Extraterrestrial Life

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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

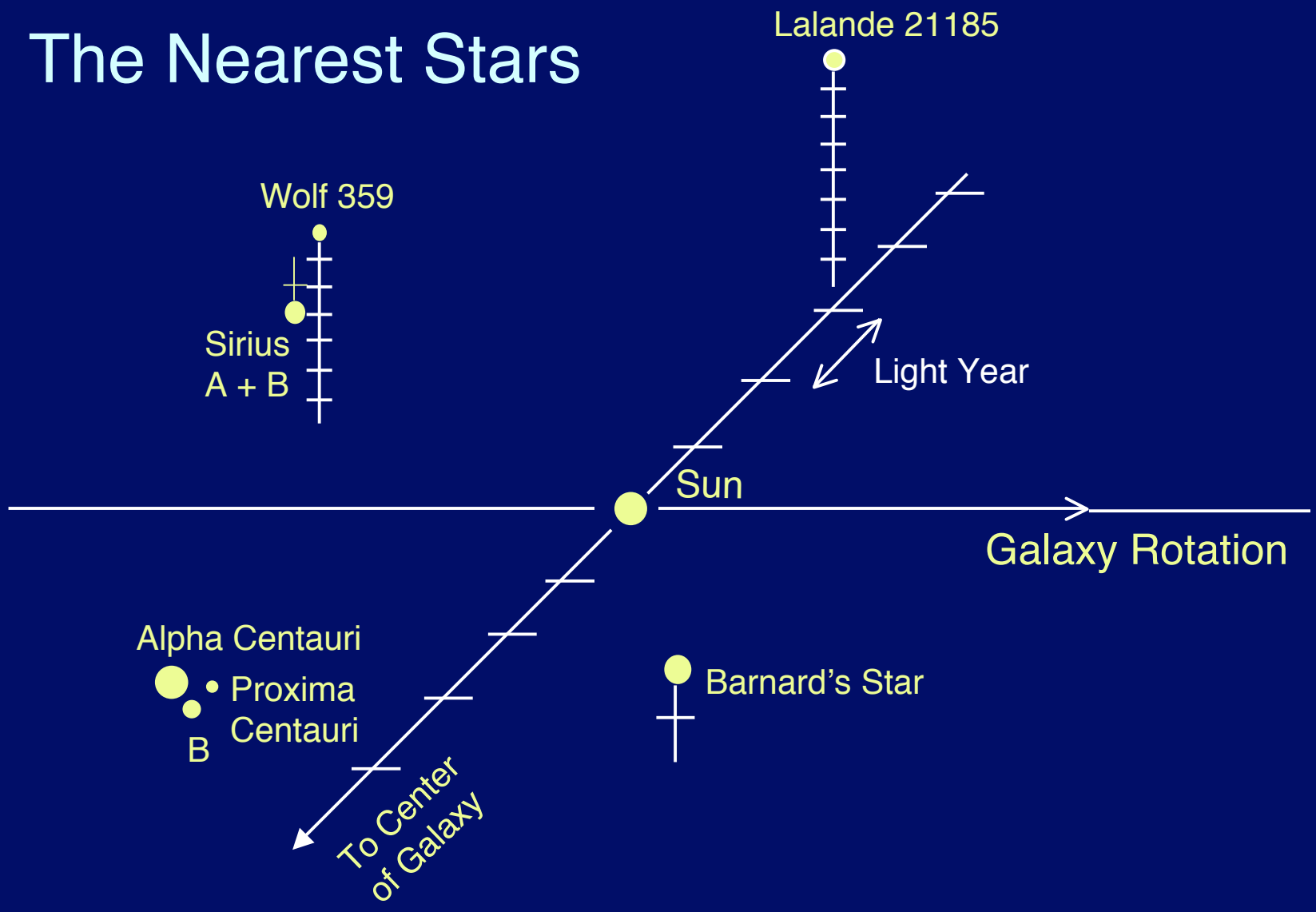
The Nearest Stars

THE NEAREST STARS

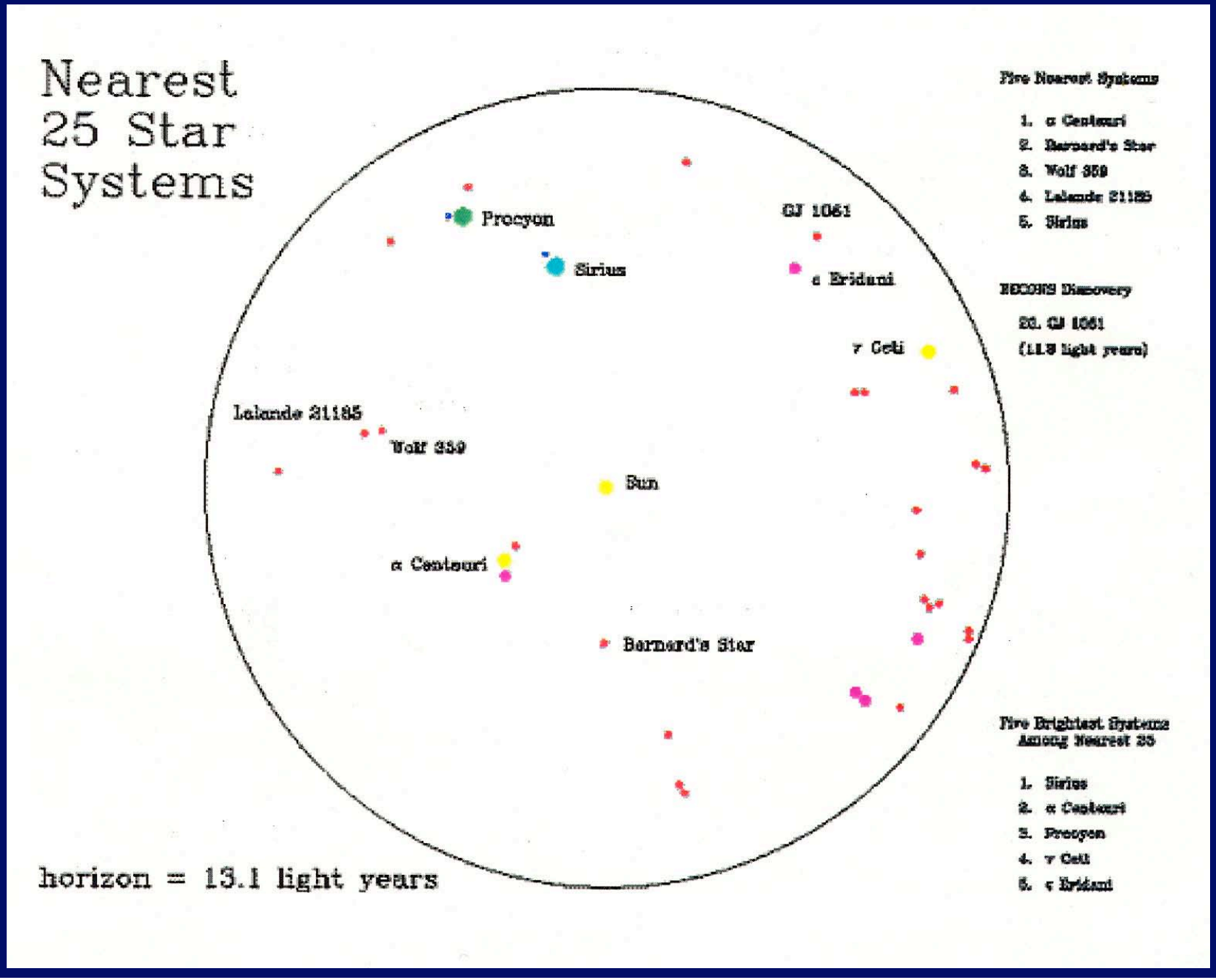
Star	Color	Distance	Closest Approach	Minimum Distance
Sun	Yellow	0.0		
Alpha Centauri A	Yellow	4.3	29,000 A.D.	3.2
Alpha Centauri B	Orange	4.3	29,000 A.D.	3.2
Proxima Centauri	Red	4.2	28,000 A.D.	3.2
Barnard's Star	Red	5.9	12,000 A.D.	3.8
Wolf 359	Red	7.8	13,000 B.C.	7.3
Lalande 21185	Red	8.2	22,000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



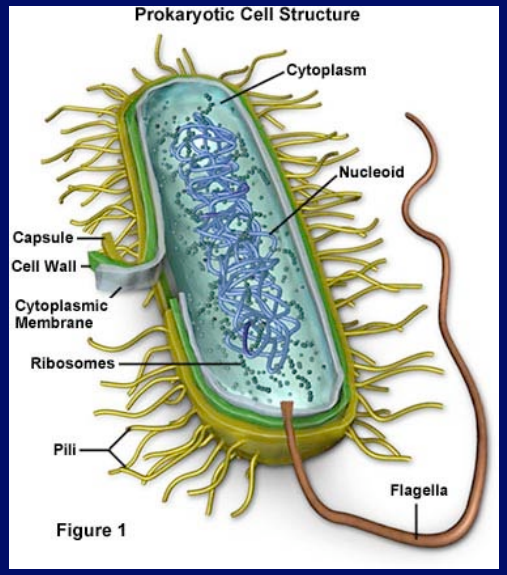
Larger Structures

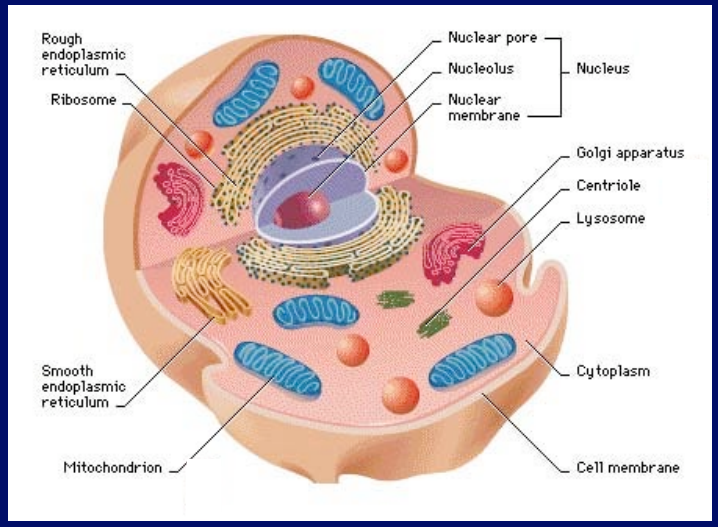
- Milky Way Galaxy 100,000 (10^5) ly across
- Local Group about 3 million (3×10^6) ly
- Virgo Cluster about 30 million (3×10^7) ly away
- Most distant galaxies we can see are about 13 billion (13×10^9) ly away

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





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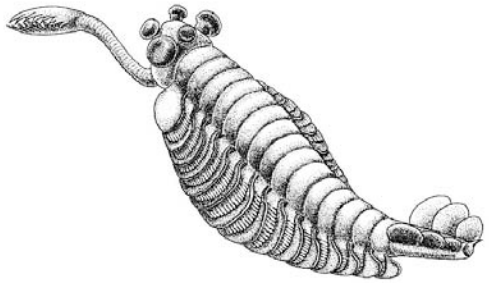

3.21. *Opabinia,* showing the frontal nozzle with terminal claw, five eyes on the head, body sections with gills on top, and the tail piece in three segments. Drawn by Marianne Collins.

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:	You Need:
Virus	< 17 Elements
Bacteria	~ 17
Human (Mammal)	~ 27

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

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

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

⇒ Some atoms from every species that ever existed

Facts from R. Davies U. Penn.

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

Symbol	Element	Bacteria	Human Beings
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:

Element	Crust	Ocean	Atmosphere
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)

Symbol	Element	% in Sun
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 $\quad r = \dfrac{10^4 \text{ l.y.}}{N^{1/3}}$

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

The Drake Equation

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