Astronomy 230

Section 1– MWF 1400-1450

106 B6 Eng Hall

<u>This Class (Lecture 20):</u>

Cultural Evolution

Presentations Friday & Monday:

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<u>Next Class:</u>

Presentations

Outline

- If a life form evolved into intelligence, what are the odds it will want to speak to us?
- We only have our sample of 1.
- What was our path?
- Our biology hasn't changed.
- Cultural evolution.
- Power through agriculture.
- Information storage problems.
- Ancient views of the Universe.

Drake Equation

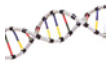
= 4.4

Intelligent Life /century

Frank Drake








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

# of advanced civilizations we can contact	Rate of formation of Sun-like stars	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
	10	**0.34**	**0.208**	**0.235**	**0.265**		
	Stars/year	Planetary System/star	Livable Planets /Planetary System	Evolved Life /Livable Planet	Intelligence /Evolved Life		

Backdrop

- Origin of modern H. sapiens is disputed, but the genetic and linguistic evidence points toward a spread of humans across Eurasia then the Americas.
- We share a common gene pool, but genetic drifts and selection for local environments created genetic differences among groups.
- These differences have little to do with the concept of race, which has been showed by genetic studies to be a meaningless concept.
- The greatest genetic and linguistic variations are found in Africa, supporting the "out of Africa" idea.

http://www.popular-science.net/img/out-of-africa.jpg

Cultural Evolution

- Once humans spread across the globe, the primary method for evolutionary change shifted from biological to cultural evolution.
- Anatomically modern H. sapiens evolved 100,000 yrs ago, but the first modern behavior did not appear until 40,000 yrs ago– e.g. cave painting.
- Regardless, there has not been any significant biological evolution for the last 40,000 yrs– e.g. brain increase.
- The rest is cultural– from hunter-gathers to cell-phone-users.
- Cultural evolution was fast.
- Is cultural evolution needed for ET? Why would a ET culture try to communicate?
  - Capability (suitable technology) and interest (worldview?).

Hunting and Gathering

- Until 10,000 years ago, H. Sapiens functioned completely as hunter-gathers.
- Small nomadic tribes with few possessions.
- Except for shortages, a fair and easy life
  - No midterms
  - Only working about 4 hours a day
  - But, no way to create surpluses or free members for other roles.

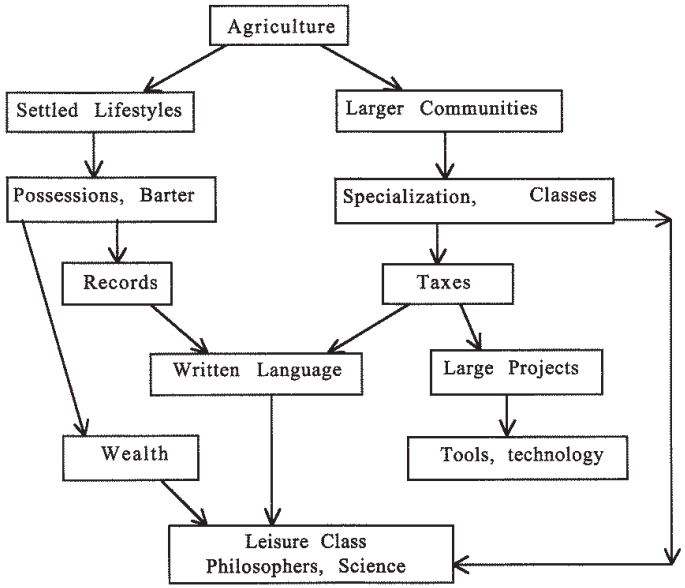
http://www.cnn.com/WORLD/9511/safrica_bushmen/

Agriculture

- Tribal societies– 100s of people into villages
- Due to agriculture, larger and larger communities and new societal organizations.
- Began about 10,000 yrs ago, around the dead sea.
  - Mixed hunting with harvesting of wild wheat and barley.
  - Storage, planting, and seed selection.
  - Mutant varieties took over and hunting decreased.
  - 1000 years later, animal domestication.
- Provided long-term settlements for cultural evolution, information, tools, and energy sources.

http://www.ffa.org/media/comm/index.html

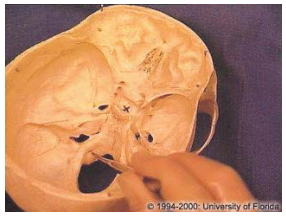
The Importance of Agriculture



Language and Information

- Limited size for brain, due to birth canal size, so limited bits of info.
- Need to develop extra-somatic (outside the body) information storage techniques.
- First method was to have info from another person.
- But the origins of language are not well understood– no fossils.
- Probably in hunting parties for large prey.
- The control of the tongue is through the hypoglossal canal (hole) in the skull. In humans it is twice as large as chimps.
- First arose about 400,000 yrs ago in Australopithecines.

http://members.aol.com/paroleinfo/PRESSURE.HTM



http://imc.gsm.com/integrated/haonline/haonline/ha/imgs/00000/3000/600/3604.jpg

Writing

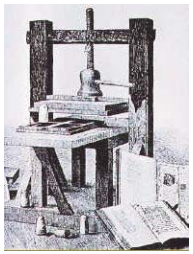
- Oral language is clearly limited.
- Development of written language provided a powerful, new source of info storage.
- Earliest appearance was in Sumer– present day Iraq (8500 BCE).
- Probably started from economic need– barter or receipts.
- Common by 3000 BCE.
- Written records of taxes and a ruling class– the rise of civilization.
- Move from symbols to syllabic language developed by 1500 BCE.

MS 3008
Account of commodities. Sumer, ca. 3200 BC.
The earliest continuous writing known

http://www.nb.no/baser/schoyen/4/4.4/441.html

Extrasomatic Storage Leaps

- Printing press (1456) – number of books jumped from 10^4 to 10^7 in 50 yrs.
- Telegraph (1844)
- Radio (1895)
- Television (1936)
- Computers (1950s)
- Internet (1970s)
  - Huge extrasomatic storage: Well above brain storage



Does all of this increase the "intelligence" of our species?

From Rocks to Metal

- Stone tools (silicates) started with H. habilis about 2 Myrs ago.
- Agriculture developed at the end of the stone age.
- First pottery (still silicates) around 7000 BCE.
- First metal (copper) in 6500 BCE, mostly ornamentation.
- The wheel was invented in 6500 BCE.
- Copper tools in 4000 BCE.
- Animal drawn vehicles & sailboats in 3300 BCE.
- Bronze (copper and tin) tools in 2800-1000 BCE (the Bronze age).
- Iron first showed up in 1500 BCE.

From Rocks, to Metal, to Rocks

- Next real step was developing energy sources.
- The industrial revolution.
- Modern technology based on electronics, crucial to our ability to communicate to ET.
- Transistor in 1948.
- Microchip in 1959.
- We went back to silicon!
- We are arguably in the “silicon age”.
- This implies knowledge of electromagnetisms and quantum mechanics.

Cultural Evolution

- What do we mean by cultural evolution?
- Is that like natural selection?
- Since technology has developed out of it, we can conclude that technology was a desirable trait that is likely to develop on any planet with competition between cultures.
- Or can we?
- If so, then would have to say that cultural evolution follows a punctuated equilibrium model.
- Or, episodic progress with long periods of dark ages.
- Like species, the fate of civilizations has been extinction, but their technology was adopted by others (cultural diffusion).

Evolution?

- The main point is how likely is it that technological civilizations exist on other planets?
- Hard to determine on Earth, but there are some points:
  - Agriculture arose independently in Mexico and probably China, Andes (potatoes), and eastern US (sunflowers).
  - Written language independently in China and the Americas, maybe India and Egypt.
  - But, the wheel was not invented outside of Sumer.
  - For recent developments, the world was in too much contact.

Questions: Variations of Civilization

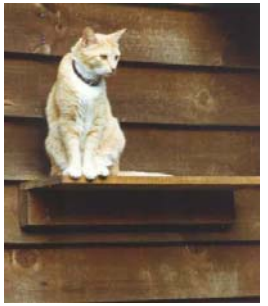
- What if the Americas had invented gunpowder?
- What if the Americas had large animals of burden?
- What if the germs of Europe were less dangerous than the germs of the Americas?
- Similar examples of cultural devastation in the Pacific Islands.
- Often cultures are wiped out from *Guns, Germs, and Steel* (by Jared Diamond).

Technology Development

- Our sample of one, makes it difficult to determine if technological development (to communication ability) is a fundamental step from intelligence.
- Does it depend on the planet– water/desert dominated?
- How would metal poor planets develop?
- Does the competition of civilizations matter?
- Is there a dependence on psychology of the intelligence life?

Next Step

- Besides needing technology, intelligent life must have a want to communicate with extraterrestrial life.
- That means that it MUST believe in the possibility of other life.
- Requires civilization to undergo three steps:
  1. A correct appreciation of the size and nature of the Universe
  2. A realization of their place in the Universe
  3. A belief that the odds for life are reasonable. They must have taken their Astro 230 class and came up with a good number of communicable civilizations in the Drake equation.



http://www.bybeeweb.com/cats/amelia-step.jpg

Big Questions

- Our capacity for interstellar communication arose at the same time as our interest in it. Coincidence?
- Can a society have a highly developed technology with an incorrect astronomy?
- What if the skies were constantly cloudy?
- What if their solar system had no other planets?
- What if they lived in a molecular cloud?
- What if they lived in a huge cluster of galaxies?

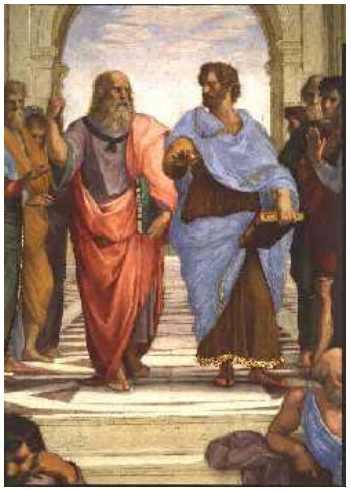
Our First View

- The first concepts of the Universe were Earth-centered.
- How did we come to this point– Astro 230?
- First recorded cosmology was from the Babylonians.
  - The Universe is a large oyster, and we are inside.
  - But other aspects of their astronomy was advanced.
  - Regularity of astronomy for crop planting, harvesting, and accurate calendars back to the 3800 BC.
- The Mayans computed the length of year to within a few seconds (0.001%).
- So early humans had a weird mixture of precise calendar astronomy with primitive concept of the Universe and mythological systems incorporating magic.

http://www.internationalenglish.co.uk/courses.htm

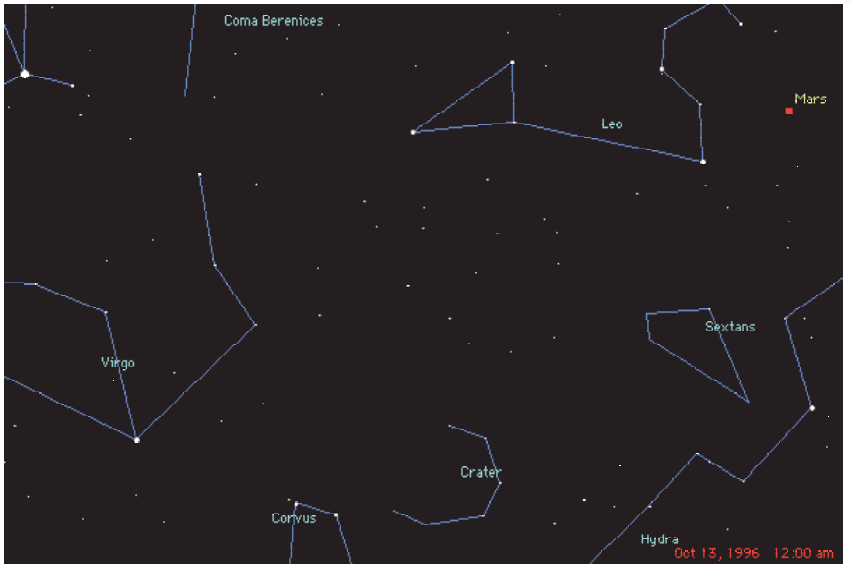
Greek Astronomy

- Greeks were excellent Astronomers
  - Cataloged star positions & brightness.
  - Systematic, quantitative observations.
  - Natural philosophers.
- They observed that the stars, Sun, and planets revolved around the Earth.
- So Earth is center of Universe- ***geocentric cosmology*** (mostly from Plato and Aristotle).
- Even though other philosophers (Aristarchus) argued for a heliocentric cosmology.
- Perfect Spheres of motion?



Mars Moves WRT the Stars!

E A S T



W E S T

Motions of Planets

- So, over time the planets seem to move along the ecliptic from <u>west to east</u> over long time periods.
  - This is called ***prograde*** motion
- But once in a while, a planet appears to stop and reverses direction
  - Reverse direction is called ***retrograde*** motion (east to west).
- Planets move counter-clockwise (looking down at the north pole)

How can we explain the Planet motion?

But for a ***geocentric cosmology*** you can't easily explain the retrograde motion of the planets.

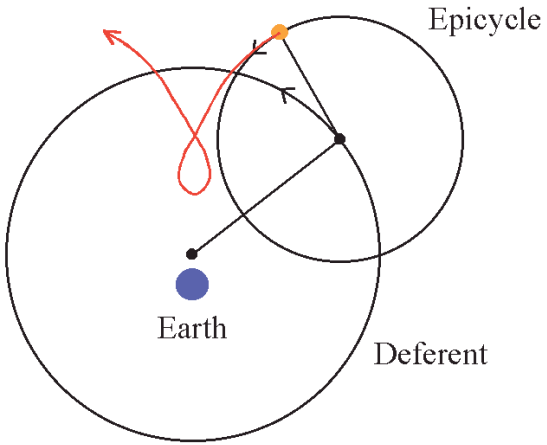
Note: perfect circles

Ptolemy (140 AD: `p` is silent)

Took geocentric model with uniform circular motion to introduce the Ptolemaic system, or model, of the Solar System that explained retrograde motion

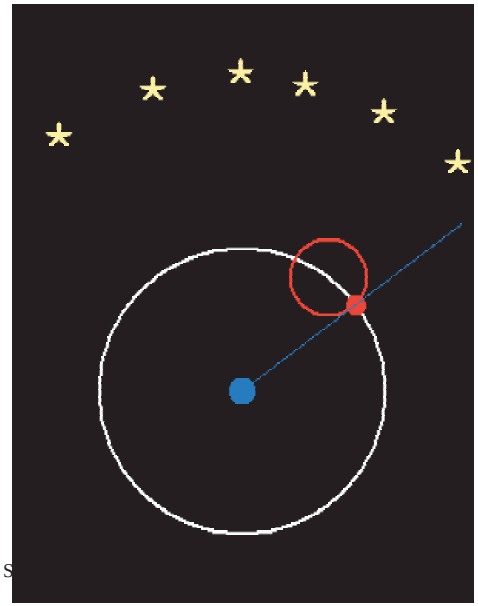
Ptolemaic system

- Geocentric
- Nice circular motion



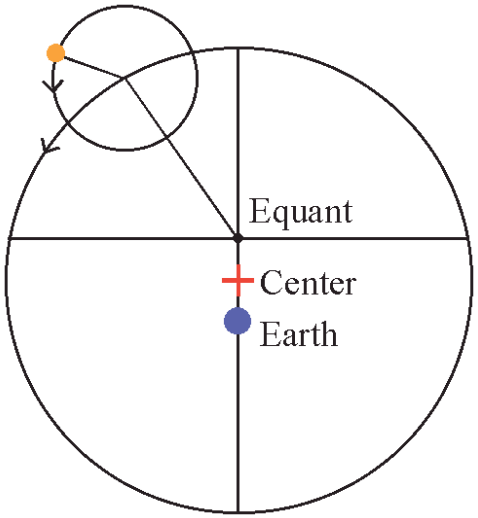
Ptolemaic system

Yes, it can explain retrograde motions



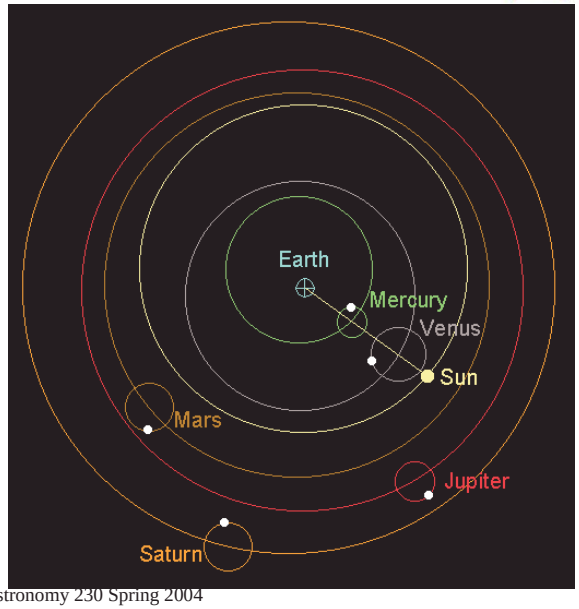
Ptolemaic system

Had to be made more complicated to account for some observations



Ptolemaic system

Overall system of the Solar System.



Ptolemy's Geocentric Cosmology:
Is it a Scientific Theory?

Yes! …and an accurate one too

- Data: Sun/moon/star motions
- Tentative Model: circular orbits
- Prediction: uniform motion on sky
- New data: retrograde motion
- Refined model: epicycles--explains data!

Result: Ptolemaic system (theory)

- *strength*: accurate fit of data
- *weakness*: predictions for new data?

More Ptolemaic Problems

- Each planet acted independently of others
- There was no universal rule governing the planets motion
- Nonetheless, for a 1000 years this model ruled western thought
- However, by the late middle-ages astronomers felt that it was too complex, and a search began for a system with simple underlying principles