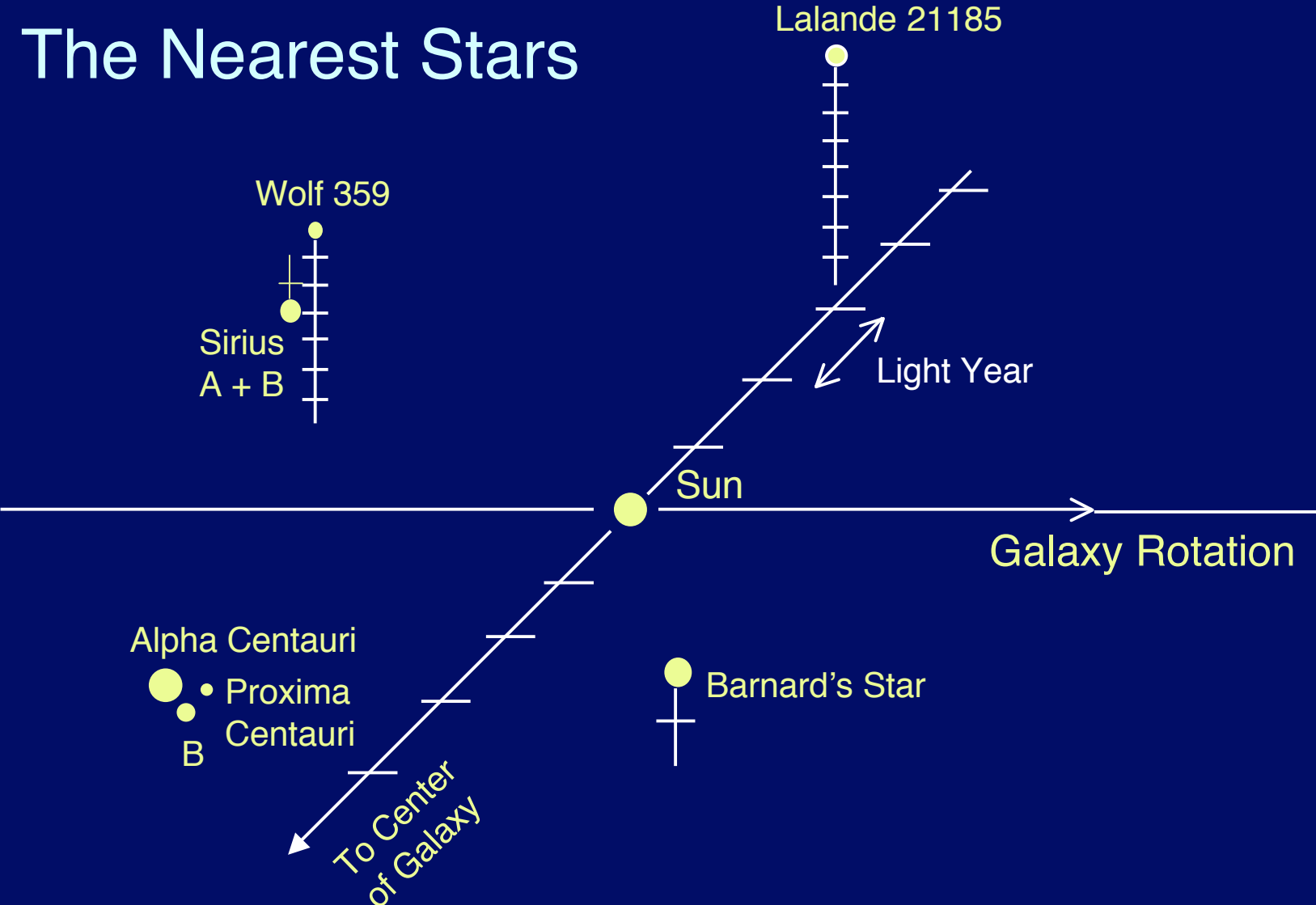
The Nearest Stars

T H E N E A R E S T S T A R S

Star	Color	Distance	Closest Approach	Minimum Distance
Sun	Yellow	0.0		
Alpha Centauri A	Yellow	4.3	29,000 A.D.	3.2
Alpha Centauri B	Orange	4.3	29,000 A.D.	3.2
Proxima Centauri	Red	4.2	28,000 A.D.	3.2
Barnard's Star	Red	5.9	12,000 A.D.	3.8
Wolf 359	Red	7.8	13,000 B.C.	7.3
Lalande 21185	Red	8.2	22,000 A.D.	4.6
Sirius A	White	8.6	64,000 A.D.	7.7
Sirius B	White	8.6	64,000 A.D.	7.7

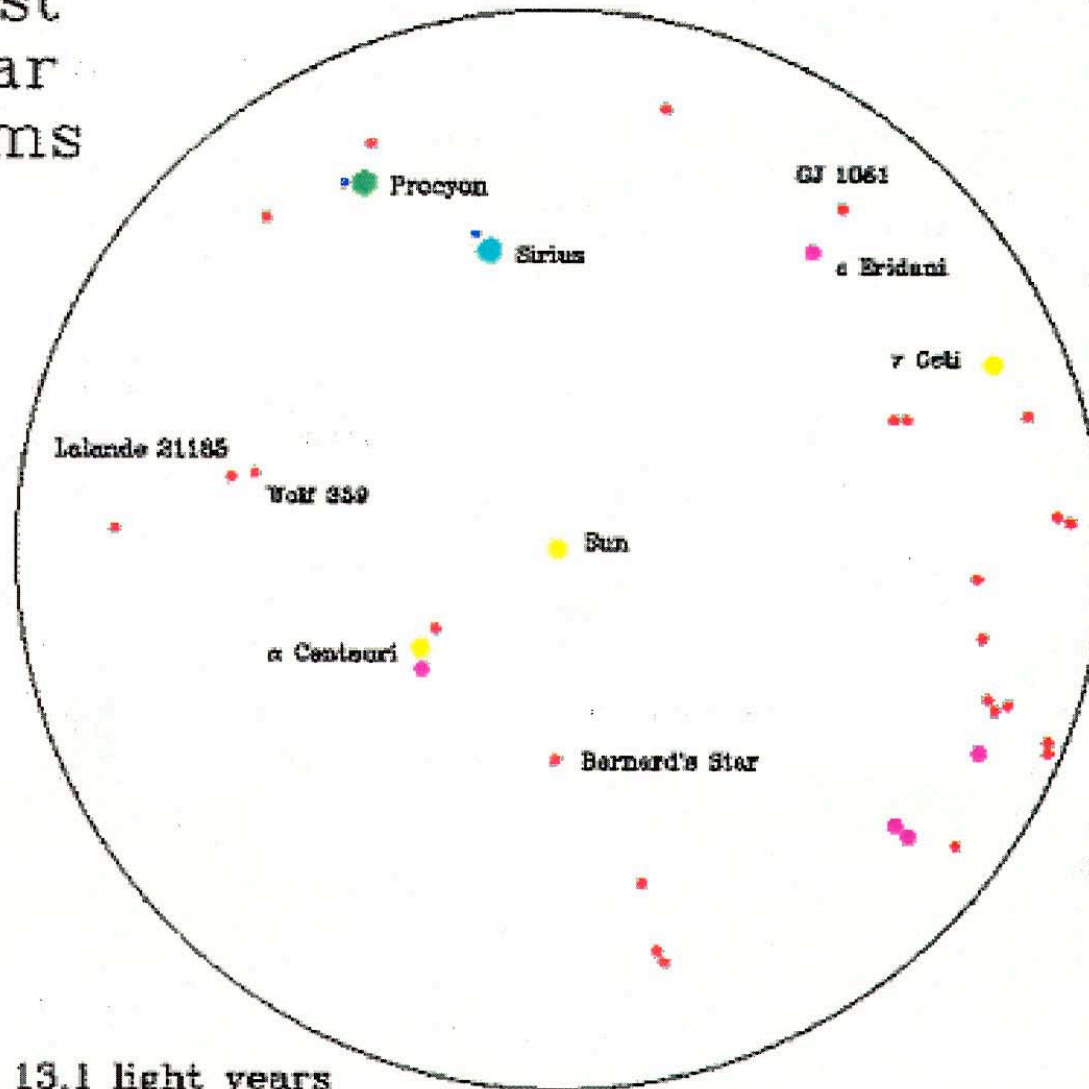
Note: Distances are in light-years with reference to the sun.

The Nearest Stars



25 Nearest Star Systems

Nearest 25 Star Systems



Five Nearest Systems

1. α Centauri
2. Barnard's Star
3. Wolf 359
4. Lalande 21185
5. Sirius

ECOHRS Discovery

20. GJ 1061
(11.8 light years)

Five Brightest Systems Among Nearest 25

1. Sirius
2. α Centauri
3. Procyon
4. γ Ceti
5. ϵ Eridani

horizon = 13.1 light years

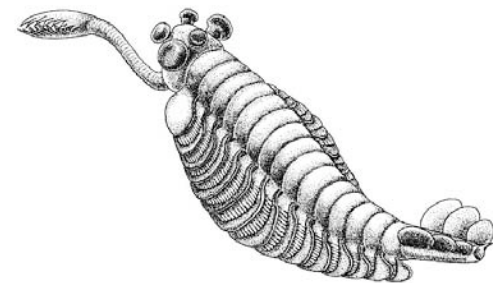
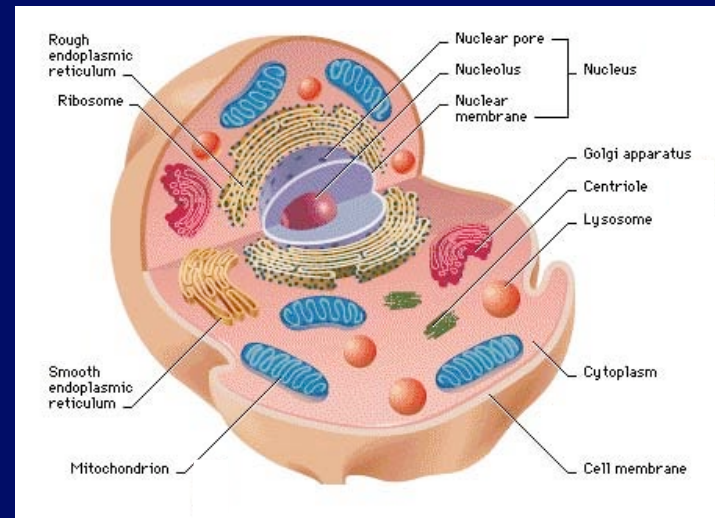
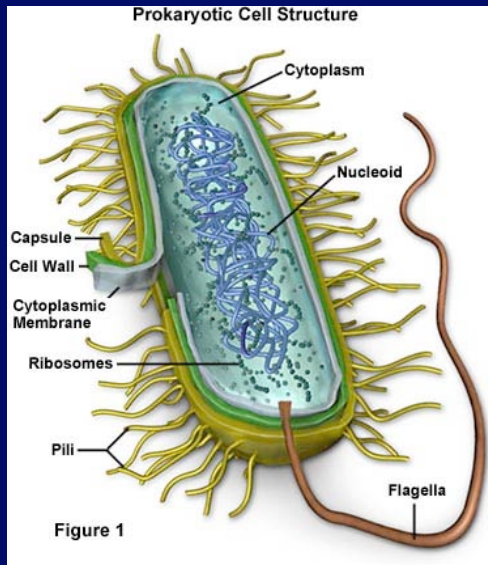
Larger Structures

- Milky Way Galaxy 100,000 (10^5) ly across
- Local Group about 3 million (3×10^6) ly
- Virgo Cluster about 30 million (3×10^7) ly away
- Most distant galaxies we can see are about 13 billion (13×10^9) ly away

Questions

- How far from Earth are the astronauts in the Shuttle?
- How far have humans traveled (in light-time units)?
- What fraction of the distance to the nearest star is that?
- Are we likely to travel to another star in your lifetimes?

Life



3.21. *Opabinia*, showing the frontal nozzle with terminal claw, five eyes on the head, body sections with gills on top, and the tail piece in three segments. Drawn by Marianne Collins.

Five Attributes of Life

1. Composed of **Organic Molecules** (Carbon Based)
2. Engages in **Metabolism**
3. **Reproduces**
4. **Mutates** (Evolves)
5. Changes in Response to Environment (**Sensitivity**)

Questions

- Can you think of a counter-example to each of these?
- Something alive without these attributes?
- Something not alive **with** these attributes?

Alternative Approach to Definition of Life

Based on Ecological aspect

Clare Folsom (Onsager-Morowitz)

“Life is that property of Matter that results in the Coupled Cycling of bioelements in Aqueous Solution, ultimately driven by radiant energy to attain Maximum Complexity”

Very general - but what does it mean?

Gaia - Geochemical & Biological Cycles

Life on Earth as “Organism” (James Lovelock)

Requirements for Life

To Make A:

Virus

Bacteria

Human (Mammal)

Phosphorus (P) and Potassium (K) in shortest supply

You Need:

< 17 Elements

~ 17

~ 27

Average Human Being contains 6×10^{27} atoms

⇒ At least one atom of every stable element and some unstable (radioactive) elements (^{14}C , ^3H , ^{40}K)

⇒ Some atoms from every species that ever existed

Leaving aside rare elements, all life has similar composition: (All % by number of atoms)

<u>Symbol</u>	<u>Element</u>	<u>Bacteria</u>	<u>Human Beings</u>
H	Hydrogen	63%	61%
O	Oxygen	29%	26%
C	Carbon	6.4%	10.5%
N	Nitrogen	1.4%	2.4%
P	Phosphorus	0.12%	0.13%
Ca	Calcium		0.23%
S	Sulfur	0.06%	0.13%

HCON	Essential, most common
PS	Also essential
Ca	Bones

Also Fe (Iron) Hemoglobin
Mg (Magnesium) Chlorophyll

Composition of the Earth:

<u>Element</u>	<u>Crust</u>	<u>Ocean</u>	<u>Atmosphere</u>
Oxygen	47%	~ 33%	21%
Silicon	28%		
Nitrogen			78%
Hydrogen		~67%	(0.011% Carbon)

Question: Which is most similar to that of life?

Composition of life **more like** Composition of Sun (Universe)

<u>Symbol</u>	<u>Element</u>	<u>% in Sun</u>
H	Hydrogen	93%
He	Helium	6.4%
O	Oxygen	0.06%
C	Carbon	0.03%
N	Nitrogen	0.011%

Aside from He, HOCN

Where did these elements come from?

Appendix 5

Drake Equation:

$$N = R_* f_p n_e f_\ell f_i f_c L$$

- N = number of communicable civilizations in our galaxy
- R_* = rate at which stars form
- f_p = fraction of stars which have planetary systems
- n_e = number of planets, per planetary system, which are suitable for life
- f_ℓ = fraction of planets suitable for life on which life actually arises
- f_i = fraction of life-bearing planets where intelligence develops
- f_c = fraction of planets with intelligent life which develop a technological phase during which there is capability for and interest in interstellar communication
- L = average lifetime of communicable civilizations
- r = average distance to nearest civilization

	R_*	f_p	n_e	f_ℓ	f_i	f_c	L	N	r
Estimate									
Birthrate									

if $N > 8000$ $r = \frac{10^4 \text{ l.y.}}{N^{1/3}}$

if $N < 8000$ $r = \frac{5 \times 10^4 \text{ l.y.}}{N^{1/2}}$

The Drake Equation

Drake Equation:

$$N = R_* f_p n_e f_\ell f_i f_c L$$

- N = number of communicable civilizations in our galaxy
- R_* = Rate at which stars form
- f_p = Fraction of stars which have planetary systems
- n_e = Number of planets, per planetary system, which are suitable for life
- f_ℓ = Fraction of life bearing planets where intelligence develops
- f_c = Fraction of planets with intelligent life which develop a technological phase during which there is a capacity for and interest in interstellar communication
- L = Average of lifetime of communicable civilizations
- r = Average distance to nearest civilization