Extraterrestrial Life

How To Succeed: Part 1

- Show up (lectures and sections)
- Read and understand syllabus and schedule
- Ask about anything you don’t understand
- Read the material assigned BEFORE class
- Write down questions about anything you don’t understand
- If not clarified in class, ASK!
- After class, write a summary of material
- Read and Follow the UT Honor Code

UT Honor Code

- **Student Honor Code**
- As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity.
- **University Code of Conduct**
- The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community.
- http://deanofstudents.utexas.edu/sjs/spot_honorcode.php

The Nature of the Topic

- Extraterrestrial: outside the Earth
  – leads us to study the Universe
- Life:
  – Terrestrial knowledge
  – Earth provides only known example
  – Beware “Earth Chauvinism”

Themes

- Cosmic Evolution
  - Early in course, especially
- The Drake Equation
  - Throughout course
- Contact
  - Late in course

Controversial Issues

- Evolution
- Climate Change
- Alien Visitations (UFOs)

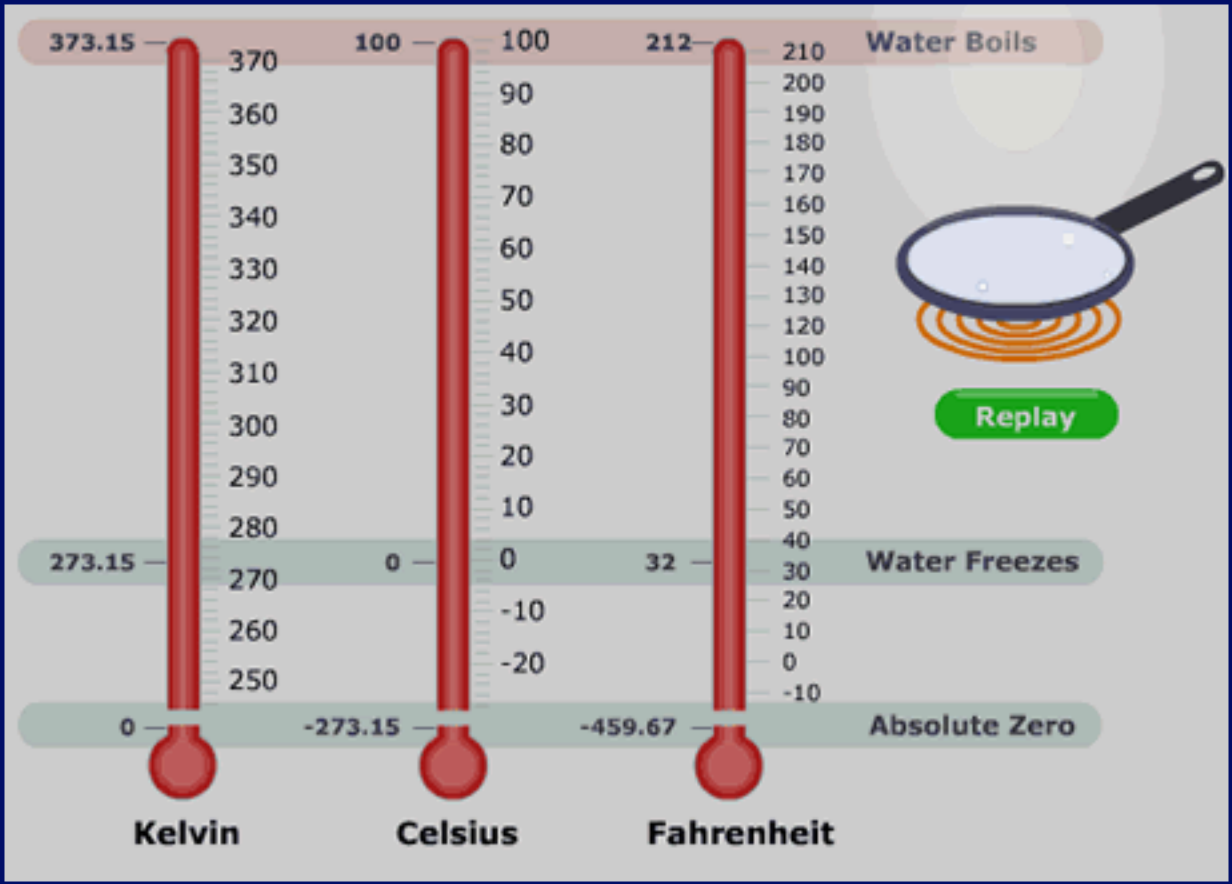
- None of these are controversial among scientists, but they are controversial in the public arena.

My Objectives for Course

- Guide you in understanding the scientific world view
- Help you to understand the deep connections between the Universe and life
- Give you the tools to make your own judgments

Mathematics

Temperature Scales

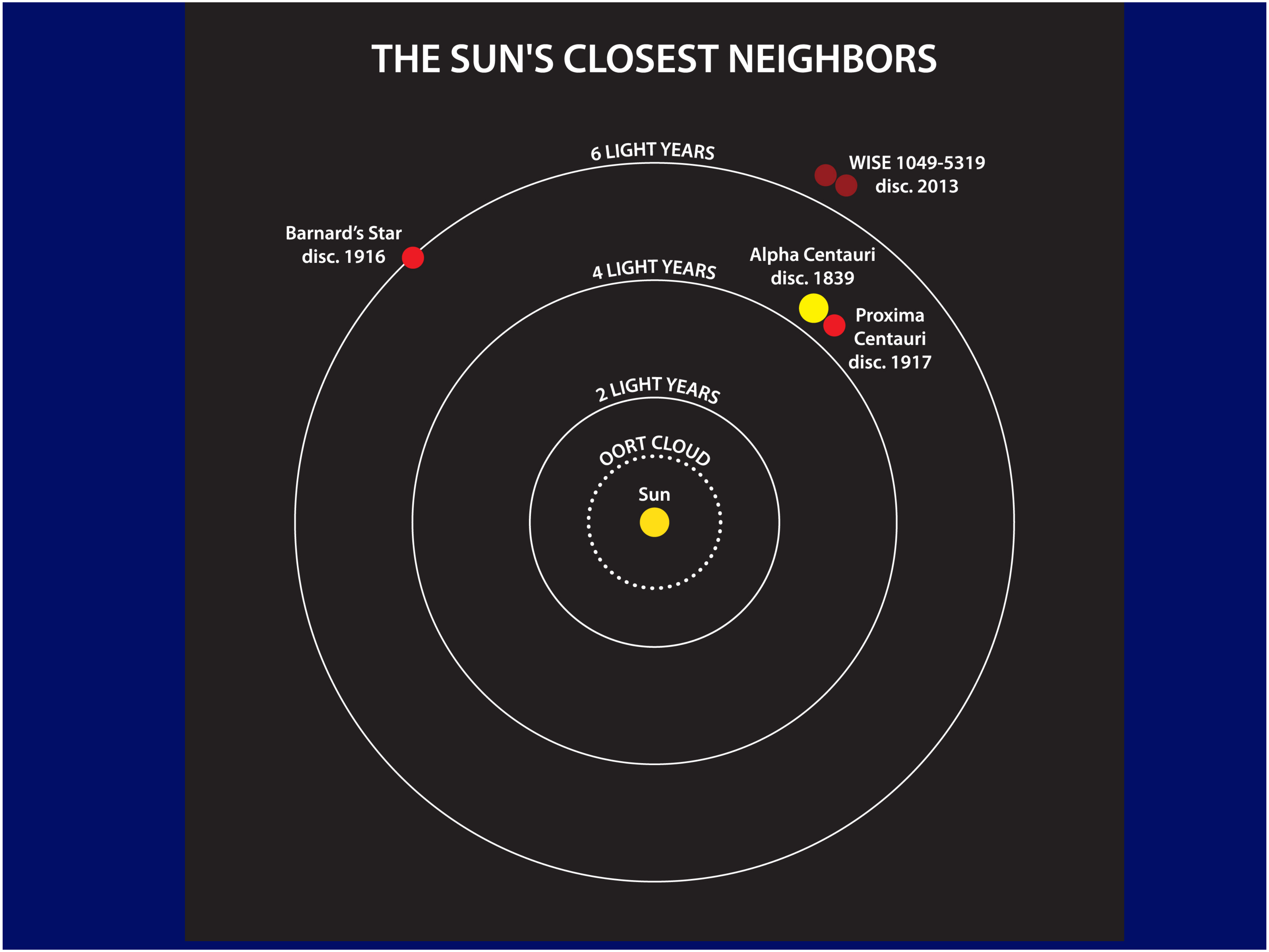


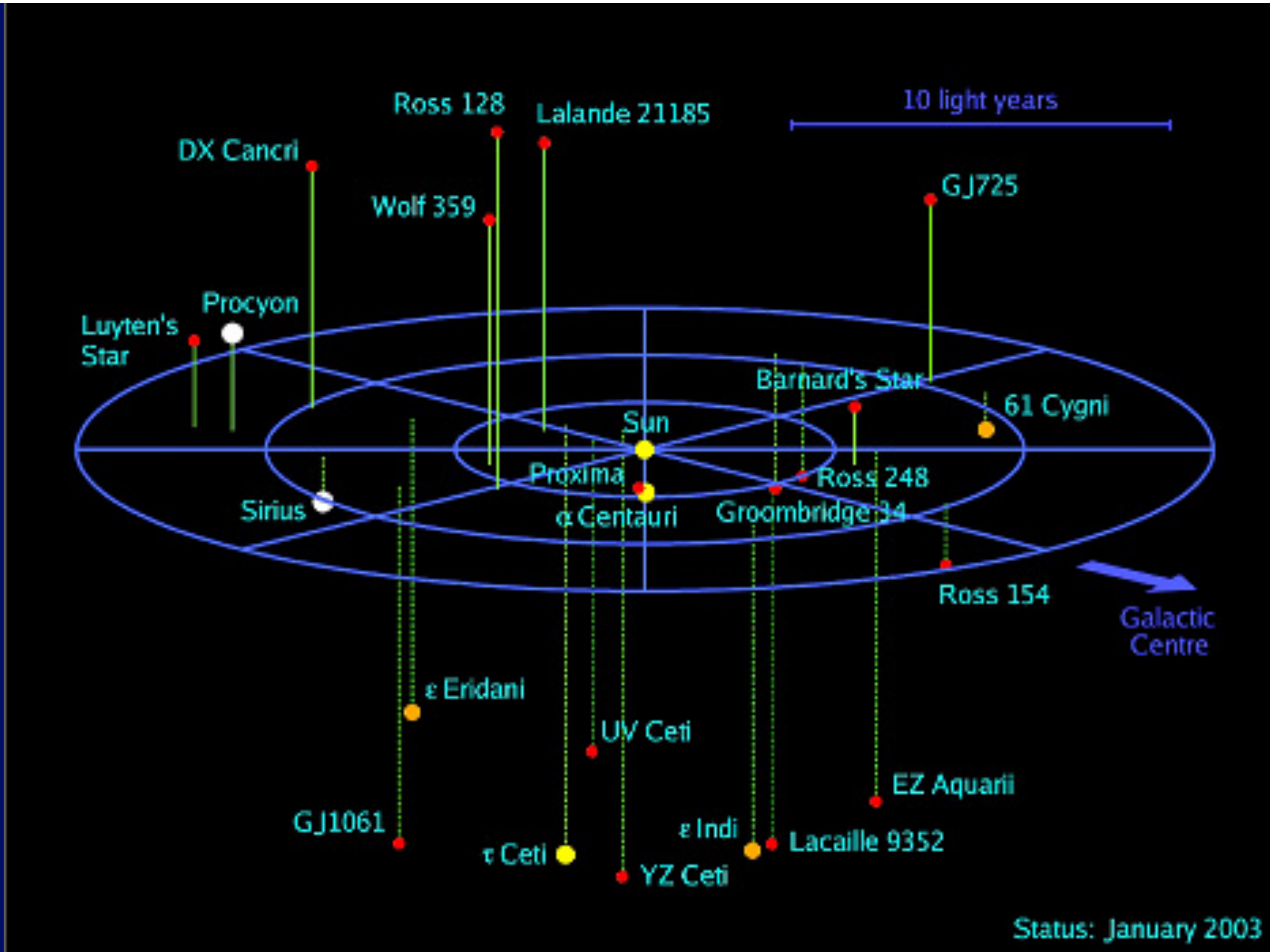
The Cosmic Context

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 SUN'S CLOSEST NEIGHBORS
6 LIGHT YEARS
WISE 1049-5319
disc. 2013
Barnard's Star
disc. 1916
Alpha Centauri
disc. 1839
4 LIGHT YEARS
Proxima
Centauri
disc. 1917
2 LIGHT YEARS
OORT CLOUD
Sun



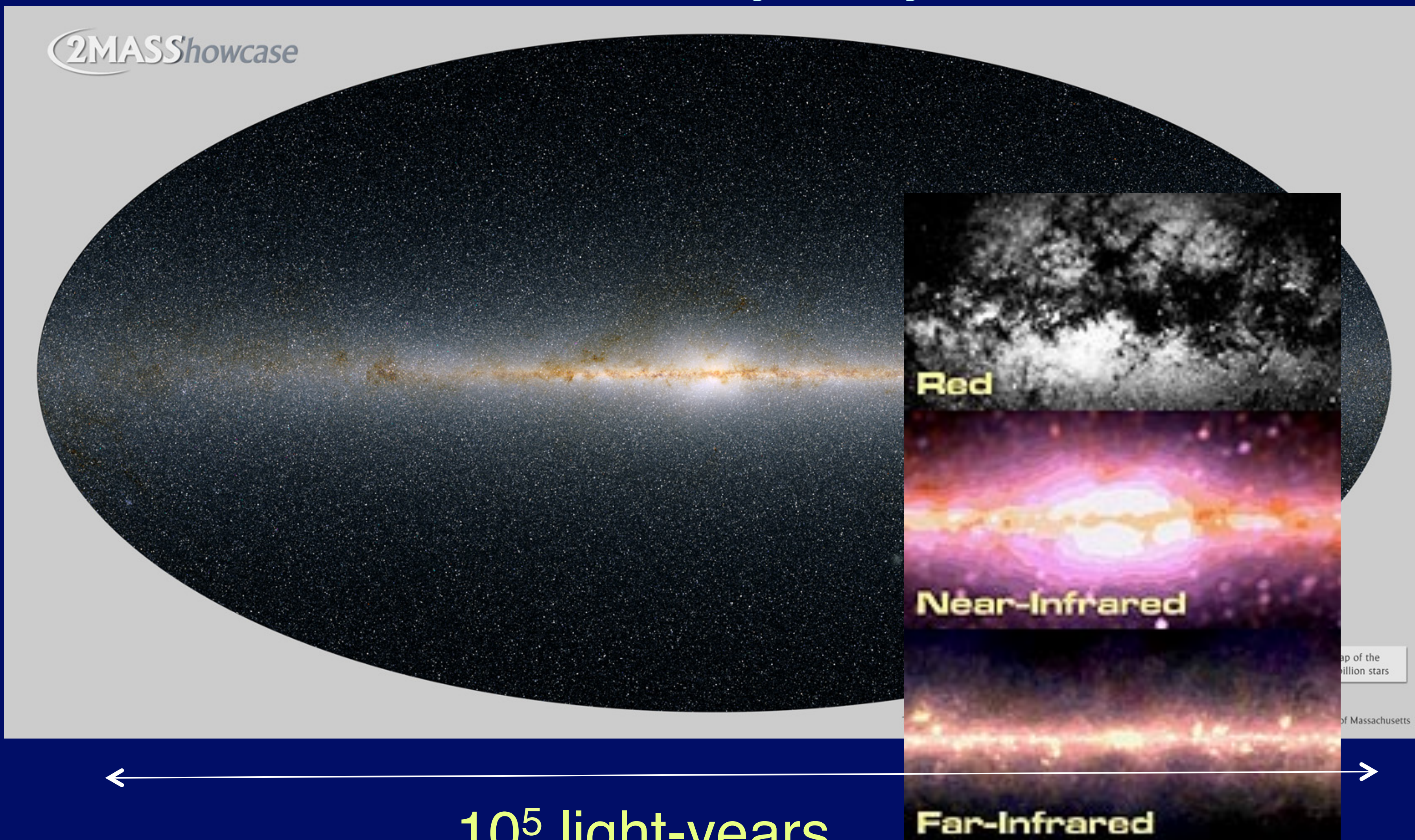
3D Map of Known Stellar Systems in the Solar Neighbourhood

ESO PR Photo 03c/03 (13 January 2003)

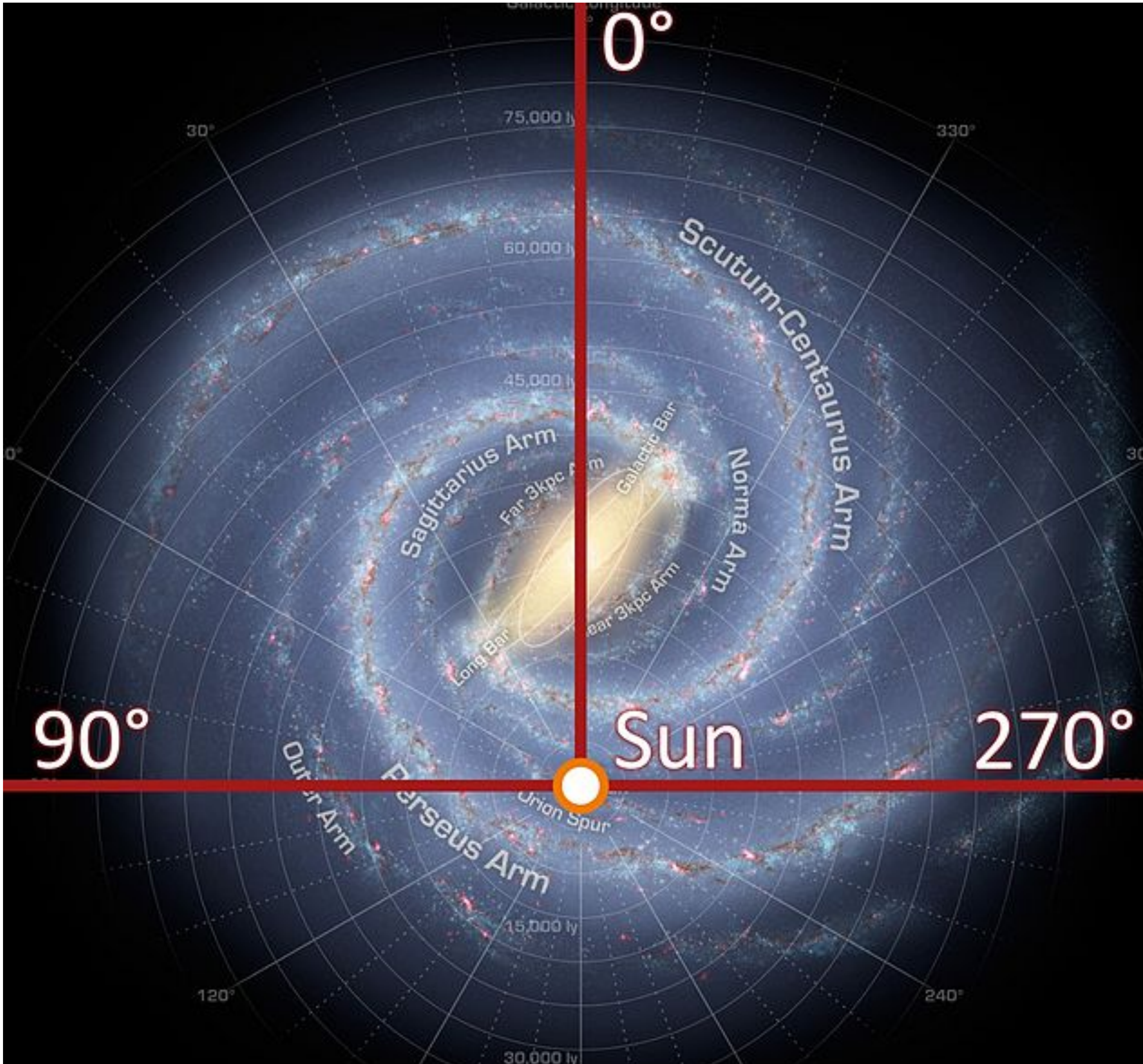
Larger Structures

- 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 40 billion (40×10^9) ly away

The Milky Way



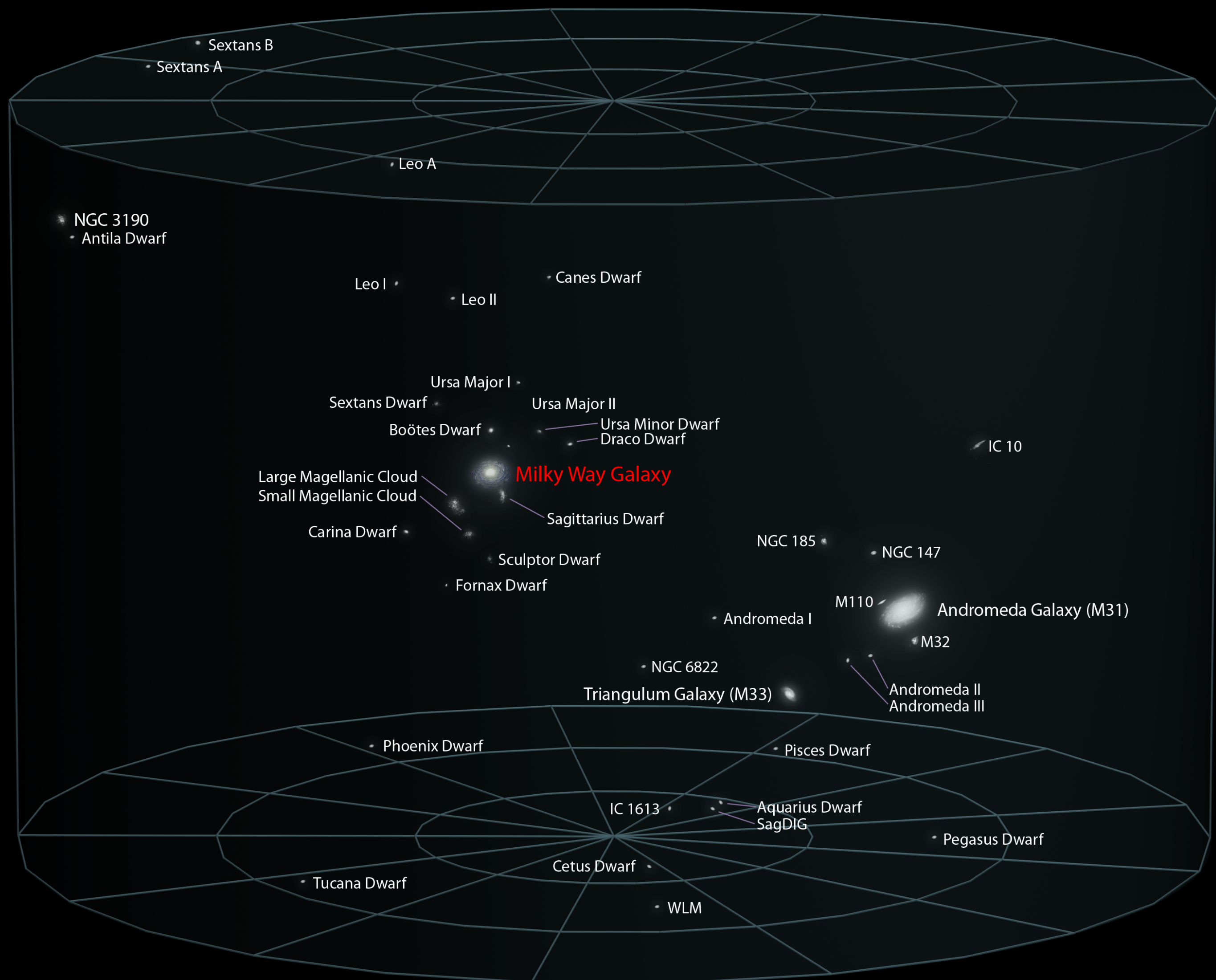
10^5 light-years



0°
90°
270°
Sun
30°
330°
120°
240°
75,000 ly
60,000 ly
45,000 ly
30,000 ly
15,000 ly
Scutum-Centaurus Arm
Sagittarius Arm
Norma Arm
Far 3kpc Arm
Galactic Bar
Long Bar
Perseus Arm
Orion Spur

~ 10^5 ly

Local Galactic Group

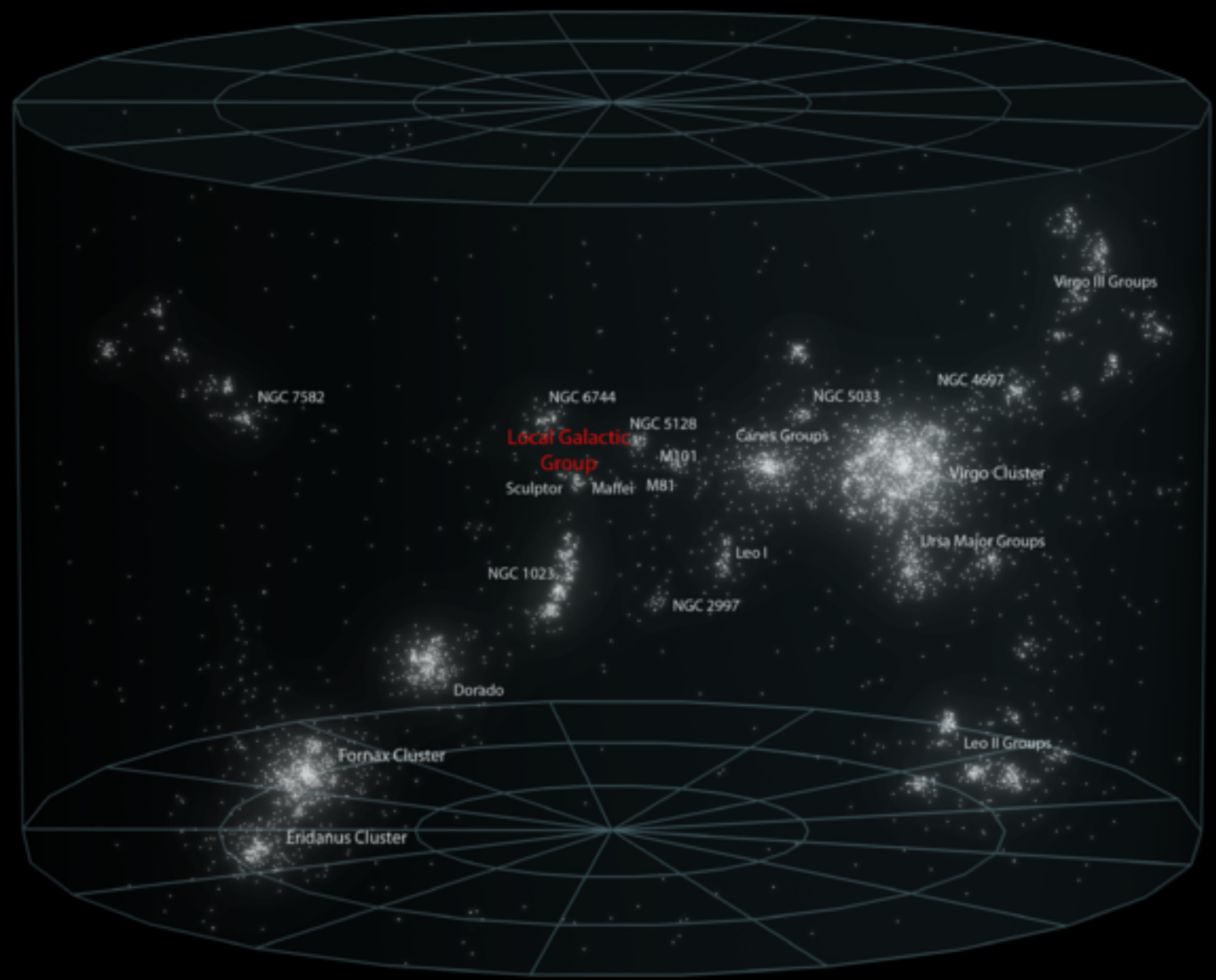


~ 3×10^6 ly

Central Part of Virgo Cluster

3 x 10^7 light-years away

Virgo Supercluster



~ 10^8 ly

The Hubble Deep Field

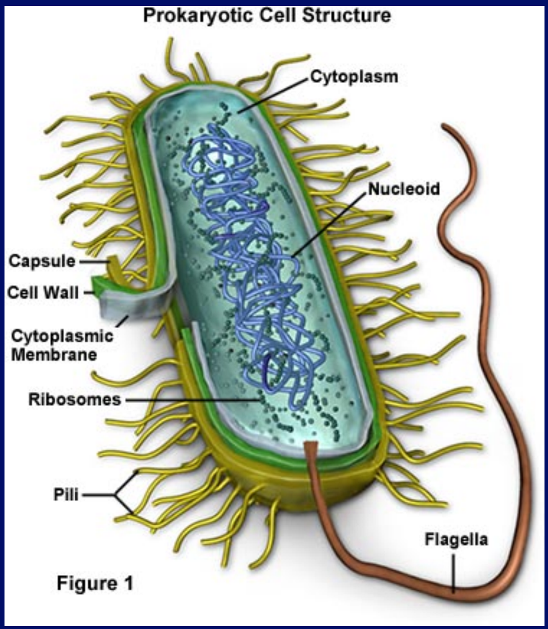
Try this Link

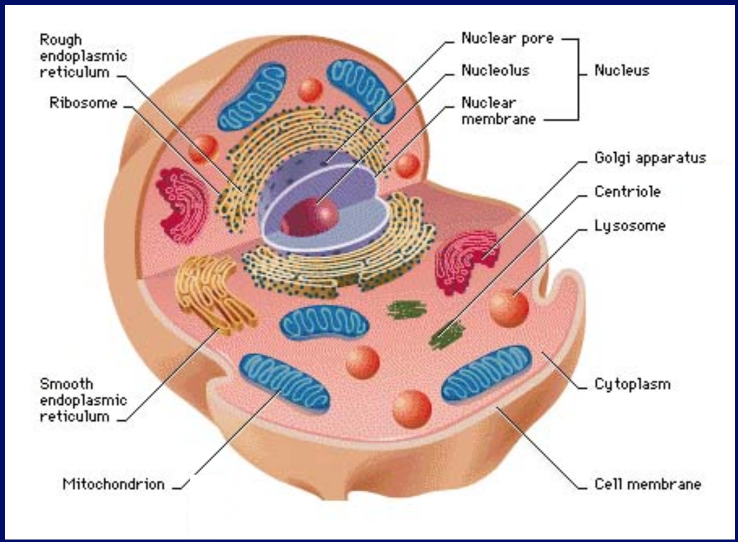
http://www.atlasoftheuniverse.com/index.html

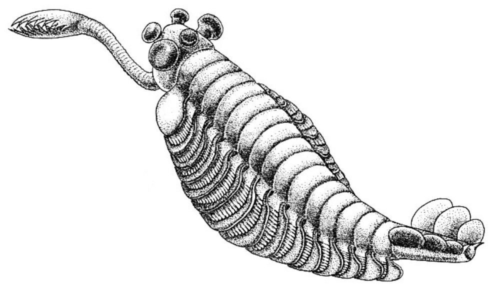
Questions

- 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 $\boxed{\text{Coupled Cycling}}$ 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

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

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

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

The Drake Equation

Drake Equation:

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

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