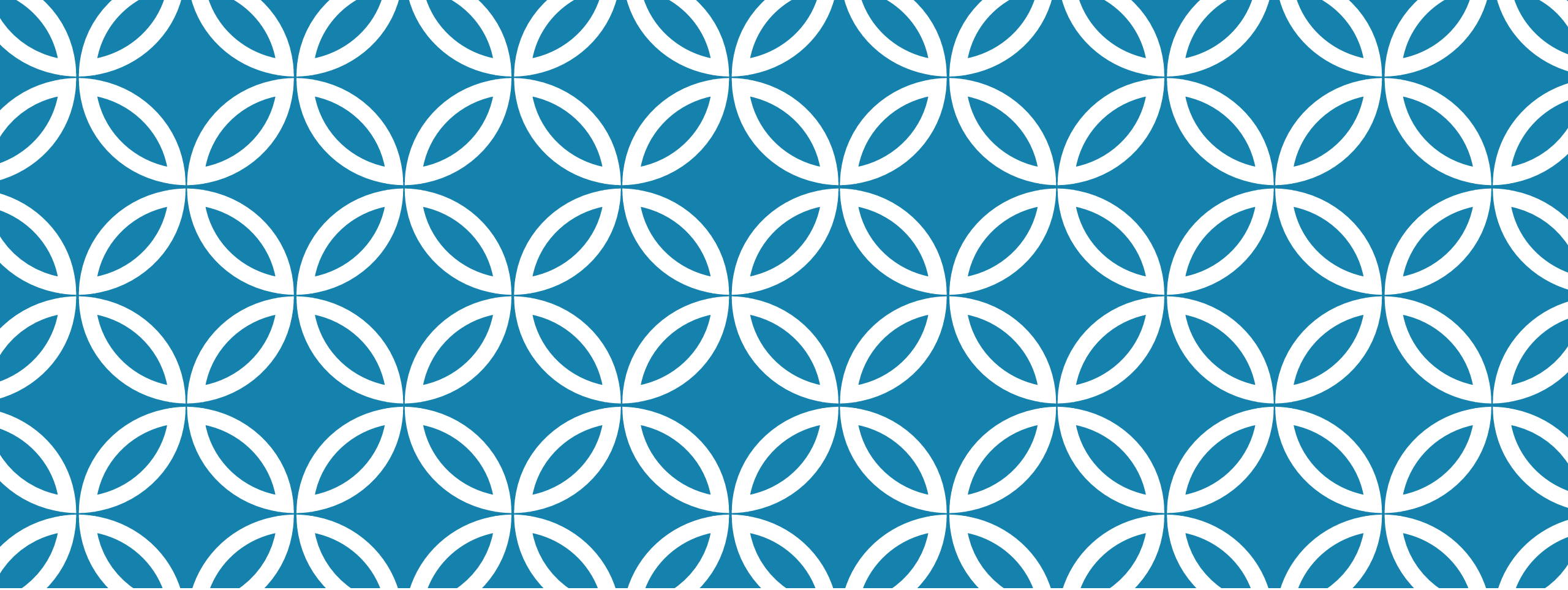


CHAPTER 5.4

Cladistics

CLADISTICS

Ancient greek: κλάδος (kládos) 'branch‘

Clade : A group of organisms, both extant and extinct that share an ancestor.

Cladistics : A system of classifying organisms according to shared characteristics, based on ancestry.

Cladogram : A diagram that shows the evolutionary relationship of a group of organisms.

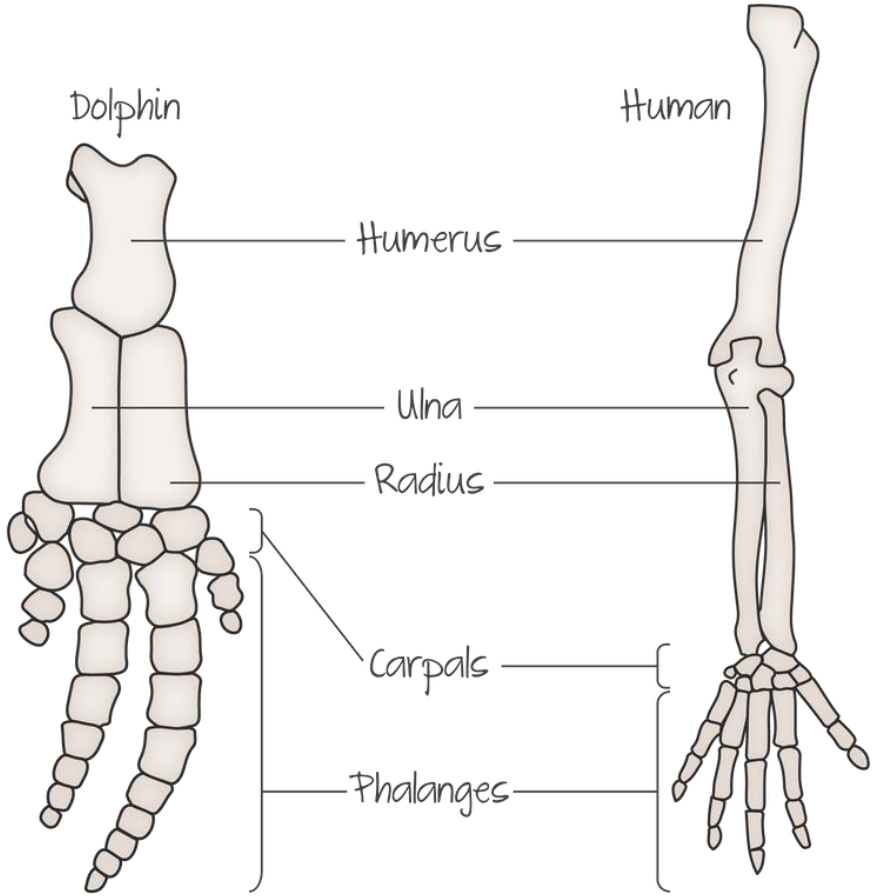
REVISION HOMOLOGOUS STRUCTURES

Homologous structures:

similar in position, structure, and evolutionary origin, but not necessarily function

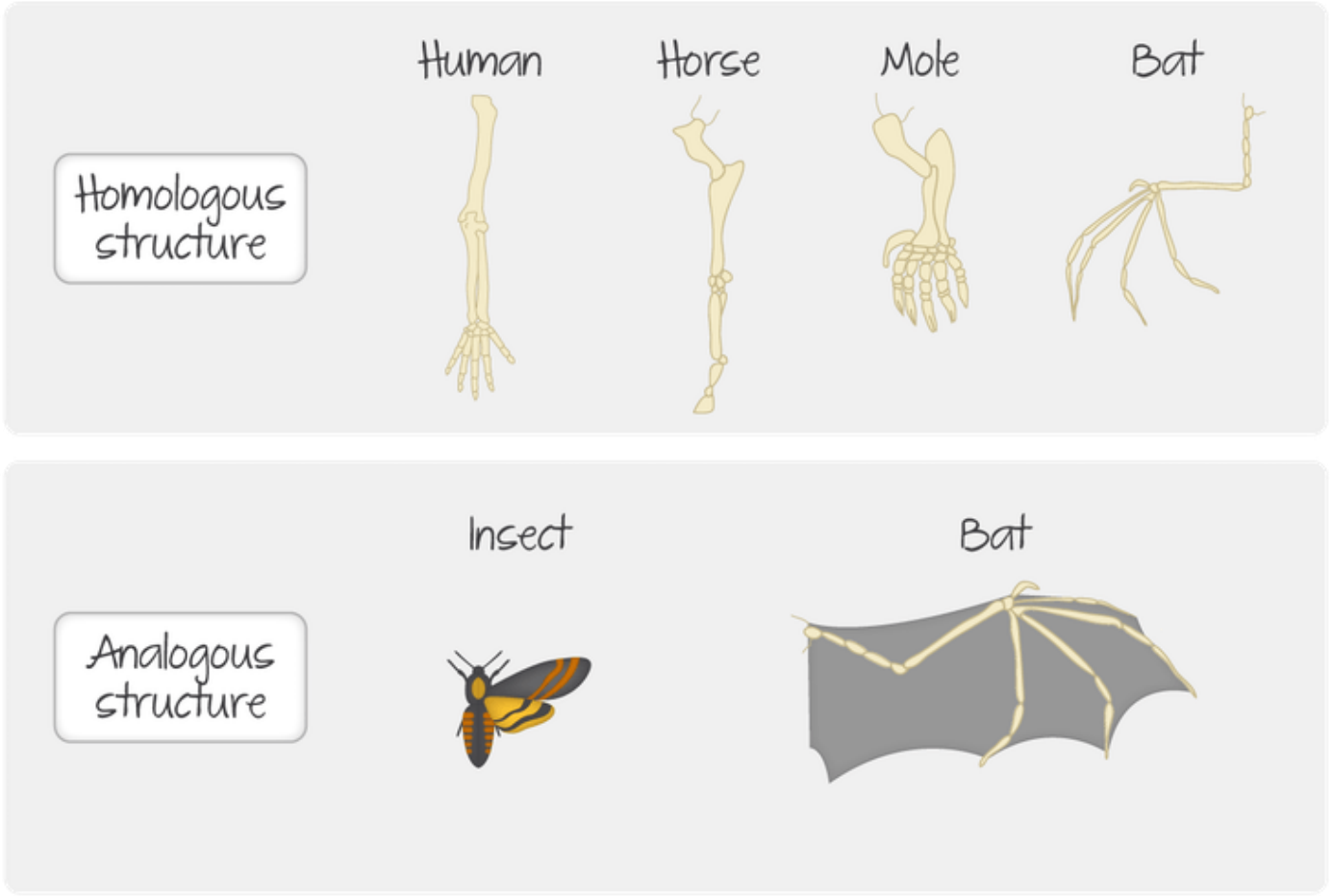
Divergent evolution:

two separate species → a similar structure, but use it in different ways because of environment.



REVISION: ANALOGOUS VS HOMOLOGOUS

REVISION: ANALOGOUS VS HOMOLOGOUS



REVISION: ANALOGOUS STRUCTURES

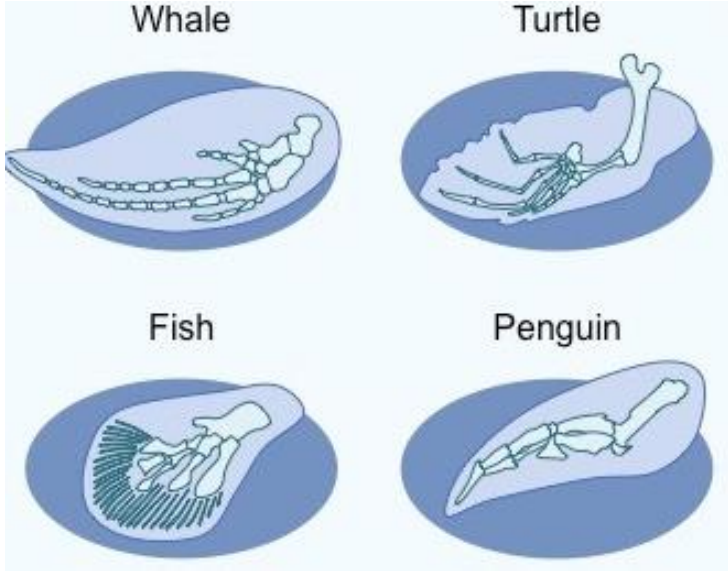
Analogous:

similar function but different evolutionary origin

e.g. bird and insect wings

Convergent evolution:

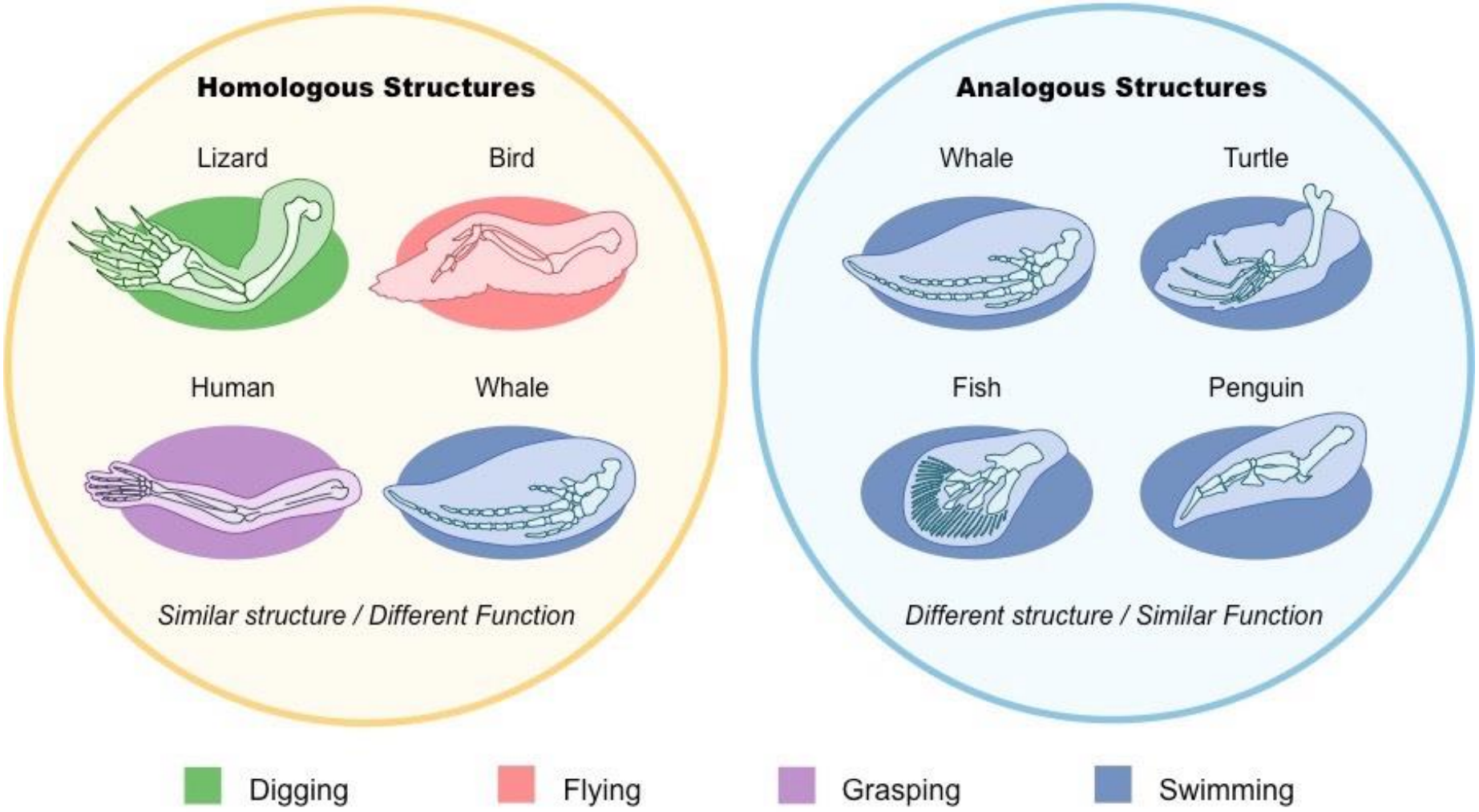
Different ancestor, but structures develop to resemble each other and have the same function.



REVISION: ANALOGOUS VS HOMOLOGOUS

Homologous Structures	Analogous Structures
Due to common ancestry	Due to common selection pressures
Arise via divergent evolution	Arise via convergent evolution
Example: Pentadactyl limb in vertebrates	**Example:** Wings in insects, birds and bats

REVISION: HOMOLOGOUS VS ANALOGOUS



CLADES

Clade = group of organisms → evolved from a common ancestor

each clade consists of a common ancestor (node) and all of its descendants

clade memberspossess common traits due to a shared evolutionary lineage

Figure 1. Basking shark.

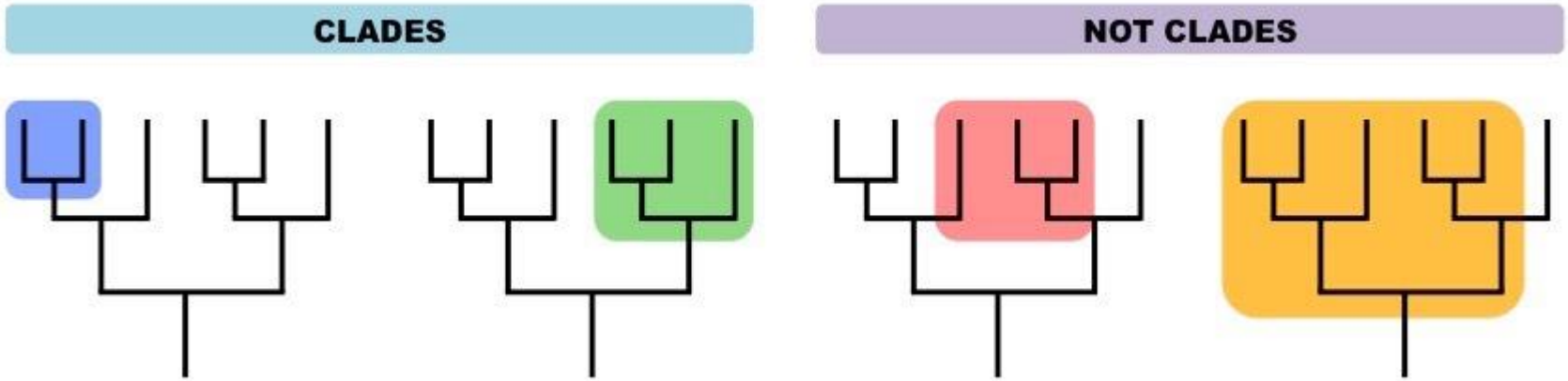
Figure 2. Common southern stingray.

CLADES

Node = speciation event via divergent evolution

Cladograms show probable sequence

Fewer nodes between two groups → more closely related

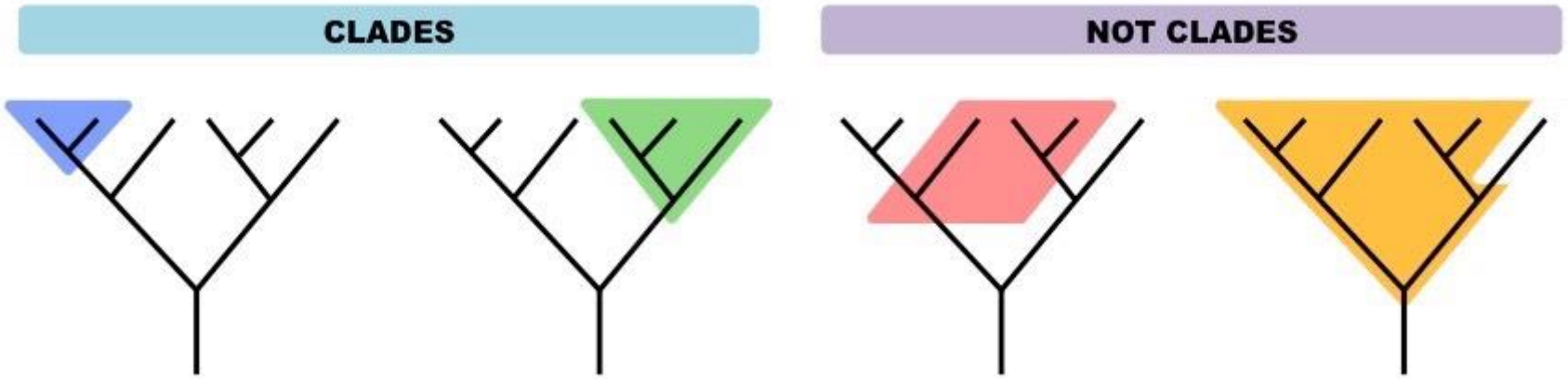


CLADES

Node = speciation event via divergent evolution

Cladograms show probable sequence

Fewer nodes between two groups → more closely related

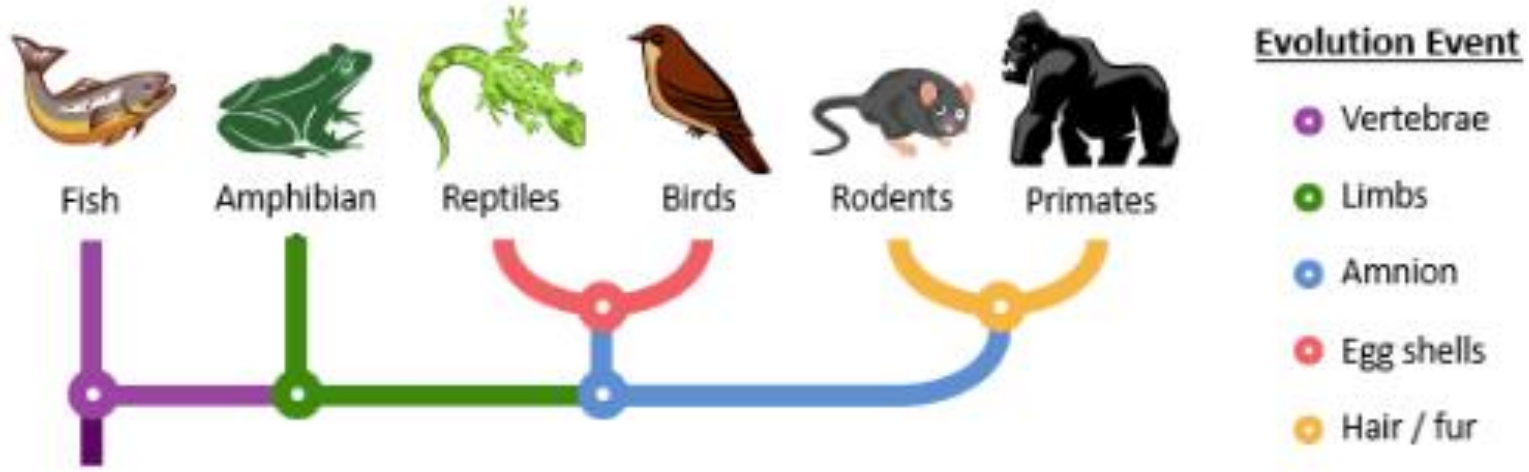


CLADES

Node = speciation event via divergent evolution

Cladograms show probable sequence

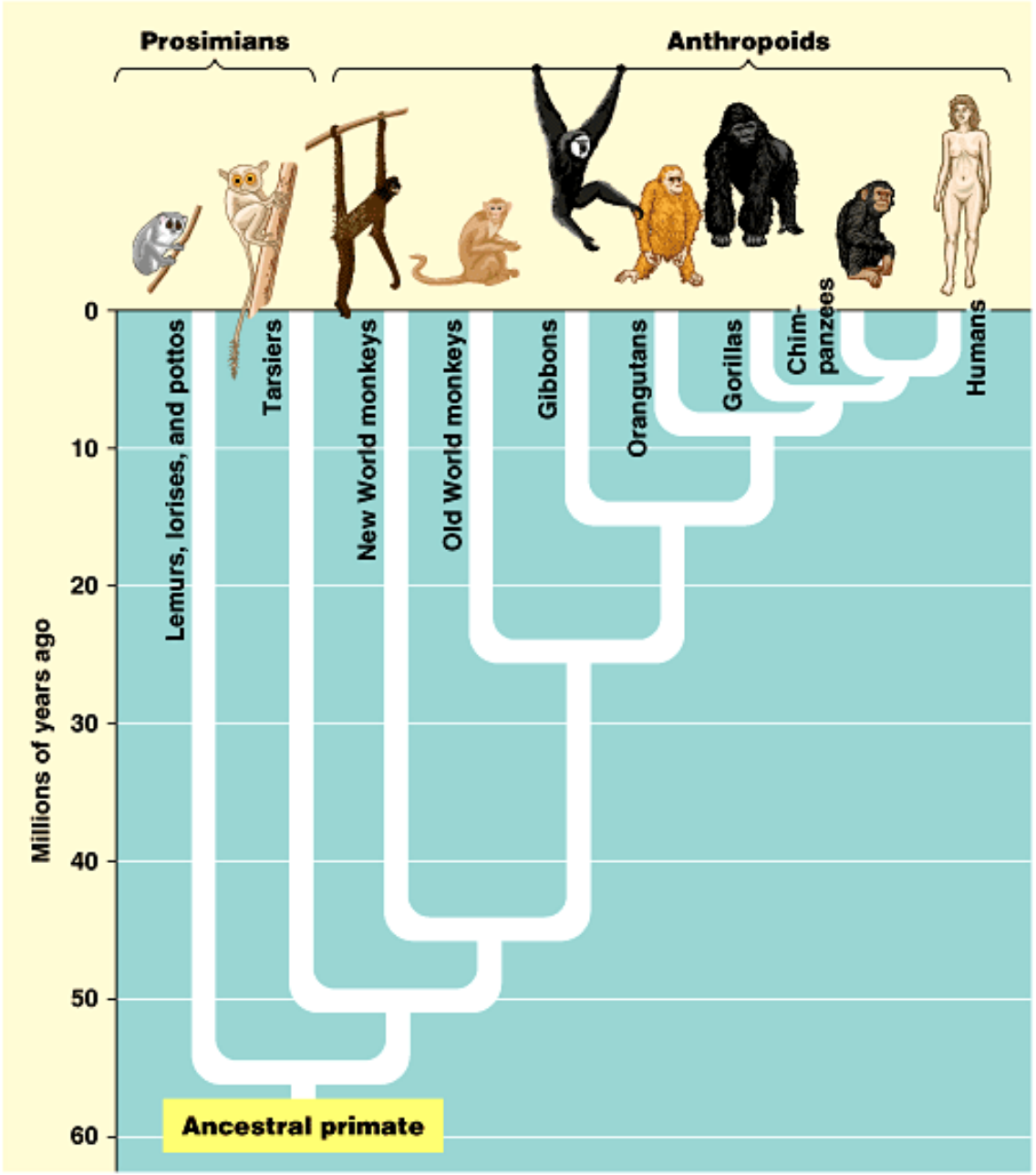
Fewer nodes between two groups → more closely related



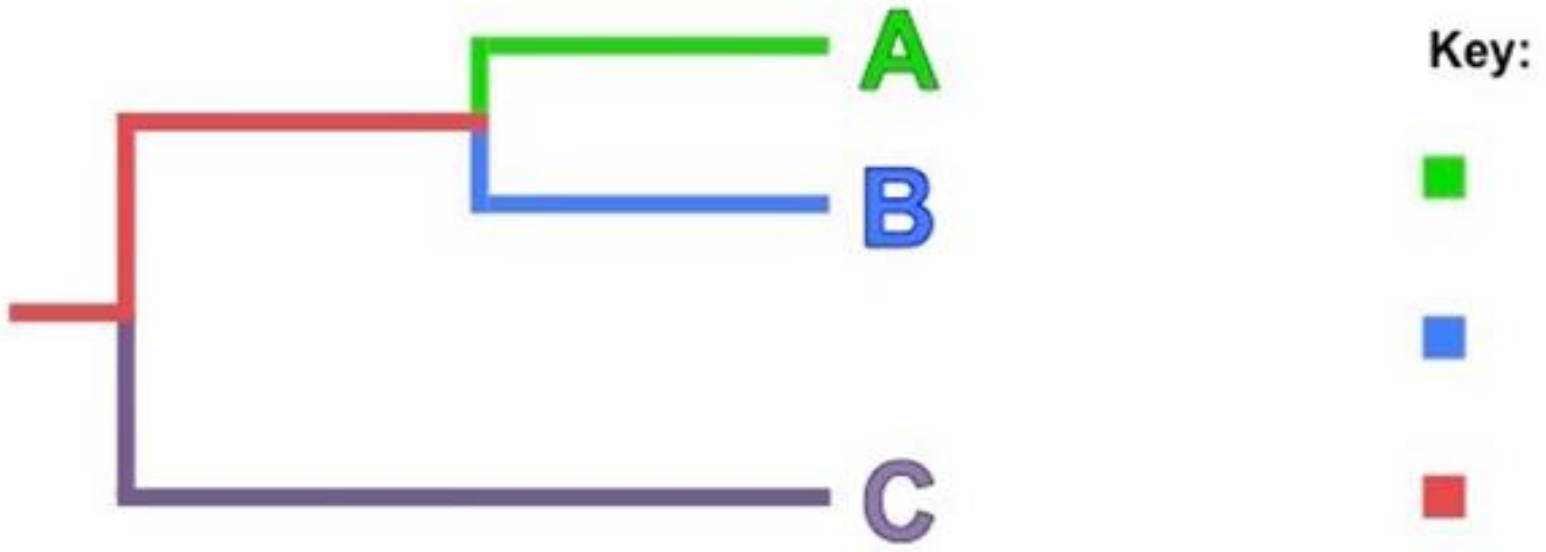
EXAMPLE:

Humans, chimps, gorillas, orangutans and gibbons = Hominoids

Hominoids + Old World and New World monkeys = Anthropoids



CLADOGRAMS



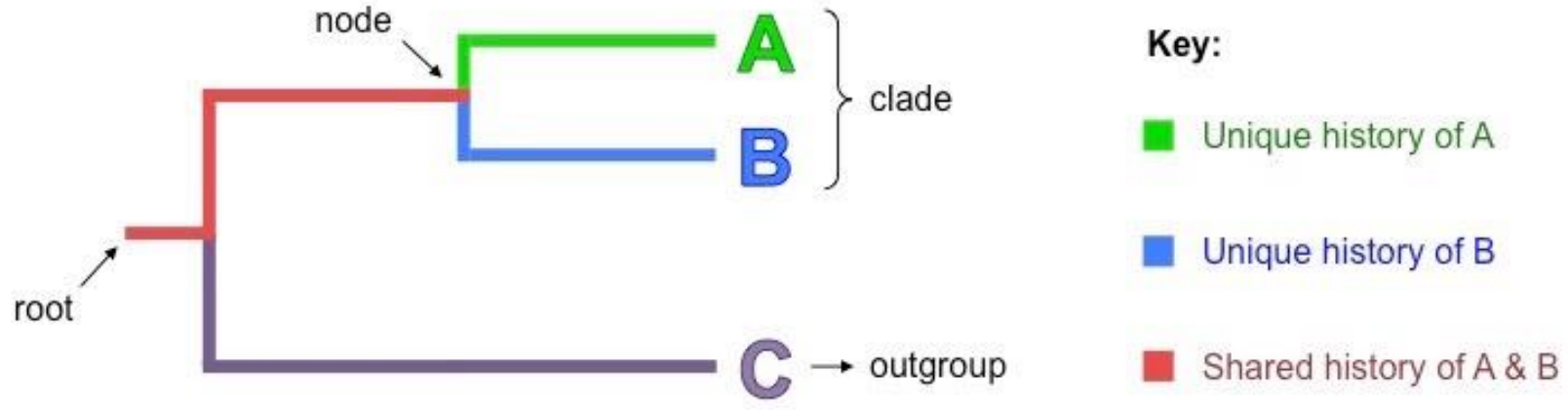
CLADOGRAMS

Root – initial ancestor common to all organisms within the cladogram

Nodes – each node = hypothetical common ancestor

Outgroup – most distantly related species in cladogram (often reference group)

Clades – A common ancestor and all of ist descendants



CONSTRUCTING CLADOGRAMS

Comparison of features or molecular evidence

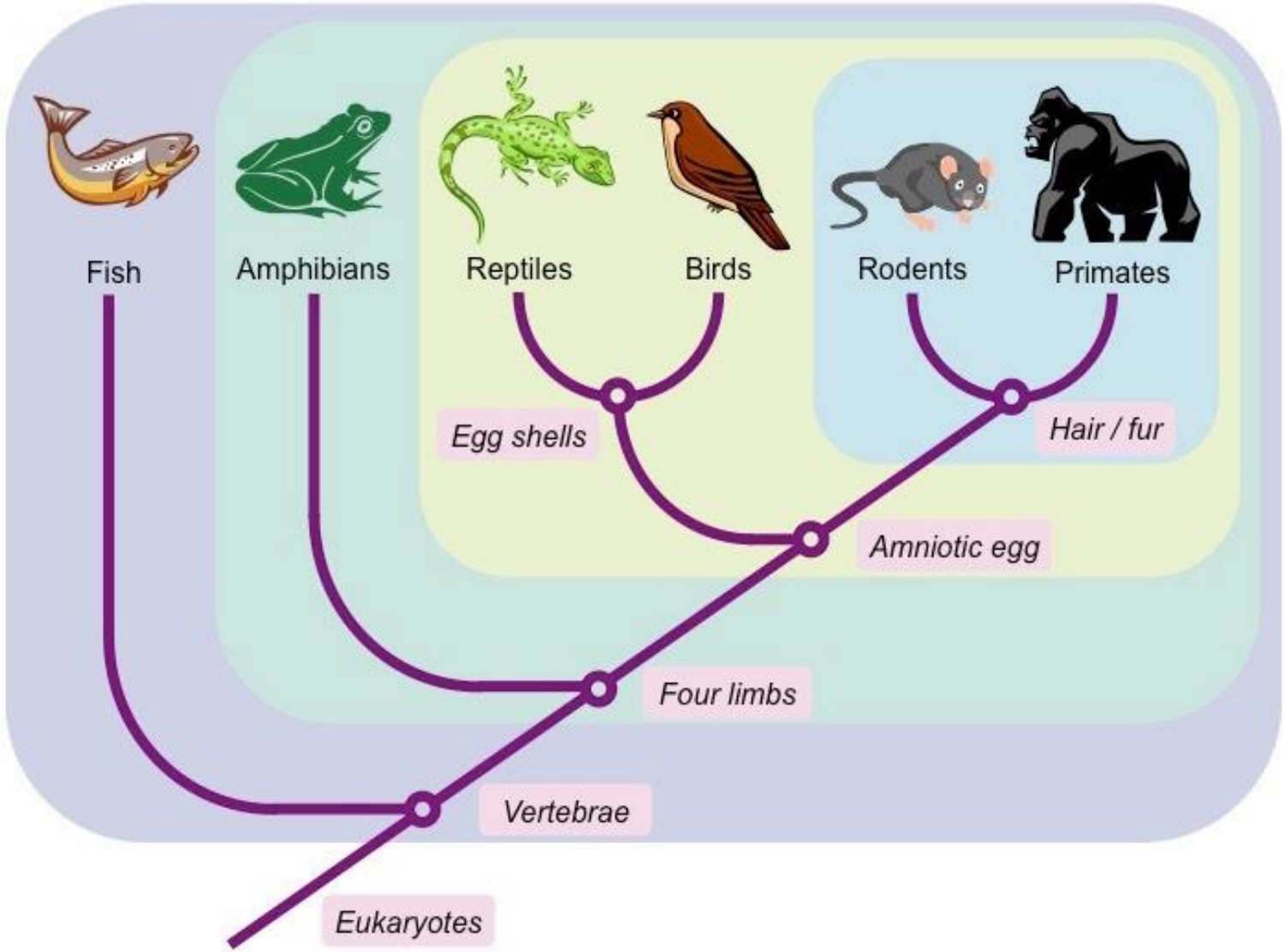
Historically→ structural features

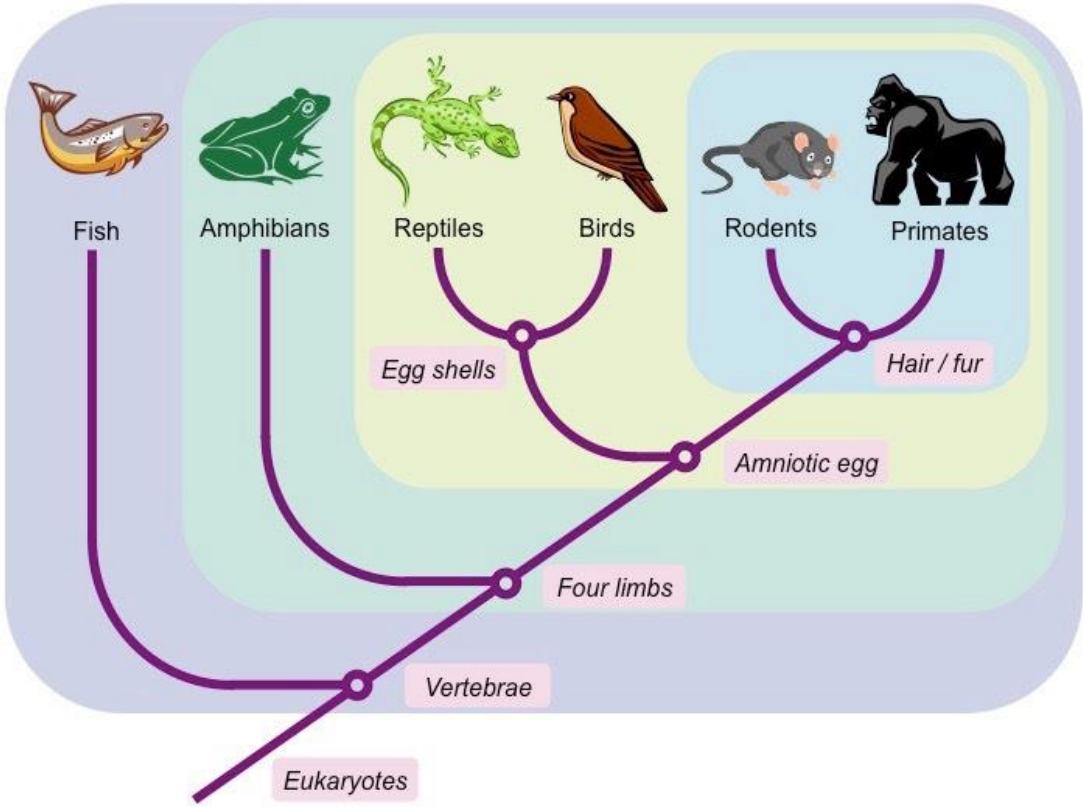
Nowadays → molecular evidence more common

EXAMPLE:

	Vertebrae	Four limbs	Amniotic egg	Egg shells	Hair/fur
Frog	✔	✔	–	–	–
Rodent	✔	✔	✔	–	✔
Lizard	✔	✔	✔	✔	–
Gorilla	✔	✔	✔	–	✔
Fish	✔	–	–	–	–
Bird	✔	✔	✔	✔	–

EXAMPLE:


Fish
Amphibians
Reptiles
Birds
Rodents
Primates
Egg shells
Hair / fur
Amniotic egg
Four limbs
Vertebrae
Eukaryotes

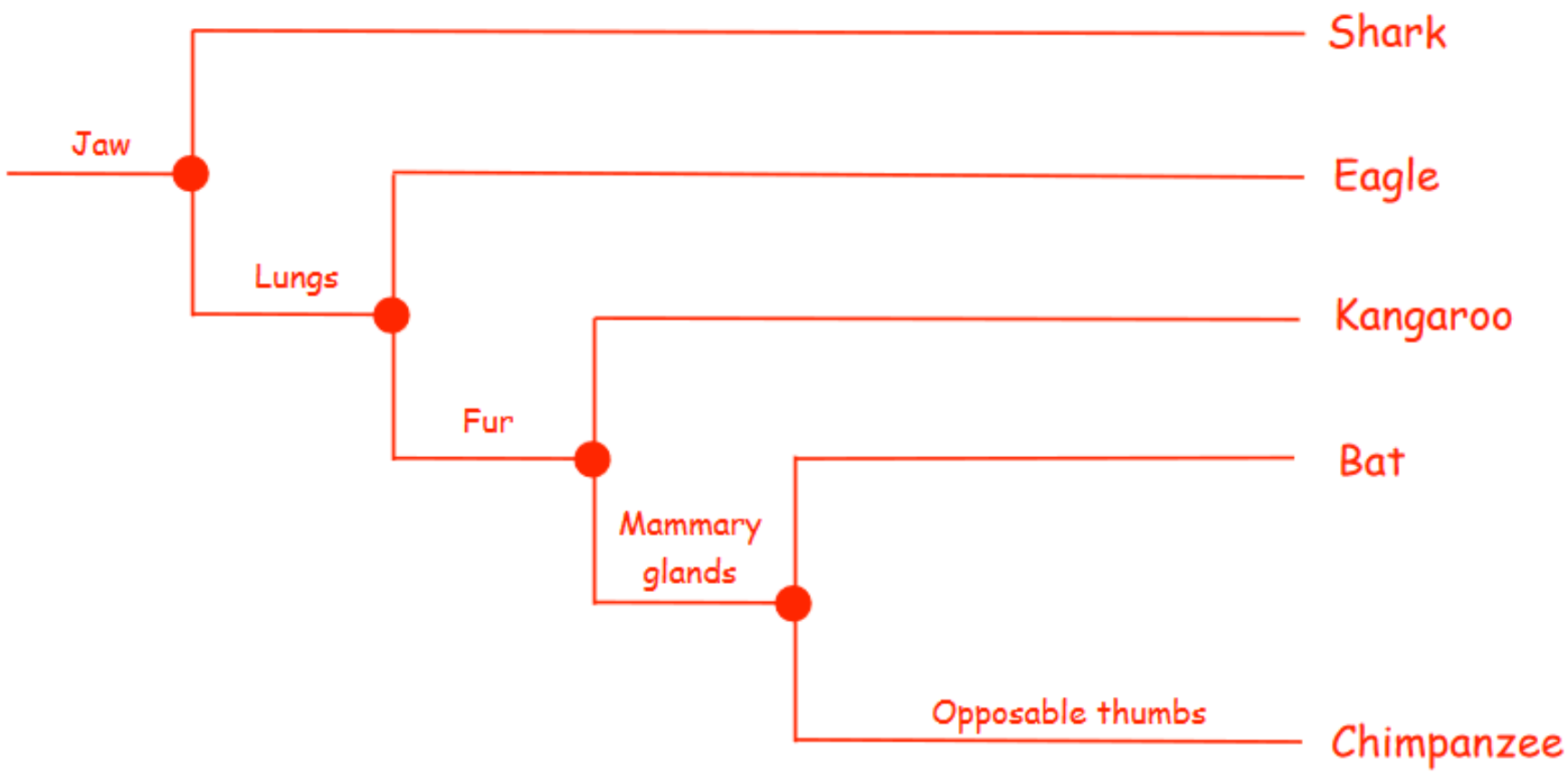


	Vertebrae	Four limbs	Amniotic egg	Egg shells	Hair/fur
Frog	✔	✔	–	–	–
Rodent	✔	✔	✔	–	✔
Lizard	✔	✔	✔	✔	–
Gorilla	✔	✔	✔	–	✔
Fish	✔	–	–	–	–
Bird	✔	✔	✔	✔	–

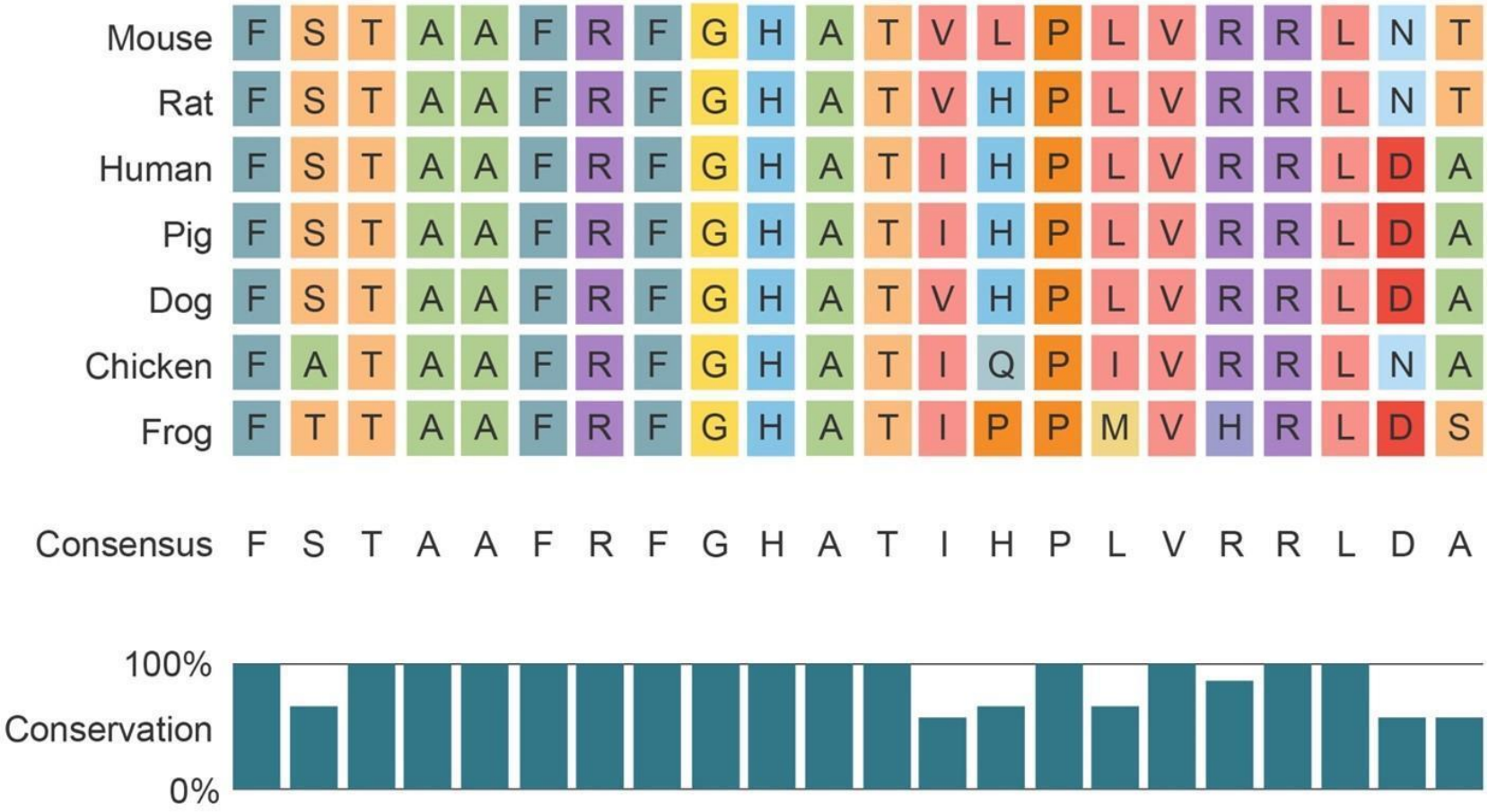
TASK:

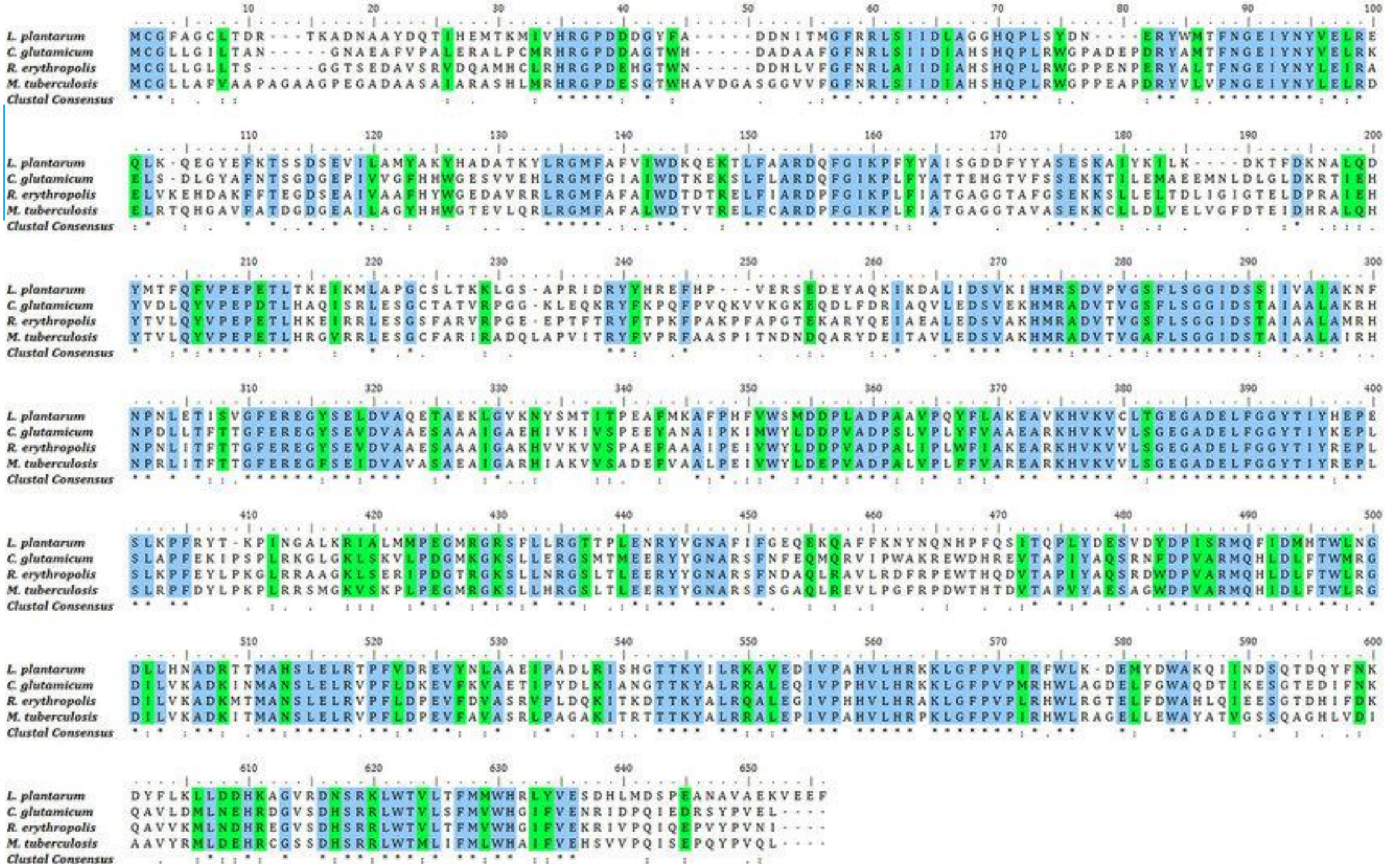
Create a simple cladogram from the following information:

Taxa	Characteristics
Bat	Fur, jaws, lungs, mammary glands
Eagle	Jaws, lungs
Kangaroo	Fur, jaws, lungs
Shark	Jaws
Chimpanzee	Fur, jaws, lungs, mammary glands, opposable thumbs


Shark
Jaw
Eagle
Lungs
Kangaroo
Fur
Bat
Mammary glands
Opposable thumbs
Chimpanzee

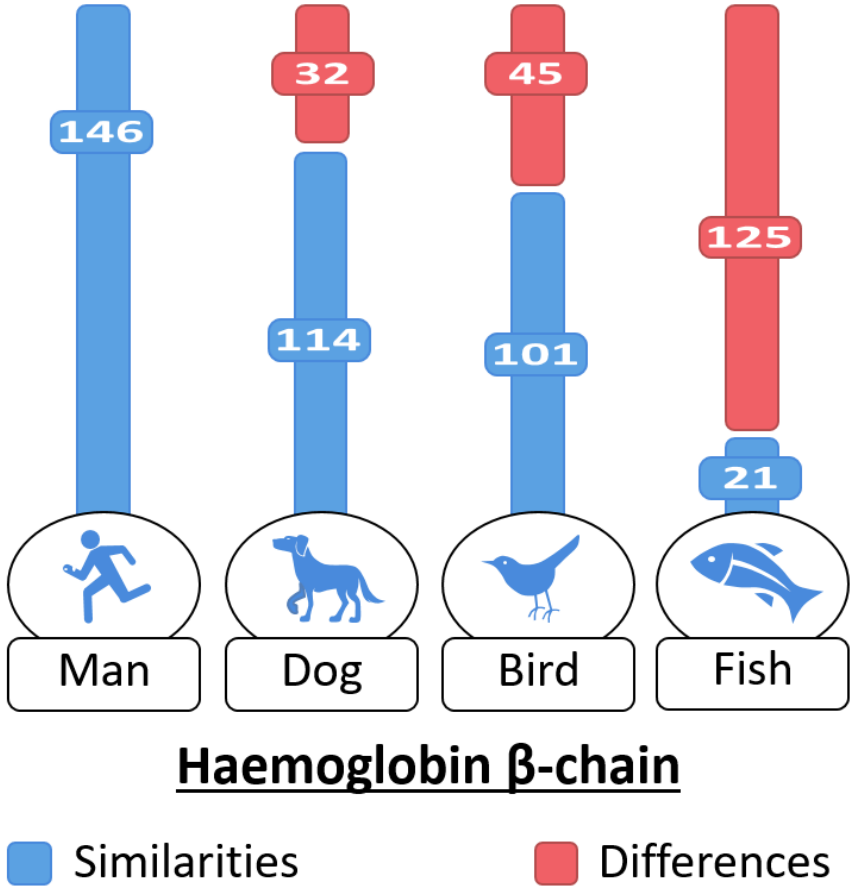
MOLECULAR EVIDENCE

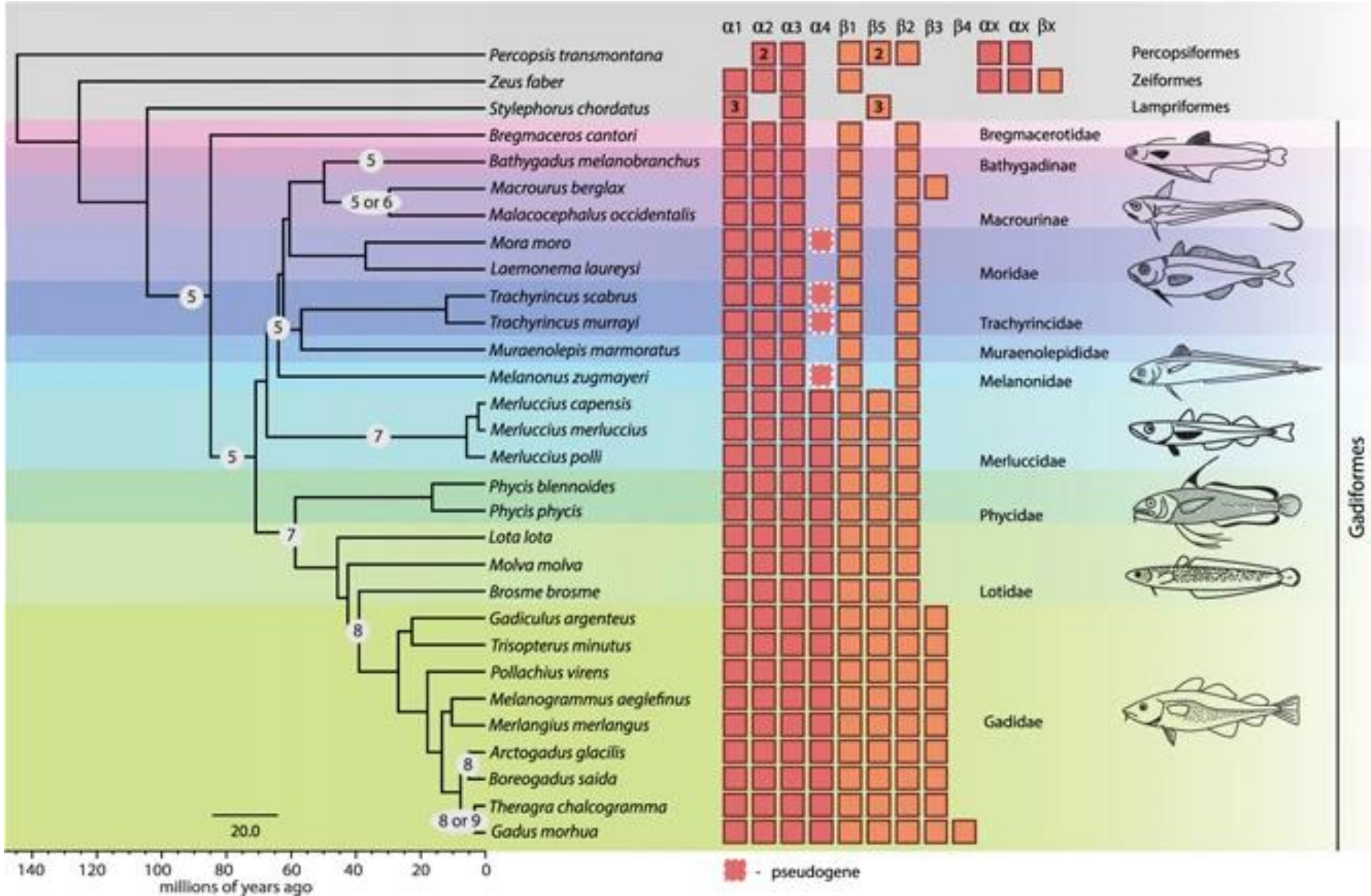



L. plantarum
C. glutamicum
R. erythropolis
M. tuberculosis
Clustal Consensus

MOLECULAR EVIDENCE

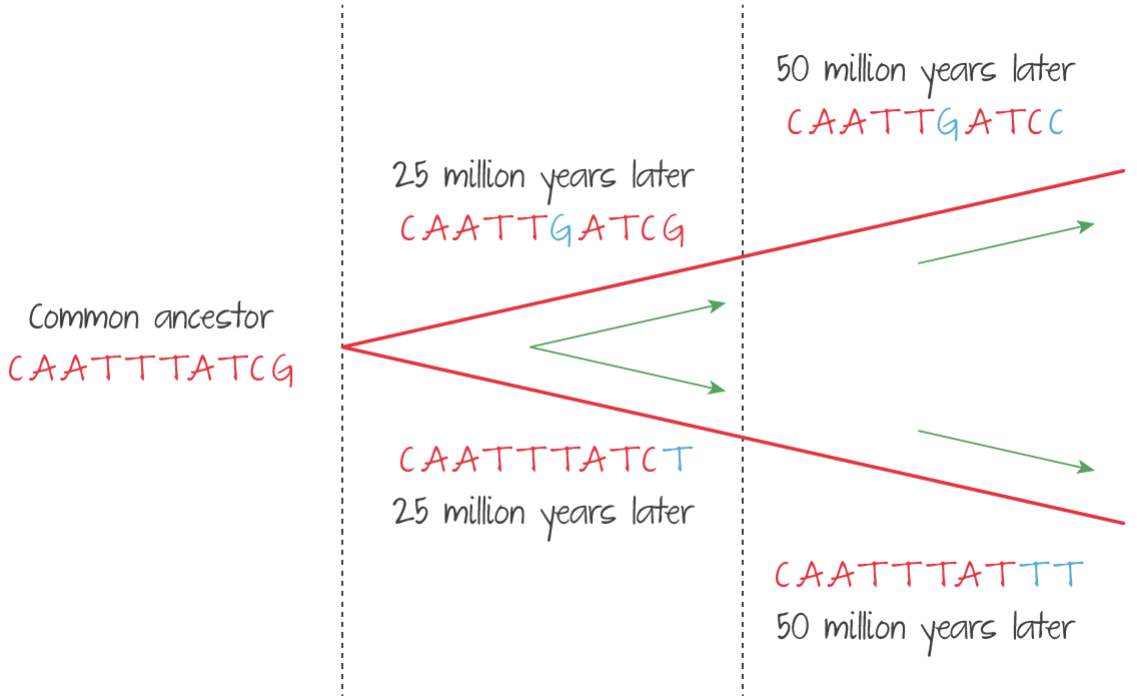
Evidence for which species are part of a clade can be obtained from the base sequences of a gene or the corresponding amino acid sequence of a protein.

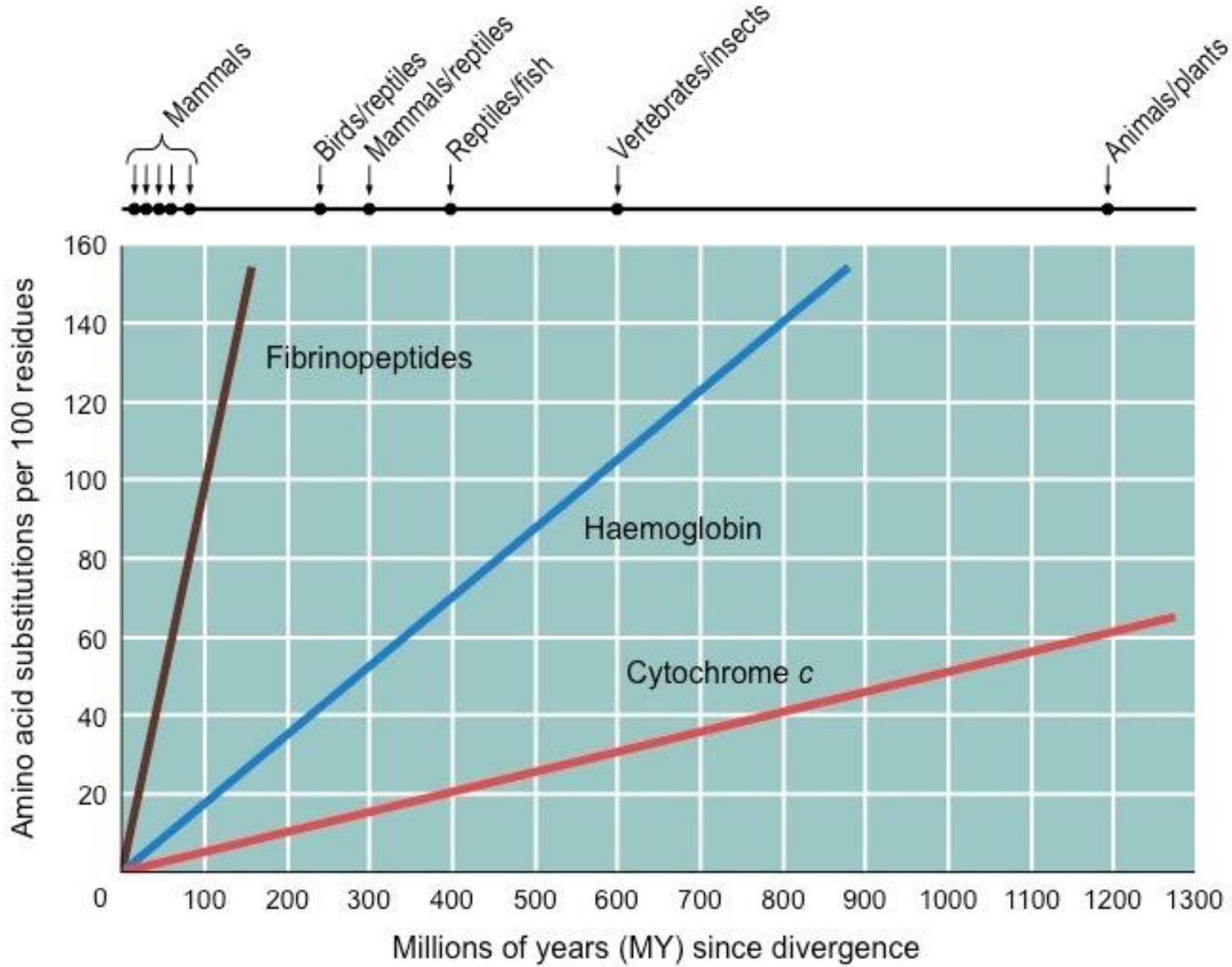



α1 α2 α3 α4 β1 β5 β2 β3 β4 αx αx βx
Percopsis transmontana
Zeus faber
Stylephorus chordatus
Bregmaceros cantori
Bathygadus melanobranchus
Macrourus berglax
Malacocephalus occidentalis
Mora moro
Laemonema laureysi
Trachyrincus scabrus
Trachyrincus murrayi
Muraenolepis marmoratus
Melanonus zugmayeri
Merluccius capensis
Merluccius merluccius
Merluccius polli
Phycis blennoides
Phycis phycis
Lota lota
Molva molva
Brosme brosme
Gadiculus argenteus
Trisopterus minutus
Pollachius virens
Melanogrammus aeglefinus
Merlangius merlangus
Arctogadus glacilis
Boreogadus saida
Theragra chalcogramma
Gadus morhua
5
5 or 6
5
5
5
7
7
8
8
8 or 9
20.0
140 120 100 80 60 40 20 0
millions of years ago
Percopsiformes
Zeiformes
Lampriformes
Bregmacerotidae
Bathygadinae
Macrourinae
Moridae
Trachyrincidae
Muraenolepididae
Melanonidae
Merluccidae
Phycidae
Lotidae
Gadidae
Gadiformes
- pseudogene

MOLECULAR CLOCKS

The **molecular clock** is a figurative term for a technique that uses the mutation rate of biomolecules to deduce the time in prehistory when two or more life forms diverged.

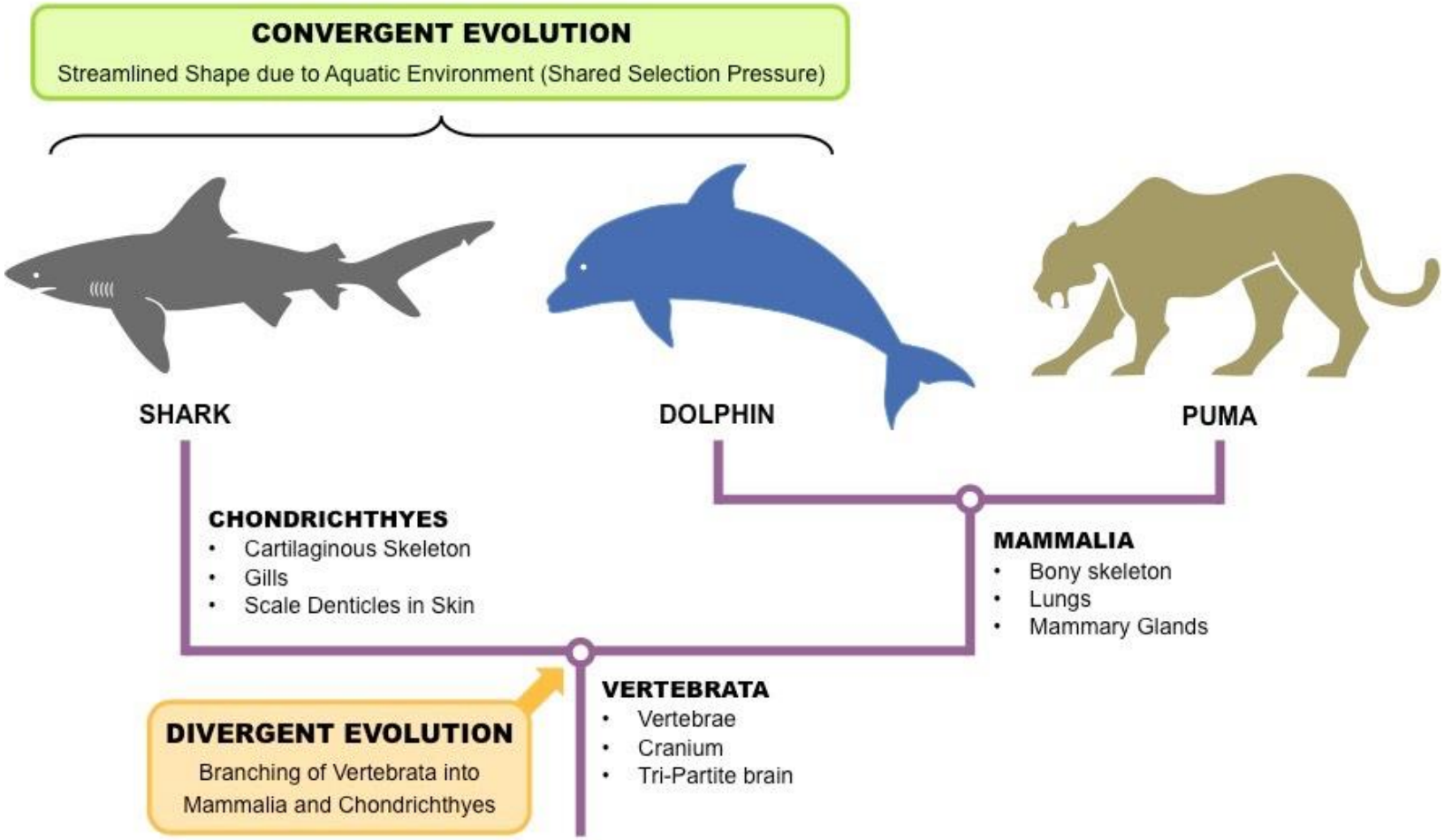



Mammals
Birds/reptiles
Mammals/reptiles
Reptiles/fish
Vertebrates/insects
Animals/plants
Amino acid substitutions per 100 residues
160
140
120
100
80
60
40
20
0
Fibrinopeptides
Haemoglobin
Cytochrome c
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Millions of years (MY) since divergence

EXAMPLE:

- a gene which mutates at a rate of 1 bp per 100,000 years has 6 bp different, divergence occurred 600,000 years ago

CLADISTICS: CONVERGENT & DIVERGENT EVOLUTION



MOLECULAR EVIDENCE → RECLASSIFICATION

Crocodiles have been shown to be more closely related to birds than lizards, despite closely resembling lizards in structure

RECLASSIFICATION OF THE FIGWORT FAMILY

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