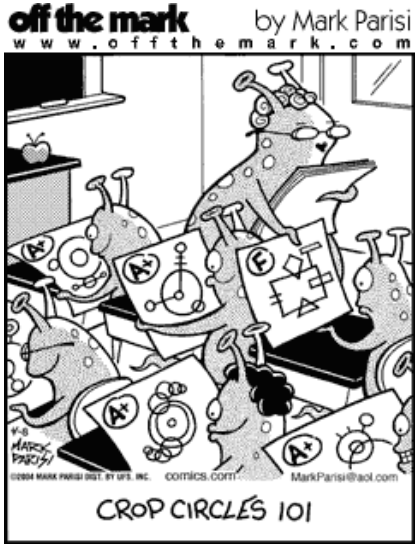
Astronomy 230



This class (Lecture 16):
Biological Evolution
Tom Patterson
Tim Ferencak
Jeffery Lipsey

Next Class:

Biological Evolution
Fred Knecht
William Kormos
Adam Molski

Oct 31:

Kerry Doyle
Steven Novak

Music: *The Space Race is Over* – Billy Bragg

HW #3

- **Katelyn Swartz:**
  http://www.billymeier.com/
- **Ryan Peterson:**
  http://www.space.com/scienceastronomy/alien_intelligence_021202.html

Presentations

- **Tom Patterson:**
  Human Colonization of Planets/Asteroids
- **Tim Ferencak:**
  Interplanetary and Interstellar Travel
- **Jeffery Lipsey:**
  Non-Carbon Based Life

Outline

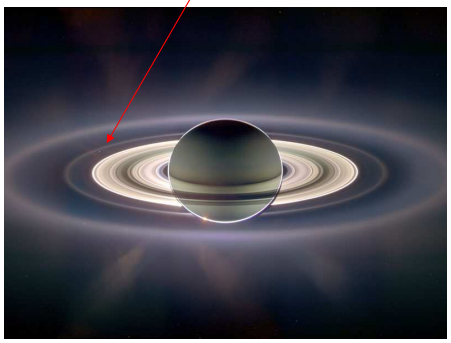
- Life in our Solar System?
- Two types of cell life: Eukaryotes and Prokaryotes.
- All life can be divided into 3 types:
  - Bacteria
  - Archaea
  - Eukarya

Conclusion

- ***No conclusive evidence exists for life in our solar system besides on Earth***
- But, possibilities exist for life
  - Venus's clouds may have migrated life.
  - Mars may have some microbial history linked to water, and perhaps some subsurface life.
  - Jupiter's reducing atmosphere may harbor sinkers.
  - Europa's sub-crustal oceans may harbor life, even fish-like life.
  - Titan is still very interesting
    - Thick atmosphere
    - Reducing chemistry

No Intelligent Life

- We might find evidence of some sort of life in the next decade, but very unlikely to find complexity needed for intelligent and communicative life.
- Apparently in our system, Earth's conditions are necessary.
- Other planets may have microbial forms of life, and maybe complex fish-like organisms, but we don't expect communicative beings.



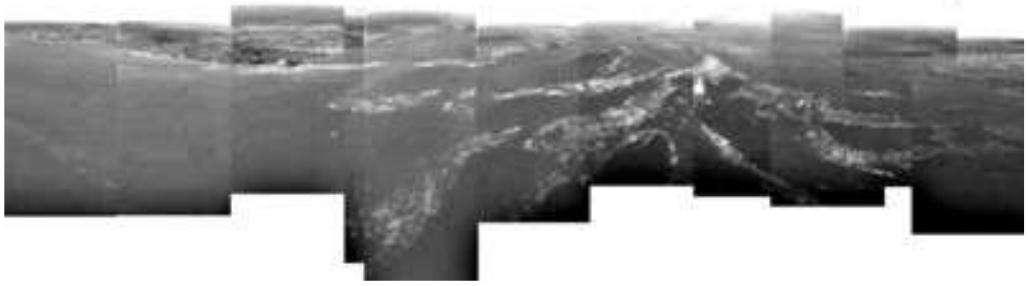
http://antwrp.gsfc.nasa.gov/apod/ap061016.html

How to search for life?

- How do we search for life in our Solar System and beyond?
- What test will indicate life exclusively?
- Remember the Viking problems on Mars.
  - Need flexibility to test interpretations.
- But, it is difficult to anticipate fully the planet conditions.

How to search for life?

- Is is apparent that future missions need to land as near as possible to sites of subsurface water or other solvents.
- On Titan, what are the important tests for determining biological signatures of non-water life?
- What if the life is still in the protolife stage? Can we detect that?
- The boundary between chemical and biological processes is difficult to distinguish.



Decision Trees– Search for Life

- Wait for it to come to us via meteorites or comets.
- Robotic one-way investigations– Mars rovers.
- Fetch and return with samples.

http://www.ibiblio.org/wm/paint/auth/friedrich/tree.jpg

Problems

- In the last 2 cases, we have the problem of contamination by Earth life.
- Organisms can live in Mars-like conditions on Earth.
- If some Earth life survives the space journey, it could colonize Mars, possibly destroy any Martian life. Think of Kudzu.
- Current missions must be sterilized.

http://www.hope.edu/academic/biology/faculty/evans/images/Angiosperms/CoreEudicots/EurosidsI/Fabaceae/Kudzu.JPG

Biomarkers: How to look for extrasolar life.

- We need to decide how to search for biomarkers or chemical signatures of life.
- On Earth, methane and oxygen are indicators. They normally react. Something is keeping it out of equilibrium. Sort of like Venus disequilibrium.
- The Galileo spacecraft on its way out to Jupiter, turned and looked at the Earth.
- Did it detect life?

Biomarkers: Looking at Earth.

- Strong "red edge" from reflected light. Absorption from photosynthesis.
- Strong O_2. Keeping oxygen rich atmosphere requires some process. It should slowly combine with rocks.
- Strong methane. Should oxidize. Replenished by life.
- Strange radio emissions that could be intelligent life.
- Recently, researchers have looked at the Earthshine from the moon.
- They agree with Galileo result. There is life on Earth.
  - Water
  - Oxygen
  - Tentative detection of "red edge"

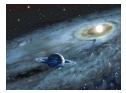
http://epod.usra.edu/archive/epodviewer.php3?oid=56256

Drake Equation

Frank Drake

That's 2.6 life-arising systems/decade








$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

# of advanced civilizations we can contact in our Galaxy today	Star formation rate	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that commun-icate	Lifetime of advanced civilizations
	15 stars/ yr	0.5 systems/ star	2.7 x 0.134 = 0.36 planets/ system	0.095 life/ planet	intel./ life	comm./ intel.	yrs/ comm.

Evolution of Intelligence

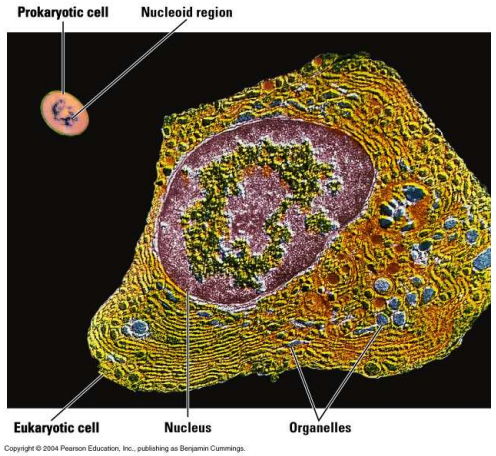
- First, we will examine the diversity of life; the fossil record shows a huge diversity with time.
- Organisms range from bacteria to humans.
- 1.8×10^6 known species
  - Insects account for most (1.0×10^6)
  - Estimated that only 10% are known.
  - Bacteria are hard to classify– only 4000 species so far.
- Remember that all of these organisms use nearly identical genetic codes, so life descended from a common ancestor.
- Primary challenge of biology is to explain how life from a single type of organism, diversified so much.
- Evolution is the primary concept.

Life

If we took all the biomass of all the animals, and all the biomass of all the viruses, bacteria, protozoa, and fungi– who weighs more?

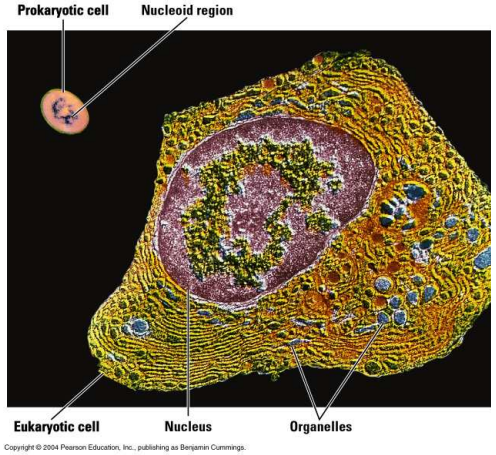
Classification of Life

1. Prokaryotes
   - No cell nucleus– DNA floating around
   - Always single-cell creatures like bacterium
   - Came first
   - Outnumber and outweigh the second class (eukaryotes)



Classification of Life

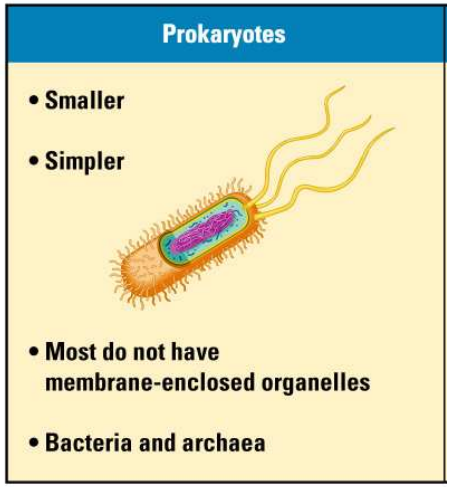
2. Eukaryotes
   - Have a cell nucleus, a membrane to protect the DNA
   - Basis of all multi-cell creatures
   - Also some single-cell creatures like amoebas.
   - DNA arranged into chromosomes in nucleus– 23 pairs for humans.



Prokaryotes

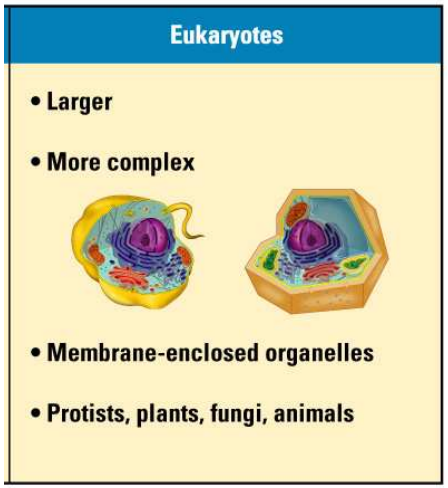
Divided into 2 domains:

1. Eubacteria or "true" bacteria
2. Archaea
   - Thought to be oldest life forms.
   - Often found in harsh environments: hot springs, undersea vents, salty seashores, etc, which were probably more common on the early Earth.
   - Some live deep underground, and may represent a significant fraction of the Earth's biomass.
   - Some evidence that ancient organisms were heat-lovers (maybe)



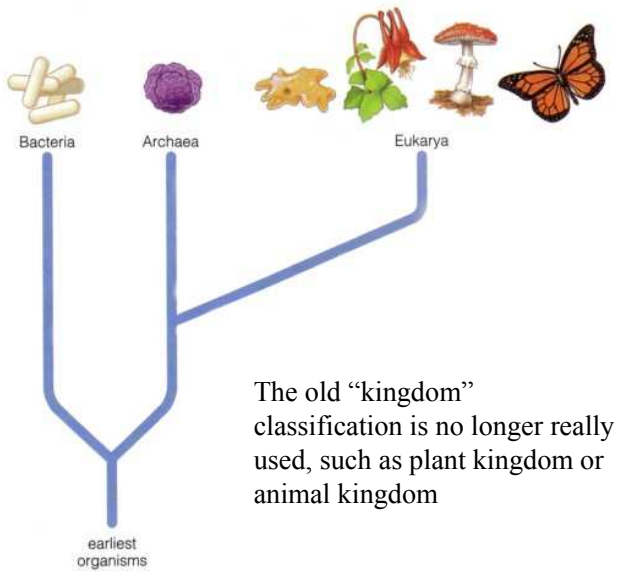
Eukaryotes

- All animals, plants, and fungi.



3 Domains of Life

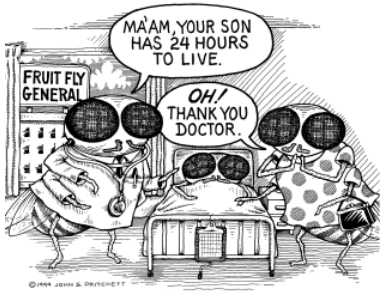
- Genetically speaking, Archaea and Eukarya are more similar to one another than are Bacteria and Archaea
- Implies that Archaea and Bacteria split and then all Eukarya split from Archaea
- A major implication for the evolution of life on Earth



The old "kingdom" classification is no longer really used, such as plant kingdom or animal kingdom

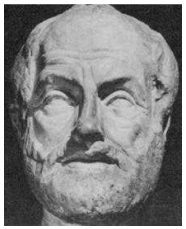
Genetic Relations

- This is a major change from the old methods of assigning groups based on outward form and anatomy.
- Instead based on studies of the genetic code.
- Surprise: Human and chimpanzees share about 99% of the same DNA, and about 97% with mice.
- Surprise: 2 species of fruit fly look very much alike, but only share about 25%. Some of this differences is due to *junk* DNA.



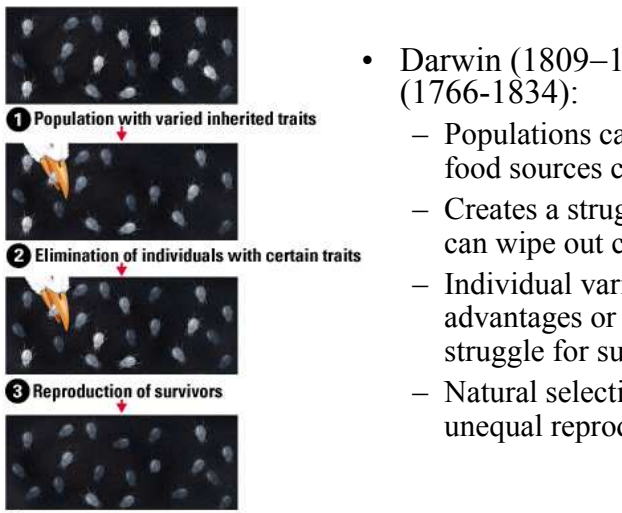
http://www.uglybug.org/index00.shtml
http://www.pritchettcartoons.com/fruitfly.htm

Changes?



- Today's view: evolution is the most important and unifying property of life.
- Anaximander (c. 610–547 BC): life arose in water and gradually became more complex
- Empedocles (c. 492–432 BC): survival of the fittest (but, "*a good idea stated within an insufficient theoretical frame loses its explanatory power and is forgotten*" by Hans Reichenbach)
- Aristotle (384–322 BC): species are fixed and independent of each other → evolution discarded for 2000 years
- Fossil record: slowly broke down the Aristotelian theory

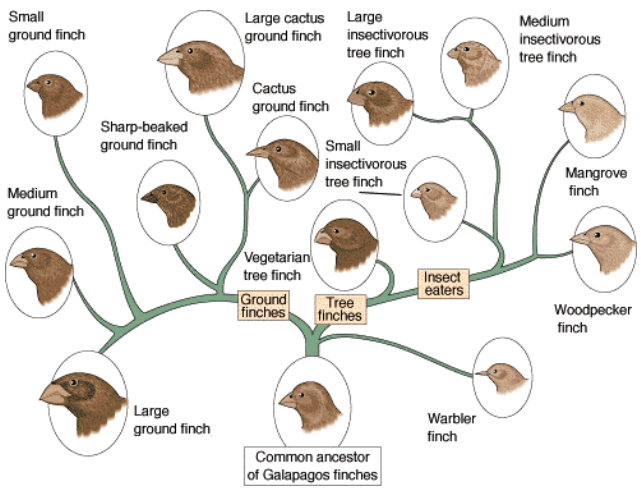
For the Species Survival



- Darwin (1809–1882) & Malthus (1766-1834):
  - Populations can grow faster than food sources can support them.
  - Creates a struggle for survival that can wipe out competitors.
  - Individual variations has advantages or disadvantages in the struggle for survival
  - Natural selection can create unequal reproductive success

Filling the Niche with Finch

- Other Evidence:
  - Adapted species in the Galápagos Islands, in particular finches
  - Artificial breeding of house/farm animals and vegetables
- DNA is really the mechanism of natural selection, but evolution requires both heredity and environment



Mutant Sex

- Mutations from changes in the bases of DNA.
- Usually copying errors, but also radiation– radioactivity, cosmic rays, chemical agents, or UV light.
- About 3 mutations per person per generation.
- Most mutations are neutral, changes in the *junk* DNA.
- Why is sex important to this class?

http://www.mutantx.net/features/press_vw_sexy.html

Mutant Sex

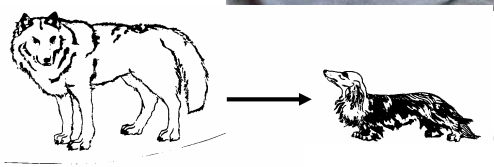
- Sexual reproduction leads to greater genetic diversity– a difference between prokaryotes and eukaryotes?
- Asexual reproduction does not allow 2 new and beneficial mutations to combine.
- Blackberries have not changed much in 10 millions years, but sexual plants have produced: raspberries, thimbleberries, cloudberries, dewberries, etc.
- Sex is useful in the process, but the mutations are still key.

http://www.alcasoft.com/arkansas/blackberry.html

Does it take a long time?

Cabbage, kale, kohlrabi, brussels sprouts, cauliflower and broccoli have same common ancestor– wild mustard. All bred by humans on a very short time scale.

This is selective breeding, but still the potential is in the DNA.



Or domestic lap dogs from wolves in about 5000 years.