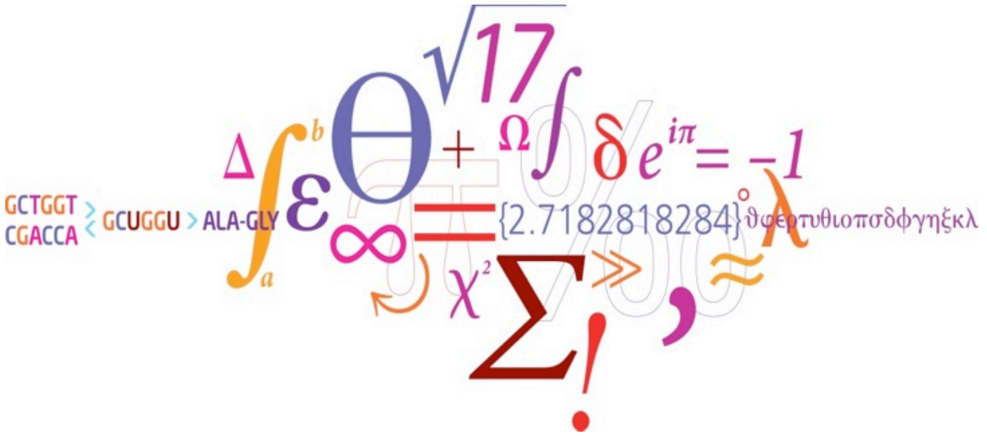
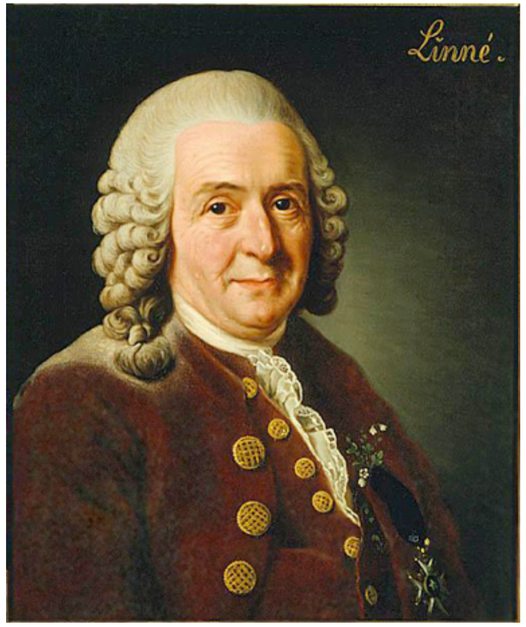
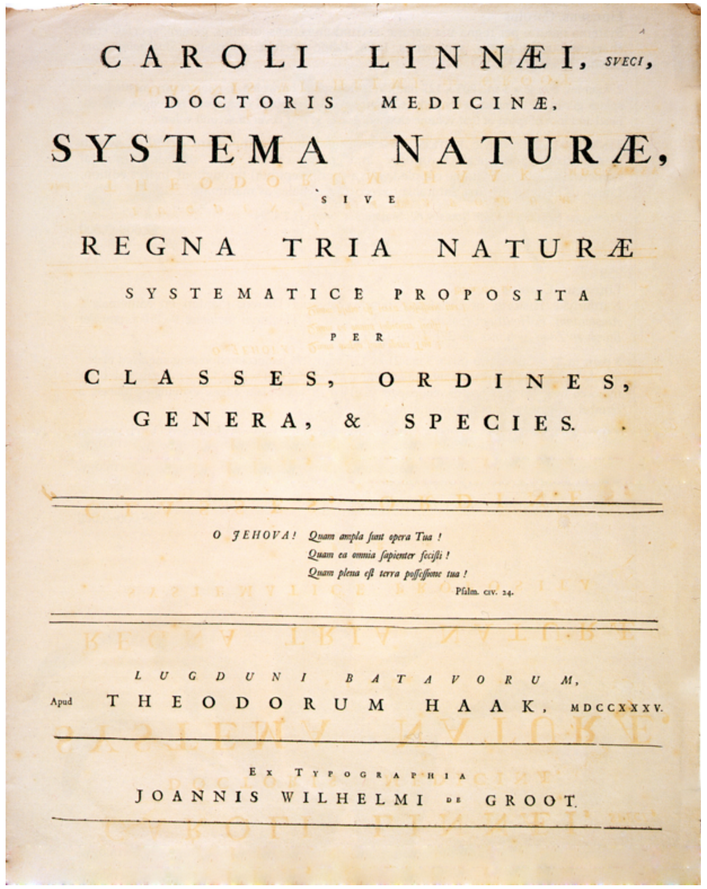
# Common Descent



# Classification: Linnaeus




Carl Linnaeus
1707-1778
image source: wikimedia


CAROLI LINNÆI, SVECI,
DOCTORIS MEDICINÆ,
SYSTEMA NATURÆ,
SIVE
REGNA TRIA NATURÆ
SYSTEMATICE PROPOSITA
PER
CLASSES, ORDINES,
GENERA, & SPECIES.

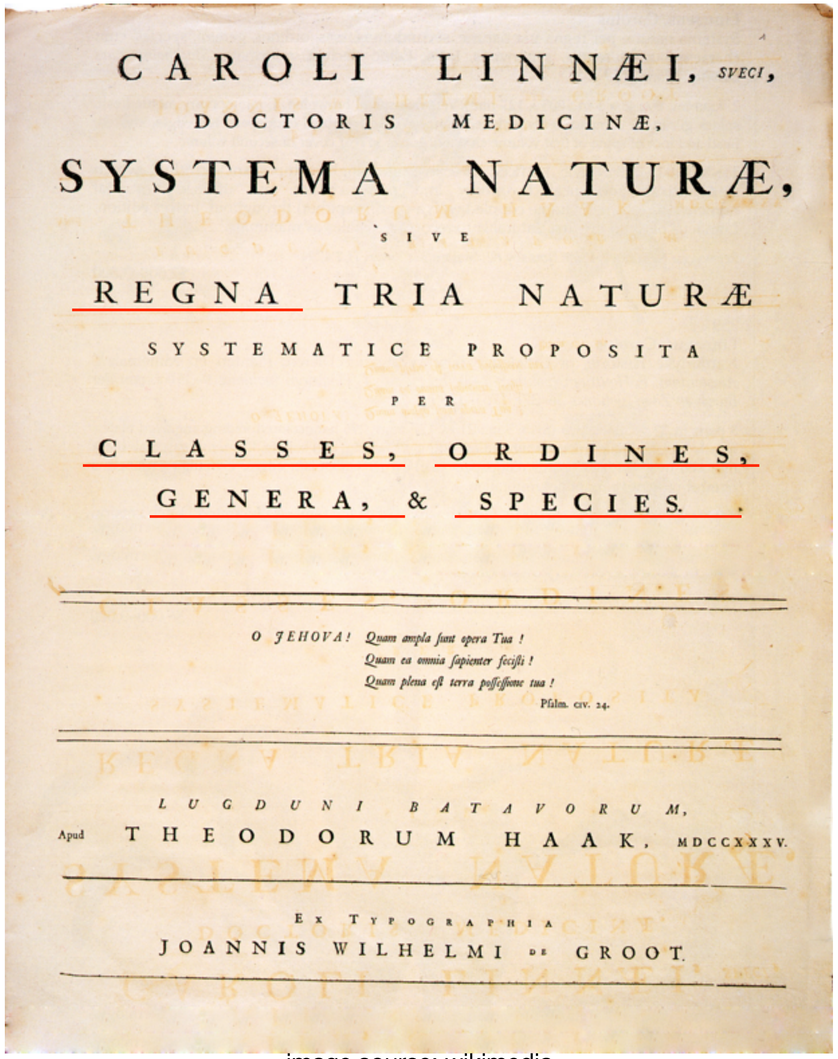
O JEHOVA! Quam ampla sunt opera Tua!
Quam ea omnia sapienter fecisti!
Quam plena est terra possessione tua!
Psalm. civ. 24.

LUGDUNI BATAVORUM,
Apud THEODORUM HAAK, MDCCXXXV.

EX TYPOGRAPHIA
JOANNIS WILHELMI DE GROOT.

Systema Naturae: first edition published in 1735
image source: wikimedia

# Classification: Linnaeus



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EX TYPOGRAPHIA
JOANNIS WILHELMI DE GROOT.

image source: wikimedia

- Nested hierarchy (groups within groups)

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

# Classification depicted as a tree

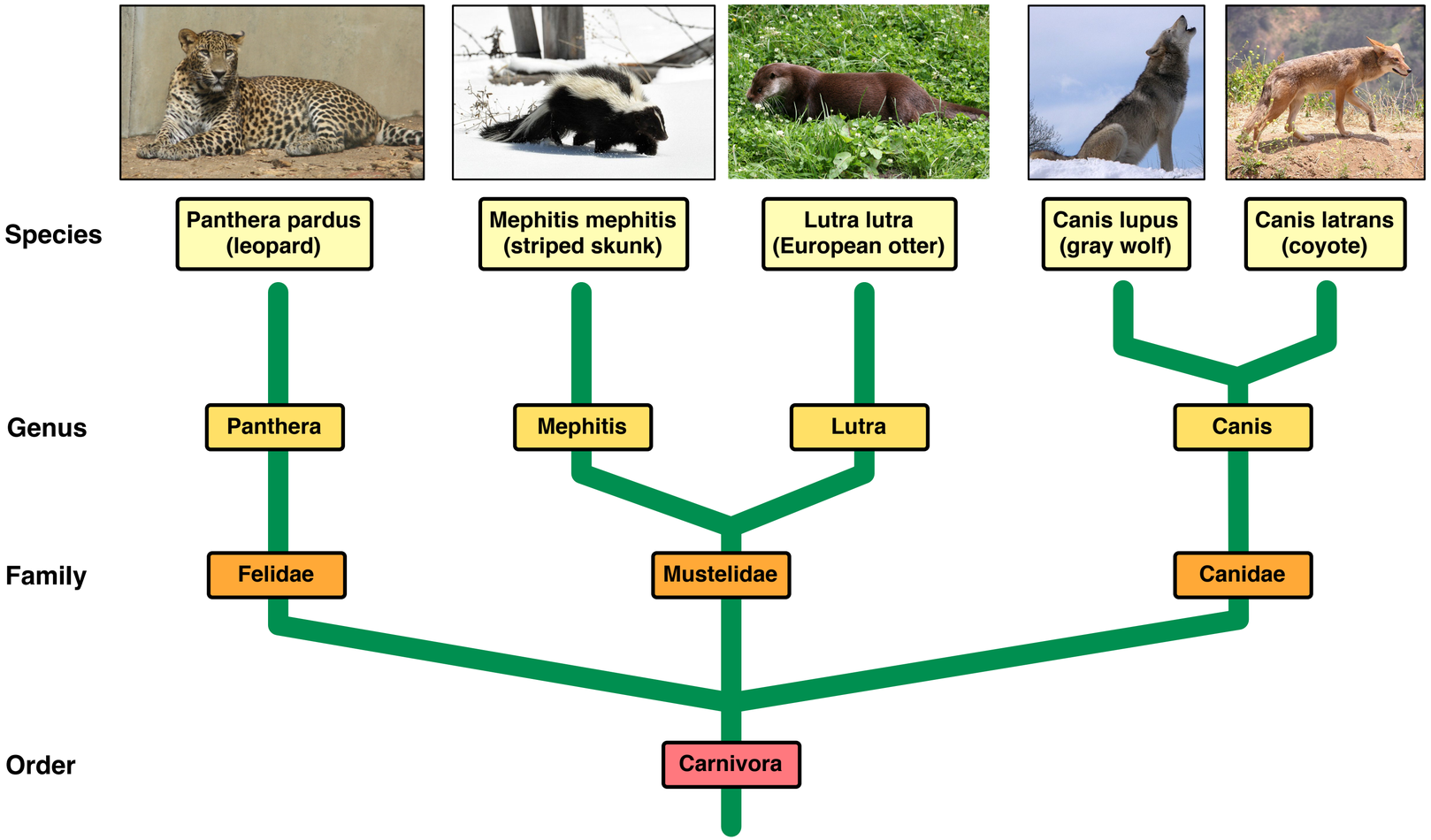
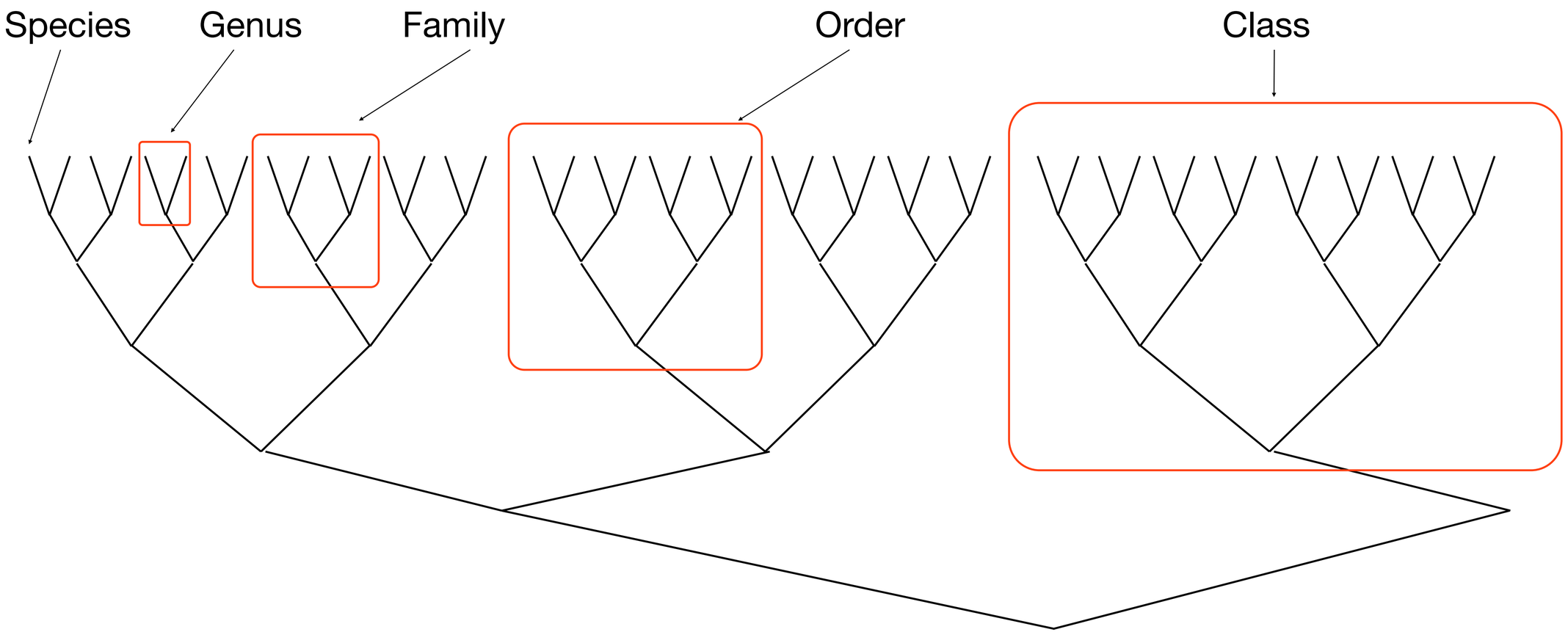
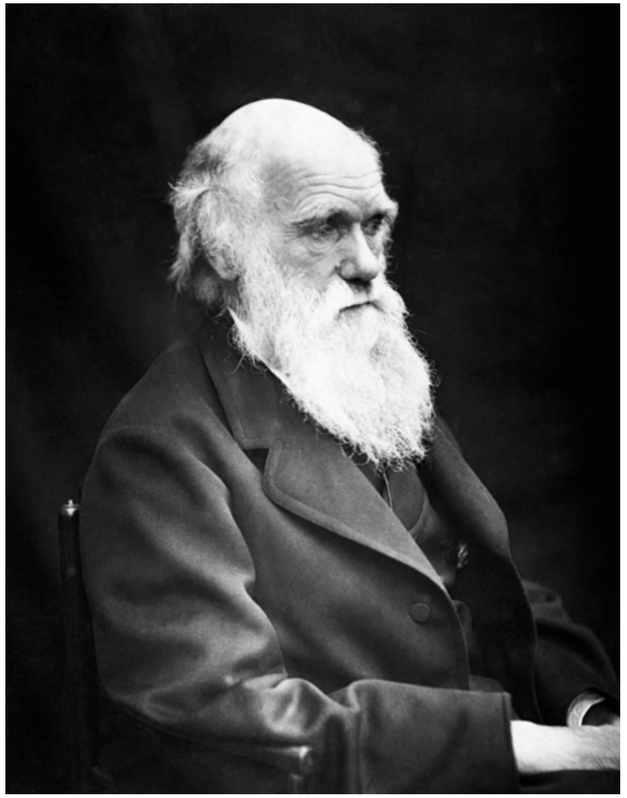



image sources: wikimedia (#1, #2, #3, #4, #5)

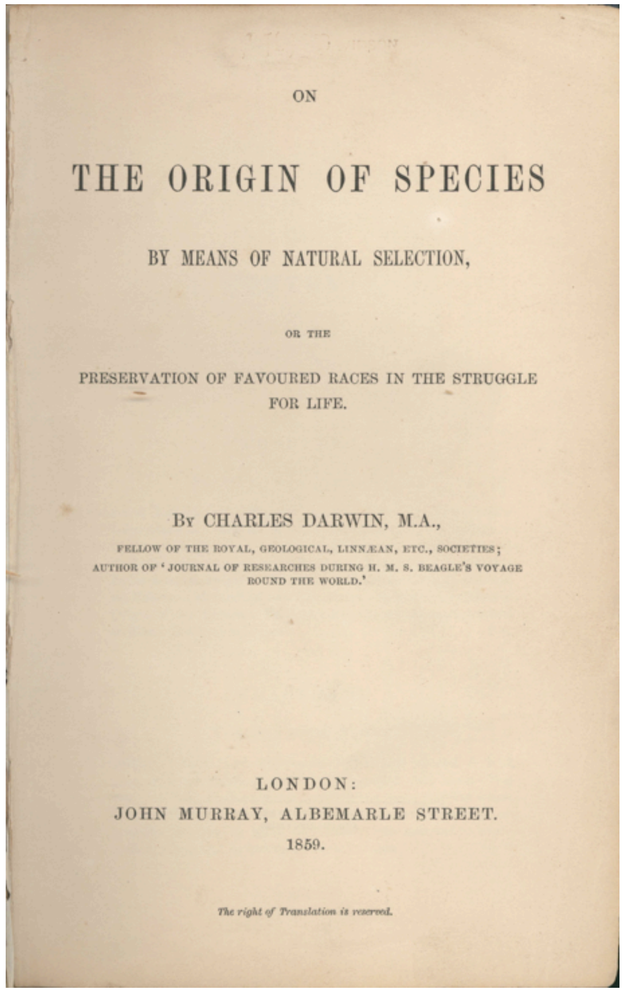
# Classification depicted as a tree



# Theory of evolution



Charles Darwin
1809-1882
image source: wikimedia



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

*The right of Translation is reserved.*

image source: wikimedia

# Phylogenetic basis of systematics

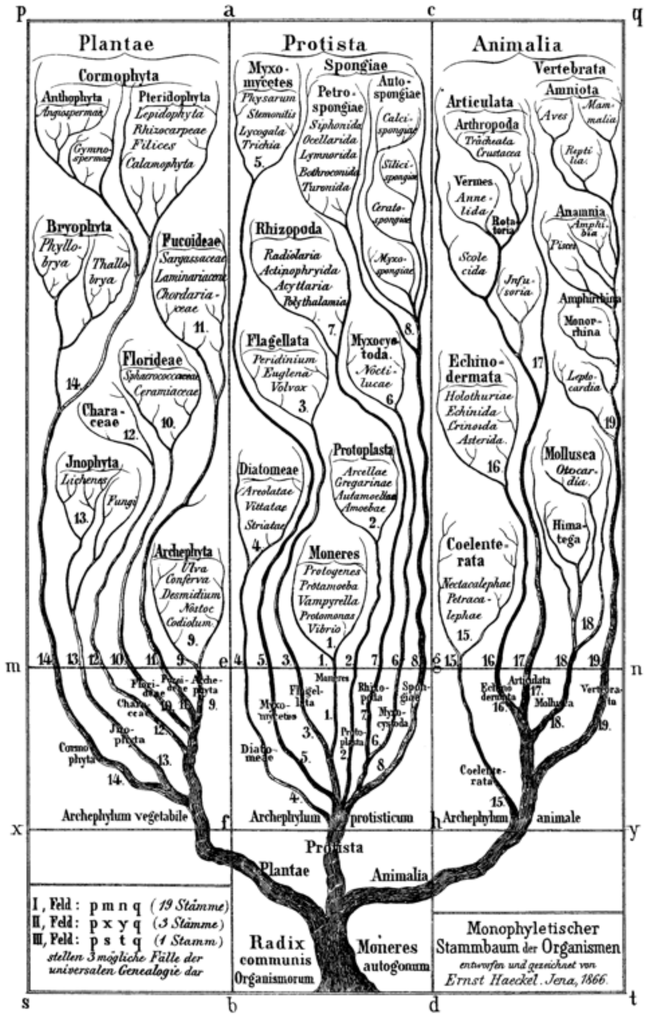
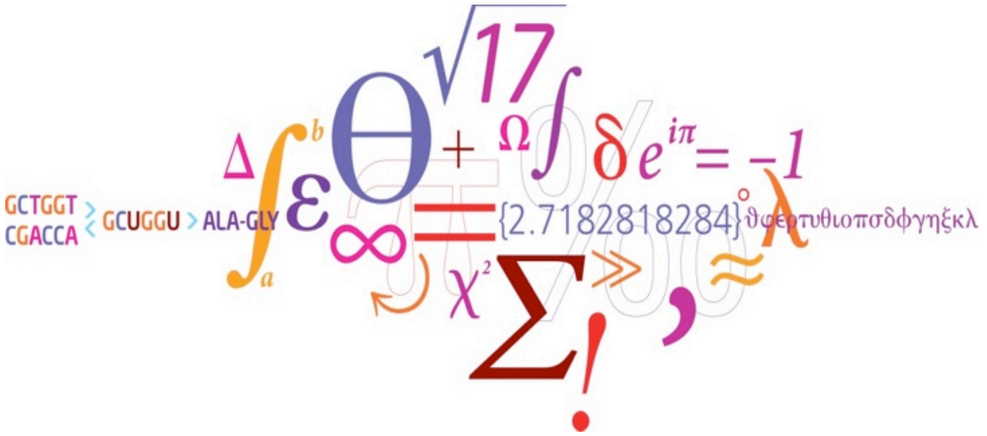



image source: wikimedia

- Darwin: Ordering principle is shared descent from common ancestors.
- Today, systematics is explicitly based on phylogeny.

# Natural Selection



# Natural Selection: Darwin's four postulates

- Individuals within species vary in their characteristics.
- Some of these variations are heritable.
- In every generation, more young are produced than can survive to reproduce.
- The survival and reproduction of individuals is not random: Individuals who survive and go on to reproduce are those with the most favorable variation. They are naturally selected
- Consequence: Populations change over time - they adapt to their environment.

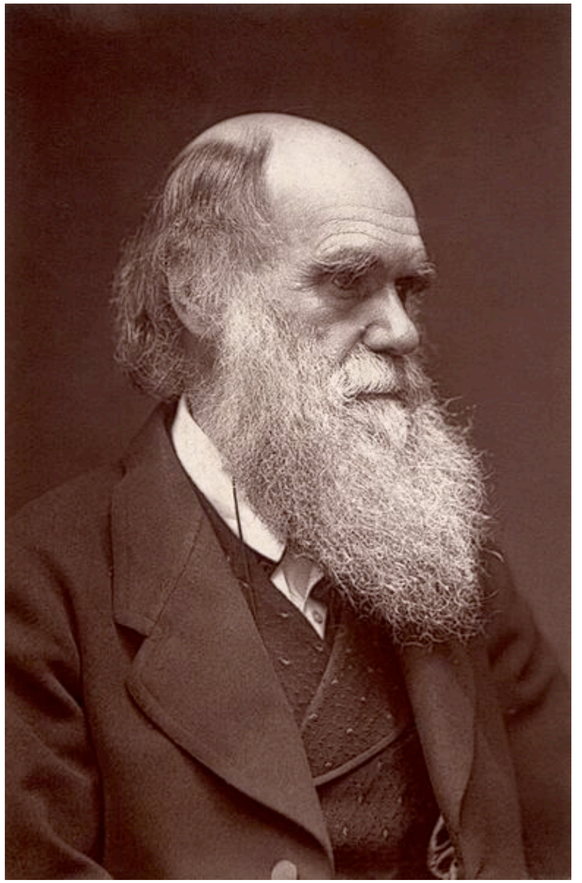
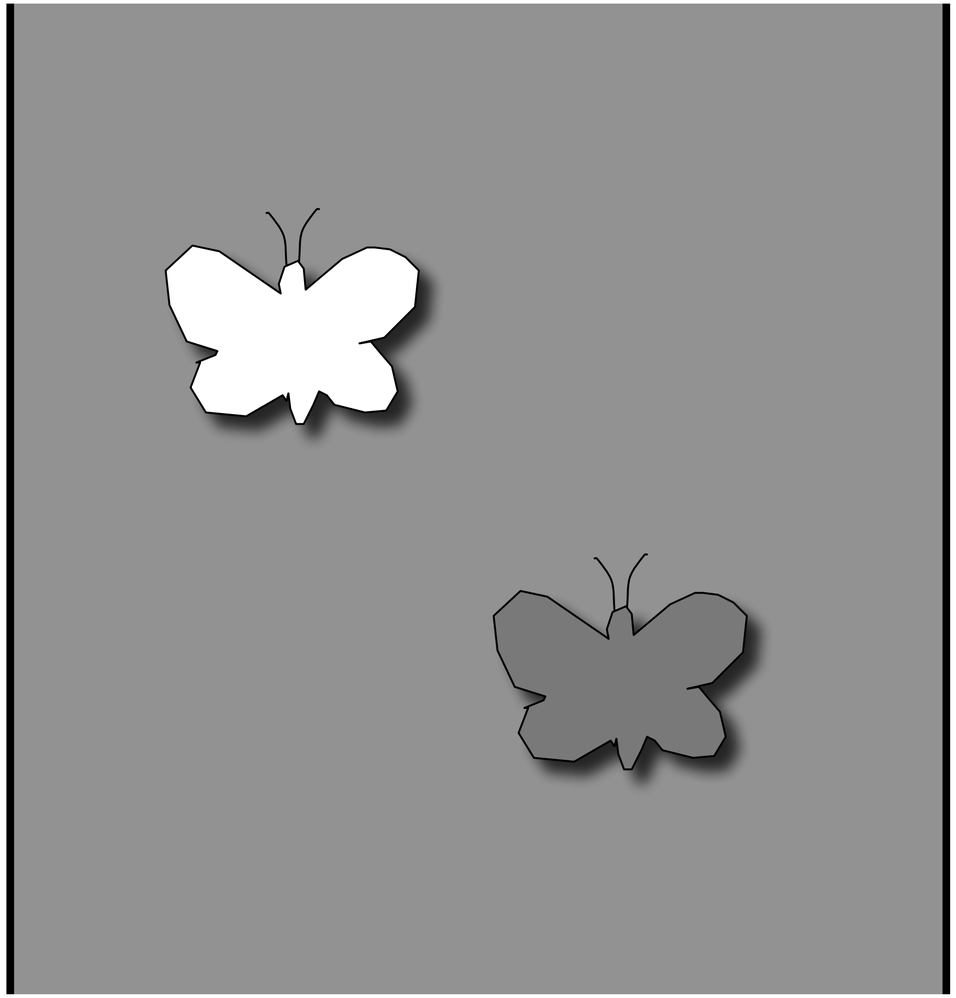


image source: wikimedia

# Evolution by Natural Selection is a Two-step Process



1. **DNA mutations**:
   Random generation of diversity

2. **Natural Selection**:
   Non-random, differential survival and reproduction of variants

# Molecular Basis for Heredity: DNA

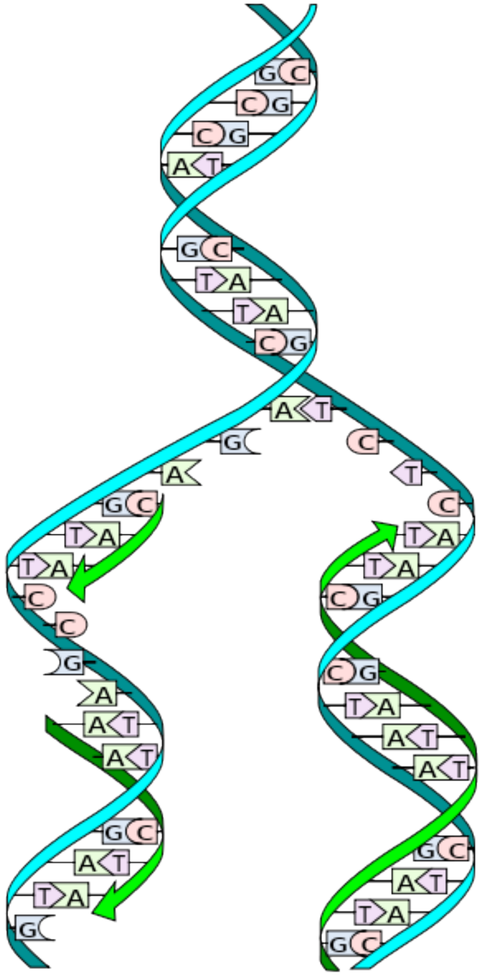
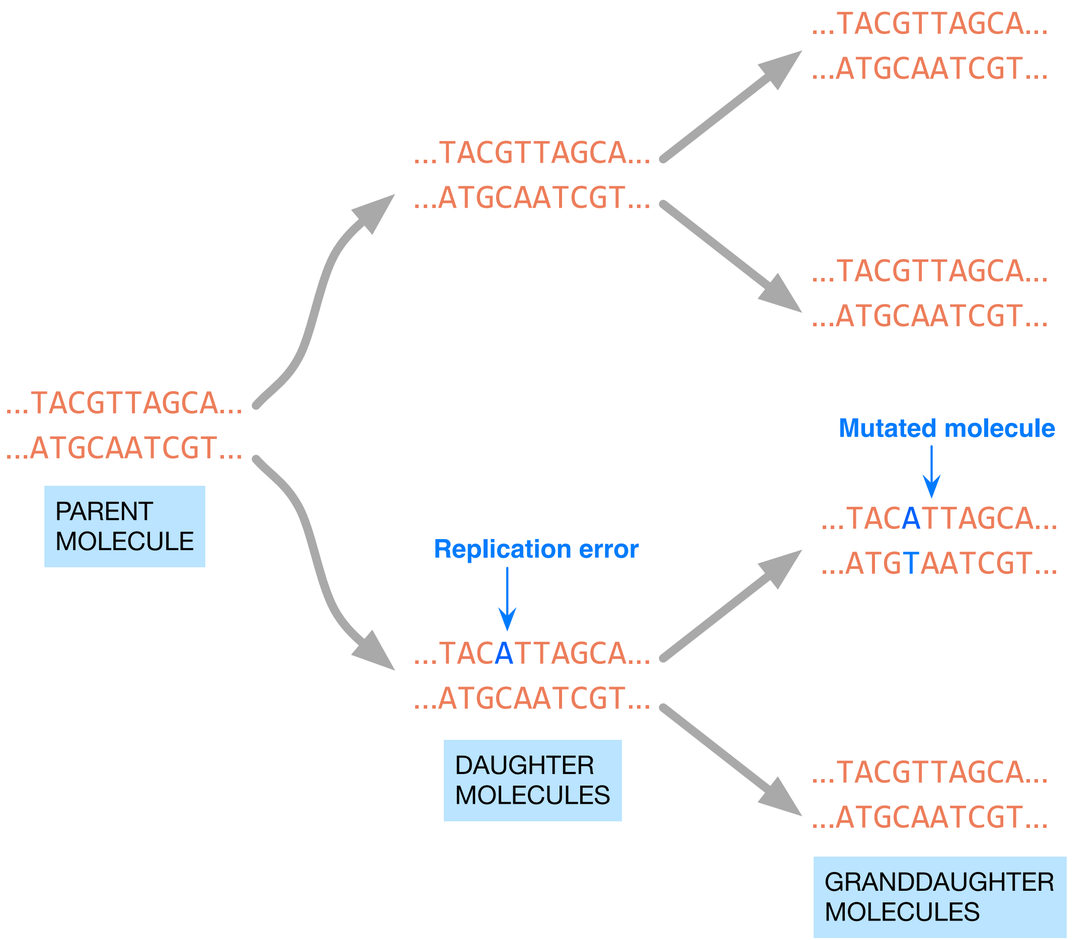
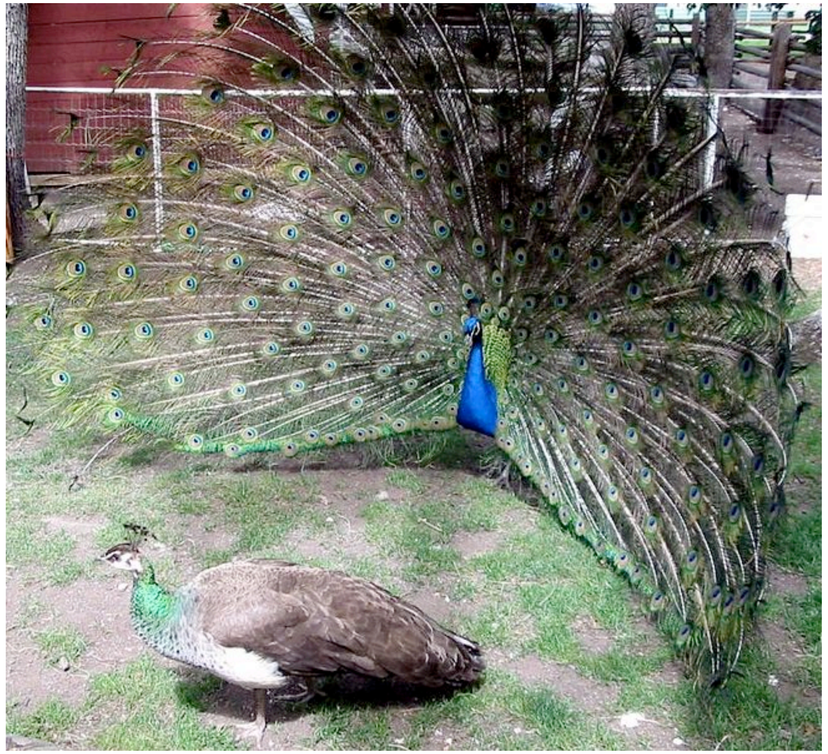


image source: wikimedia

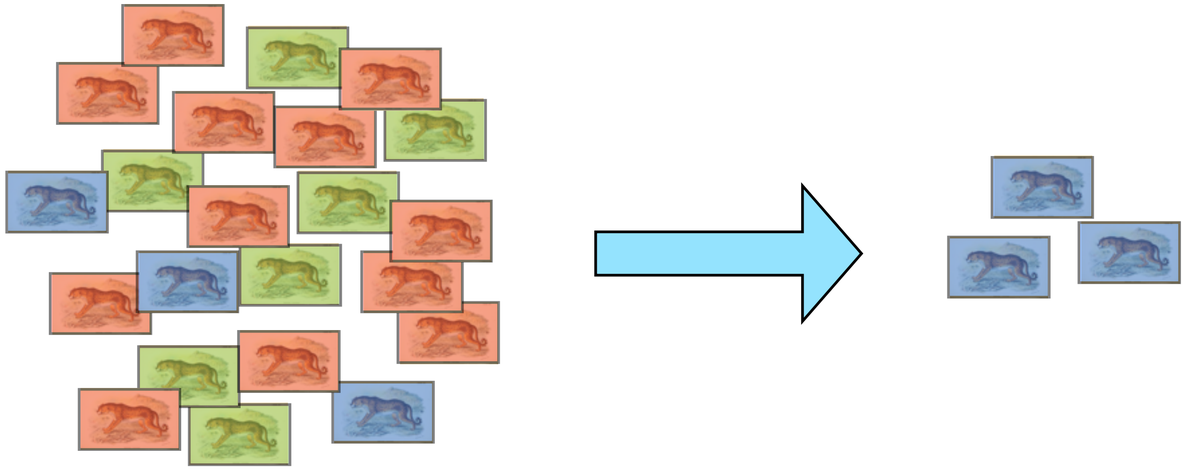
# Molecular Basis for Variation: DNA Mutation



# Other causes of evolution



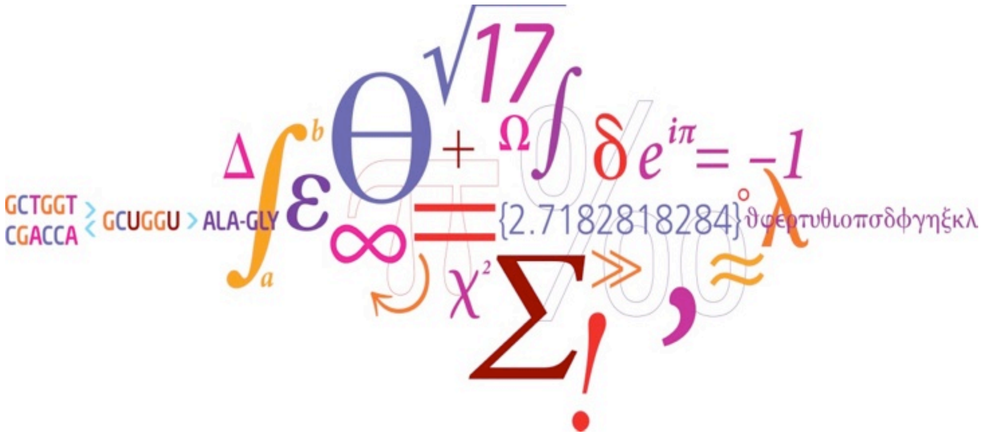
Sexual selection



Genetic drift (bottlenecks,
founder effect, neutral evolution)

image sources: wikimedia (#1, #2)

# The Evidence for Common Descent




# 29+ Evidences for Macroevolution

## *The Scientific Case for Common Descent*

*Version 2.85*



[Last Update: January 8, 2006]



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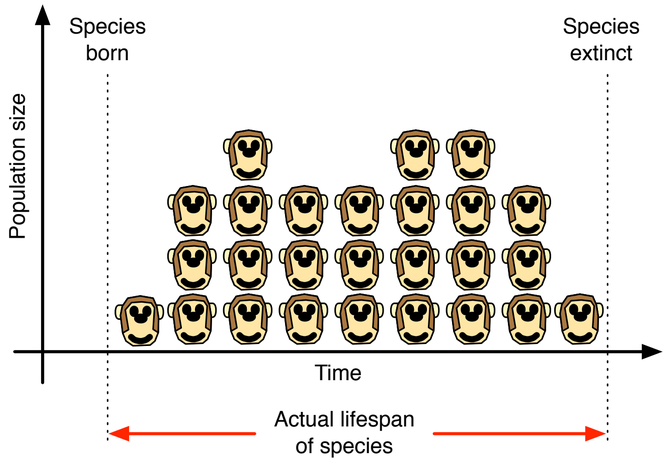
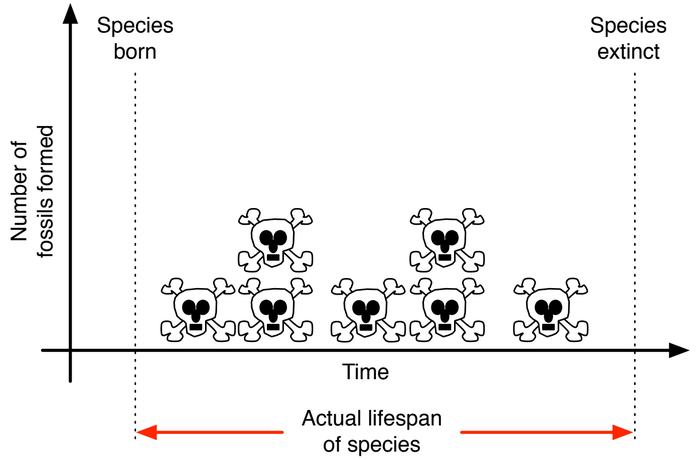
## *Introduction*

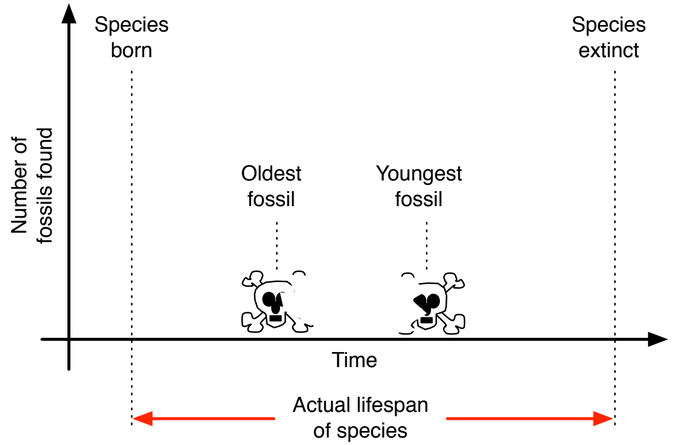
Evolution, the overarching concept that unifies the biological sciences, in fact embraces a plurality of theories and hypotheses. In evolutionary debates one is apt to hear evolution roughly parceled between the terms "microevolution" and "macroevolution". Microevolution, or change beneath the species level, may be thought of as relatively small scale change in the functional and genetic constituencies of populations of organisms. That this occurs and has been observed is generally undisputed by critics of evolution. What is vigorously challenged, however, is macroevolution. Macroevolution is evolution on the "grand scale" resulting in the origin of higher taxa. In evolutionary theory it thus entails common ancestry, descent with modification, speciation, the genealogical relatedness of all life, transformation of species, and large scale functional and structural changes of populations through time, all at or above the species level (Freeman and Herron 2004; Futuyma 1998; Ridley 1993).

Common descent is a general descriptive theory that concerns the genetic origins of living organisms (though not the ultimate origin of life). The theory specifically postulates that all of the earth's known biota are genealogically related, much in the same way that siblings or cousins are related to one another. Thus, macroevolutionary history and processes necessarily entail the transformation of one species into another and, consequently, the origin of higher taxa. Because it is so well supported scientifically, common descent is

# Expected Gaps in Fossil Record



# Fossil Record, Distribution of Living and Extinct Animals

- Older geological strata contain extinct organisms
- Fossils in adjacent strata are typically more similar than fossils in non-adjacent strata
- Fossils in the top (most recent) strata are very similar to contemporary species
- Fossils become progressively more different from contemporary species in progressively older (lower) strata.
- Fossils appear in the order which we would predict from the universal tree
- Fossils in a specific location are typically more closely related to local contemporary organisms.
- Closely related contemporary species are typically also close geographically, regardless of their habitat or specific adaptations.

image source: wikimedia

# Fundamental unity of life

- All species use same genetic material (DNA/RNA)
- All species use catalysts (enzymes) based on protein molecules built from the same set of 20 amino acids (from more than 390 naturally occurring)
- All species use extremely similar metabolic pathways and enzymes for their basic metabolism (e.g., glycolysis, the citric acid cycle, and oxidative phosphorylation).
- All species use the same genetic code (or minor variations)

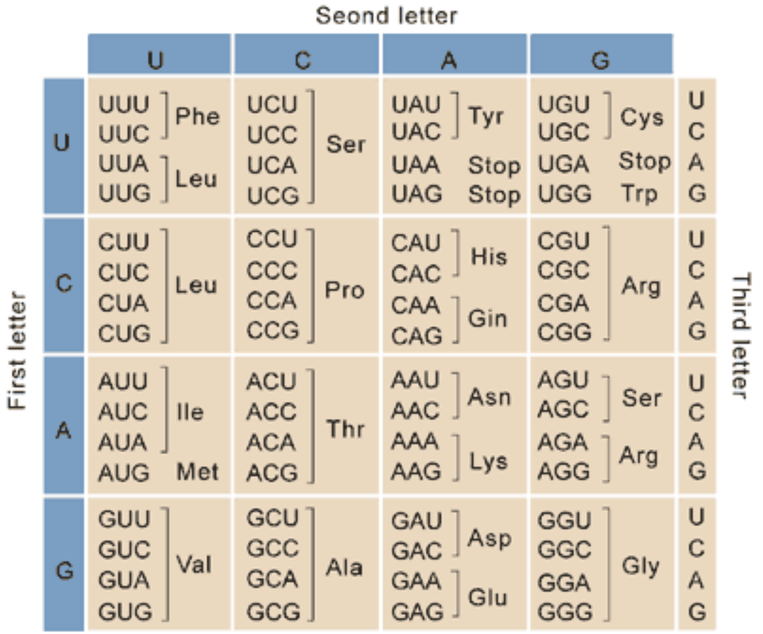
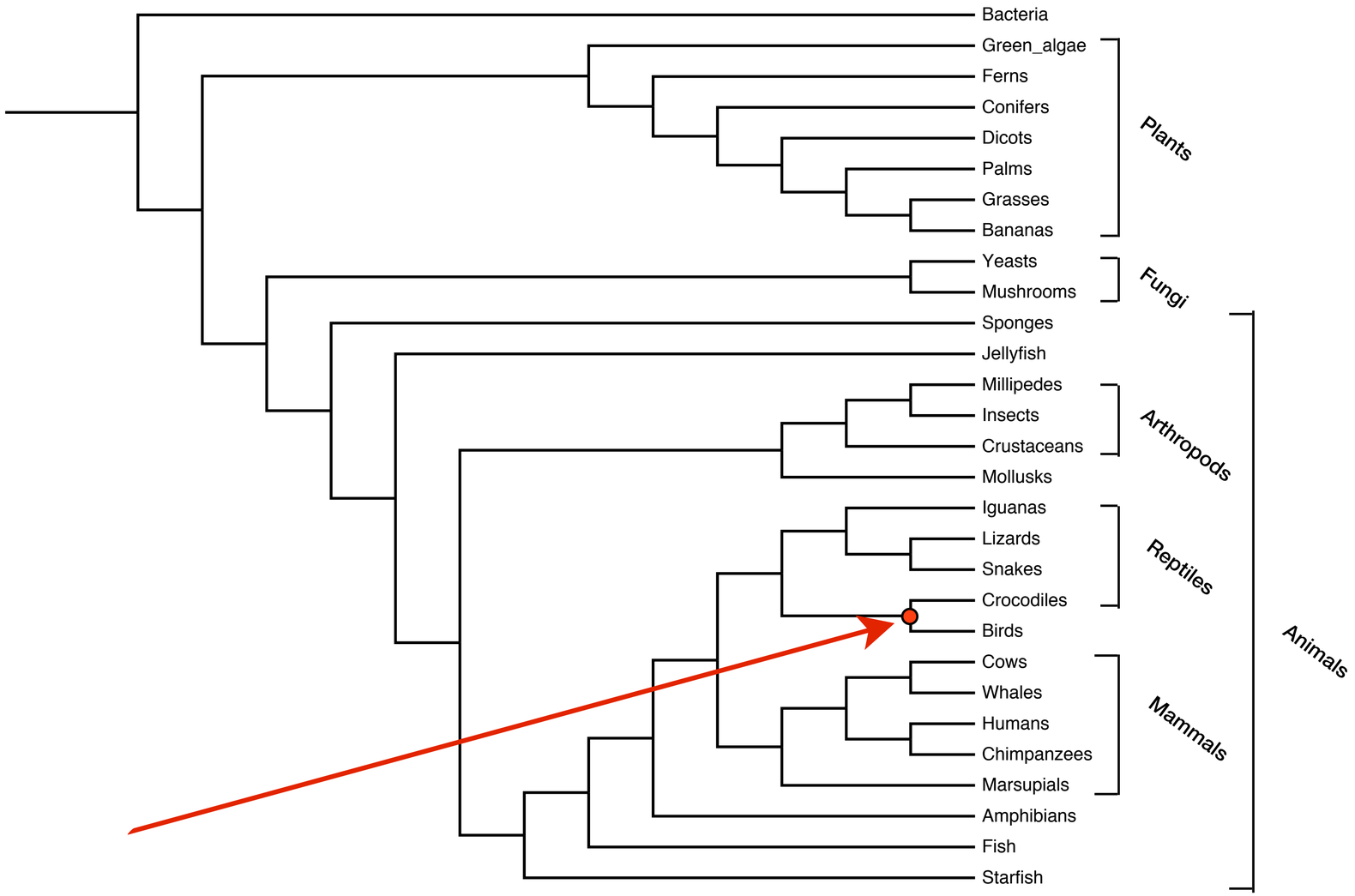



image source: wikimedia

# Transitional Forms Should Conform to the Universal Tree

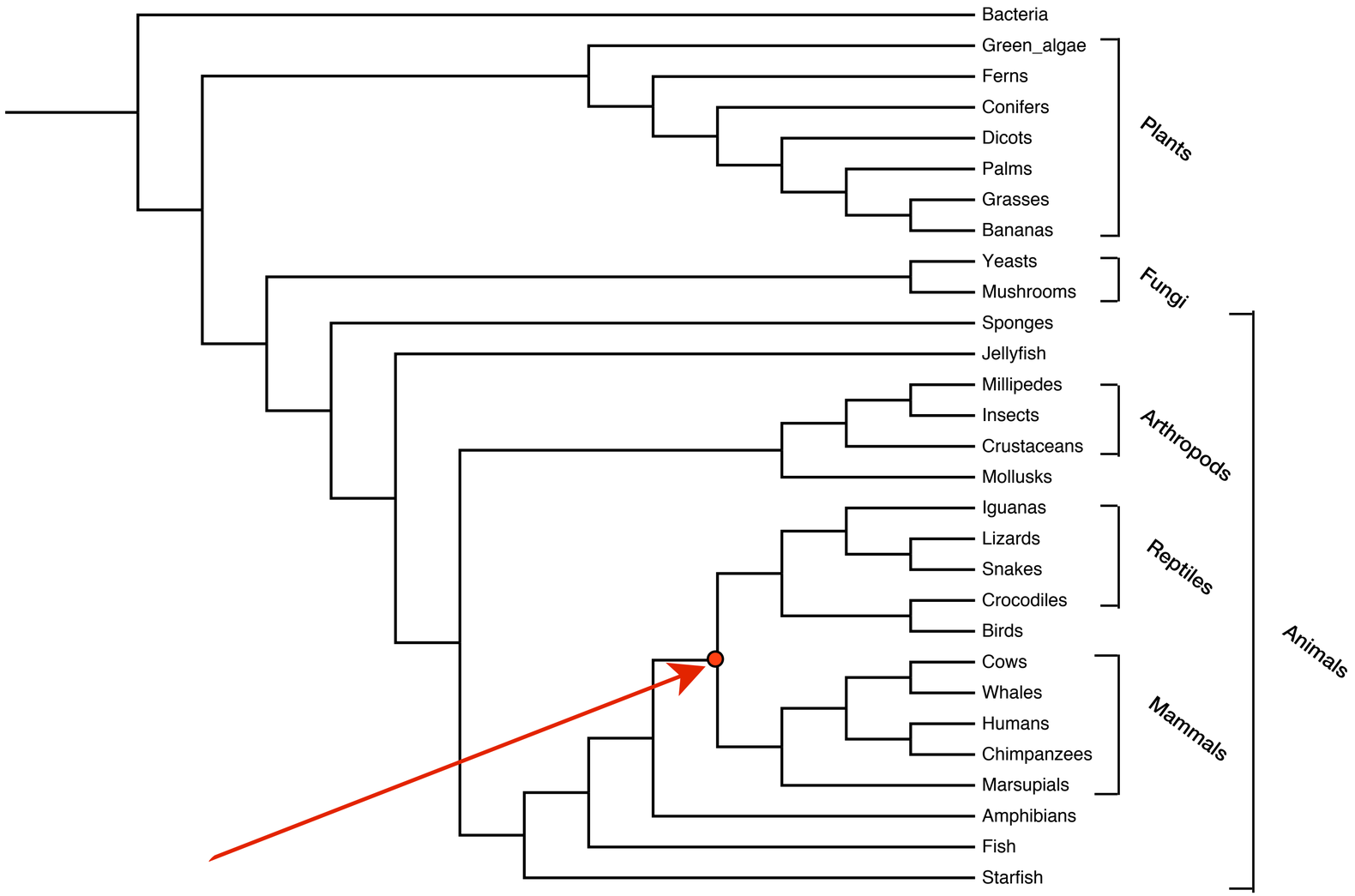


# Transitional Forms Should Conform to the Universal Tree

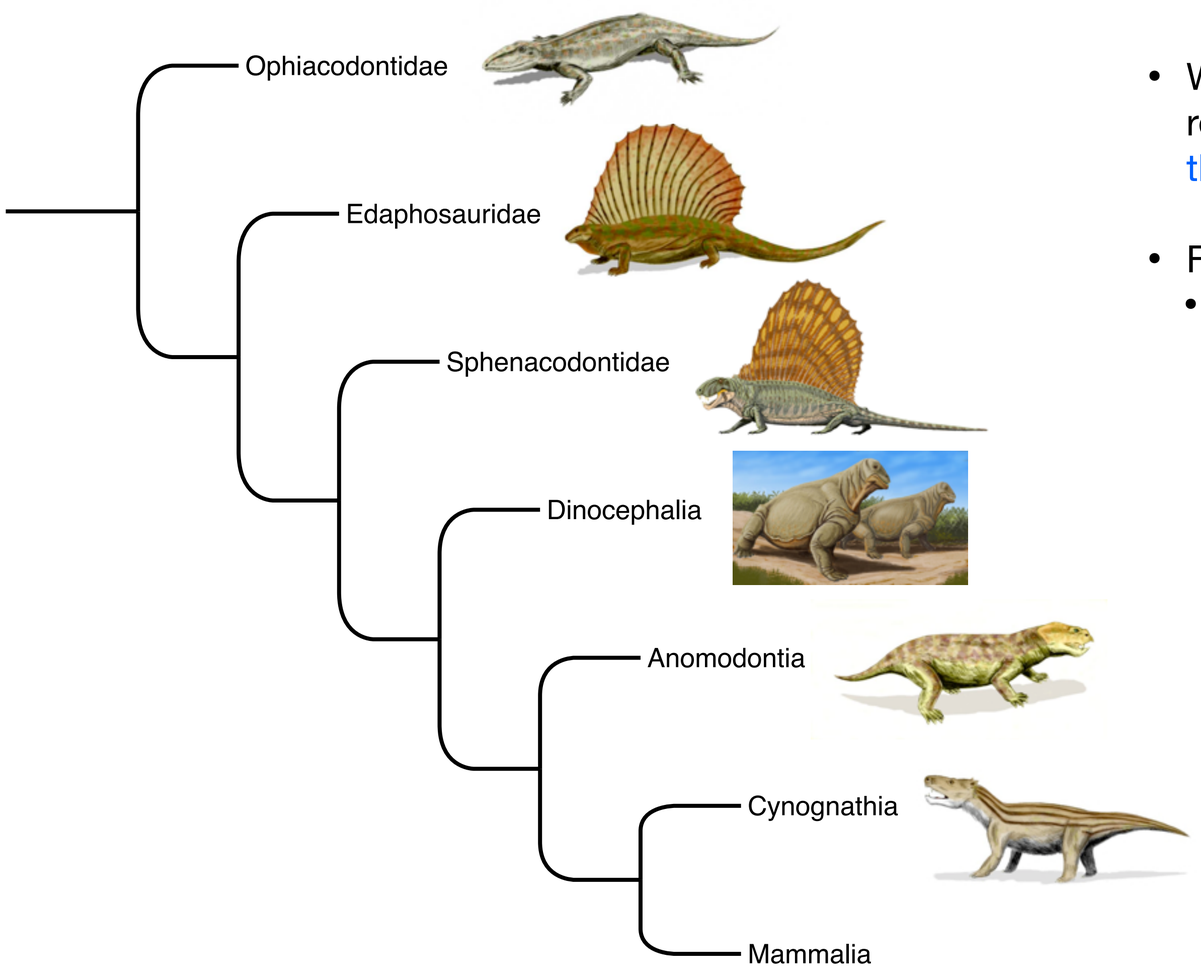
image source: wikimedia

- We have found a quite complete set of dinosaur-to-bird transitional fossils with no morphological "gaps",
- Represented by Eoraptor, Herrerasaurus, Ceratosaurus, Allosaurus, Compsognathus, Sinosauropteryx, Protarchaeopteryx, Caudipteryx, Velociraptor, Sinovenator, Beipiaosaurus, Sinornithosaurus, Microraptor, Archaeopteryx, Rahonavis, Confuciusornis, Sinornis, Patagopteryx, Hesperornis, Apsaravis, Ichthyornis, and Columba, among many others
- Found in expected geological strata:
  - after appearance of reptiles, before appearance of birds
- For instance: Archaeopteryx
  - Reptile-like: fingers, teeth, tail
  - Bird-like: Feathers

# Transitional Forms Should Conform to the Universal Tree



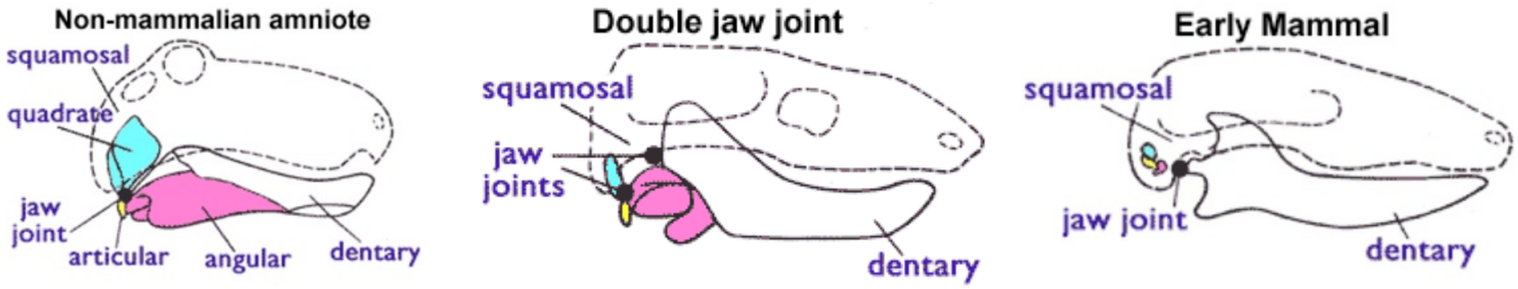
# Transitional Forms Should Conform to the Universal Tree




- We also have an exquisitely complete series of fossils for the reptile-mammal intermediates, ranging from the pelycosauria, therapsida, cynodonta, up to primitive mammalia.
- Found in the expected geological strata:
  - After appearance of reptiles, before appearance of mammals

image sources: wikimedia (#1, #2, #3, #4, #5, #6)

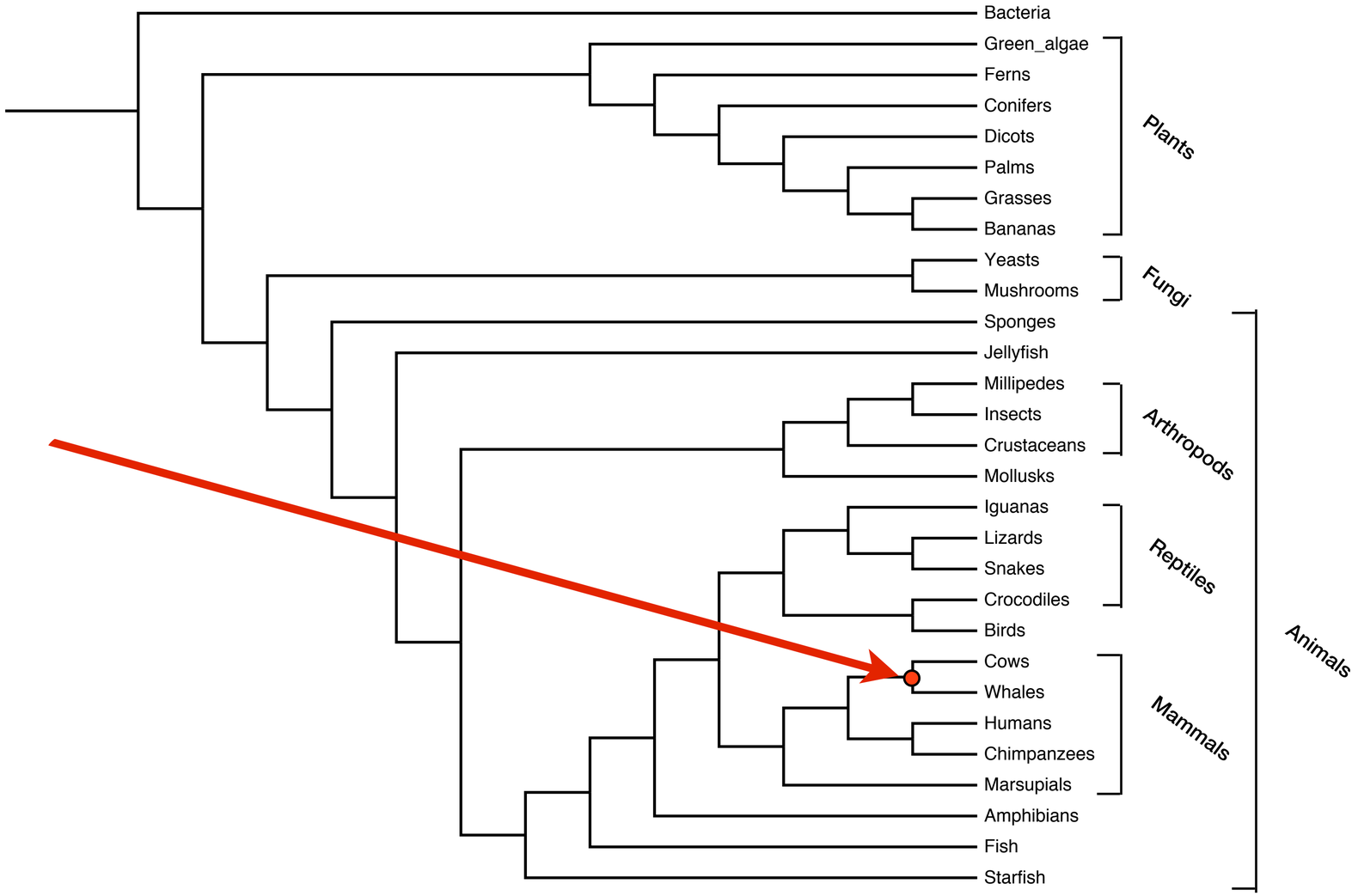
# Transitional Forms Should Conform to the Universal Tree




- Interesting example: gradual evolution of anvil and hammer in mammalian middle ear from reptilian jawbones:
- Articular --> Malleus (hammer);  Quadrate --> Incus (anvil)
- Also evident from fetal development:
- In the reptilian fetus, two developing bones from the head eventually form two bones in the reptilian lower jaw, the quadrate and the articular.
- The corresponding developing bones in the mammalian fetus eventually form the anvil and hammer (incus and malleus) of the mammalian middle ear.

image sources: wikimedia (#1, #2)

# Transitional Forms Should Conform to the Universal Tree



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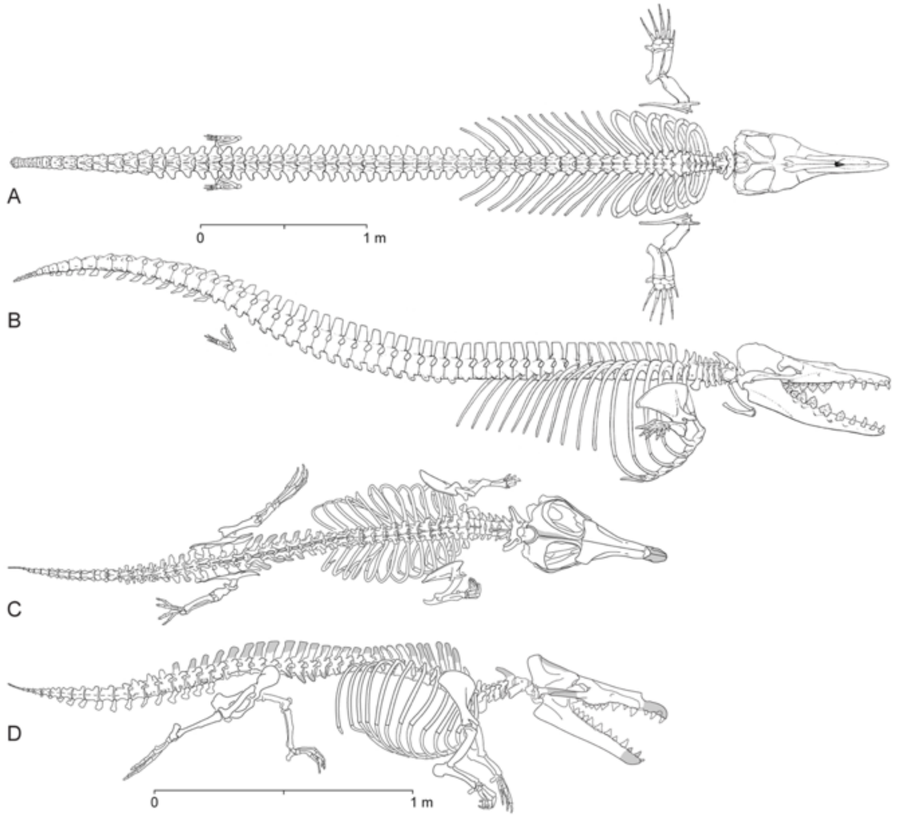
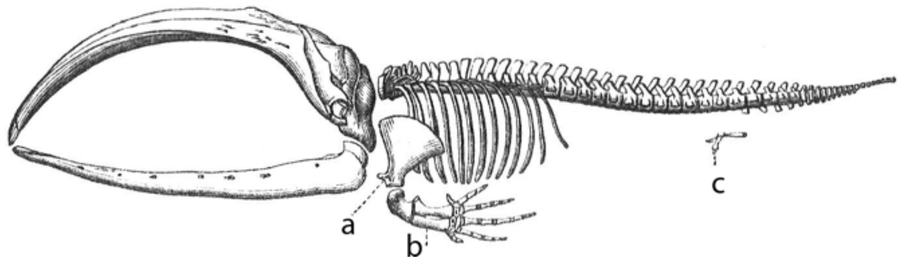



Skeletons of *Dorudon atrox* and *Maiacetus inuus* in swimming pose

image source: wikimedia

- We have found several transitional forms of whales with legs, both capable and incapable of terrestrial locomotion
- For instance: *Ambulocetus, Rodhocetus, Pakicetus, Maiacetus, Basilosaurus, Dorudon*.
- Found in expected geological strata:
  - After appearance of mammals, before appearance of whales

# Vestigial Structures

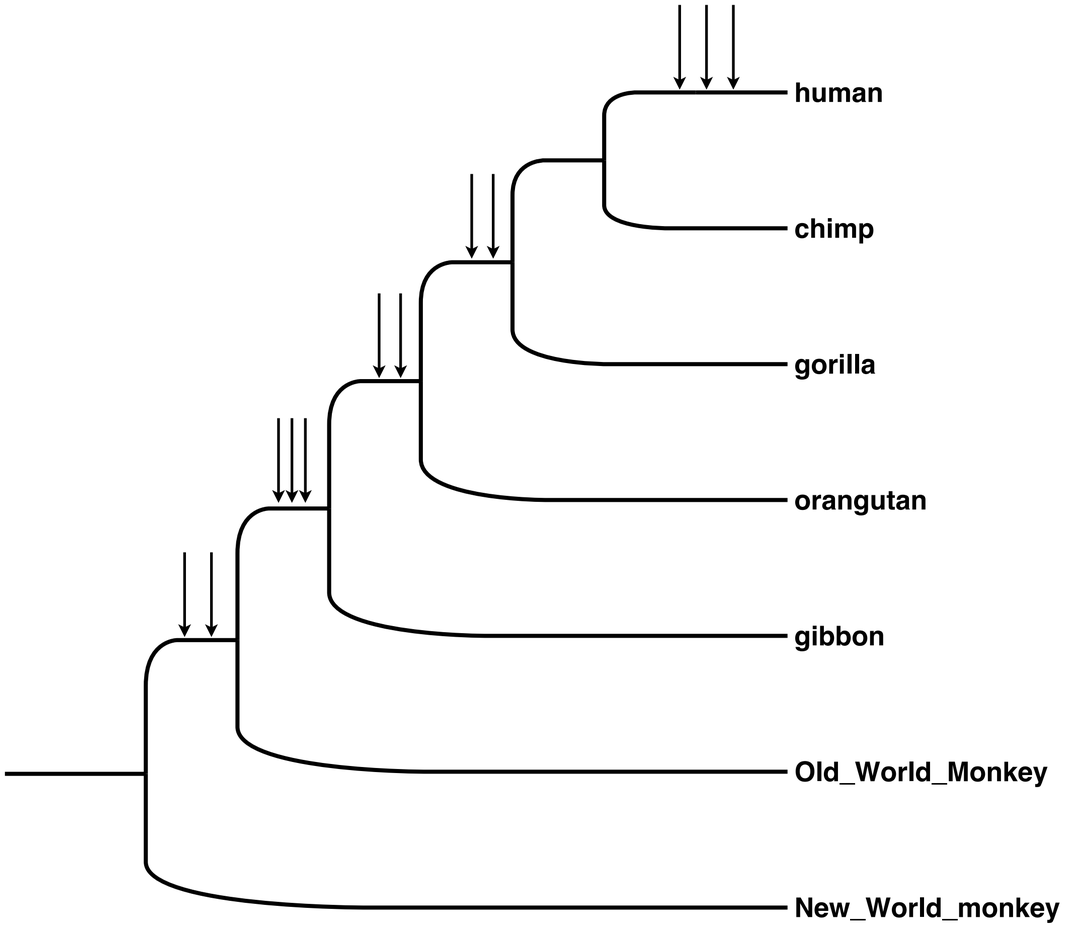



Ostrich, *Eleodes hispilabris* (flightless beetle), Texas blind salamander, baleen whale

- Vestige: a reduced and rudimentary structure compared to the same complex structure in other organisms. Vestigial characters, if functional, perform relatively simple, minor, or inessential functions using structures that were clearly designed for other complex purposes
- From common descent and the constraint of gradualism, we predict that many organisms should retain vestigial structures as structural remnants of lost functions. Note that the exact evolutionary mechanism which created a vestigial structure is irrelevant as long as the mechanism is a gradual one.

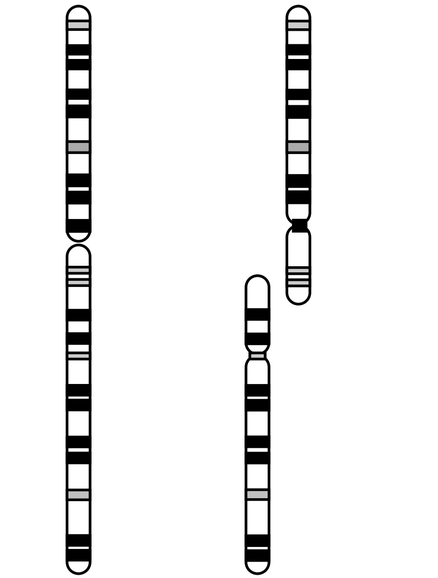
image sources: wikimedia + insectimages (#1, #2, #3, #4)

# Molecular Evidence: Endogenous Retroviruses




- **Endogenous retroviruses** are molecular remnants of a past parasitic viral infection
- Make up 5-8% of of human genome (about 100,000 fragments)
- Many endogenous retroviruses are shared between human and other animals (i.e., the same retroviral sequence is present in the same location in the genomes). Human and chimp share most of their ERVs
- Pattern of shared ERVs forms nested hierarchy - a reflection of the fact that once a retrovirus has inserted into the germ-line DNA of a given organism, it will be inherited by all descendants of that organism (e.g., Lebedev et al., Gene 247, 265–277, 2000).

# Human chromosome 2 evolved by fusion of two ancestral ape chromosomes



Human chr. 2 Chimp chr. 2a + 2b

- All great apes except humans have 24 pairs of chromosomes.
- Humans have only 23 pairs of chromosomes
- The chimpanzee has near-identical DNA sequences to human chromosome 2, but they are found in two separate chromosomes.
- Human chromosome 2 contains remnants of a second, vestigial centromere
- Human chromosome 2 has additional telomere sequences in the middle

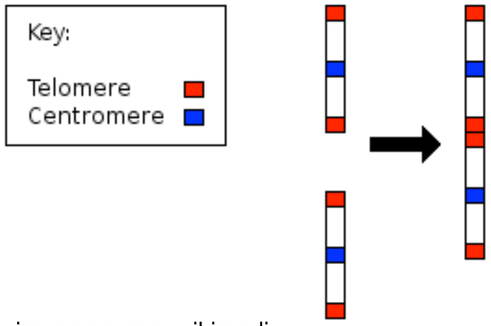
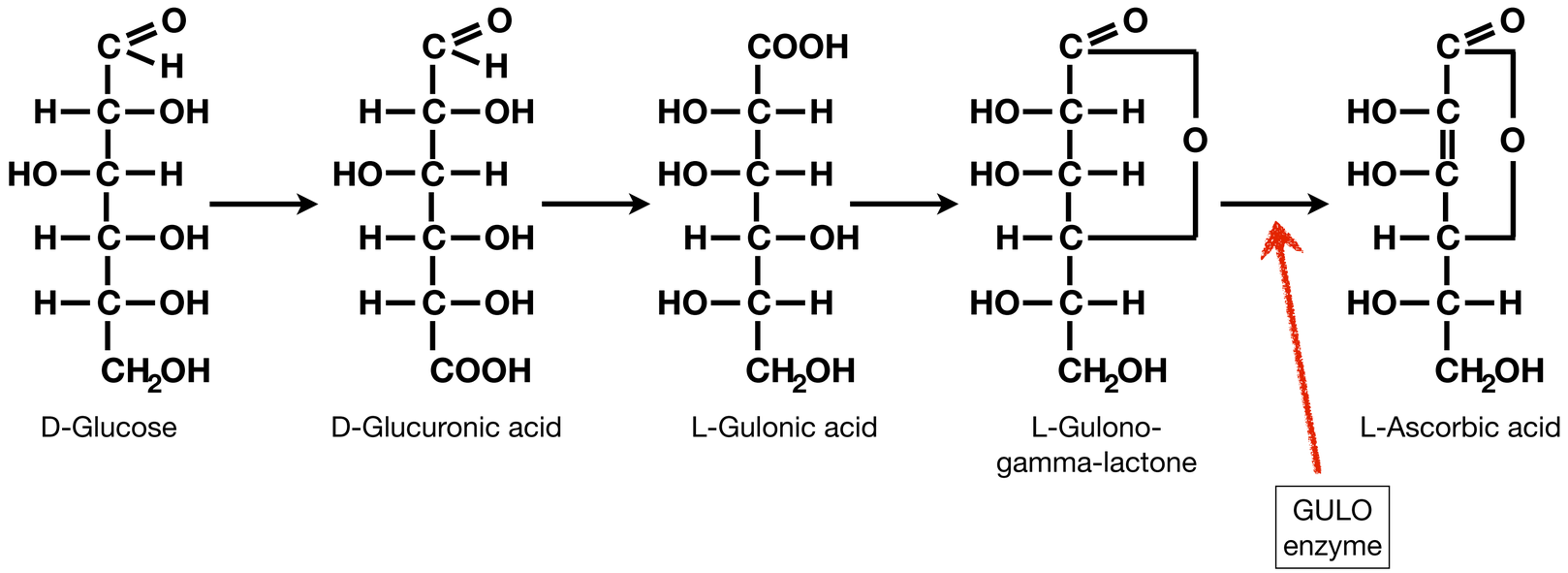



image source: wikimedia

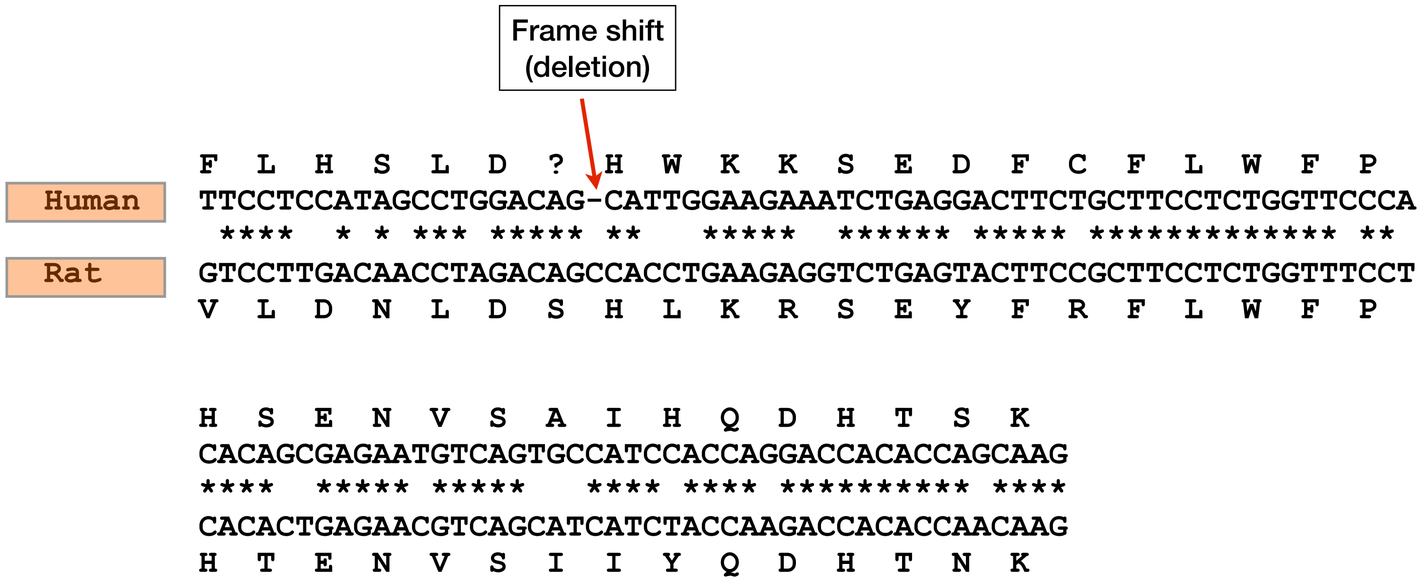
# Biosynthesis of vitamin C: lack of ability in humans and other primates




- Metabolic pathway of vitamin C biosynthesis in animals

- Nearly all animals can synthesize vitamin C (L-ascorbic acid) from D-Glucose
- Humans and other primates are unable to do this and therefore need a dietary intake of vitamin C (e.g., citrus fruits) to prevent scurvy
- This deficiency is caused by lack of functional “GULO” enzyme (L-gulonolactone oxidase)

# Biosynthesis of vitamin C: pseudo-gene present in primate genomes




Alignment of part of human and rat GULO genes

- Non-functional remnant of GULO gene is present in these species, and is clearly related to the functional form present in other animals
- Lack of functionality of this “pseudo-gene” (GULOP) is caused by several mutations (including frame-shifts)

# Etc., etc., etc.

- Ontogeny: often an organism's evolutionary history is represented temporarily in its development (hind limbs in whales and snake embryos, tails in human embryos, gill pouches in mammal embryos, ...)
- Atavism: Occasionally contemporary animals are born with characters representative of remote ancestors (living whales with hindlimbs, human babies born with tails, ...).
- Atavisms and vestiges are always found to be consistent with the universal tree (organisms always have atavistic or vestigial characters that are predicted to have been present in an ancestor).
- Extensive genetic change has repeatedly been observed in lab and wild populations of animals
- Numerous observations of morphological change in populations of living organisms (changes in color, size, length, width, and number of physical aspects of organisms)
- Many observations of newly acquired functions (bacteria that evolved to use nylon and pentachlorophenol as their sole carbon source, bacteria that evolved to synthesize new amino acids, crustaceans that evolve new defenses to predators, etc.)
- Experimental observations of speciation (according to the biological species concept): plants (with and without polyploidization), fruit fly, house fly, apple maggot fly, gall former fly, flour beetles, polychaete worm. (Major changes seen for asexual species also)