

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

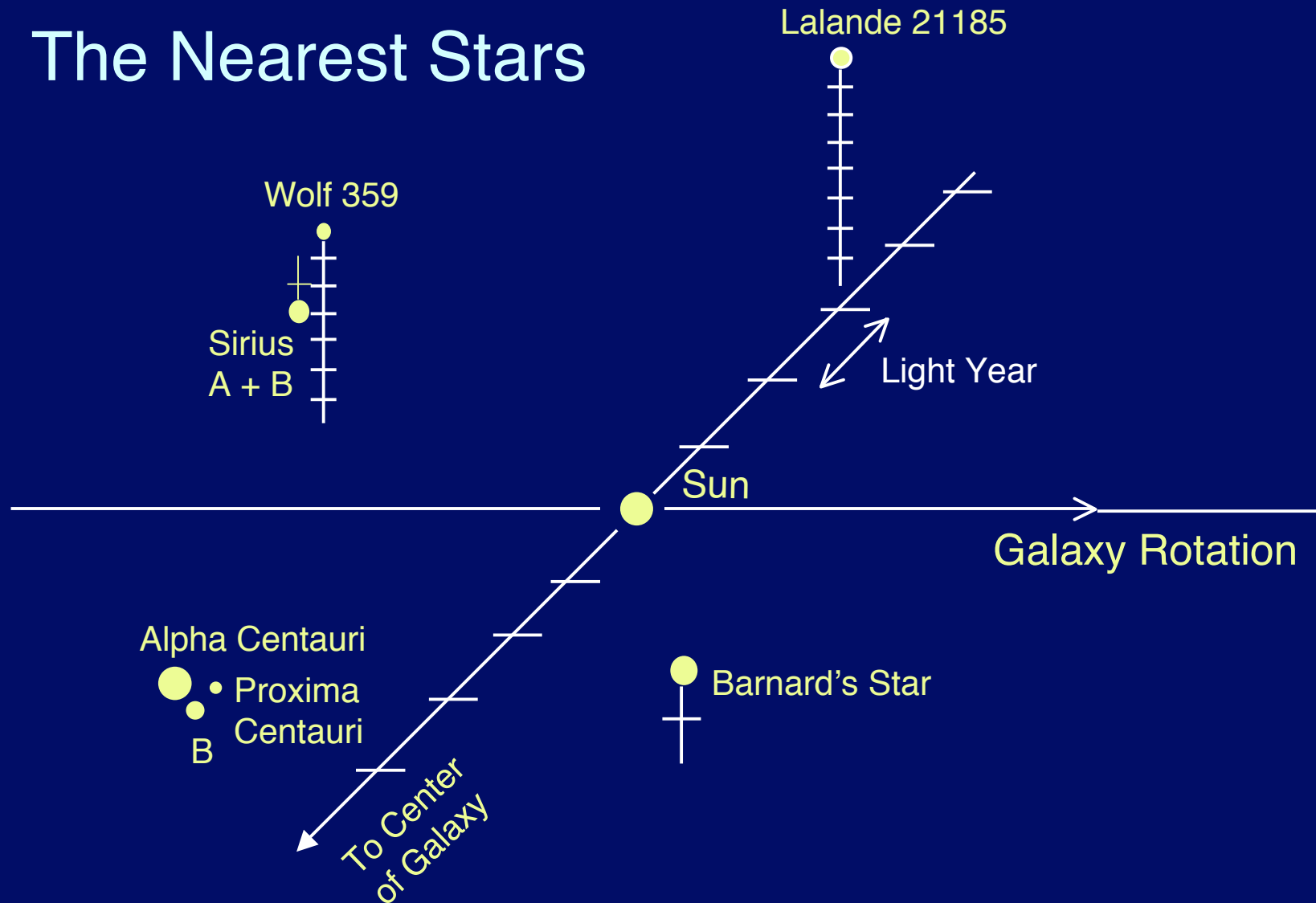
The Cosmic Context

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

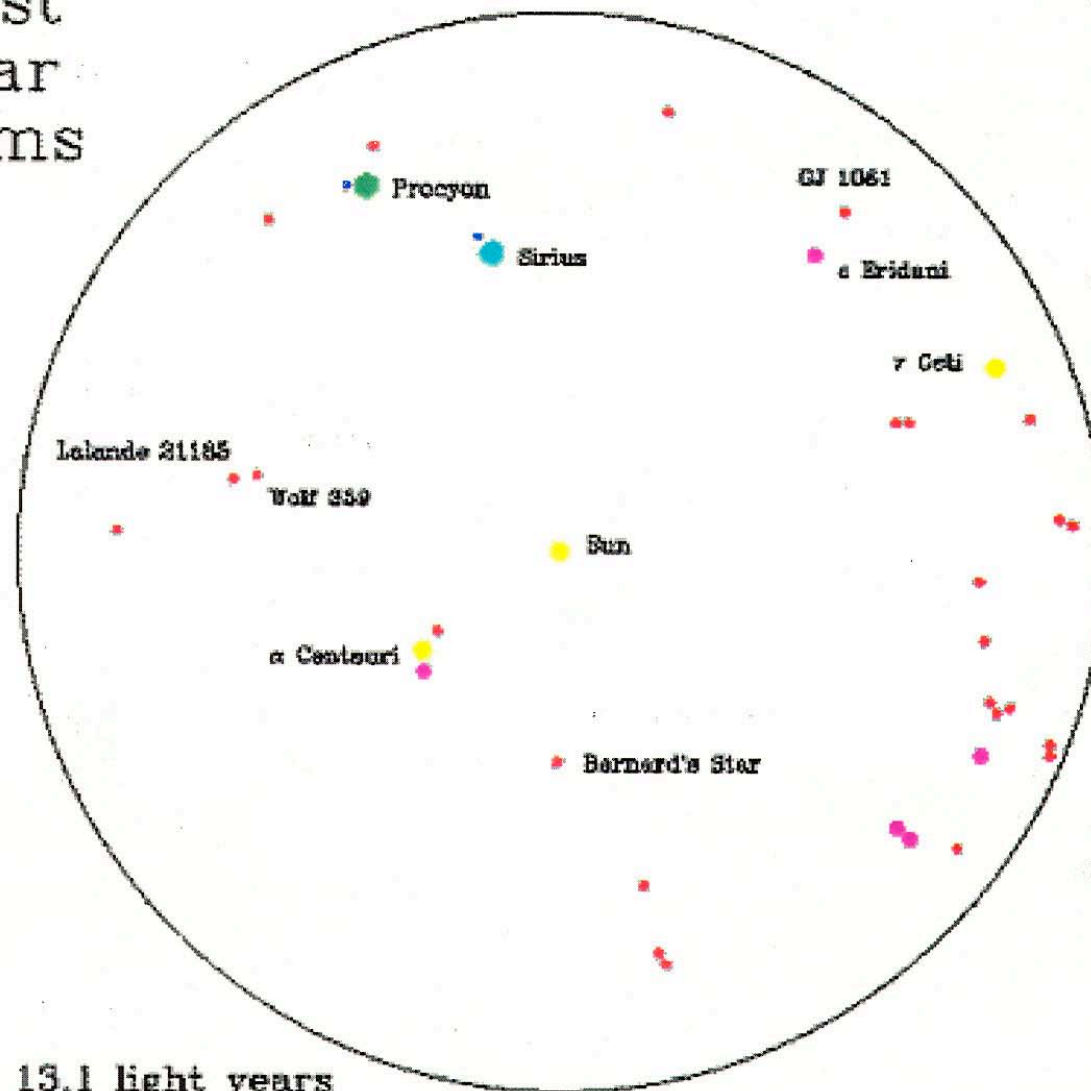
Note: Distances are in light-years with reference to the sun.

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

NEOWISE 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

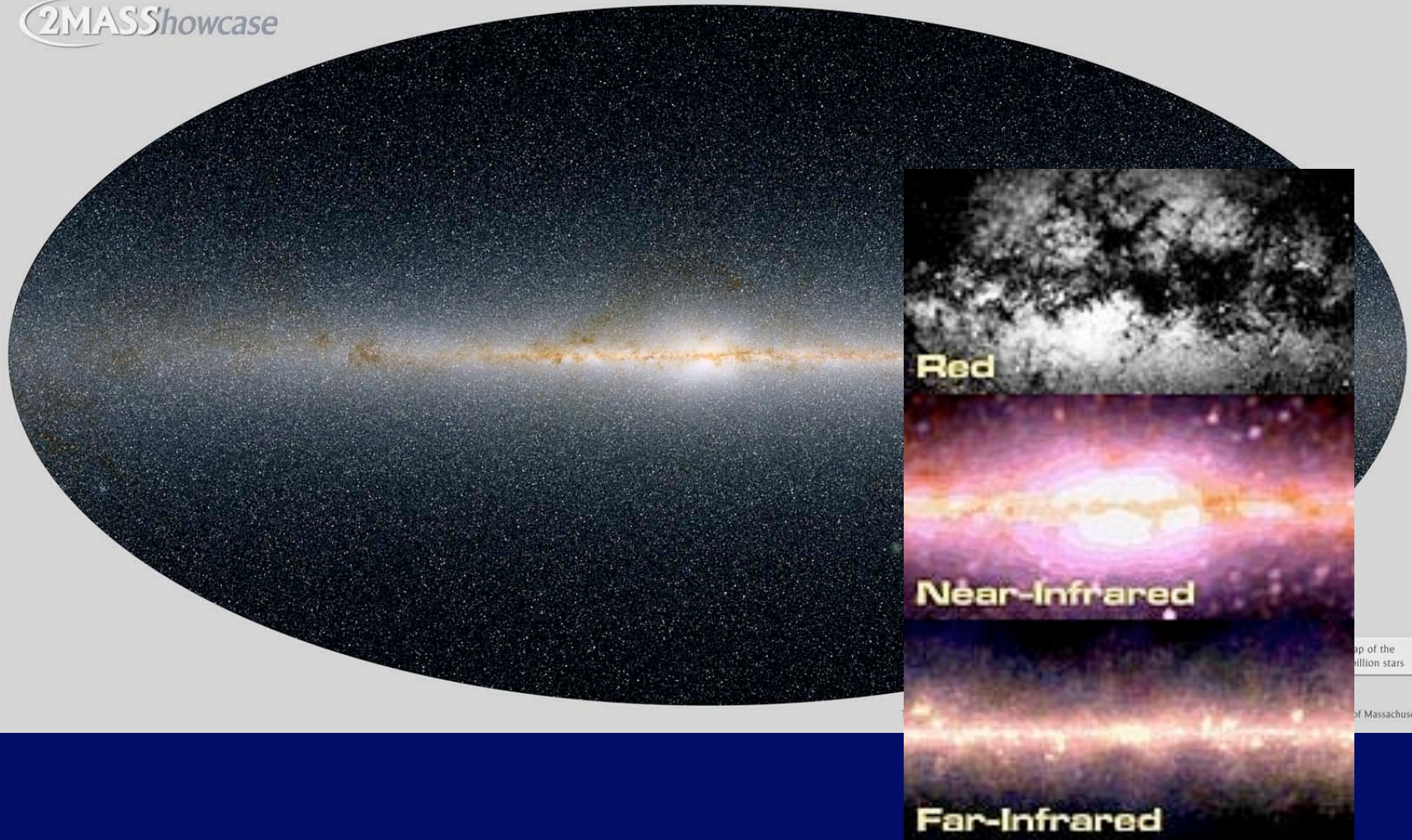
horizon = 13.1 light years

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
- Most distant galaxies we can see are about 13 billion (13×10^9) ly away

The Milky Way

2MASShowcase



Our Location in the Milky Way



The Local Group

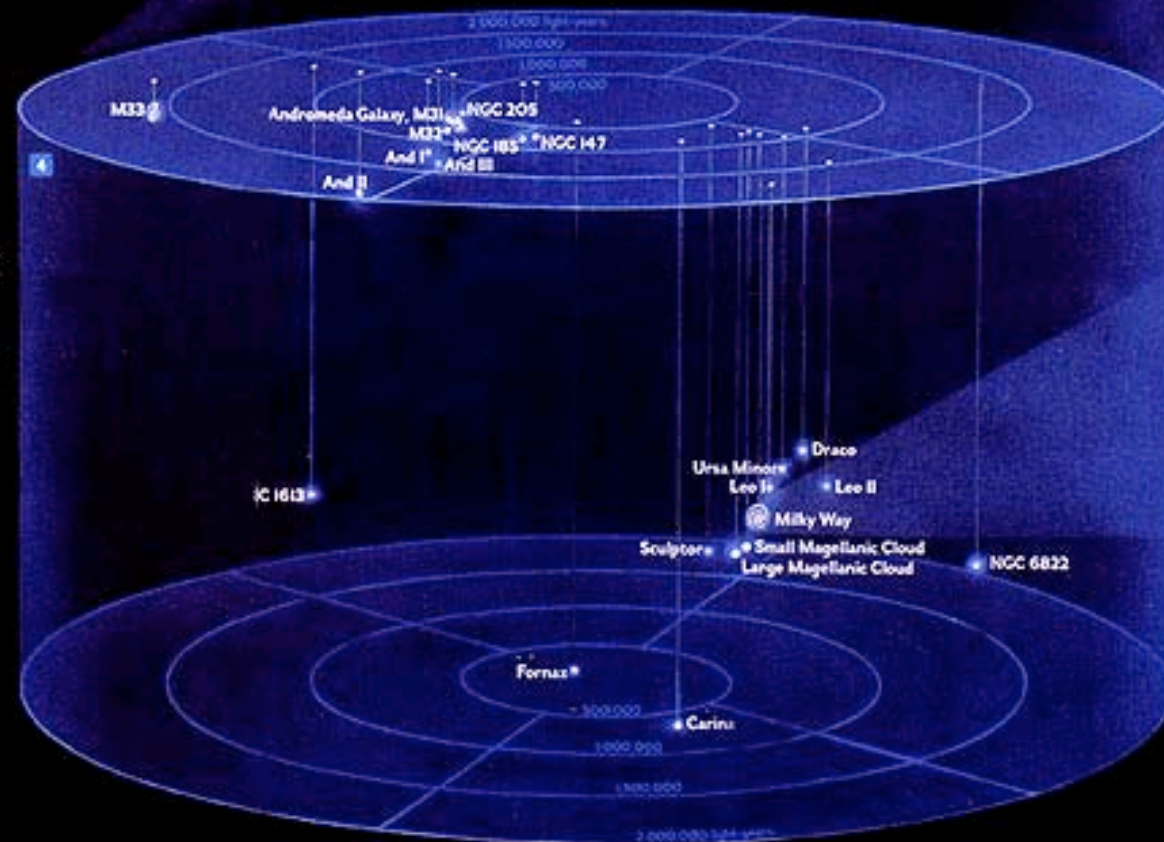
2 million light years

4. LOCAL GROUP

Beyond the Milky Way we have located galaxies in every direction. Our own is part of a loosely bound cluster of some 20 galaxies, called prosaically the Local Group. "Galaxies are to astronomy what atoms are to physics," astronomer Allan Sandage has said, and this group illustrates the variations.

The Milky Way, its sister Andromeda (M31), and the smaller M33 are fast-rotating spirals. Hundreds of star clusters and dust clouds lie within the Andromeda galaxy, itself once mistakenly identified as a nebula, or cloud, in the Milky Way galaxy.

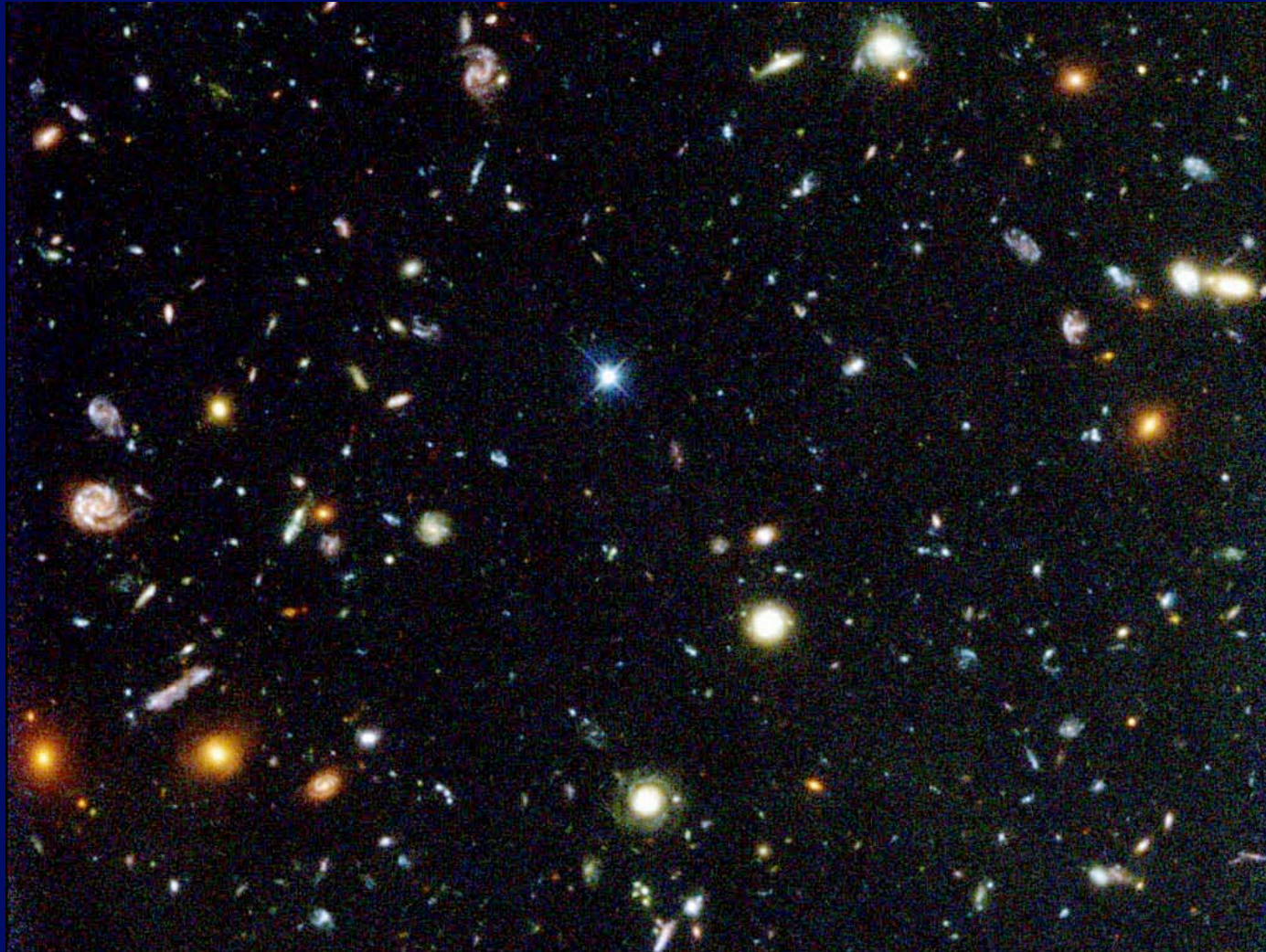
NGC 205 is an elliptical galaxy, consisting mainly of old stars. The Large and Small Magellanic Clouds are irregular galaxies, described as haze in the southern sky by Magellan's crew in 1520. These member galaxies, all moving in random paths, are held together by gravity, even as the universe expands.



Central Part of Virgo Cluster



The Hubble Deep Field



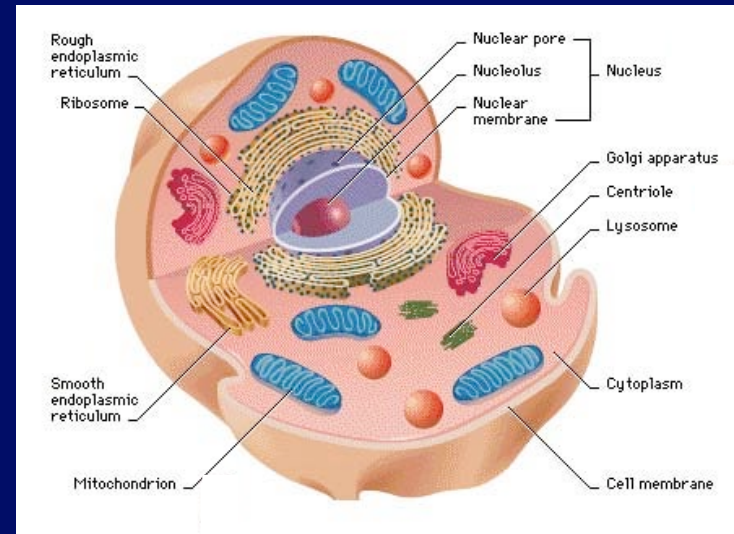
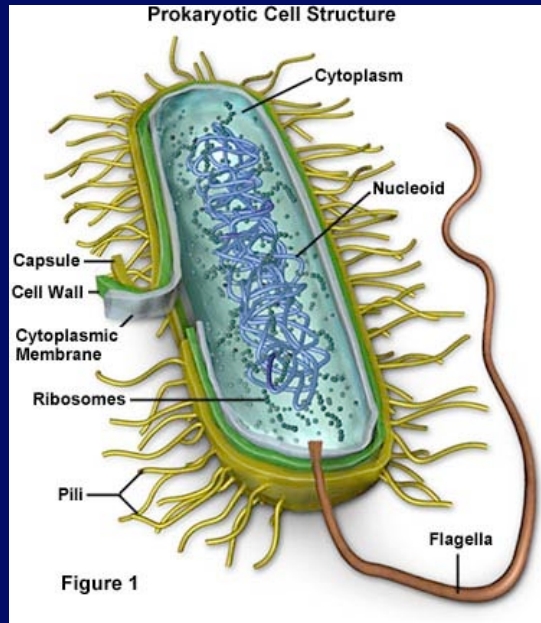
Try this Link

<http://www.atlasoftheuniverse.com/index.html>

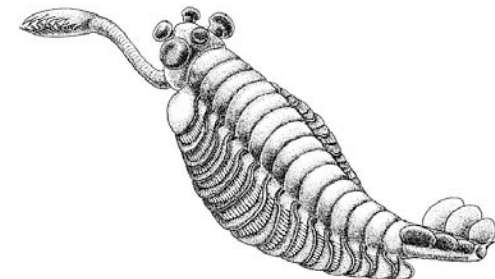
Questions

- How far from Earth are the astronauts in the Space Station?
- 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



126 | WONDERFUL 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:

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

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

The Drake Equation

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