

Astronomy 330: Extraterrestrial Life



This class (Lecture 22):

Evolution of Humans

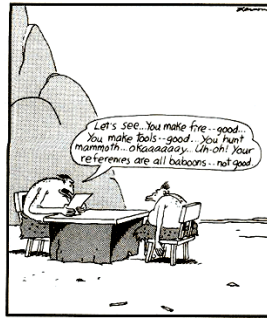
Saaya Nath

Obinna Onyemepu

Next Class:

Evolution of Culture

Brandon Murchison



Primitive resumes

Music: Human Behavior – Bjork

Article Forum open— selection due April 21st

HW #2



Quinn Calvert

http://www.bibliotecapleyades.net/vida_alien/alien_contact04.htm

Frank Drake and Carl Sagan used the Arecibo telescope to send a message, and a reply came in the form of a "crop circle"

Zachary Brewer

<http://www.sherryshriner.com/sherry/reality.htm>

author of this website is claiming that all humans are secretly controlled by aliens. "Trust me. I know I'm right."

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Drake Equation

That's 9 life systems/year

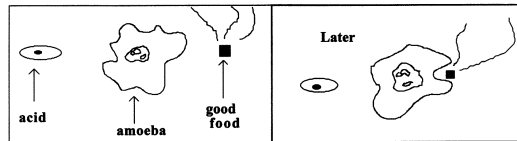
Frank
Drake



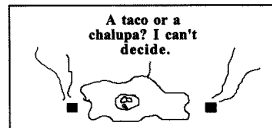
$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

# of advanced civilizations we can contact 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 communicate	Lifetime of advanced civilizations
	30 stars/yr	0.8 systems/star	$4 \times 0.47 = 1.88$ planets/system	0.2 life/planet	intel./life	comm./intel.	yrs/comm.

The Intelligent Amoeba

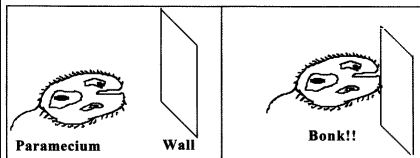


Can model its environment.

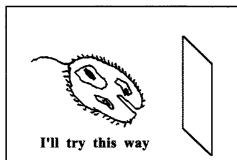


But if two pieces of food are placed nearby?

The Intelligent Paramecium?

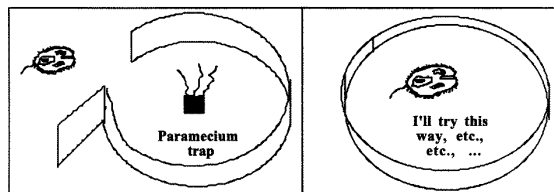


One cell,
but more
complex



Has a primitive
form of memory

Intelligence Breakdown



Doesn't realize to give up.

Smarter than an amoeba, but no Einstein
Complexity does imply some intelligence
Seems to be a continuum of intelligence



Evolution of Intelligence



Our Definition: *The ability to model the world, including the organism's own self.*

Single Cell organisms can do this to some degree

Intelligence is a continuum, not a unique aspect of humanity

Why apparent gap between humans and all other life on Earth?



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Origin of Human Intelligence



If intelligence is a continuum, we are essentially the same as other organisms.

But what can we use to measure this continuous value?



Common Dolphins sounds
<http://neptune.sdsmta.td.com/dolphinsounds.html>

Intelligence could be defined by the quantity of information stored in the organism

DNA Storage

DNA Storage



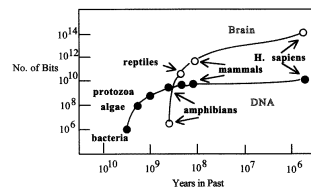
Binary arithmetic Yes = 1
No = 0

4 Options for each DNA base = 2 bits

Each codon has 3 bases, so 6 bits

Humans have 3×10^9 bases times 2 bits/base = 6×10^9 bits

This is approximately 750 Mbytes = 400 books of 500 pages each.



DNA Storage: Caveats



Amount of junk DNA make this approach problematic

Recall that about 2% of human DNA encodes proteins:
 1.2×10^8 bits (15 Mbytes) or 800 books

If junk DNA is significant, some organisms (like a newt or lily) would have more than 10^{11} bits (12.5 GB)

Note: Less intelligent organisms did not disappear

Thus *no trend* for organisms to get smarter!

Diversity of life with time led to some species with intelligence

Niche is found where intelligence is preferred

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Limited Pockets in Genes



Limits to the quantity of information
genes can store



Try to store too much information and
mutations can wipe you out.

Eukaryote error rate is about 10^{-9} , limiting
amount of storage to about 10^{10} bits

Genetic storage is all *read-only*.



Limited Pockets in Genes



What did *life* do?

Evolution devised a new,
extra-genetic method to
store information

Life developed a nervous
system and a brain



More bits of storage that
are *read/write*.

We can learn!



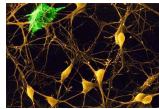


Info Storage in Brains?



How can we calculate information storage in the brain?

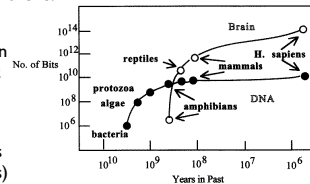
10^{11} nerve cells (neurons) in human brain



Neurons are analog not binary, and they are all interconnected via synapses to 10^3 other neurons.

Impulse triggers a chain of neurons to fire, thus we can model information content as stored in synapses

Information content is thus $10^{11} \times 10^3$ bits (12.5 TBytes)



Intelligence



Intelligence *seems* to be an advantageous trait

Some connection between rise of complexity and intelligence

Increased genetic diversity is the key

More organisms of different types ➔ Increased likelihood of a more intelligent species



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Intelligence



Drake Equation

We want to calculate the number of ET civilizations that might communicate.



N



Humans are only species on Earth to develop advanced technology

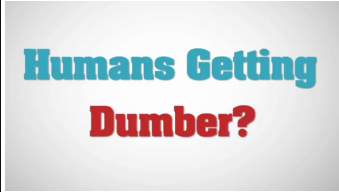
Need human or better level of intelligence?



Intelligence



How does this apply to alien civilizations?



Development of humans:
Controversial



Fossil record incomplete

First mammals: 200 Myrs ago

Mammals were small segment of life until ~ 65 Myrs ago

Our species is the only one on Earth to have developed a technological civilization.
How likely is that to happen on other planets?

Rise of Mammals



Resulting climate change and mass extinction favored mammals.

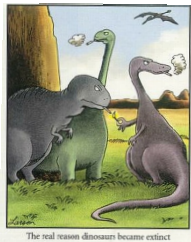
Burrow or Underwater

Diet

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Mammals first appeared on the fossil stage about 200 Myrs ago, but were minor players until about 65 Myrs ago.

Rise of Mammals



Less Credible Theories

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Mammals first appeared on the fossil stage about 200 Myrs ago, but were minor players until about 65 Myrs ago.

Primates



Humans are primates

Primate branch at least 65 Myrs
Possible older (85 Myrs)?

Primary Characteristics:

- flat fingernails
- eyes in front of face
- no sharp teeth or claws
- primarily adapted for life in trees
- some have large **brain:body** ratio but most don't

Primates



Most primates have not successfully developed high intelligence

One Exception!

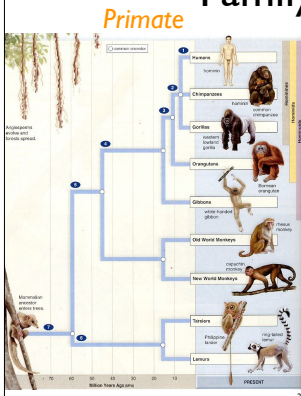


That One

Not That One



Family Tree



Trend of adaption to life in trees

Toe claws to gripping with toes or fingers

This allowed tool use

Nocturnal to Daytime

Increased visual acuity

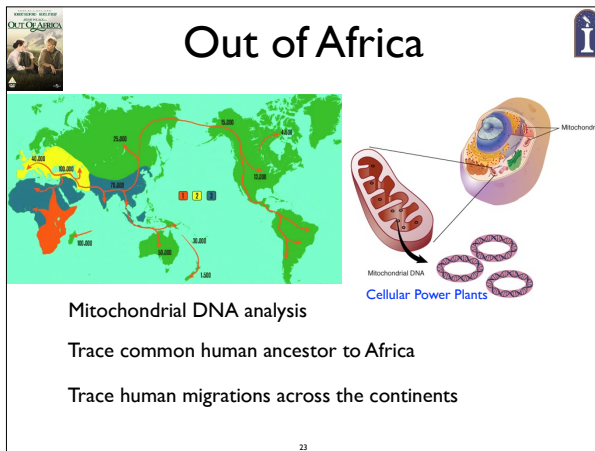
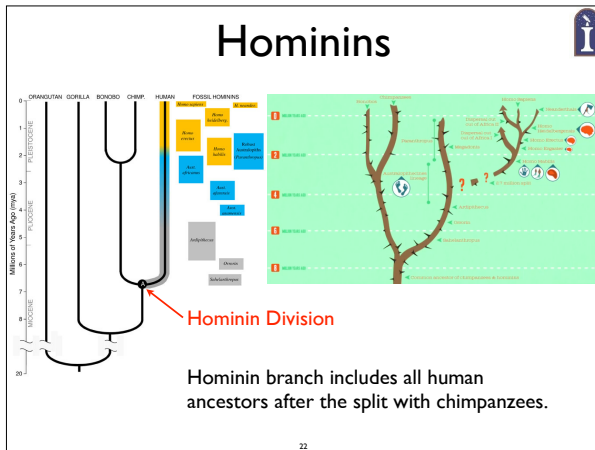
round face

forward eyes

color-sensitive eyes

Mutations were random

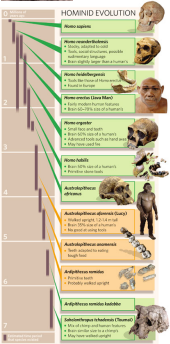
Characterized by: bipedal locomotion, an upright position, and a large brain that lead to: tool use, language, and culture.



Mitochondria make ATP, and run a lot of cell functions



The Last 5 Myrs



HOMO HABILIS

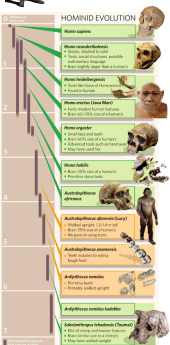
- Brain 50% size of a human's
- Primitive stone tools

Tool Usage
Increased brain size



HOMO HABILIS

The Last 5 Myrs



HOMO ERECTUS (Homo Erectus)

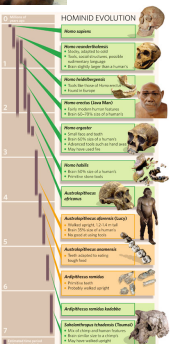
- Tools like those of Homo habilis
- Found in Europe

Homo erectus (Homo Erectus)

- Fairly modern human
- Travelers



The Last 5 Myrs



Homo mandchaliensis

- Stocky, adapted to cold
- High, vocal, expressive, possibly rudimentary language
- Brain slightly larger than a human's

Overlapped with Homo Sapiens
Social Structures

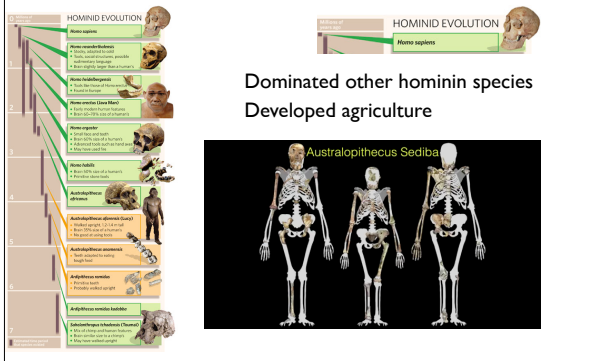




The Last 5 Myrs



1:18



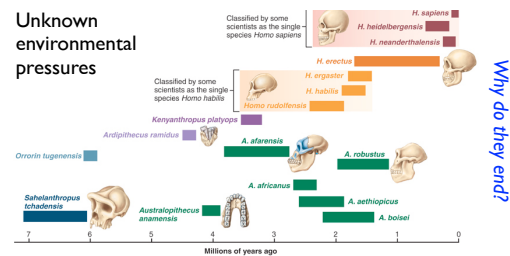
The Family Album



Evolutionary path was not linear and smooth.

Multiple hominin species coexisting

Unknown environmental pressures



Path to Intelligence

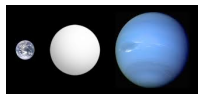


The path of hominin evolution is interesting, controversial, and still being illuminated.

Our path to intelligence took ~ 4 Billion years!

This path was not obvious *a priori*

Unlikely that life would follow a similar path again



The general lesson is that **Diversity** is the key!



Ancestors



Origin of modern humans

Depended on **adaption** to environment niches.

Explosion of different species

One **path** led to bigger brains

Why?

Environment?

Plausible that given enough time this can happen wherever **Life** originates.

