Evolution

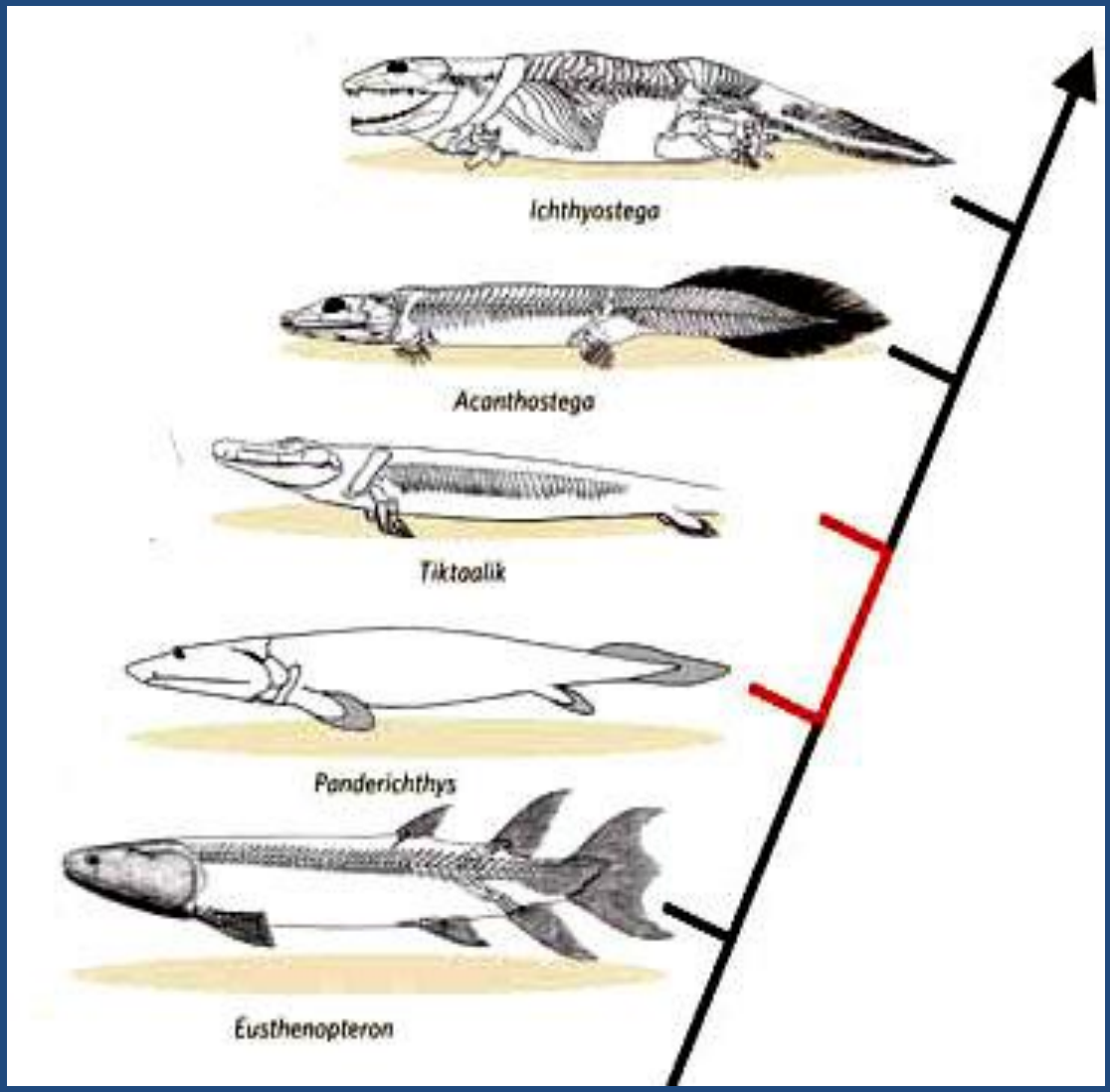
Department of Biology, Medical Faculty, Medical University of Sofia

Evolution is gradual

Early amphibians take to land

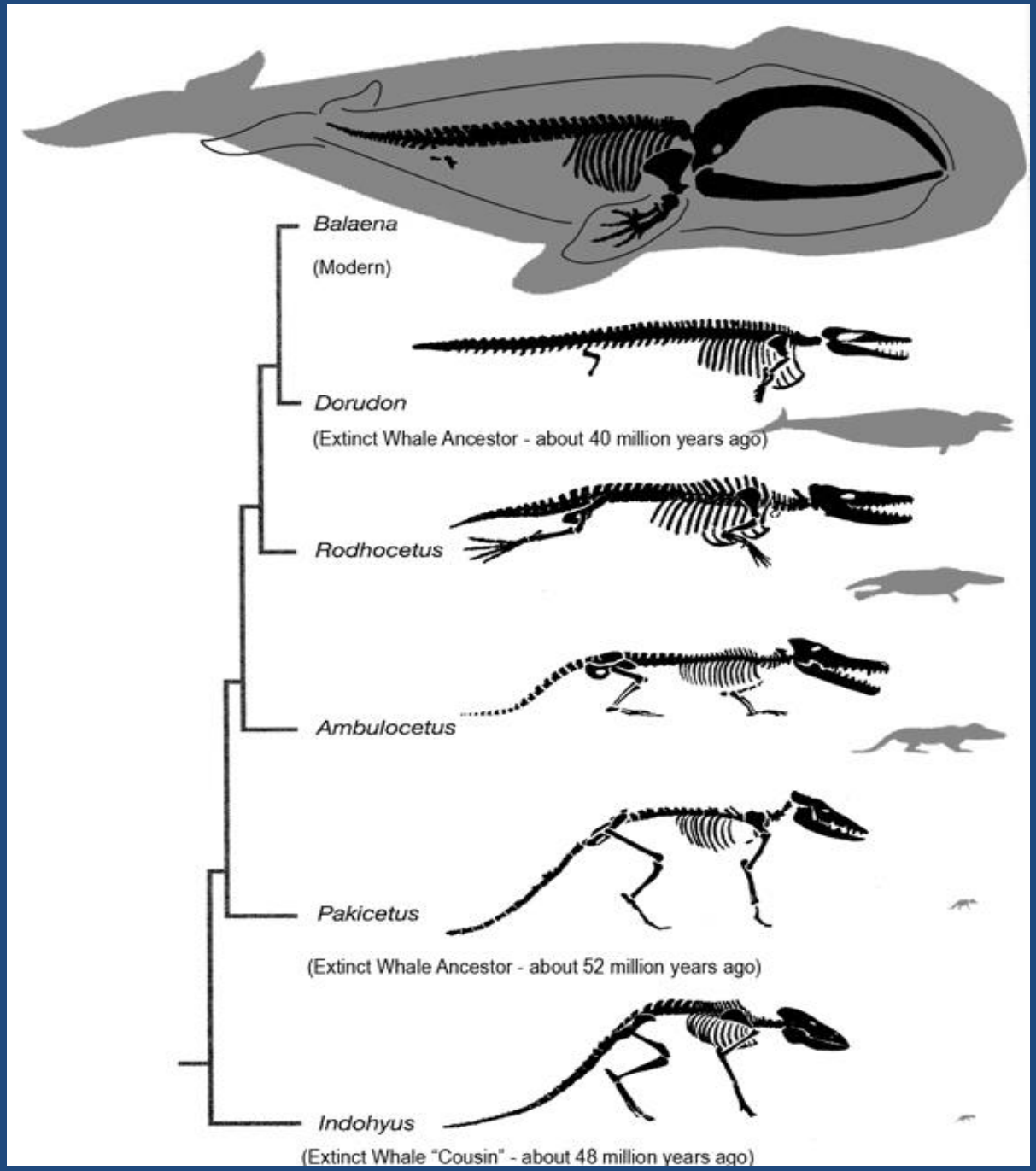
Complex systems such as organisms can evolve only gradually. Any sudden major change will destabilize the system and so will be lethal or pathological. To be tolerated by natural selection, even major genotype rearrangements such as polyploidization must have relatively small phenotypic effects.

Looking at today's species, it may be difficult to imagine that such radical transitions as becoming terrestrial (or secondarily aquatic) may have happened gradually. The fossil record, however, proves that precisely this has been the case.



http://scienceblogs.com/pharyngula

Cetaceans take back to water



From www.bio.miami.edu

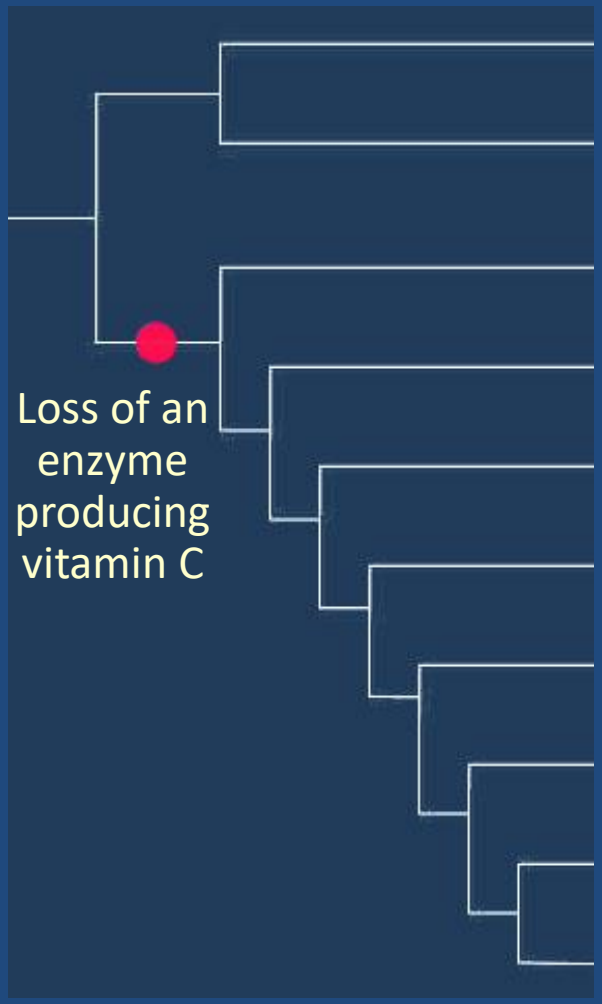
Fossils of transitional forms are often found

Example: Archaeopteryx, a very early bird with teeth and a long tail

James L. Amos, National Geographic Society

Such fossils are paleontological evidence for evolution.

Evolution is irreversible



Lemurs

Lorisoids

Tarsiers

Prosimians

New World monkeys

Old World monkeys

Gibbons

Orangutans

Gorillas

Chimpanzees

Humans

Simians

Once lost, the ability of primates to synthesize vitamin C was never regained.

Proteins and genes are more similar in closely related species than in distantly related ones

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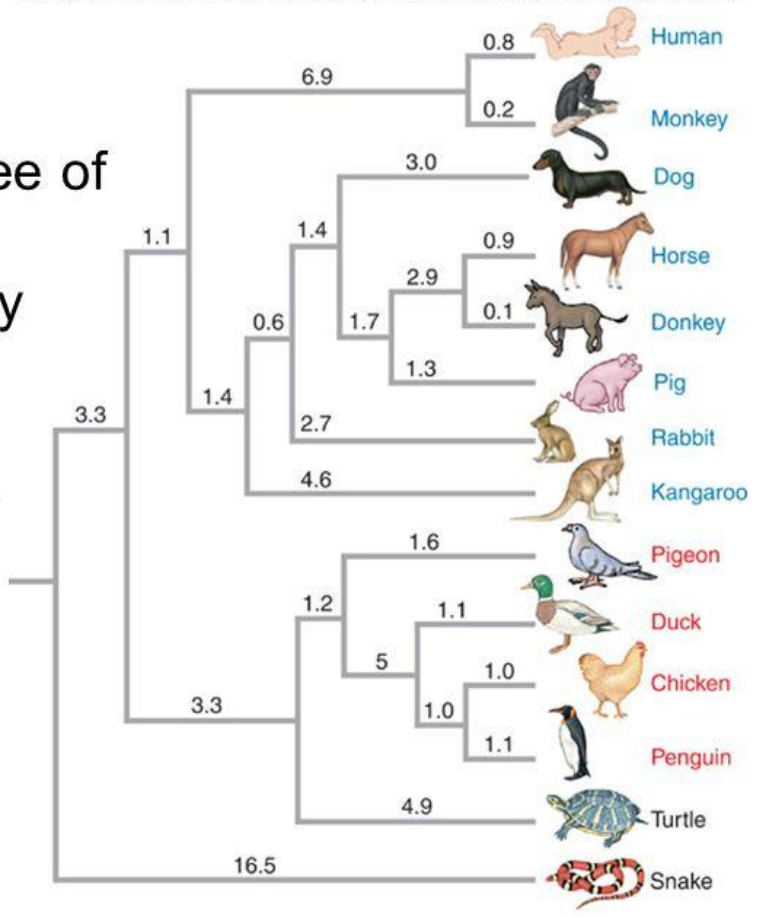
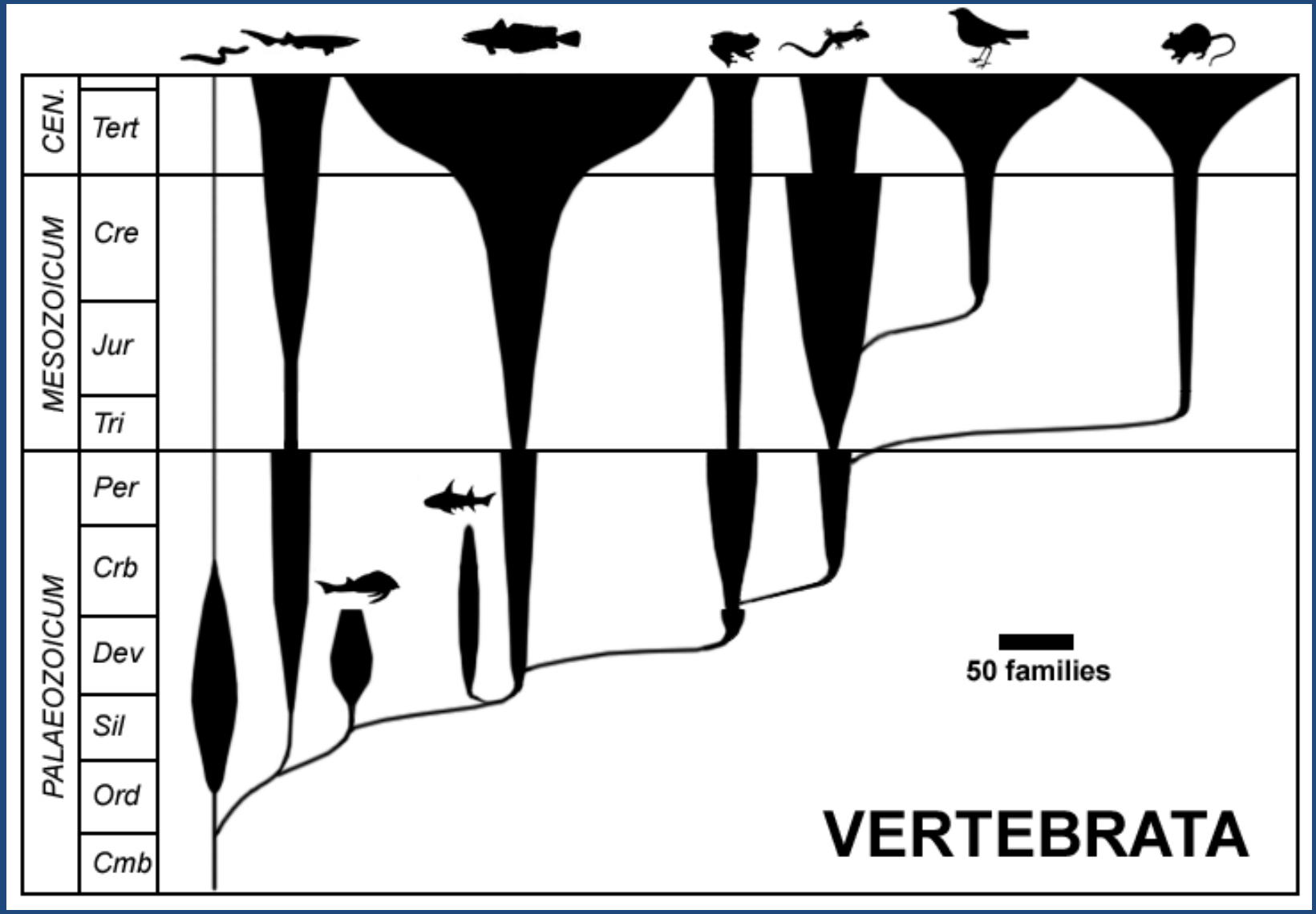
Early phylogenetic tree of amniotes based on cytochrome c gene by Fitch and Margoliash (1967).

Note: Numbers on branches. These represent estimated numbers of mutational changes in gene.



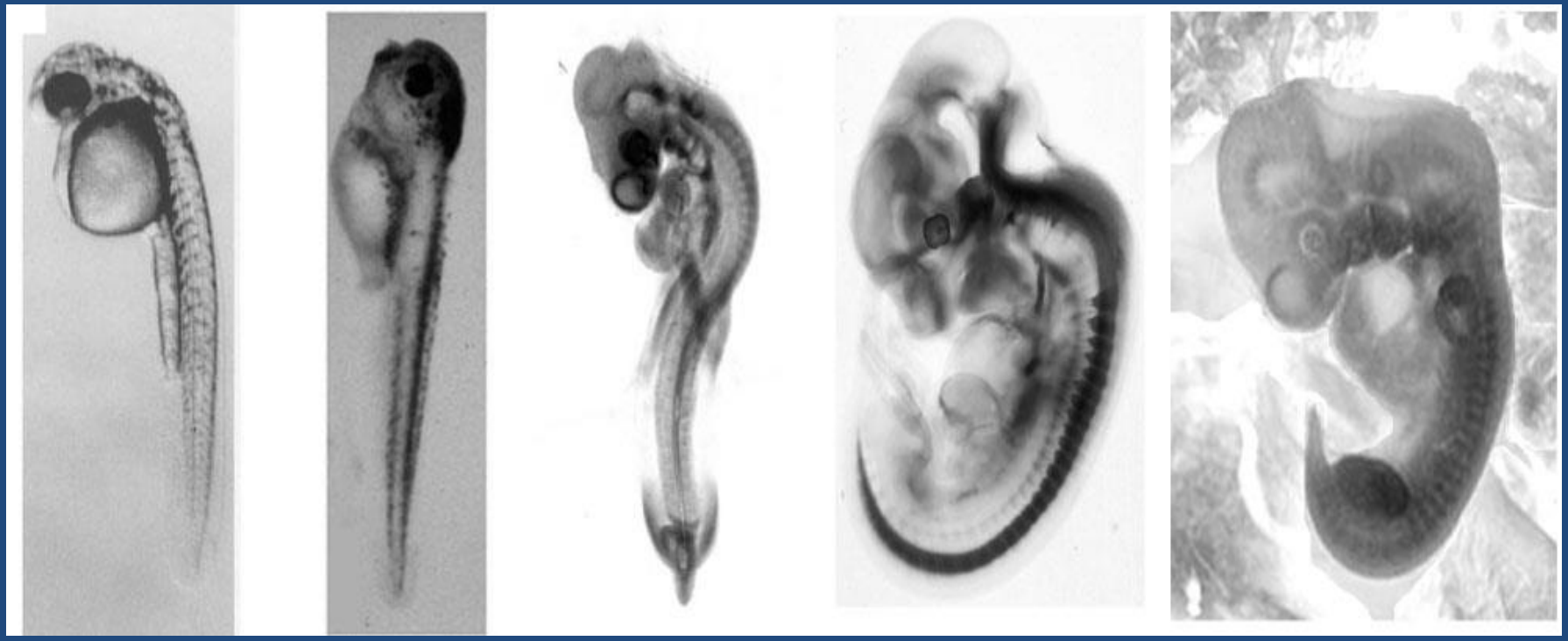
This is molecular evidence for evolution.

In large animals, such as vertebrates, adults may look very different…



Petter Bøckman / Wikimedia

…but at some stage their embryos look similar, reflecting the common origin



This is embryological evidence for evolution.

Sources: Kimmel et al., Dev. Dyn. 203: 253-310, 1995
http://www.ucl.ac.uk/cdb/research/dale/dale_lab
https://rowan.biology.ualberta.ca/courses/biol108/?Page=3048
http://www.yale.edu/mcdb/facultystaff/zhong.html
http://en.wikipedia.org/wiki/Embryo

Evolution is based on variability created by mutations

www.katiephd.com

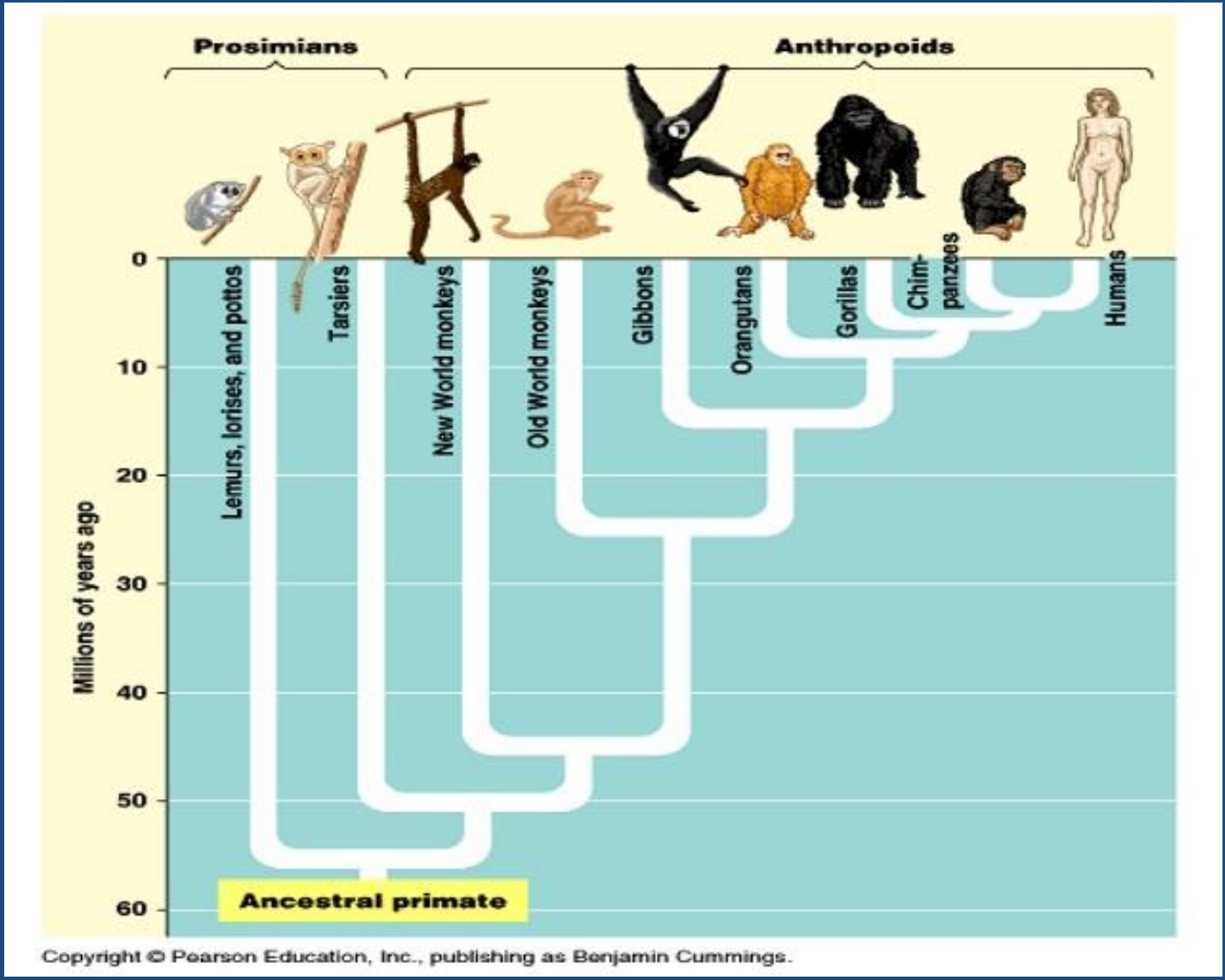
The diversity created this way is then “filtered” by natural selection

Katerina Hlavata
https://www.flickr.com/photos/kachnch/16364273038

Artificial selection acts in a way similar to natural selection

https://yougov.co.uk/news/2015/11/20/revealed-britains-most-loved-dog-breeds/

Evolution and relationships of primates



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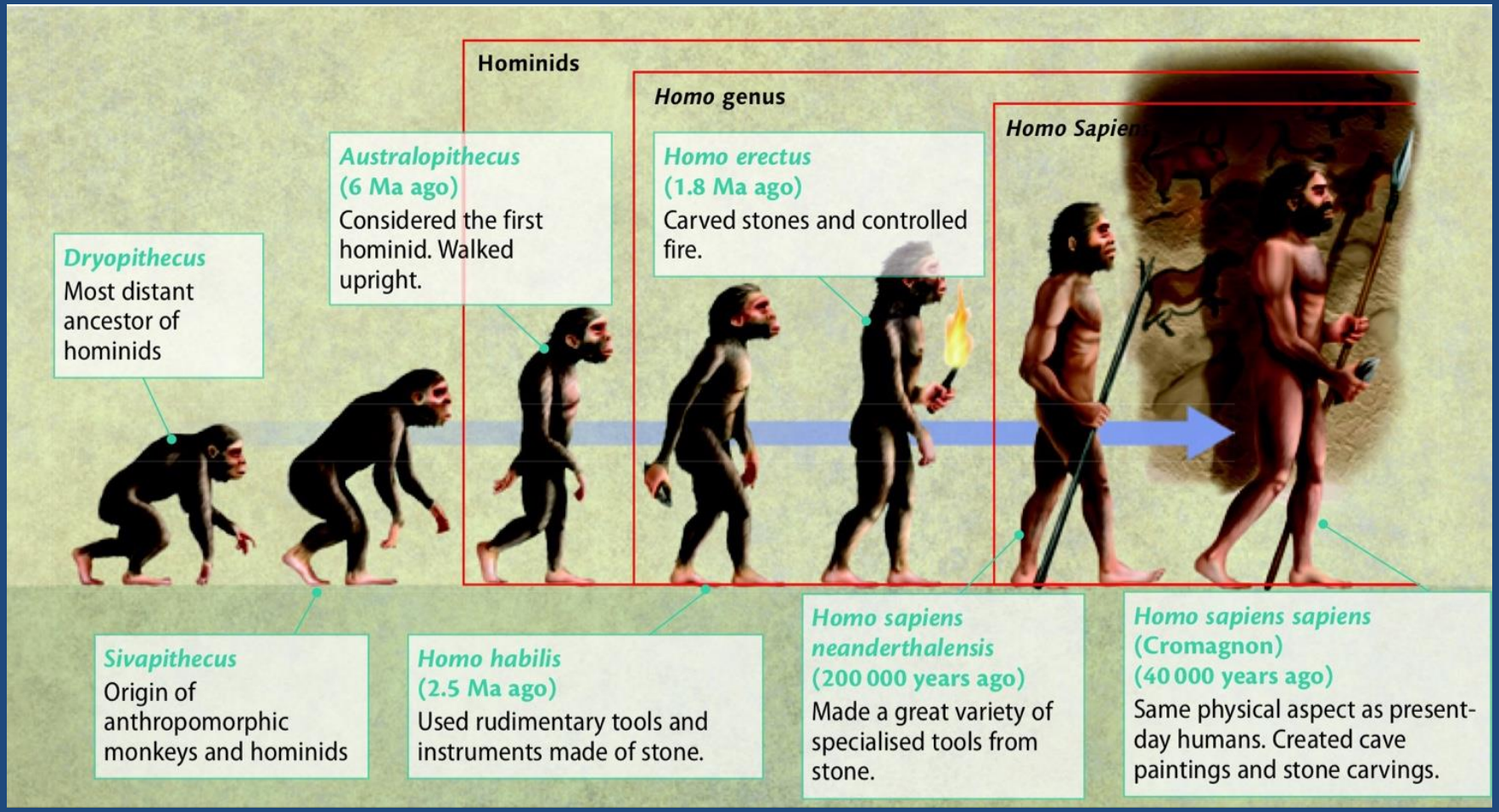
Human evolution



Paula Catalan

Family Hominidae (great apes)
orangutans, gorillas, chimpanzees, humans

- Long childhood: young are breastfed for several years and reach maturity at about 10 years.
- Large brain and very high intelligence: use and make tools, recognize themselves in mirrors, can be taught to communicate by sign language or computer symbols.
- Social groups have “culture”, e.g. West African chimpanzees more often use stone tools while East African ones prefer wood.

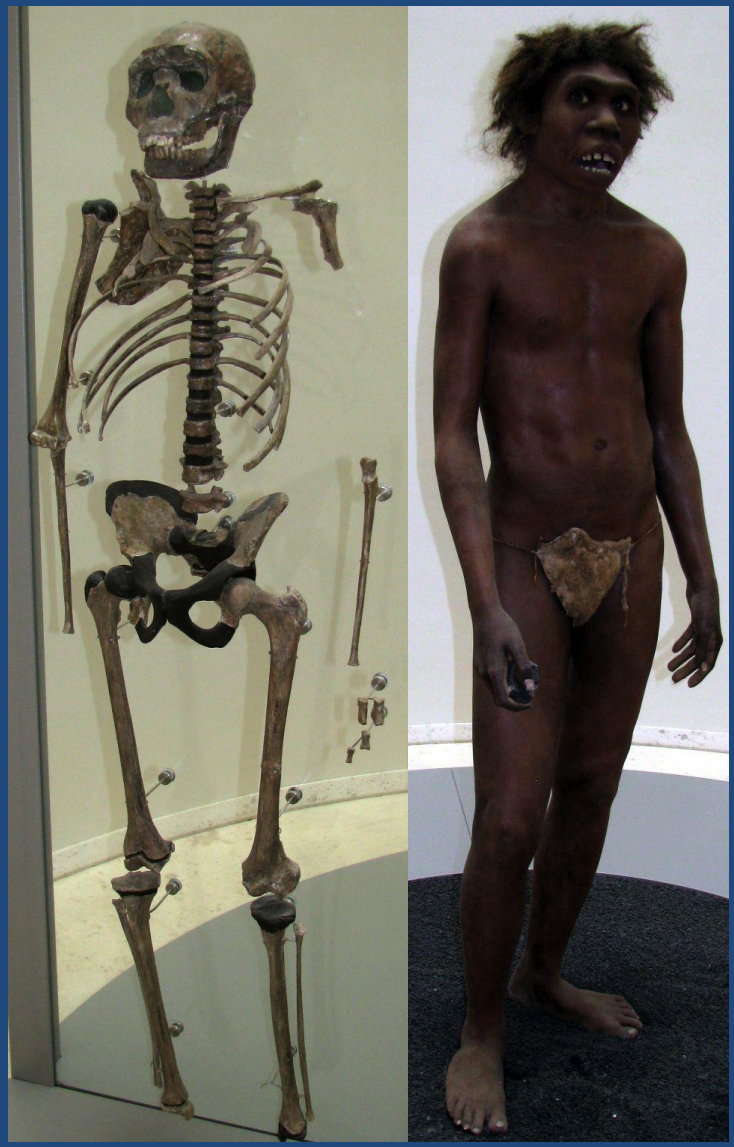
Chimpanzees cracking nuts by stone and wood tools, reflecting a cultural difference.

Human origin and evolution

- The human and his extinct close relatives are called hominins (Hominini, formerly hominids).
- Hominins and chimpanzee ancestors split 6-7 MYA.
- A number of hominin species have evolved since that time.
- Most of hominin evolution happened in Africa.

Homo erectus

- Origin: 1,9 MYA.
- Reduced facial skull and teeth.
- Enlarged brain: about 1000 cm3.
- Widened pelvis in females.
- Body hair is lost, skin darkens (about 1,2 MYA). For the next million of years, all humans will be dark-skinned.
- Improved stone tools (the Acheulean industry, named after a location in France).
- Controlled fire.
- First hominin to migrate out of Africa.



Turkana Boy – a well-preserved young male *H. erectus*: skeleton (photo by D. Hitchcock) and reconstruction (by E. Daynès)

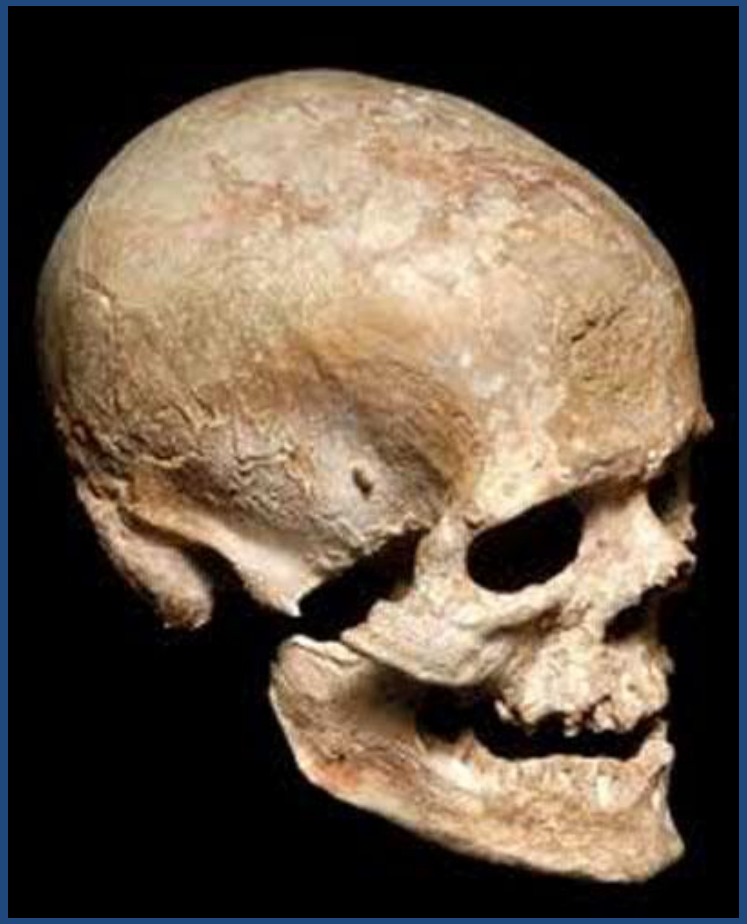
Homo neanderthalensis

- Origin: 300,000 years ago in Europe from *H. heidelbergensis*.
- Enlarged brain: up to 1600 cm3 (the average for modern humans is 1400 cm3).
- Driven to extinction by modern humans, but...
- There was some interbreeding and Neanderthal genes are preserved in modern non-African populations. Many of these genes are related to skin development and possibly have adapted our ancestors to colder climate.

Image from BBC

Homo sapiens

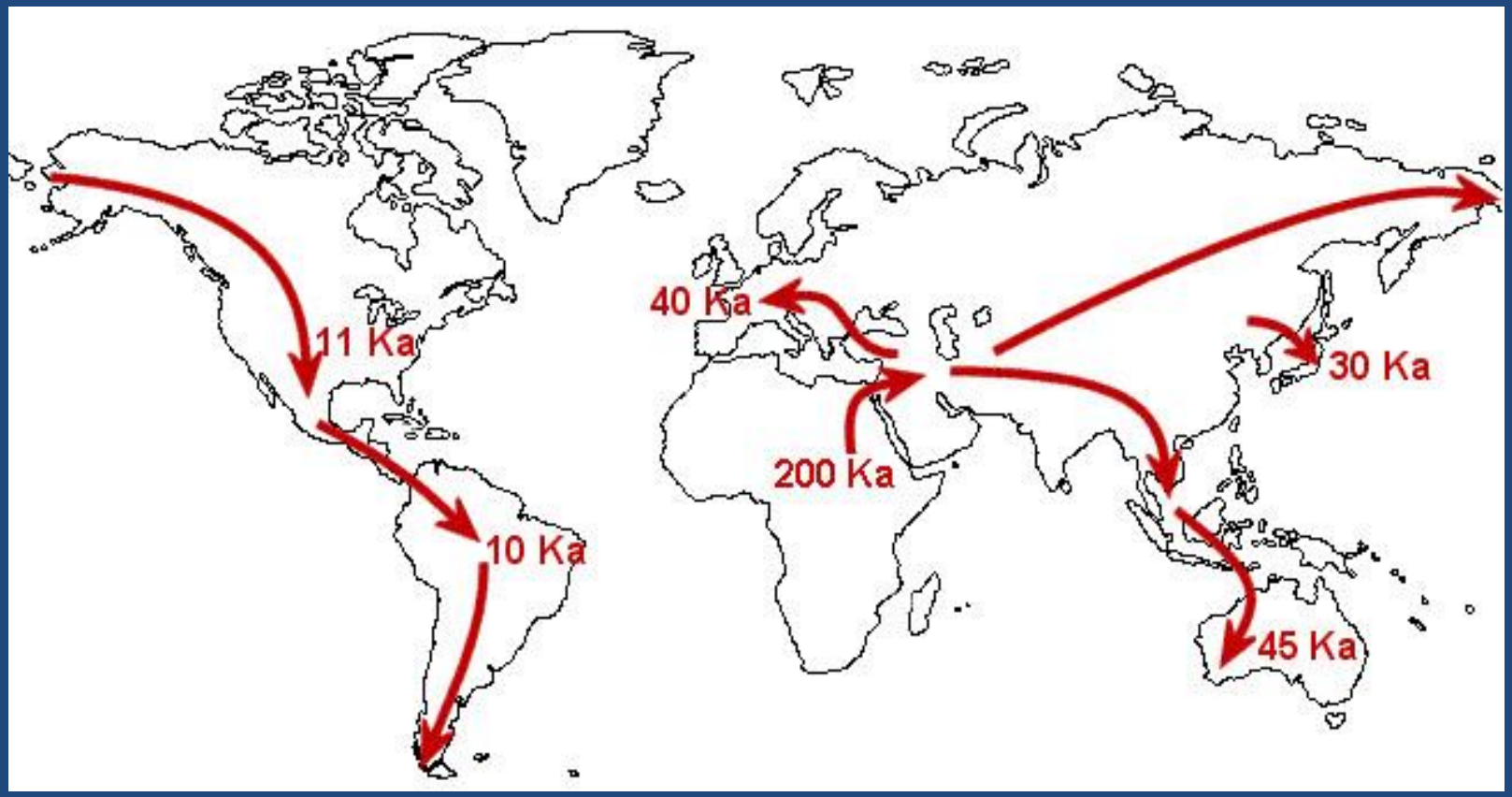
- Origin: 200,000 years ago in Africa.
- Migrated out of Africa:
- to the Middle East – 125,000 years ago;
- to South Asia – 50,000 years ago;
- to Europe – 43,000 years ago;
- to Australia – 40,000 years ago;
- to East Asia – 30,000 years ago;
- to North America – 15,000 years ago.



A skull of a Cro-Magnon, i.e. an early *H. sapiens* migrant to Europe (named after the Cro-Magnon cave in France). On average, they were more robust and had larger brains than modern-day humans.

Image from donsmaps.com

Migration of modern humans



Ka = thousands of years ago. Source: www.geo.arizona.edu

Parallel and convergent evolution

The environment in different territories is similarly subdivided into species habitats (ecological niches). Therefore, when distantly related organisms migrate to different places, they undergo similar adaptive radiation which is called parallel evolution.

As a result of parallel evolution, we can find species which are not closely related but have striking correspondence in ecology, morphology and behavior. This phenomenon is called convergence.

North American cactuses (family Cactaceae) and South African euphorbias (family Euphorbiaceae) are both adapted for survival in desert regions. Without flowers, they are practically indistinguishable. Which of these two plants is a cactus and which one is an euphorbia?

http://waynesword.palomar.edu

Convergent evolution

Convergent Evolution: Streamlining

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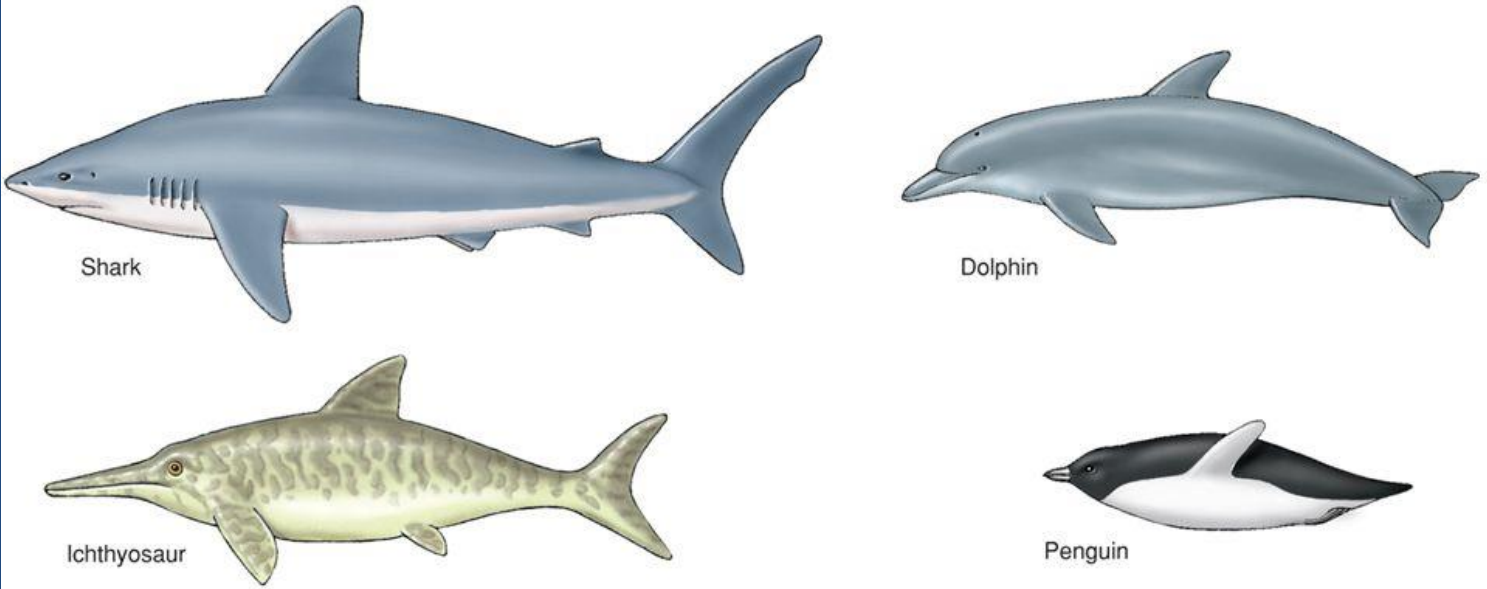

Convergent evolution is the process by which unrelated species evolve similar physical characteristics because they have similar lifestyles

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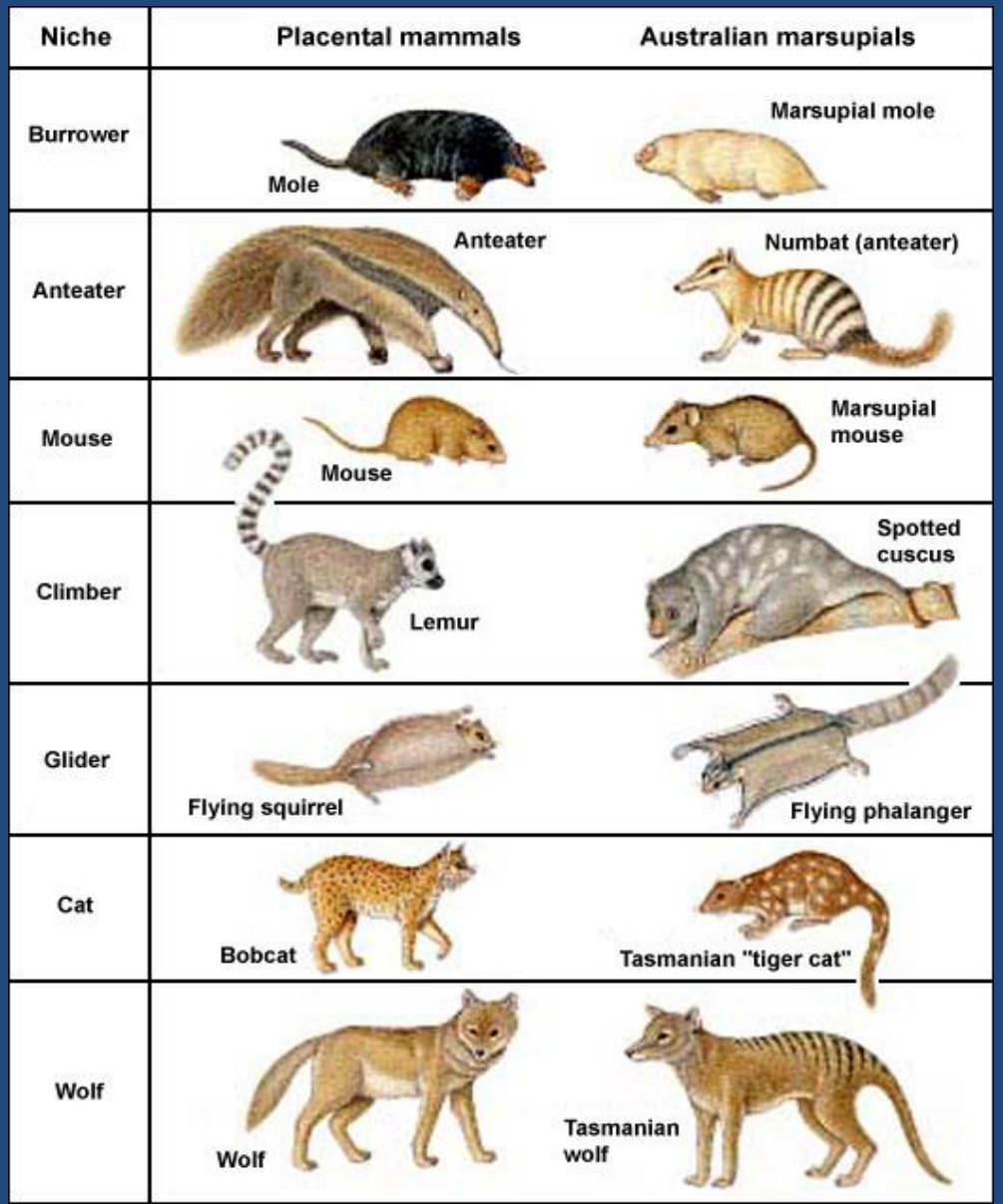
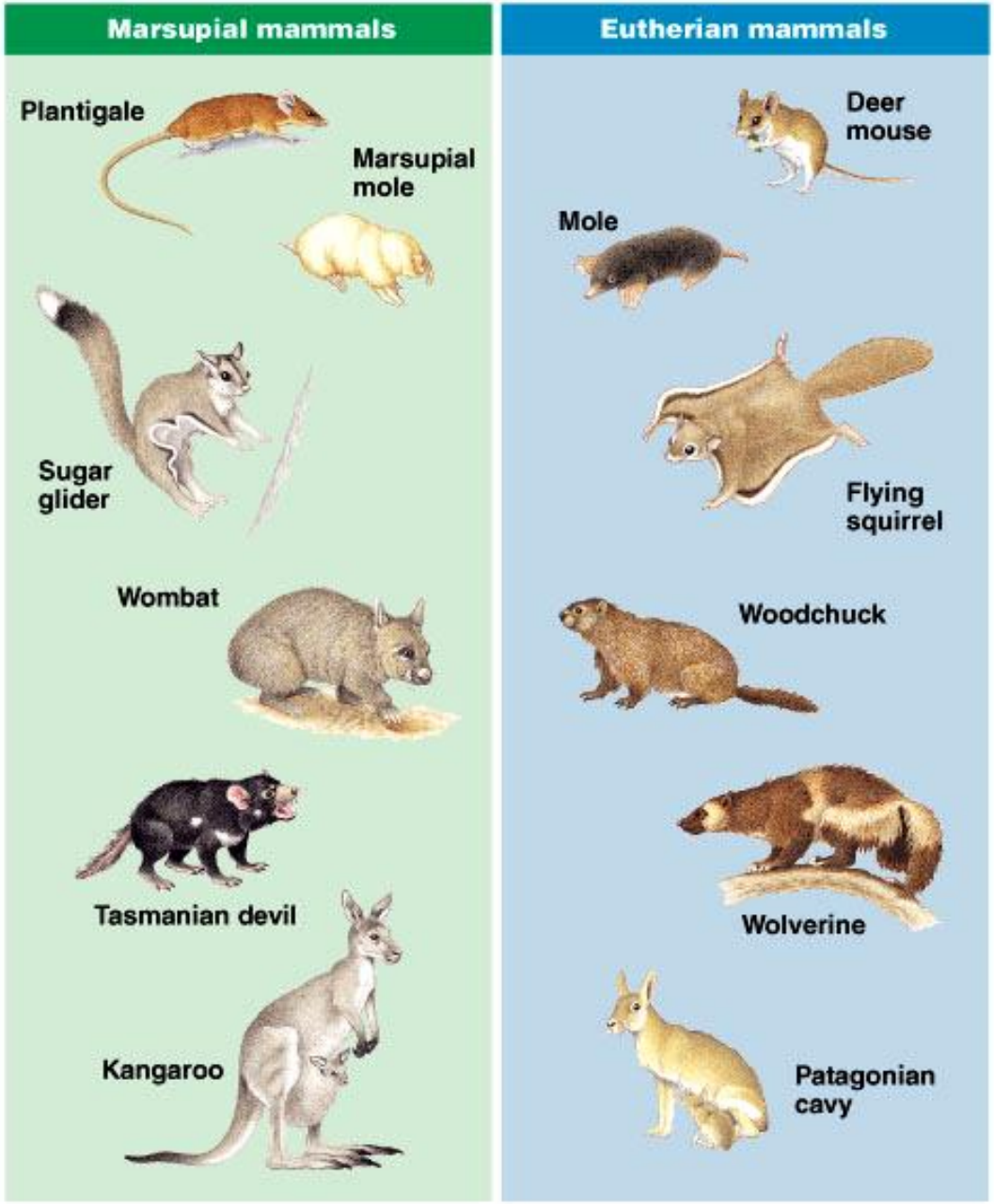
Parallel evolution of marsupial and placental mammals

The placenta gave eutherians advantage over all other mammals. They radiated and migrated quickly, driving their relatives to extinction.

However, they could not reach Australia for a long time. This allowed marsupials to undergo a parallel evolution.



From http://txtwriter.com



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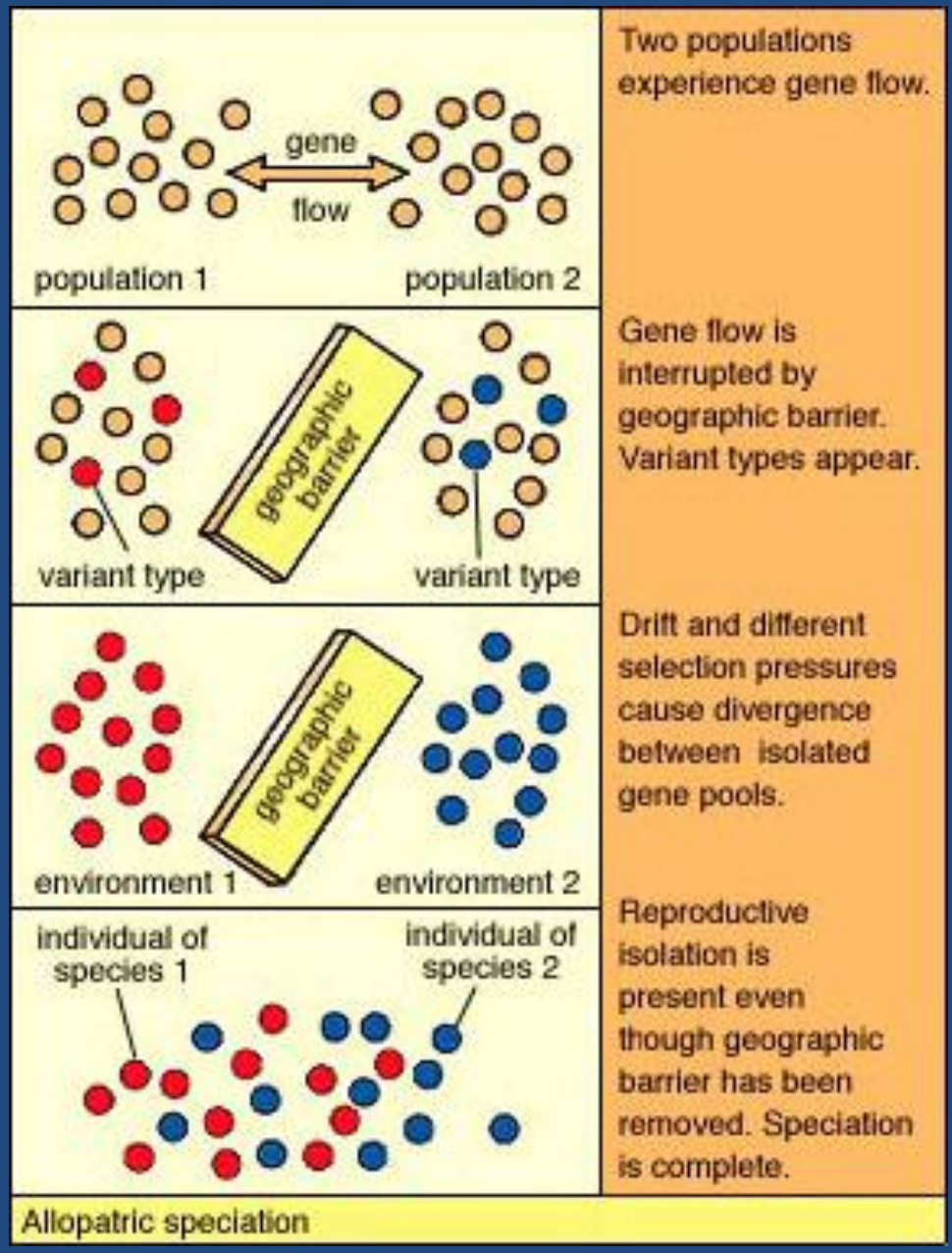
Speciation

In it, two populations of the same species are separated for a long time by a geographic barrier – sea, mountain chain etc.

With time, mutations accumulate because of selection pressure, genetic drift, or both. Because gene flow is stopped, the two populations acquire different mutations. They diverge.

When the populations eventually meet again, the differences are so deep that interbreeding is impossible or leads to unfit progeny. The geographic isolation has led to reproductive isolation.

In the drawing, the two populations change equally. In reality, the smaller one usually changes more, due to genetic drift.



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