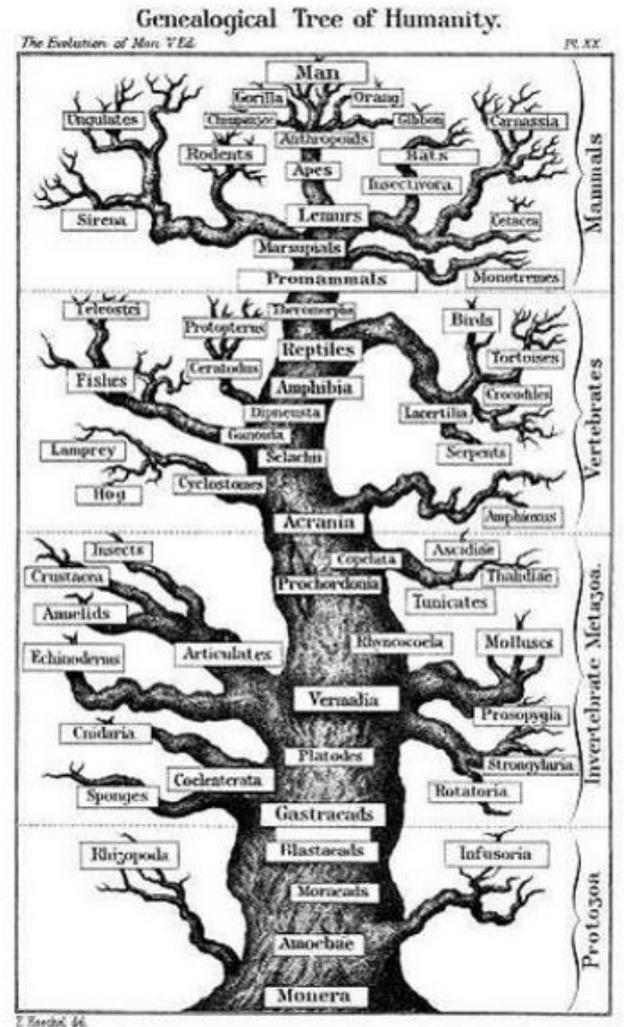
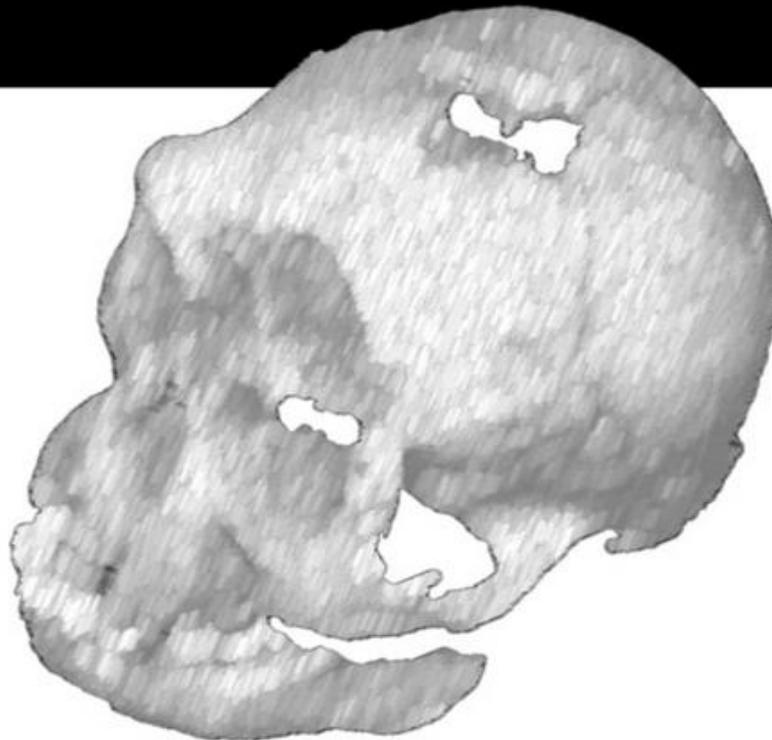


IB Biology  
Option D

## D3 Human Evolution

All syllabus statements ©IBO 2007

All images CC or public domain or link to original material.



[http://commons.wikimedia.org/wiki/File:LB1\\_skull.jpg](http://commons.wikimedia.org/wiki/File:LB1_skull.jpg)

<http://commons.wikimedia.org/wiki/File:Human-evolution.jpg>

# Primate

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

8

Features?

# Aim

To understand the significant steps in the evolution from primate to human



*D.3.4 Describe the major anatomical features that define humans as primates*

*D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens**

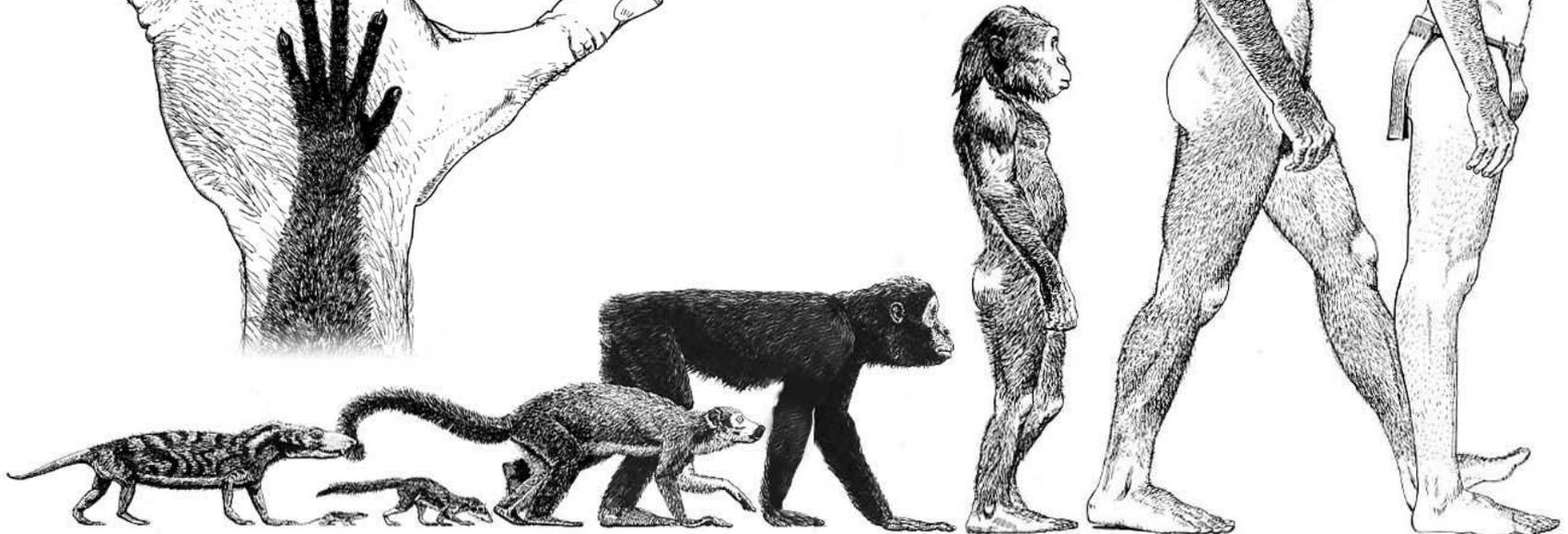


# Order Primate



**What are the distinguishing features of the order?**

**Look at the pictures/info and pick them out of the article**





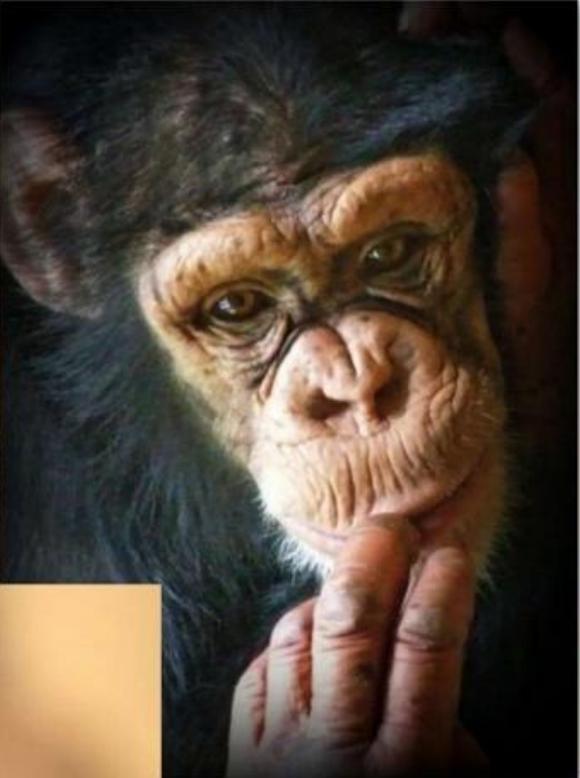
# Order Primate



Opposable thumbs



# Order Primate



Binocular  
Vision





# Order Primate

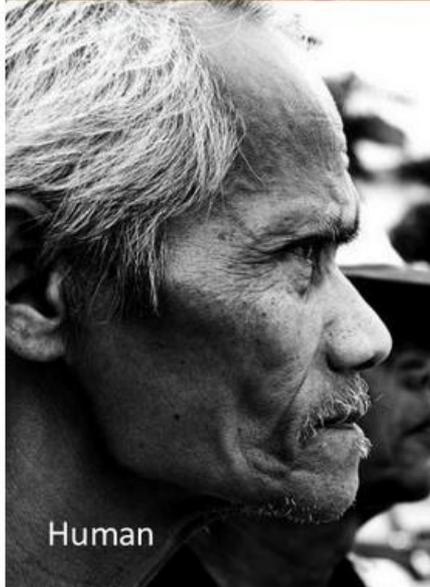
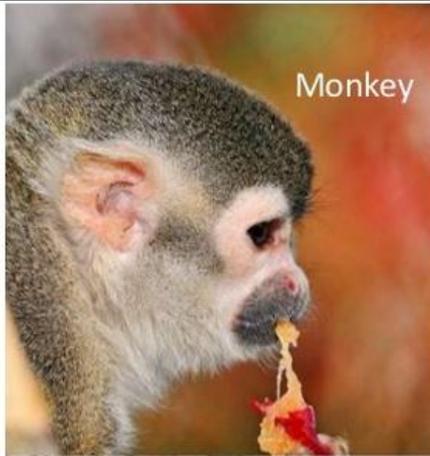
Human hands are adapted for grasping and fine manipulation. In contrast gorillas have short fingers for knuckle walking and gibbons have elongated fingers and reduced thumbs for brachiating.



<http://www.flickr.com/photos/docsearls/5500125757/>  
[http://en.wikipedia.org/wiki/File:Western\\_Lowland\\_Gorilla.jpg](http://en.wikipedia.org/wiki/File:Western_Lowland_Gorilla.jpg)  
<http://www.flickr.com/photos/cskk/2709688102/>



# Order Primate



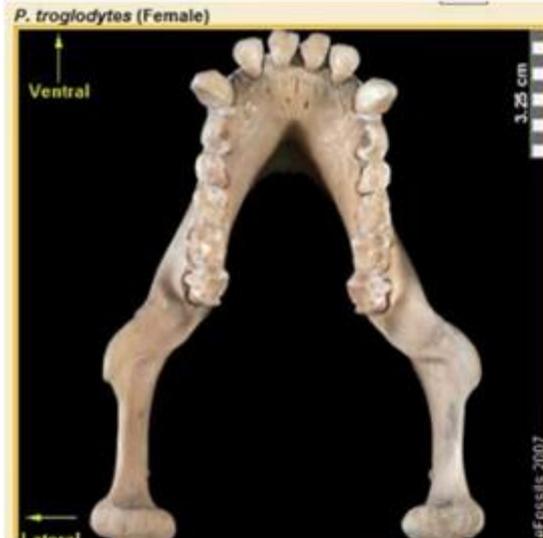
Reduced  
snout  
leading to  
reduced  
olfaction

VS.

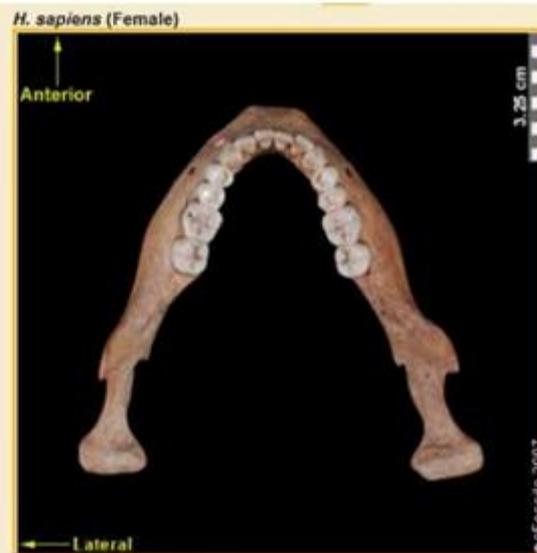
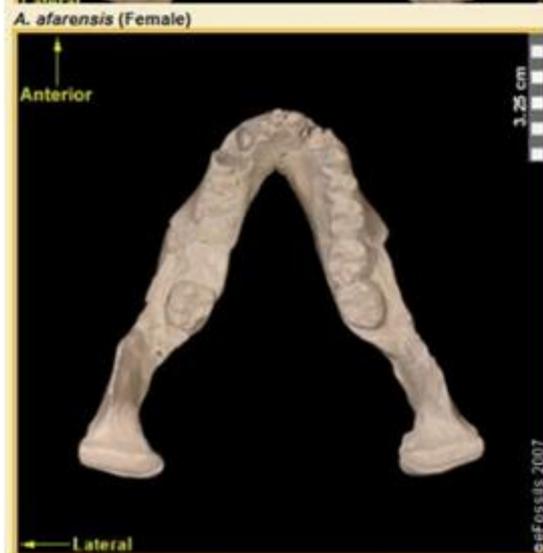




# Order Primate

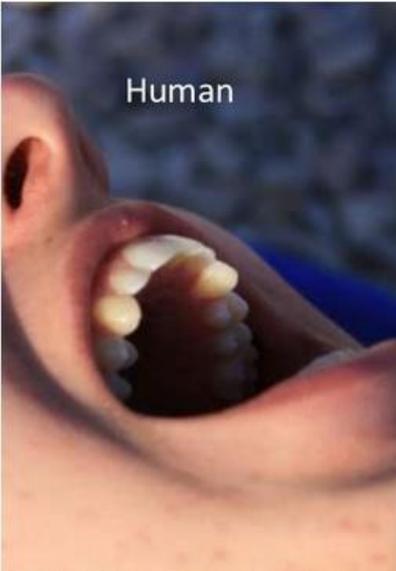


The jaw has developed from a U into a V shape. Teeth have generally reduced in size. (Chimpanzee provided for comparison)





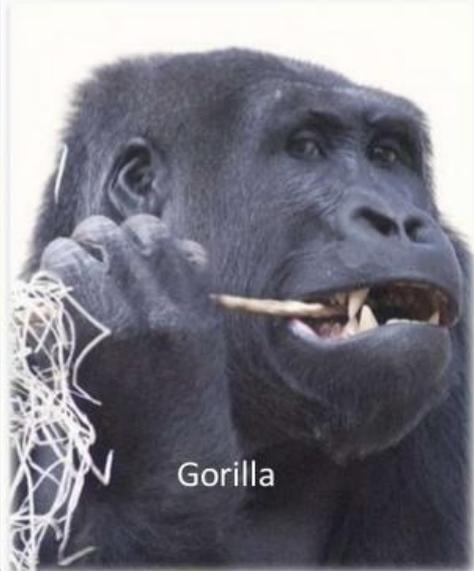
# Order Primate



Human



Baboon



Gorilla



Moo  
Cow

Generalised  
Dentition



# Order Primate

## Others:

Forelimbs able to twist

Clavicle allows wide range of arm movement

(re. the above two points: if you have a gentle and patient pet dog, give it a rub on the tummy and then move it's forelegs, they really only move in one plane)

Slower reproduction

- long gestation
- usually one offspring at a time

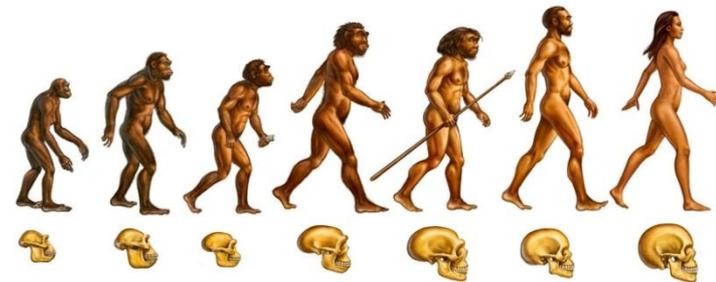
Larger skull – relative to body size

Large brain – more complex, more folds

Better visual acuity – more of the

photoreceptors have their own sensory neurons

Social dependency



# From Primate to Human



THE UNIVERSITY OF TEXAS AT AUSTIN DEPARTMENT OF ANTHROPOLOGY

## eLucy

### meet Lucy



eLucy is a website that will help you to learn about the world's most famous fossil, Lucy, a member of the species *Australopithecus afarensis*, who lived 3.2 million years ago. Lucy was discovered in 1974 in Ethiopia, and she is unique because over 40% of her skeleton was recovered, making her one of the most complete australopithecine fossils ever found. This website provides activities and lessons that will help you to learn about Lucy's place within the history of human evolution. Some activities are online, but others can be completed offline. After studying Lucy, you can investigate other aspects of human evolution at [eFossils.org](http://eFossils.org). You can learn more about the human and primate skeleton at [eSkeletons.org](http://eSkeletons.org).

Lucy began her public tour of the United States in 2007 in the exhibit, "Lucy's Legacy: the Hidden Treasures of Ethiopia."

**COMPARE LUCY**  
Visitors can view individual bones from Lucy and compare her bone morphology with the anatomy of chimpanzees and modern humans. Just select an element to get started.

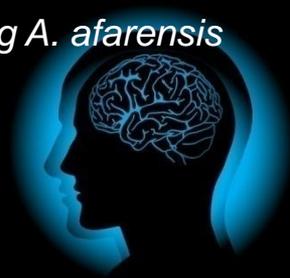
**STUDENTS > Activities**  
This section contains crosswords, puzzles, life-size printouts and other activities to help students learn more about Lucy and human origins.

**TEACHERS > Lessons**  
This section is a collection of lessons and suggested activities that may be used to supplement science classes focusing on human evolution and human origins.

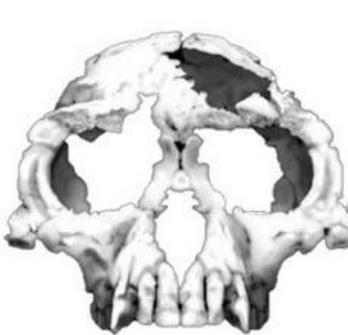
About eLucy    FAQ    Glossary    Links    eFOSSILS    eSkeletons

Lucy, an early:  
*Australopithecus*  
(Ethiopia)

D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus ramidus*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*



# Becoming Human



*Ardipithecus ramidus*



*Australopithecus afarensis*

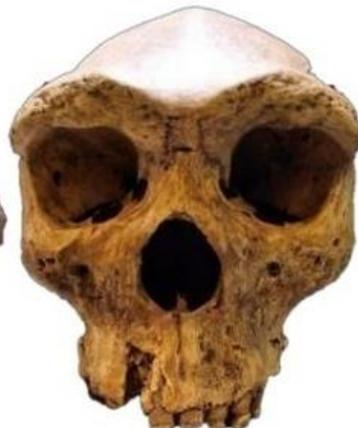


*Australopithecus africanus*

Skulls not to scale



*Homo habilis*



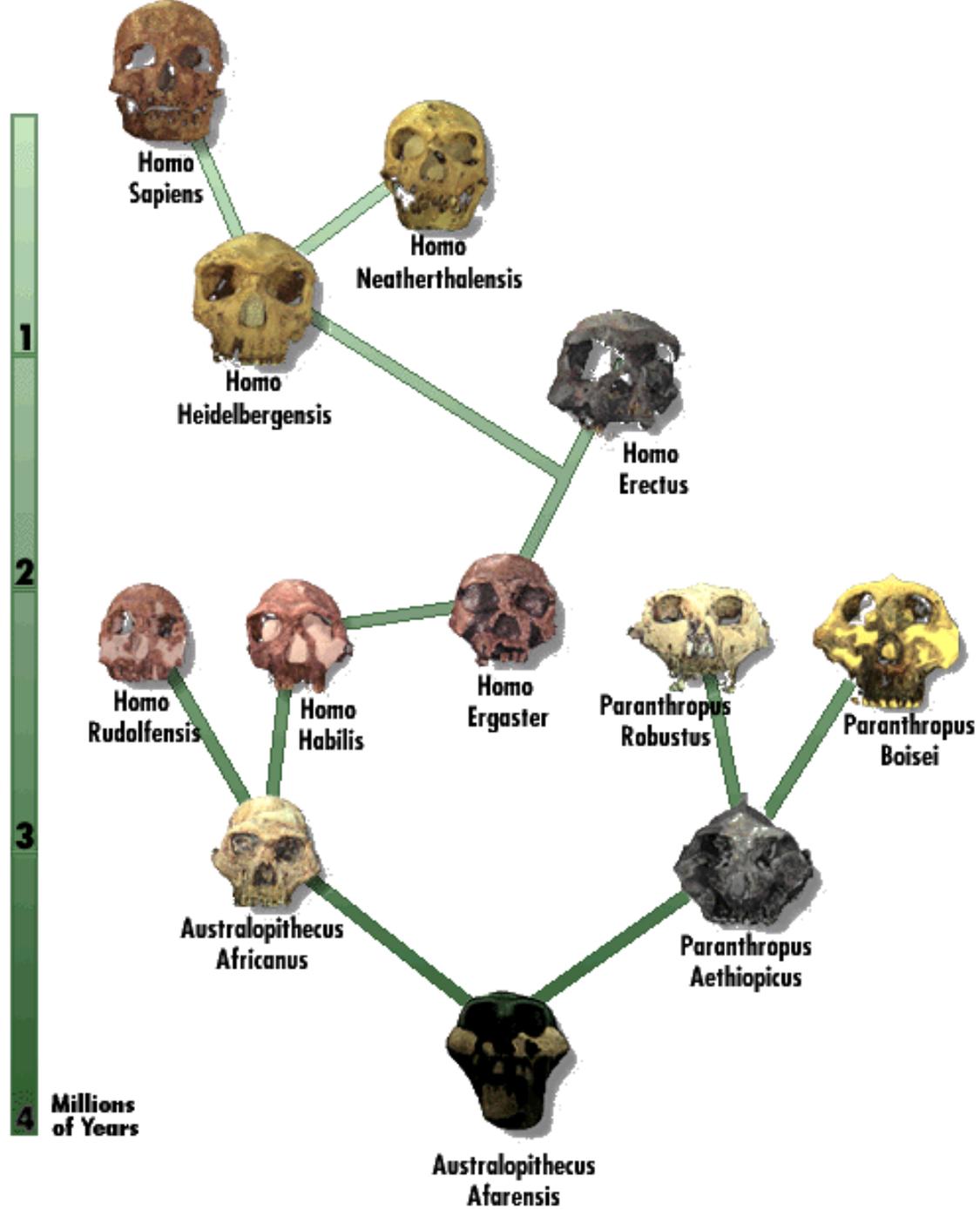
*Homo erectus*

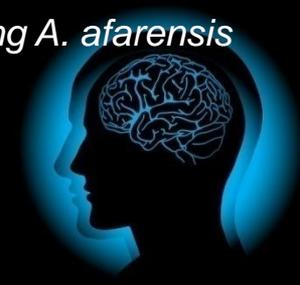


*Homo neanderthalensis*

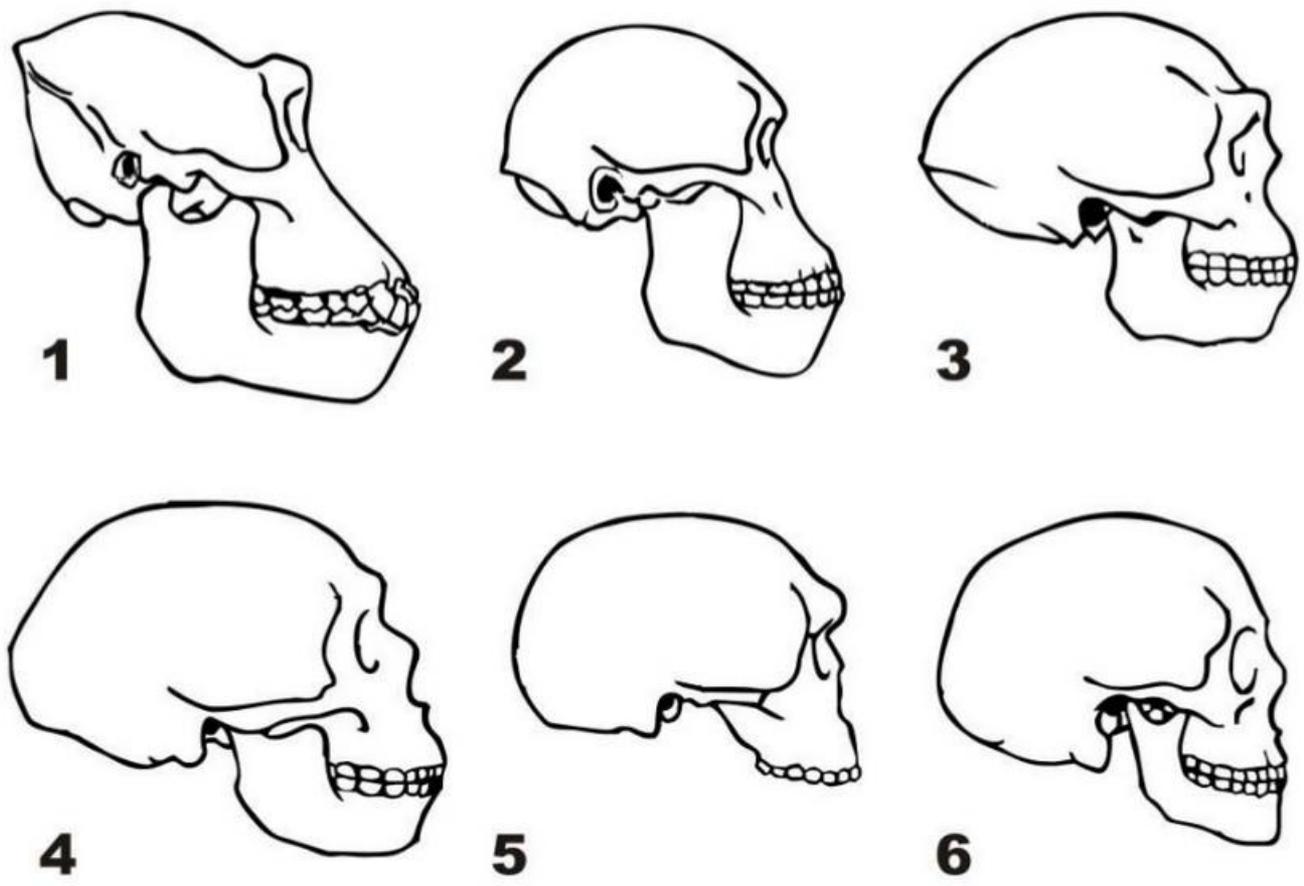


*Homo sapiens*



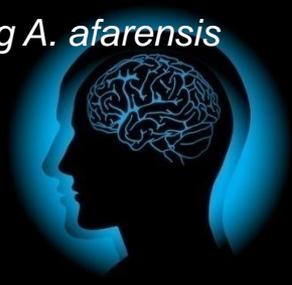


# Becoming Human



- 1. Gorilla
- 2. Australopithecine
- 3. Homo erectus
- 4. Neanderthal (La-Chapelle-au-Seine)
- 5. Steinheim Skull
- 6. Modern human

# Becoming Human



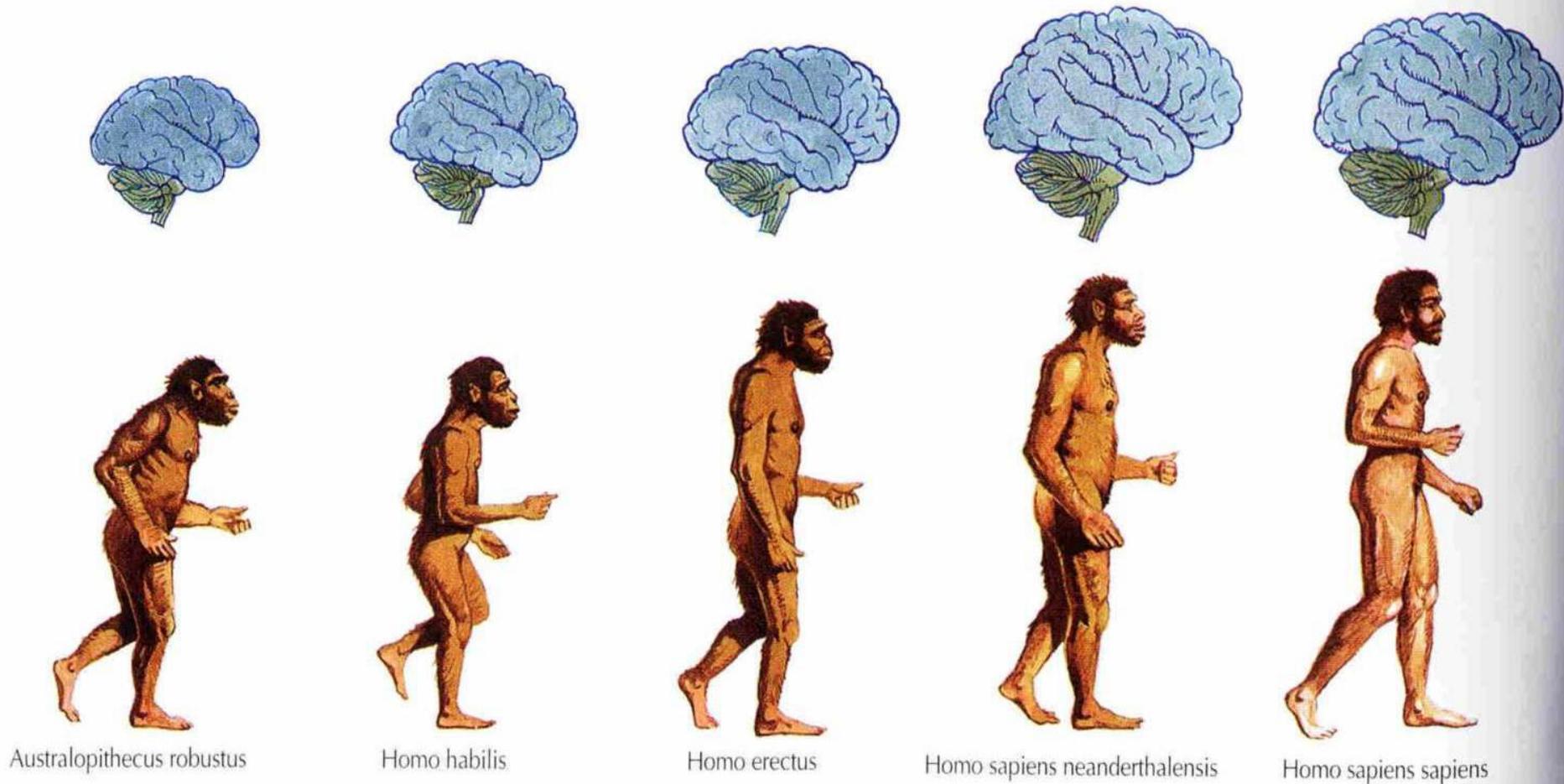
From the previous two slides you can see:

- enlargement of the brain case
- shortening of the face
- loss of brow ridges

You can't really see it but the hole in the bottom of the skull where the spinal cord exits the brain (foramen magnum) is further forward in modern humans. This distributes the weight of the head over the spine so that modern humans do not need huge neck muscles.

D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*

# Becoming Human



*Australopithecus robustus*

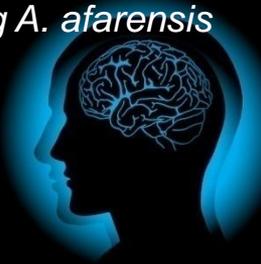
*Homo habilis*

*Homo erectus*

*Homo sapiens neanderthalensis*

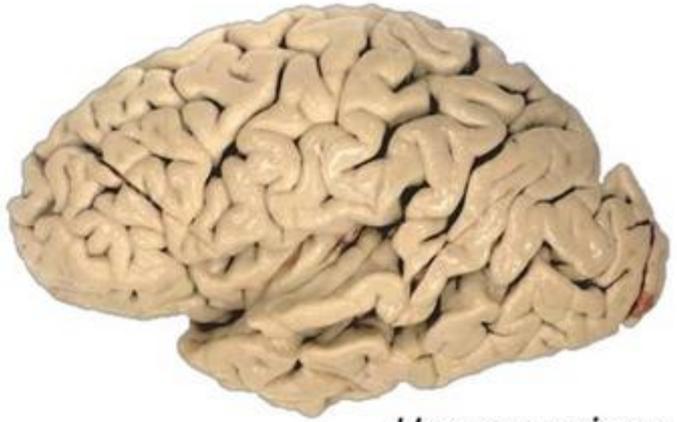
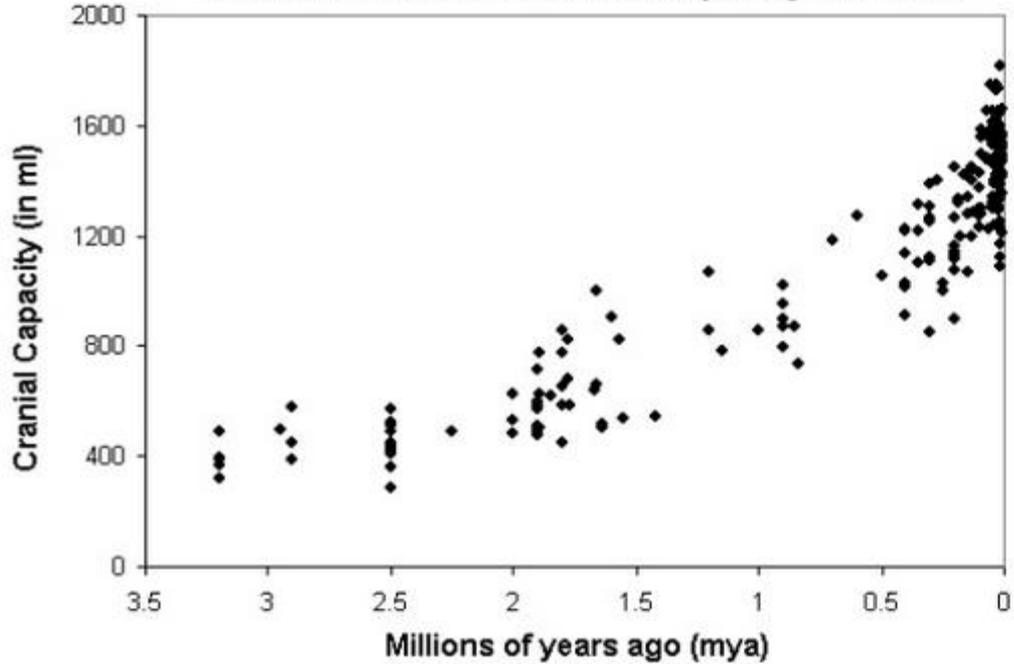
*Homo sapiens sapiens*

D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*

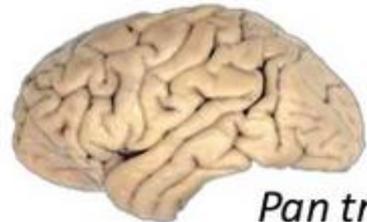


# Becoming Human

**Fossil Hominins: Cranial Capacity vs. Time**



*Homo sapiens*



*Pan troglodytes*  
(chimpanzee)

**Dataset:** All measurements of hominin cranial capacity available in the literature as of September 2000, for skulls older than 10,000 years old. Adult specimens only. Average is presented where multiple measurements were made. N = 215 points.

**Data source:** C. De Miguel and M. Henneberg (2001). "Variation in hominid brain size: How much is due to method?" *Homo* 52(1), pp. 3-58. Data copied into Excel from Appendix: "From Lucy to Boskop" (pp. 20-49).

Chart by **Nick Matzke** of **NCSE** ([www.ncseweb.org](http://www.ncseweb.org)). Free to use for nonprofit educational use (with acknowledgement). Version 1.0, September 29, 2006.



# Becoming Human

Human knees aligned under the body's centre of gravity because femurs are angled inwards.

Human legs straighten completely when walking.

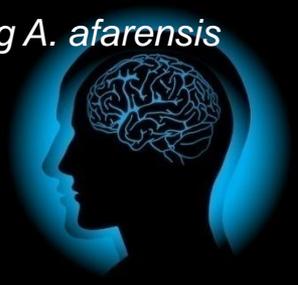
Human spine has additional curves to keep centres of mass of head and trunk aligned for bipedalism.

Big toe not opposable in humans, which allows for an arched foot.

Ratio legs:arms greater for humans than other apes

Human pelvis broader





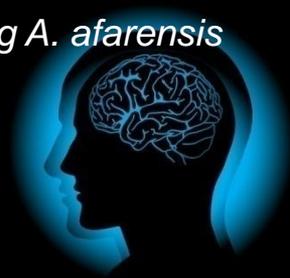
# Becoming Human

Retention, by adults in a species, of traits previously only in juveniles:

Some human characteristics thought to be a result of neoteny.

- Lack of body hair
- Small teeth and reduced numbers of teeth
- Prolonged growth period
- Long life span
- Flat face and thin skull bones
- Lactase production in adults
- Epicanthic eye fold
- Small nose
- Longer trunk relative to arms and legs

D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*

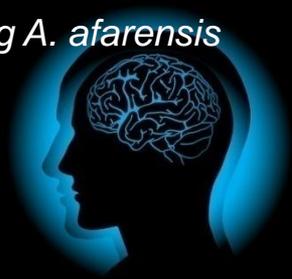


# Becoming Human

**Evolutionary Trends:** By comparing hominid fossils, we see key evolutionary trends:

Evolutionary Trend	Reason
Downward facing magnum (whole in bottom of skull)	
S Shaped curvature of spine	
Lower/Broader pelvis	
Larger brain size and encephalisation	
Relative increase in length of arm/leg bones	
Flatter face (Reduced brow ridge & jaw protrusion)	
Reduction in body hair	
Smaller teeth, more v shaped jaw and generalised dentition	
Big toe not opposable and increased size of heal bone	

D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*



# Becoming Human

**Evolutionary Trends:** By comparing hominid fossils, we see key evolutionary trends:

Evolutionary Trend	Reason
Downward facing magnum (whole in bottom of skull)	Bipedalism
S Shaped curvature of spine	Increasingly erect posture
Lower/Broader pelvis	Changing reproductive strategies
Larger brain size and encephalisation	Increasing cognitive demands of social interaction
Relative increase in length of arm/leg bones	Arms have relatively shorter due to not climbing and legs longer for walking upright
Flatter face (Reduced brow ridge & jaw protrusion)	More space for the brain and changes in diet
Reduction in body hair	Cultural evolution and warm clothing
Smaller teeth, more v shaped jaw and generalised dentition	Changes in diet
Big toe not opposable and increased size of heal bone	Allowing for an upright stance & weight bearing foot

# Becoming Human

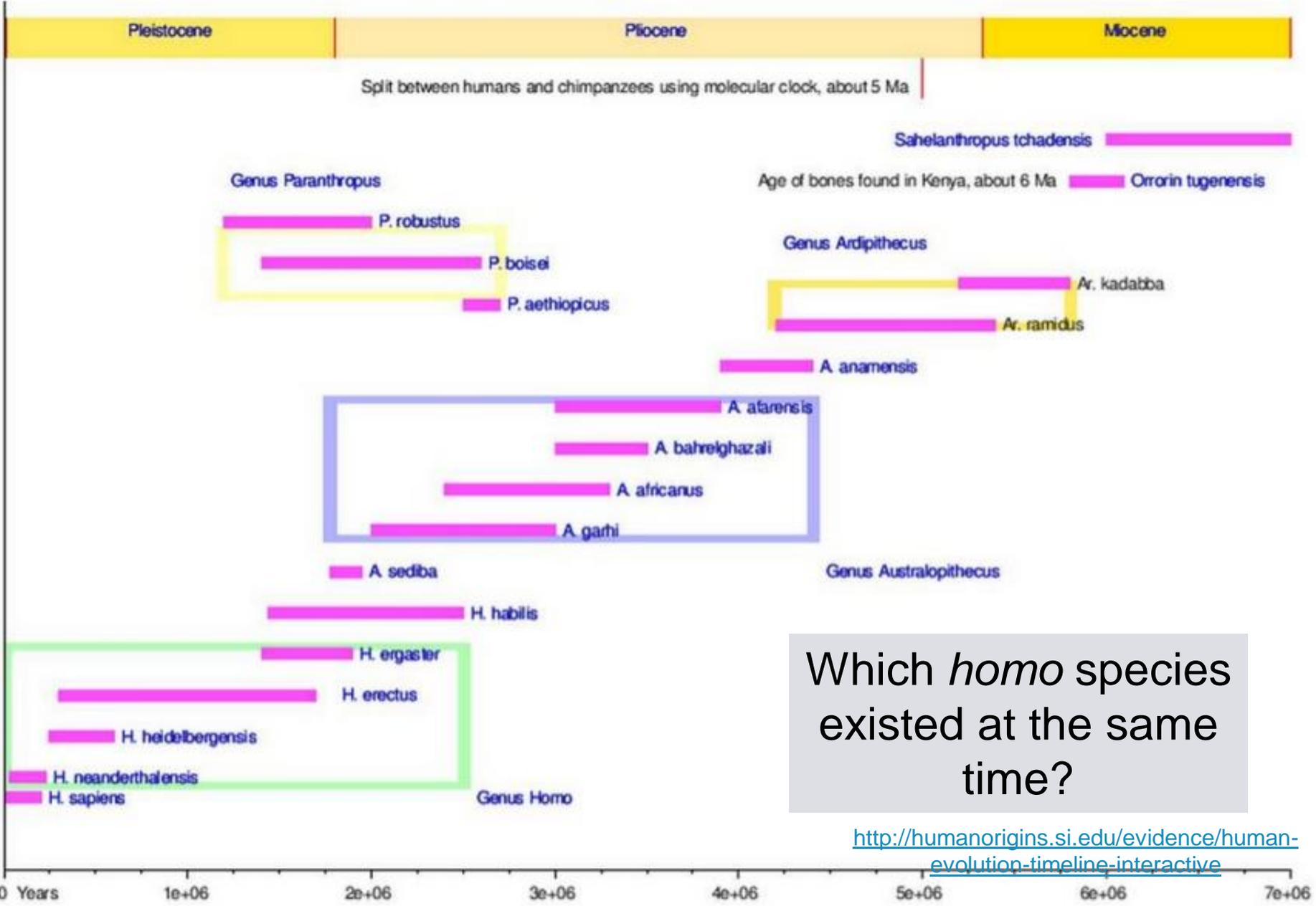


<https://www.23andme.com/gen101/prehistory/prologue/>

human prehistory: prologue



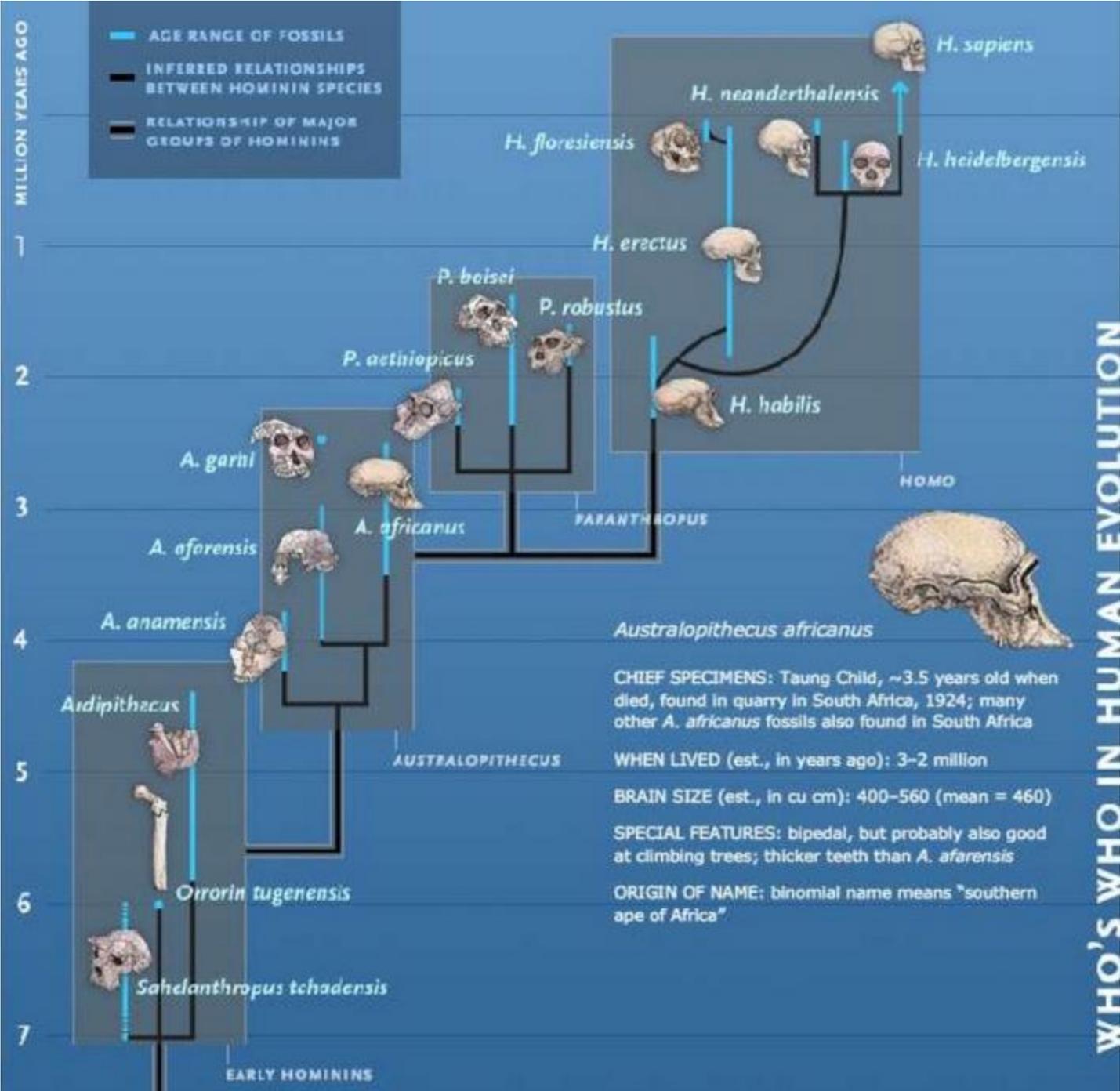
D.3.6 State that, at various stages in hominid evolution, several species may have coexisted



Which *homo* species existed at the same time?

<http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive>

Note: 1e+06 years = 1 × 10<sup>6</sup> years = 1 million years ago = 1 Ma



MILLION YEARS AGO  
7  
2  
3  
4  
5  
6  
7

— AGE RANGE OF FOSSILS  
— INFERRED RELATIONSHIPS BETWEEN HOMININ SPECIES  
— RELATIONSHIP OF MAJOR GROUPS OF HOMININS

*Ardipithecus*

*A. anamensis*

*A. afarensis*

*A. garhi*

*A. africanus*

*P. aethiopicus*

*P. boisei*

*P. robustus*

*H. erectus*

*H. habilis*

*H. neanderthalensis*

*H. floresiensis*

*H. heidelbergensis*

*H. sapiens*

PARANTHROPUS

HOMO

AUSTRALOPITHECUS

*Australopithecus africanus*

CHIEF SPECIMENS: Taung Child, ~3.5 years old when died, found in quarry in South Africa, 1924; many other *A. africanus* fossils also found in South Africa

WHEN LIVED (est., in years ago): 3–2 million

BRAIN SIZE (est., in cu cm): 400–560 (mean = 460)

SPECIAL FEATURES: bipedal, but probably also good at climbing trees; thicker teeth than *A. afarensis*

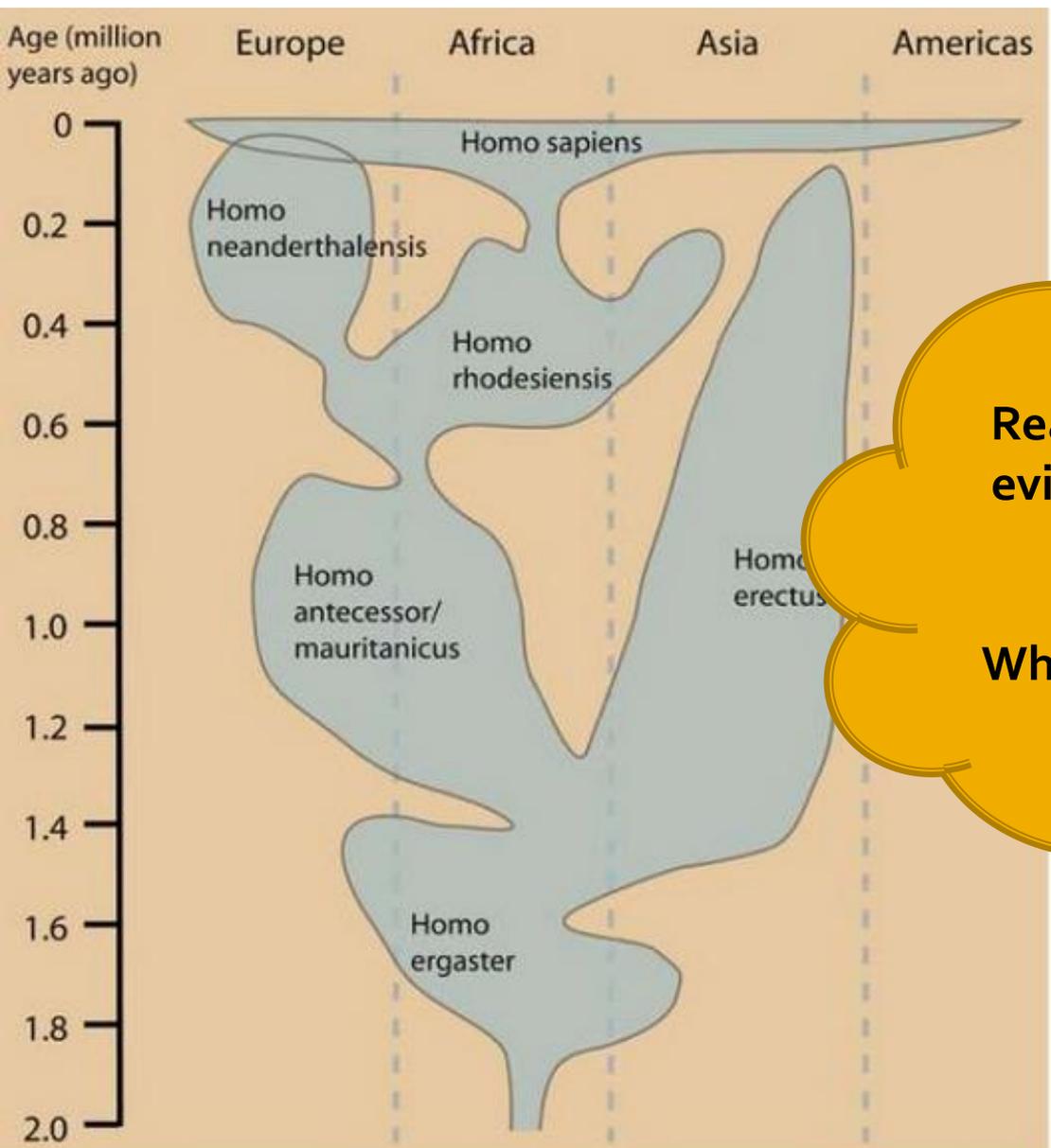
ORIGIN OF NAME: binomial name means "southern ape of Africa"

EARLY HOMININS

WHO'S WHO IN HUMAN EVOLUTION

D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*

<http://news.nationalgeographic.co.uk/news/2010/05/100506-science-neanderthals-humans-mated-interbred-dna-gene/>



Note that according to this interpretation of the fossil record *Homo sapiens* is not descended from *Homo erectus*

**TOK**

**Read the article on genetic evidence for Neanderthal - homo interbreeding**

**What does this mean about humans?**

...ted to  
...nce of the  
neanderthals in much the  
same way that indigenous  
animals like dingos are in  
danger of extinction due to  
breeding with domestic dogs.



# Aim

<http://www.youtube.com/watch?v=hSSzn4blwZg>

To understand the significant steps in  
human evolution

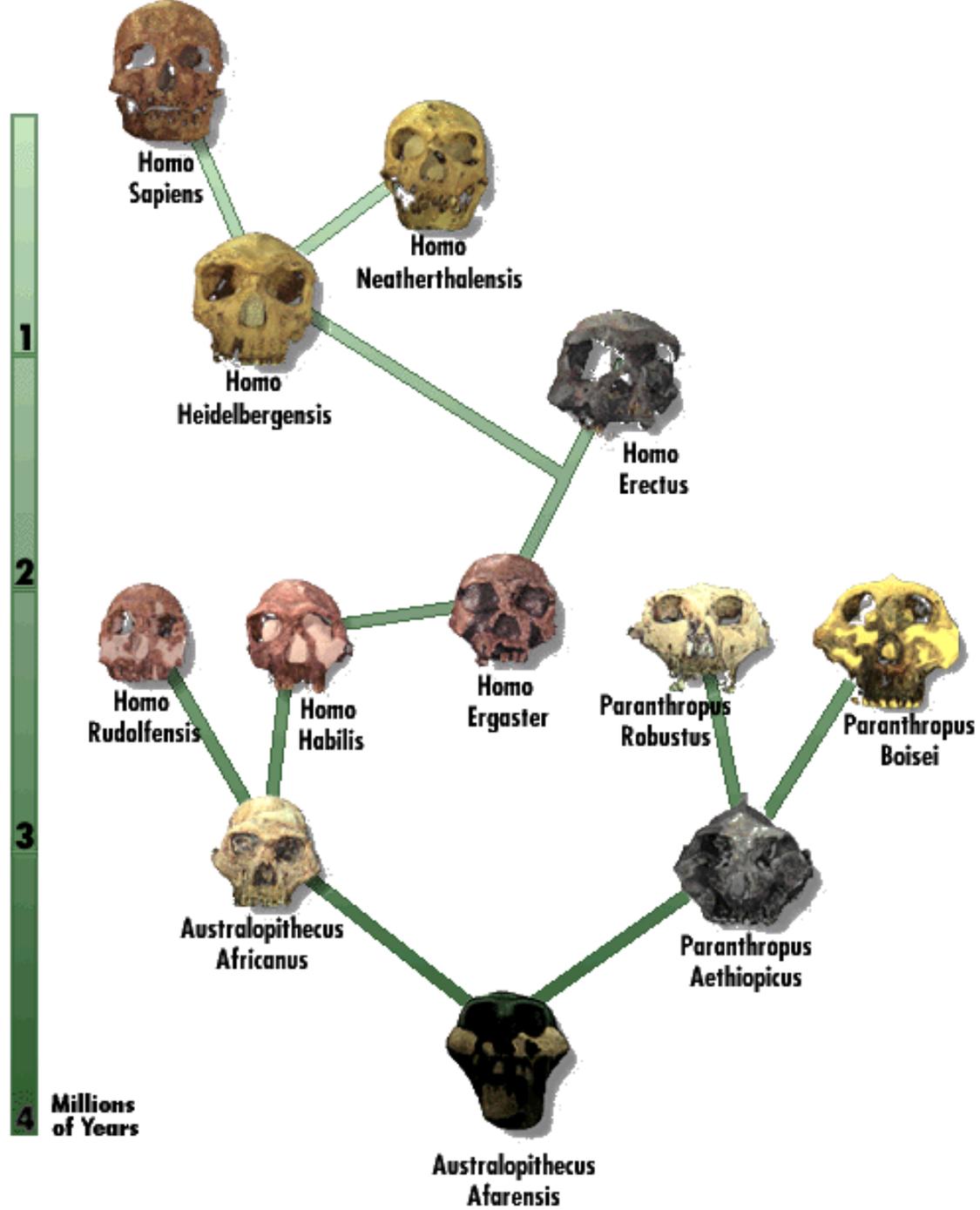


*D.3.7 Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution*

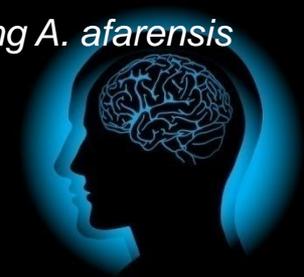
*D.3.8 Discuss the correlation between the change in diet and increase in brain size during hominid evolution*

*D.3.9 Distinguish between genetic and cultural evolution*

*D.3.10 Discuss the relative importance of genetic and cultural evolution in the recent evolution of humans*



D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*



# Becoming Human

Knowledge of approximate dates and distribution of the named species is expected. Details of subspecies or particular groups (Cro-Magnon, Peking, and so on) are not required.

Genus of Hominin	Approx. Age	Distribution	Brain Capacity	Anatomical Features	Other Facts
<i>A. ramidus</i>	5.2 – 4.4 million years	Ethiopia	375 – 550 cm <sup>3</sup>	Large upper & lower canines for diet of fruit, leaves & insects	One of the oldest known hominin fossils
<i>A. afarensis</i>	4.0 – 2.5 million years	South & East Africa	380 – 430 cm <sup>3</sup>	Smaller canines for a more omnivorous diet	'Lucy' is the most complete skeleton found (~3.2 m.y.o)
<i>A. africanus</i>	3.2 – 2.5 million years	South & East Africa	435 – 530 cm <sup>3</sup>	Low forehead & large molars	Small game hunter (moved from trees to savannah)
<i>H. habilis</i>	2.4 – 1.6 million years	South & East Africa	700 cm <sup>3</sup>	Reduced brow ridge, lighter jaw & smaller digits	Used stone tools (Oldowan tools)
<i>H. erectus</i>	1.8 – 0.1 million years	Migrated to Asia & Europe (~2.2 m.y.a)	880 cm <sup>3</sup>	Thick skull bones, formation of external nose	Use of fire and rudimentary language suspected
<i>H. neanderthalensis</i>	200,000 – 30,000 years	Europe & Western Asia	1500 cm <sup>3</sup>	Long, narrow face with broad nose and brow ridge	Cave dweller, buried dead, used flint flake tools
<i>H. sapiens</i>	140,000 – present day	Worldwide	1440 cm <sup>3</sup>	Flatter face, pointed jaw, reduced orbital ridges	Cave painting and primitive religion developed

# Becoming Human



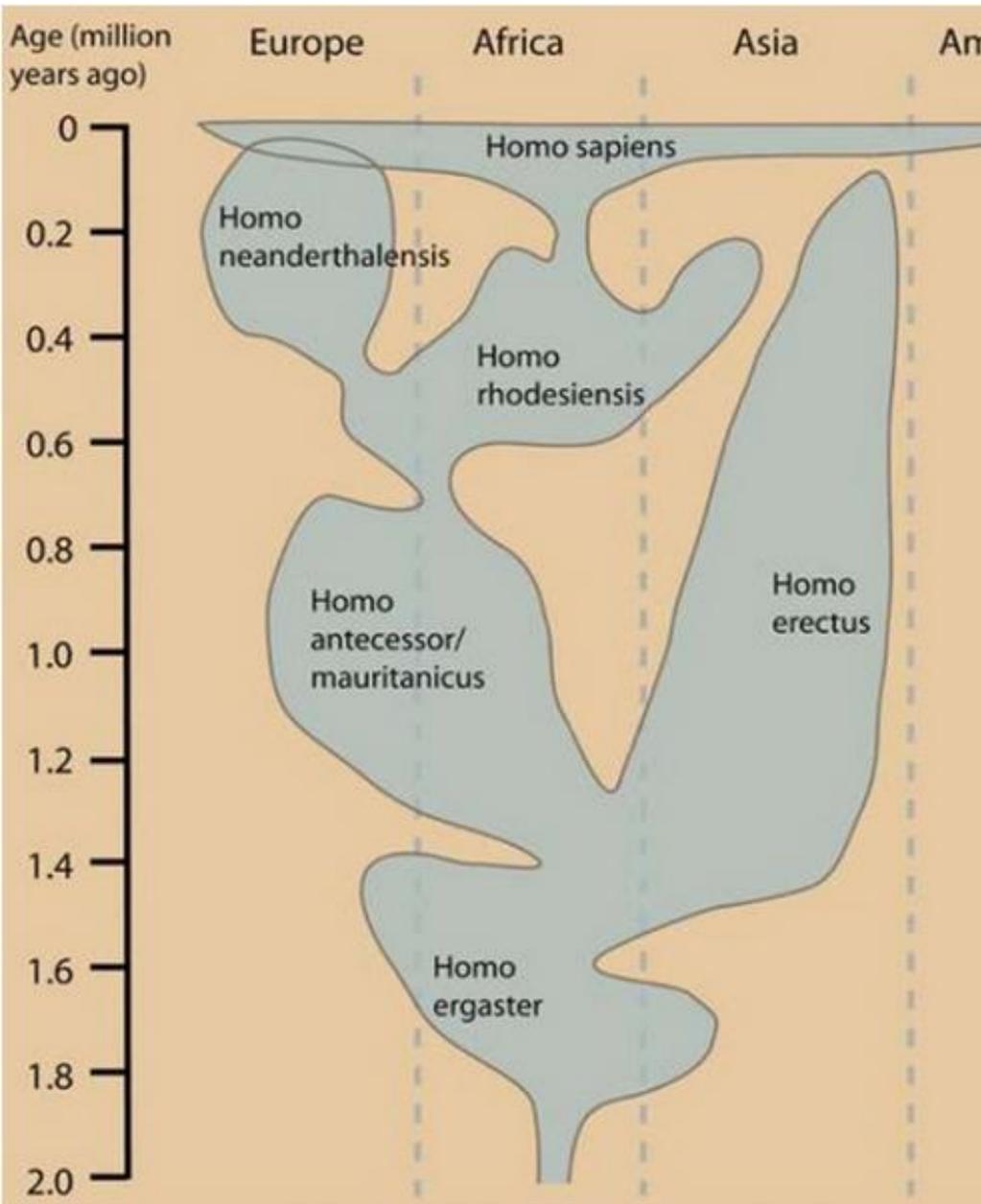
<https://www.23andme.com/gen101/prehistory/outofafrica/?play=true>

human prehistory: prologue

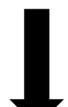


D.3.5 Outline the trends illustrated by the fossils of *Ardipithecus radius*, *Australopithecus* including *A. afarensis* and *A. africanus*, and *Homo* including *H. habilis*, *H. erectus*, *H. neanderthalensis* and *H. sapiens*

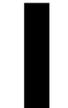
<http://news.nationalgeographic.co.uk/news/2010/05/100506-science-neanderthals-humans-mated-interbred-dna-gene/>



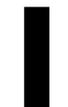
***Ardipithecus*: 5-4mya**  
Ethiopia (small country in Africa)



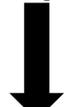
***Australopithecus*: 4-2mya**  
Africa only



**1st homo (*H. habilis*): 3-2mya**  
Africa only....



**2<sup>nd</sup> homo (*H. erectus*): 2-0.1 mya**  
Expands into Asia



**3<sup>rd</sup> homo (*H. neanderthalis*): 200-30,000 ya**  
Expands into Europe



**4<sup>th</sup>..... *Homo sapien*: 140,000 ya**  
Ubiquitous

# Becoming Human



## TOK

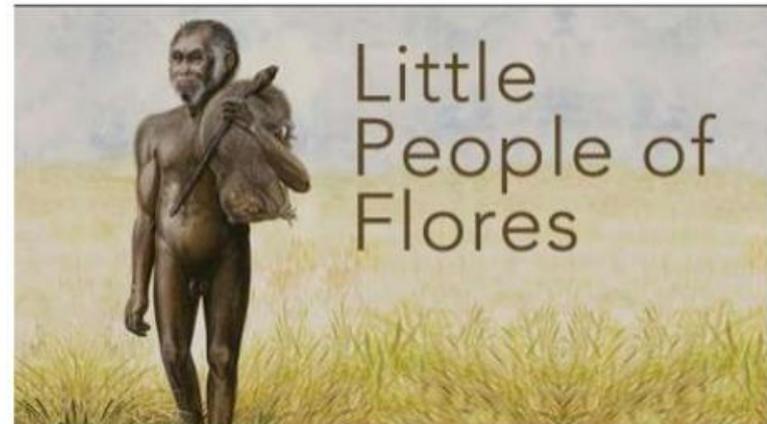
Read the article on Wikipedia about [Homo floresiensis](#)

Discovered in 2004 on the Indonesian island of Flores, it has stirred up controversy in the palaeoanthropological world. Is it a separate species or is it the remains of diseased *Homo sapiens*. You be the judge!

<http://theday.co.uk/chosen-by-you/ancient-thigh-bone-casts-doubt-on-human-origins>

## Article

Paradigm shifts are more common in a data-poor sciences

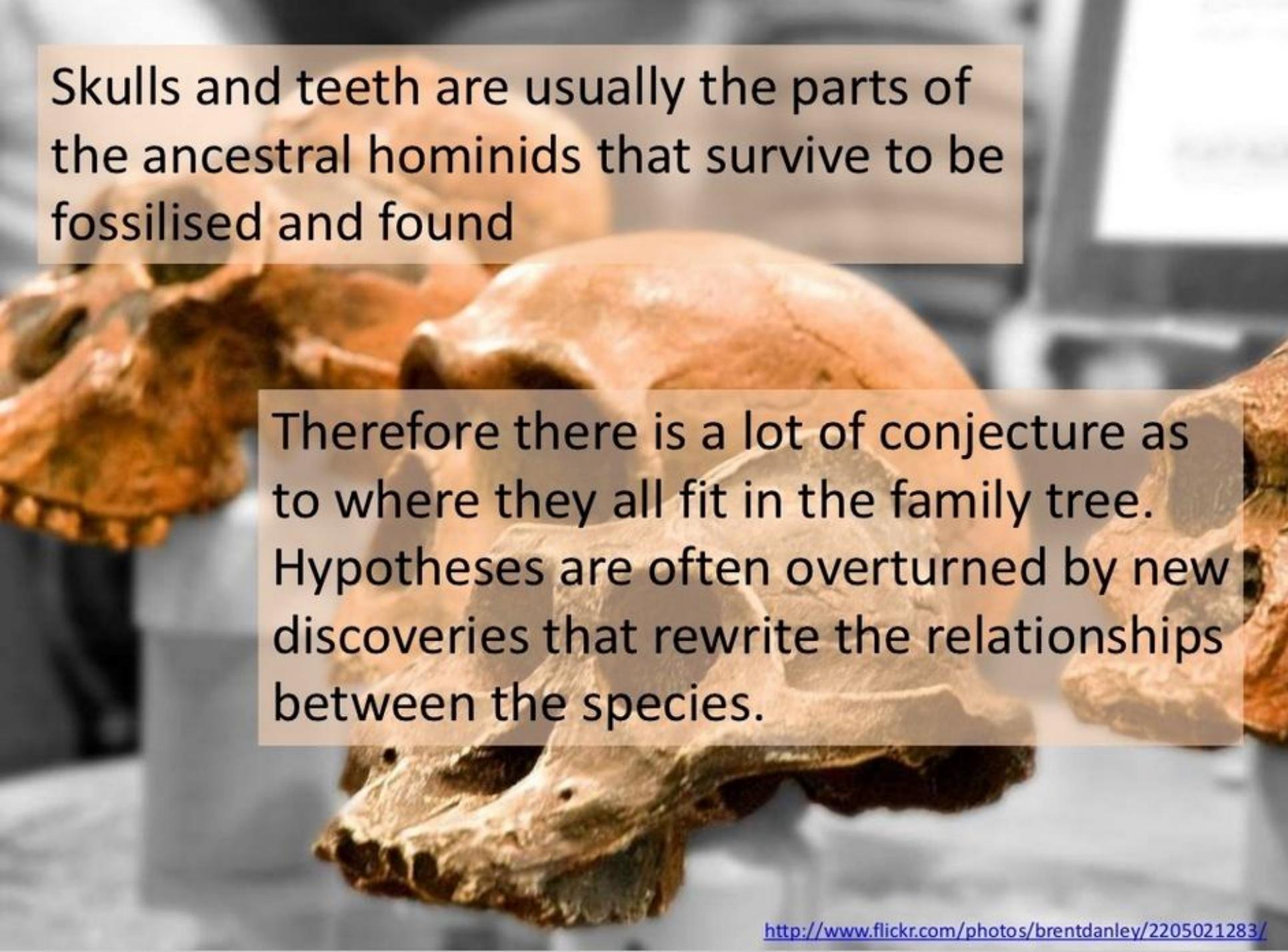


# The Fossil Record



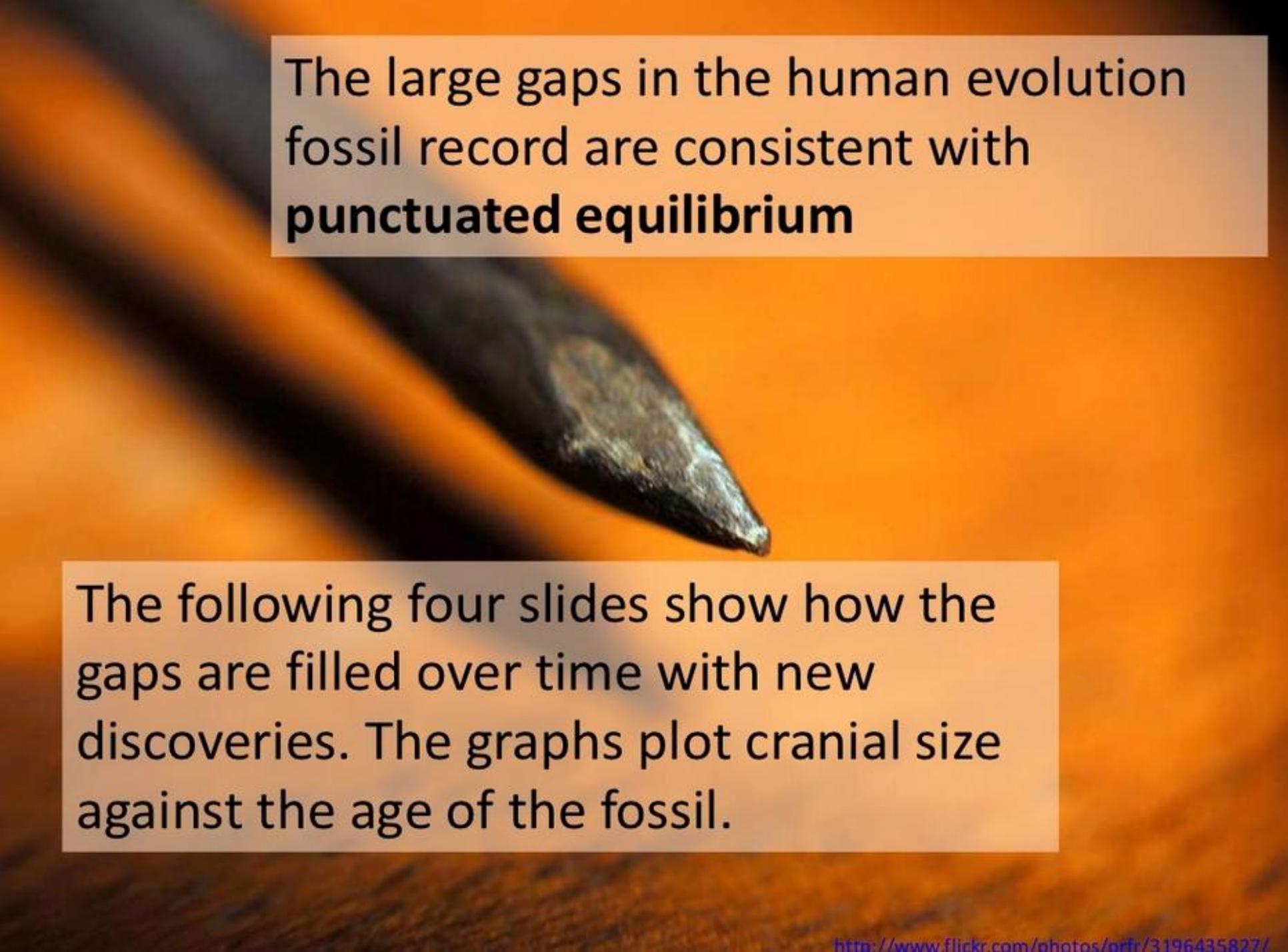
It isn't easy to create a collection of fossils that clearly show the change of species from one to another. Fossils rarely result when an animal dies for the following reasons:

- Decomposition is usually rapid; soft body parts are rarely fossilised
- Scavengers usually break up skeletons and even chew up bones
- The conditions have to be just right for fossilisation to occur.
- **Only a** tiny, tiny, tiny fraction of all of the fossils in existence have been found.

A collection of fossilized hominid skulls and teeth displayed in a museum setting. The skulls are arranged on a light-colored surface, with some showing prominent teeth. The background is slightly blurred, showing other museum exhibits.

Skulls and teeth are usually the parts of the ancestral hominids that survive to be fossilised and found

Therefore there is a lot of conjecture as to where they all fit in the family tree. Hypotheses are often overturned by new discoveries that rewrite the relationships between the species.



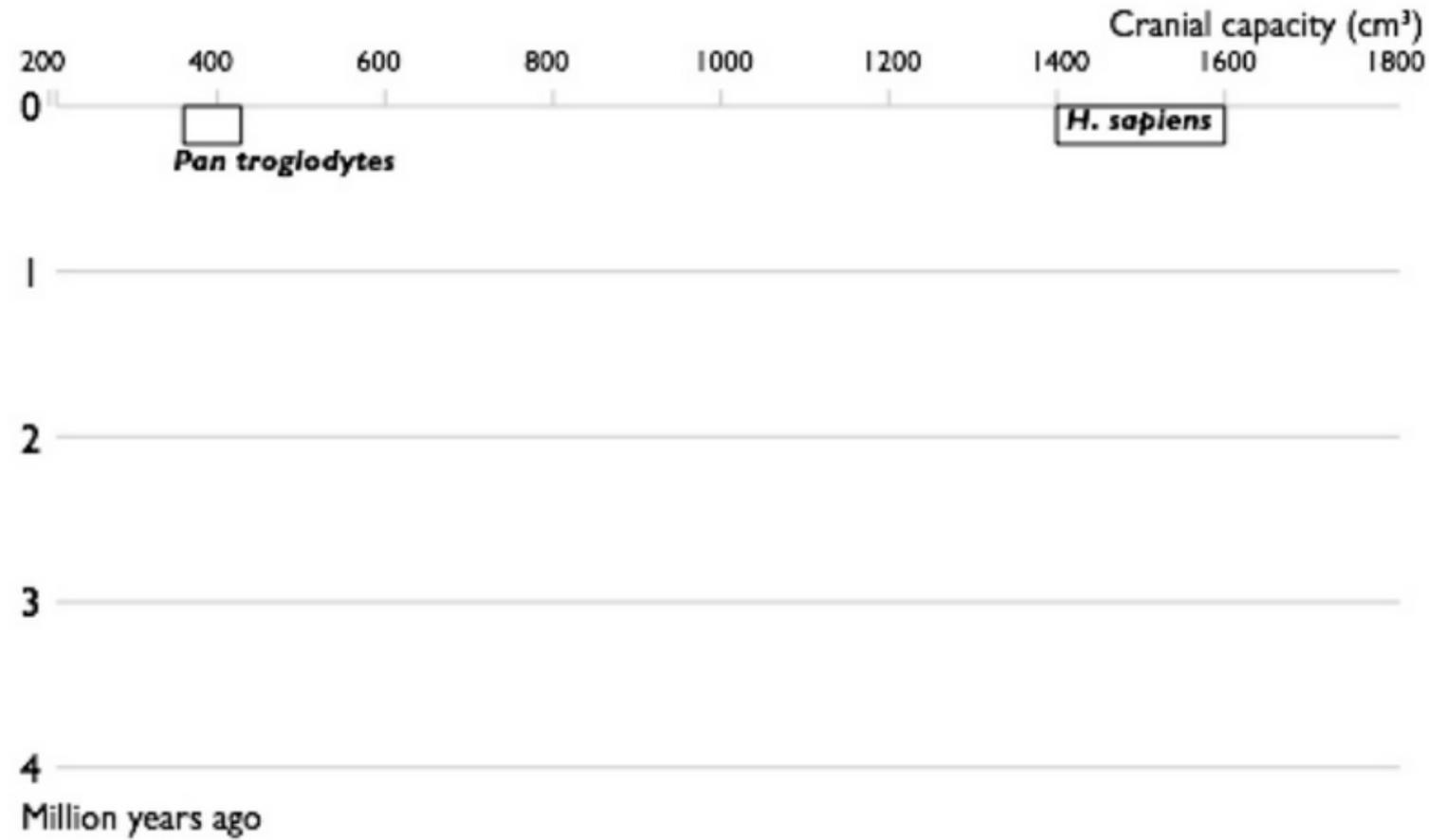
The large gaps in the human evolution fossil record are consistent with **punctuated equilibrium**

The following four slides show how the gaps are filled over time with new discoveries. The graphs plot cranial size against the age of the fossil.

D.3.7 Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution



# The Fossil Record

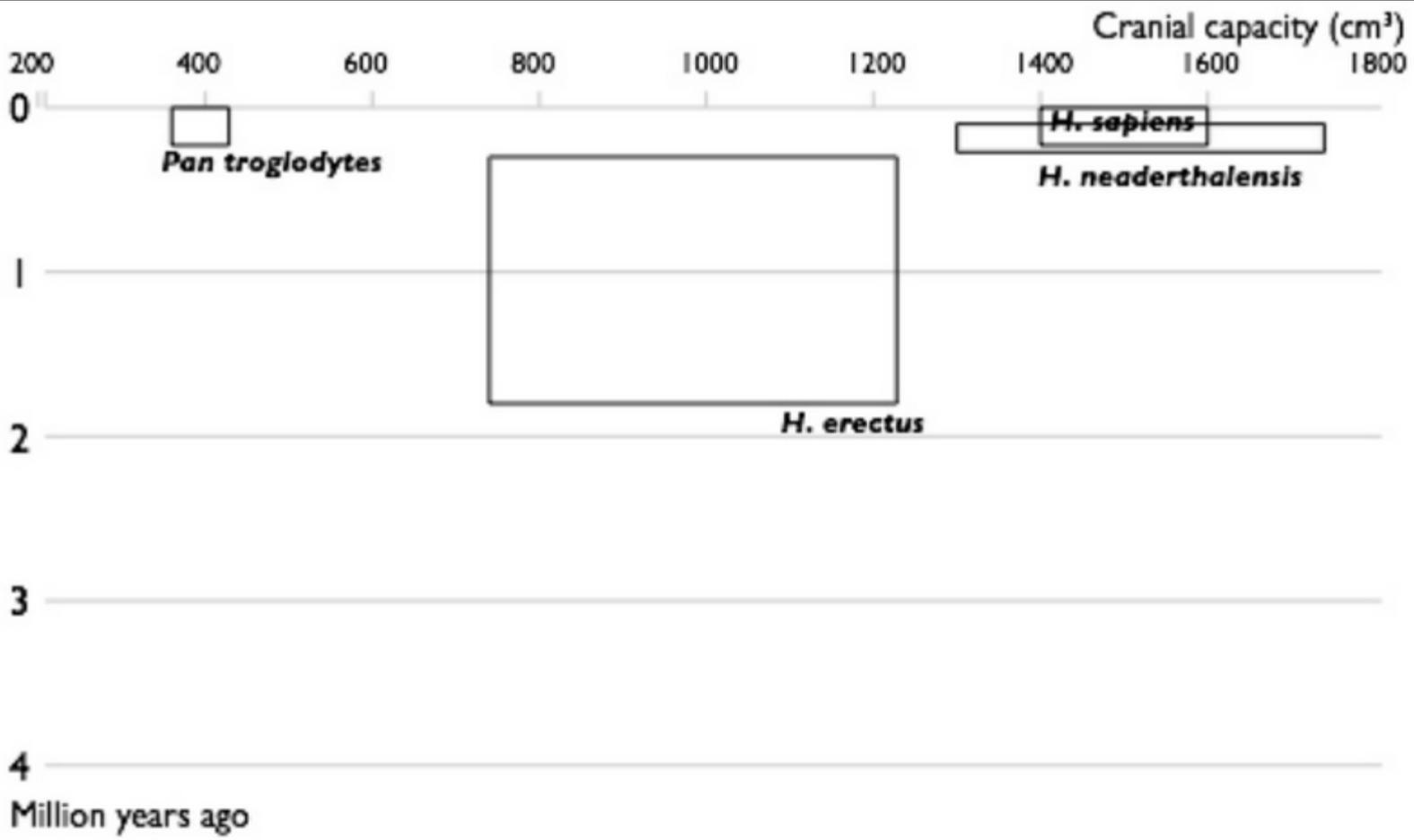


**1850**

D.3.7 Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution



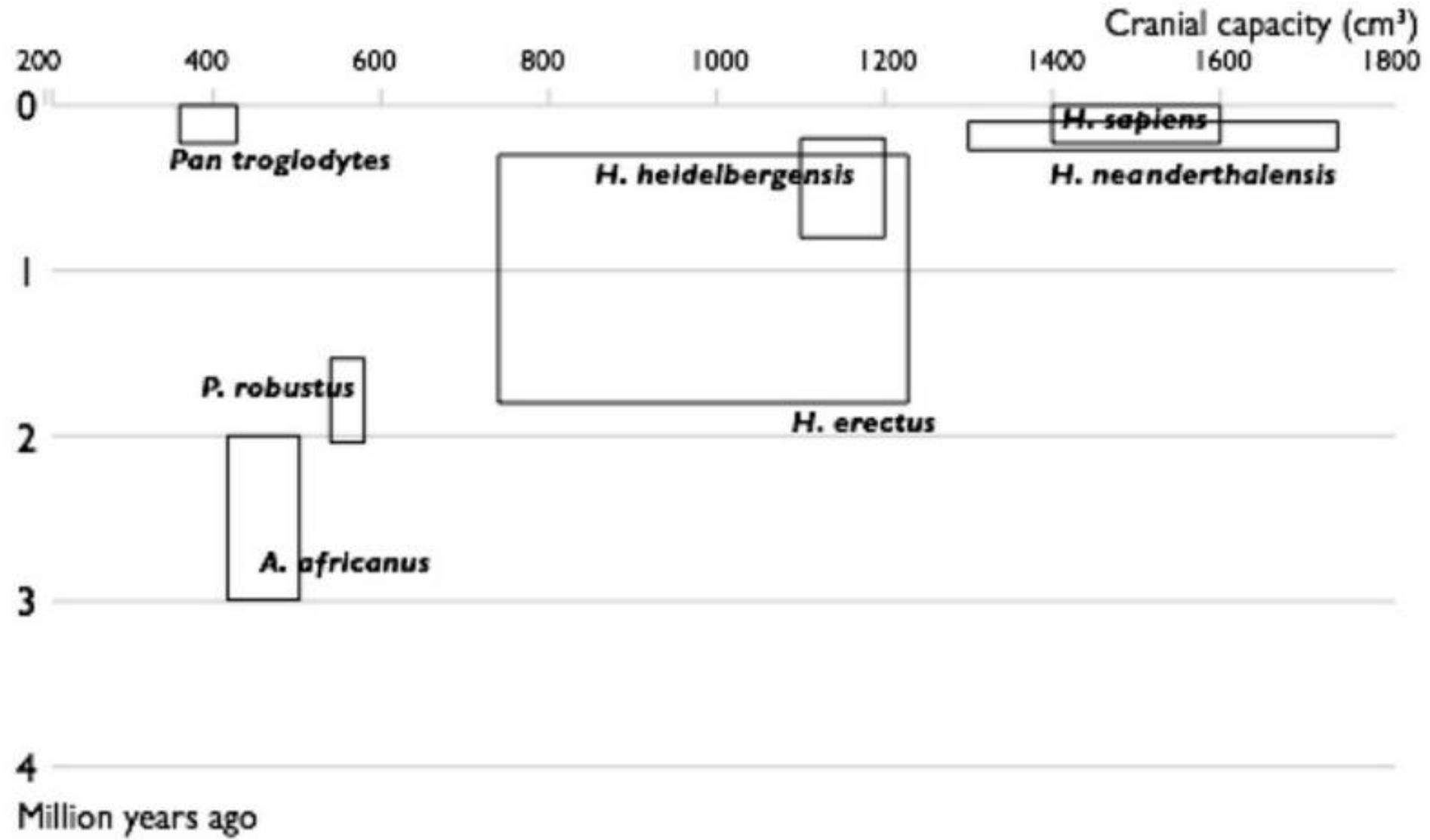
# The Fossil Record



1900

D.3.7 Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution

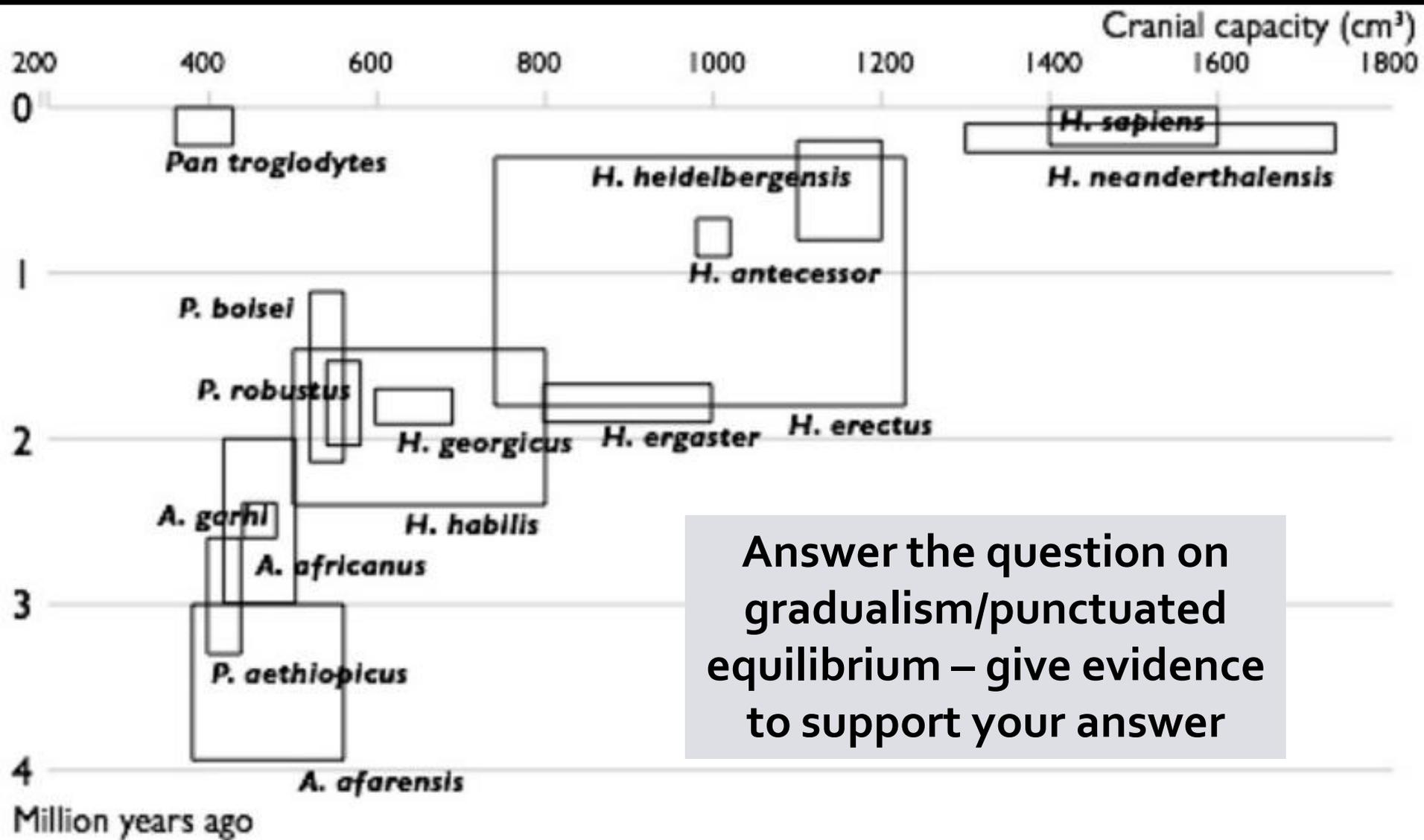
# The Fossil Record



D.3.7 Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution



# The Fossil Record



Answer the question on gradualism/punctuated equilibrium – give evidence to support your answer

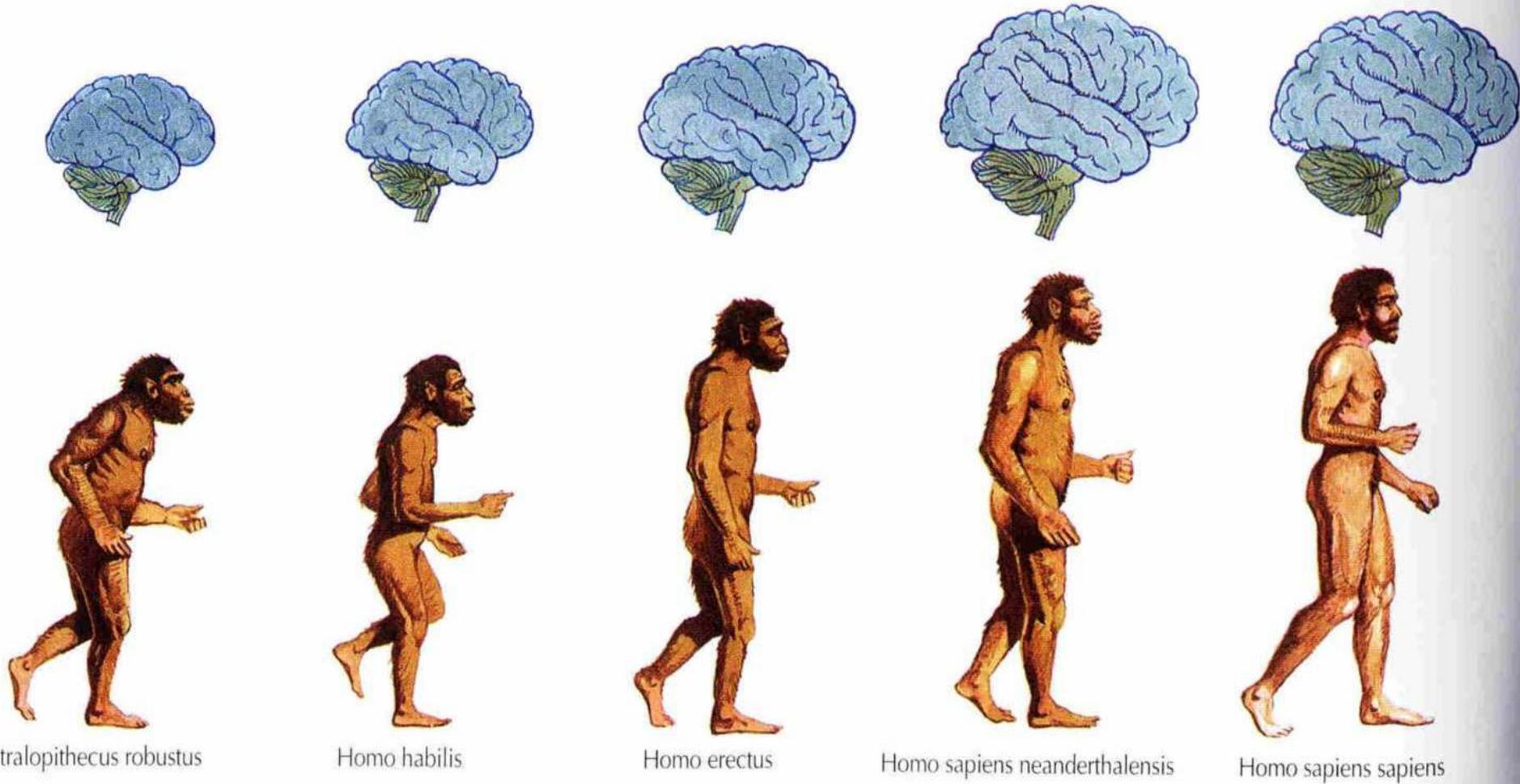
Despite the fossil evidence we have so far, there are still large gaps in our knowledge

We have no fossil for the last common ancestor of humans and chimpanzees

It is believed to have lived 6-8 million years ago

*Find out how this estimate was determined*

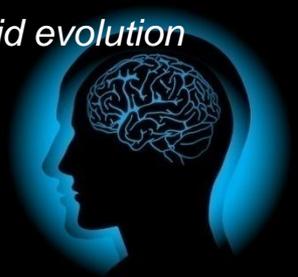
# Becoming Human - Social



D.3.8 Discuss the correlation between the change in diet and increase in brain size during hominid evolution

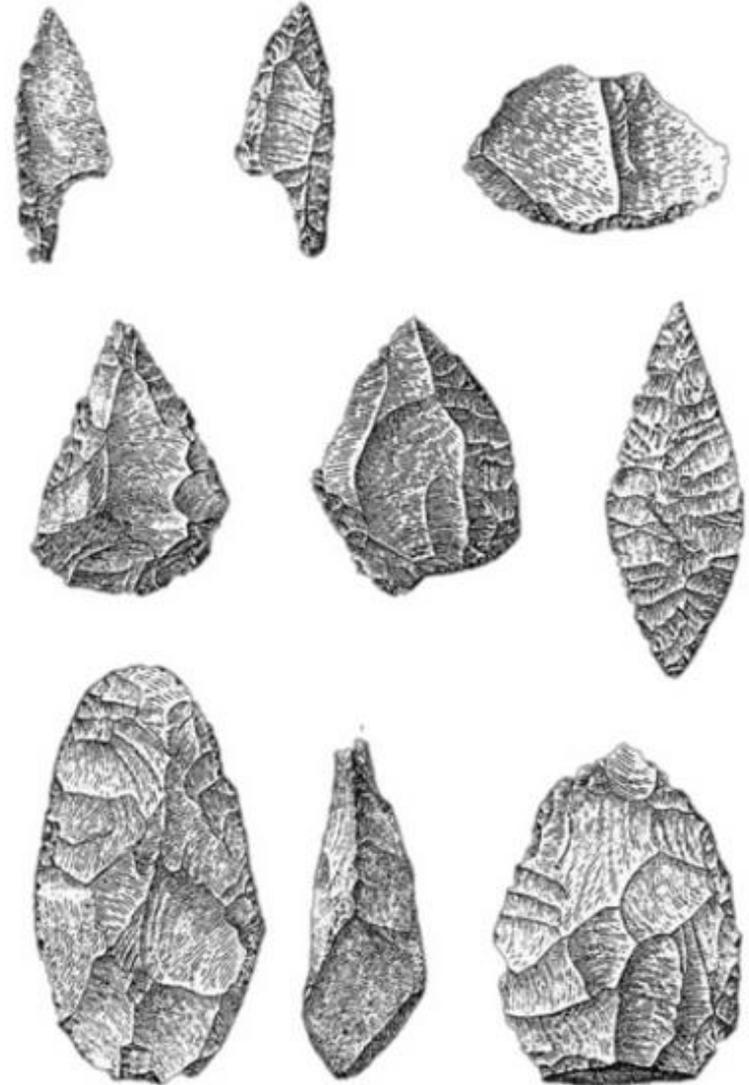
D.3.9 Distinguish between genetic and cultural evolution

# Becoming Human



The benefits of a bigger brain include:

- More complex tools
- Mastery of fire
  - Cooking
  - Warmth
  - Protection
- Greater behavioural flexibility (less reliance on instinct and better able to learn and pass on knowledge necessary to adapt to an environment)



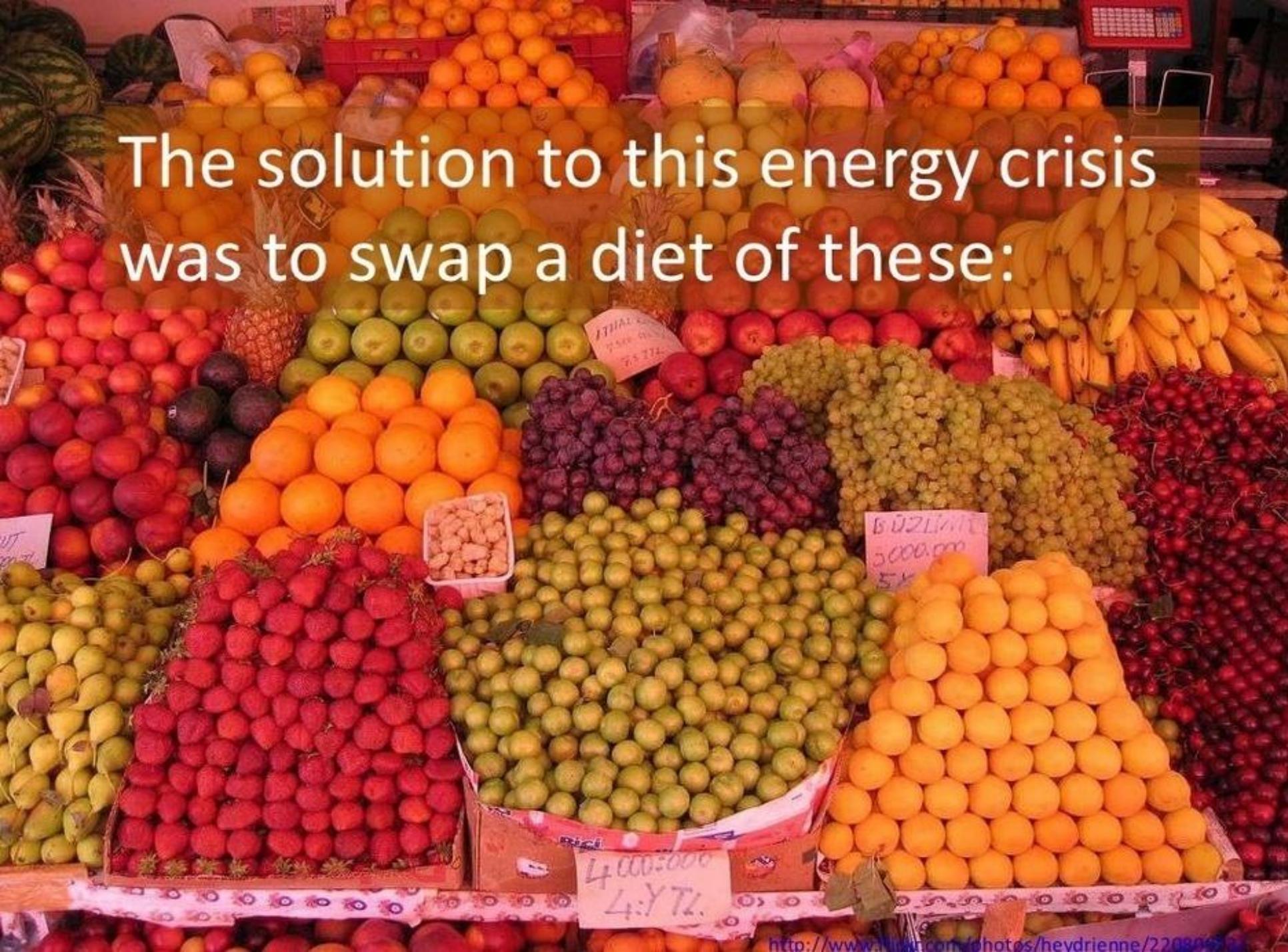


The cost of having a big brain:

- Longer gestation period
- Years of development before young can look after themselves
- Much more brain development occurs post birth than for any other animal

In summary: Big brains are energetically expensive. The mother must take in lots of energy not only during pregnancy, but for a significant time after.

Hominids needed to increase their energy uptake.

A vibrant display of fresh fruits at a market stall. The stall is filled with various fruits, including oranges, apples, grapes, strawberries, lemons, and pineapples. The fruits are arranged in neat piles and baskets. A sign in the foreground reads "4000:000 4:YTZ." and another sign in the background reads "BÜZLÜK 2000:000 5:YTZ." The overall scene is colorful and fresh.

The solution to this energy crisis was to swap a diet of these:

A close-up photograph of a large, round piece of meat, possibly a steak or roast, cooking on a metal grill. The meat is heavily charred and sizzling, with thick plumes of white smoke rising from it. Below the grill, a bright orange and red fire is visible, providing the heat for cooking. The background is dark and out of focus.

For some chunks of this:

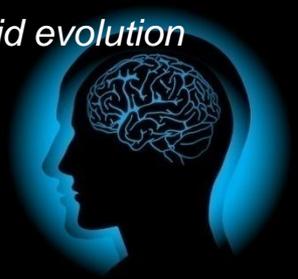
The increase in brain size observed in hominid fossils has been closely correlated with an increased intake of meat.

A bigger brain made hunting and killing easier

D.3.8 Discuss the correlation between the change in diet and increase in brain size during hominid evolution

D.3.9 Distinguish between genetic and cultural evolution

# Becoming Human



TOK

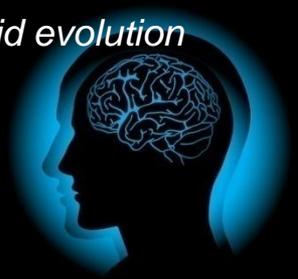
Are we still  
evolving?  
e.g.?

<http://mentalfloss.com/article/30795/5-signs-humans-are-still-evolving>

D.3.8 Discuss the correlation between the change in diet and increase in brain size during hominid evolution

D.3.9 Distinguish between genetic and cultural evolution

# Becoming Human

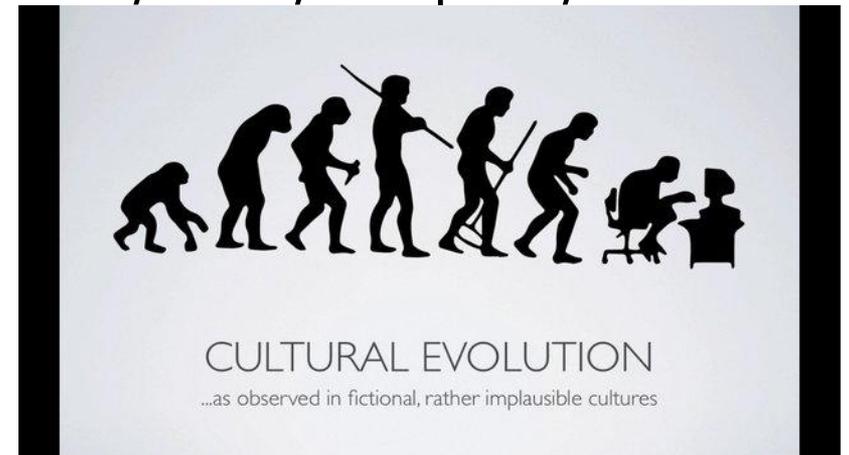


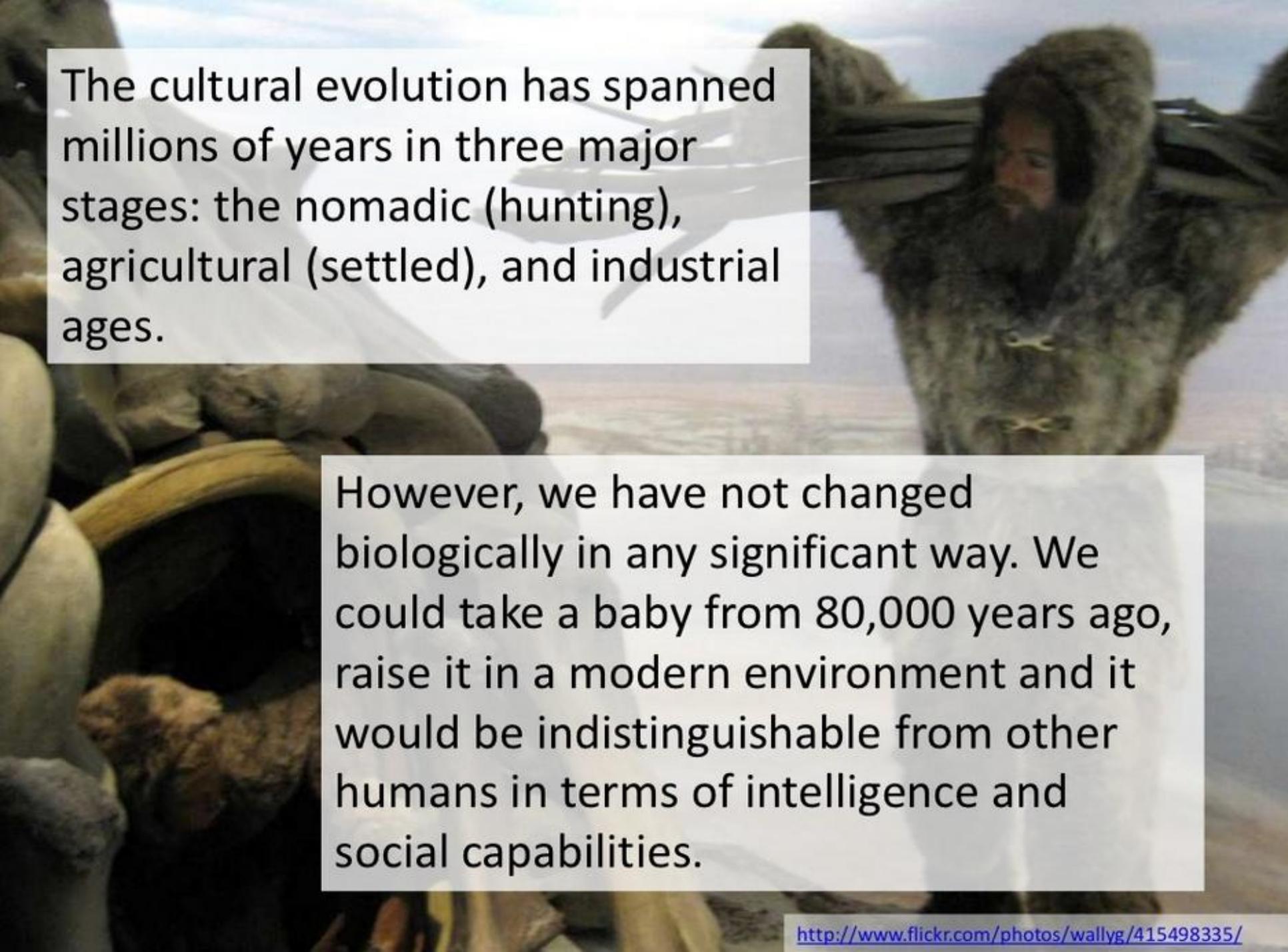
## ■ Genetic Evolution

In this context, genetic changes in the evolution of hominids (resulting in physiological change)

## ■ Cultural Evolution

Change in society – transmission of ideas and social learning through generations (fire, agriculture, tools, weapons, religions & beliefs)

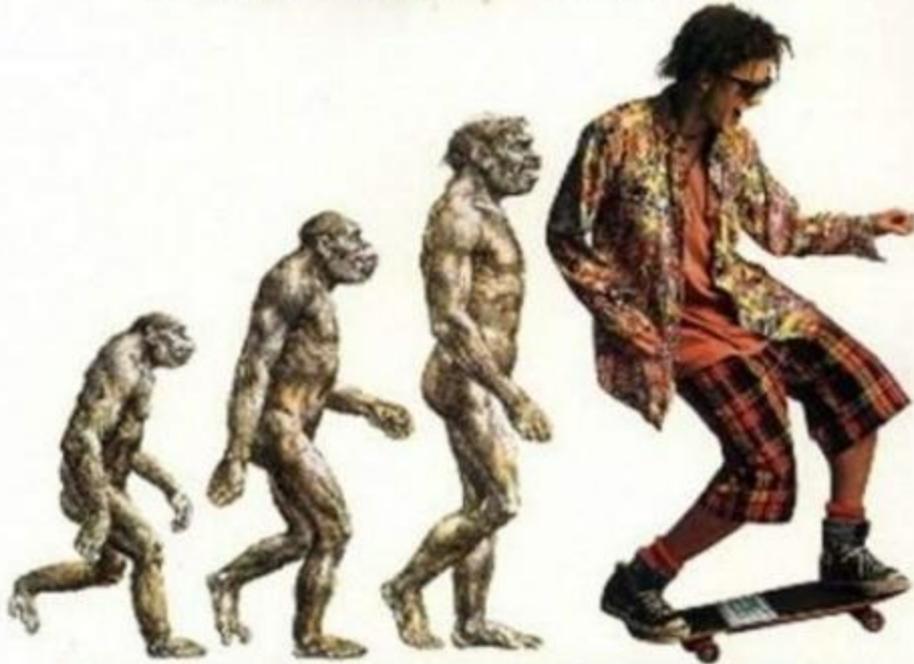




The cultural evolution has spanned millions of years in three major stages: the nomadic (hunting), agricultural (settled), and industrial ages.

However, we have not changed biologically in any significant way. We could take a baby from 80,000 years ago, raise it in a modern environment and it would be indistinguishable from other humans in terms of intelligence and social capabilities.

**WHERE THE STONE AGE  
MEETS THE ROCK AGE.**



**CALIFORNIA MAN**

**A CHILLIN' NEW COMEDY IN FULL NEANDERVISION.**

HOLLYWOOD PICTURES... TOUCHWOOD PACIFIC PARTNERS  
"CALIFORNIA MAN" SEAN ASTIN BONDAN FRASER MEGAN WARD MARIEE HARLEY RICHARD MASUR JIMMY'S CORE  
PRODUCED BY MICHAEL POTEMBERSKI WRITTEN BY J. PETER ROBINSON DIRECTED BY SIK SEARS A.C.E. COSTUME DESIGNER JAMES ALLEN EDITOR ROBERT BRINKMANN  
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**THAWING SOON AT A THEATRE NEAR YOU**

# Genes , Culture or.....?

Complete the table to  
compare genetic and  
cultural evolution

Can all types of  
evolution be split  
either category?

# Genes , Culture or.....?

## Sort the statements!

- Increased learning capacity / cognitive ability
  - Prolonged gestations
  - Bipedalism
  - Shorter finger bones and reduced reliance on forelimbs for locomotion
  - Tool manipulation
  - Development of art, science, language
  - Genetic engineering/Embryo selection
  - Medicine
  - Pollution) may increase genetic evolution (increased mutagenic rate)
- ▣ Family networks
  - ▣ Extensive migration
  - ▣ Selective breeding

# Genes , Culture or.....?

- Increased learning capacity / greater cognitive ability **G**
- Prolonged gestations **G**
- Family networks **C**
- Bipedalism **G**
- Extensive migration **B**
- Shorter finger bones/reduced reliance on forelimbs for locomotion **G**
- Tool manipulation **B** **C**
- Development of art, science, language **C**
- Genetic engineering/Embryo selection
- Medicine **B**
- Selective breeding **B**
- Pollution **B**

# Other Links



- <http://www.becominghuman.org/>
- [http://www.bbc.co.uk/sn/prehistoric\\_life/human/human\\_evolution/](http://www.bbc.co.uk/sn/prehistoric_life/human/human_evolution/)
- <http://www.eskeletons.org/index.html>
- <http://www.youtube.com/watch?v=giOqfsAxo-E>
- <http://www.youtube.com/watch?v=vK7ZE5GBNoU>
- [http://www.youtube.com/watch?v=ckTXw\\_Oitbo](http://www.youtube.com/watch?v=ckTXw_Oitbo)