- *Phylogeny & Systematics*

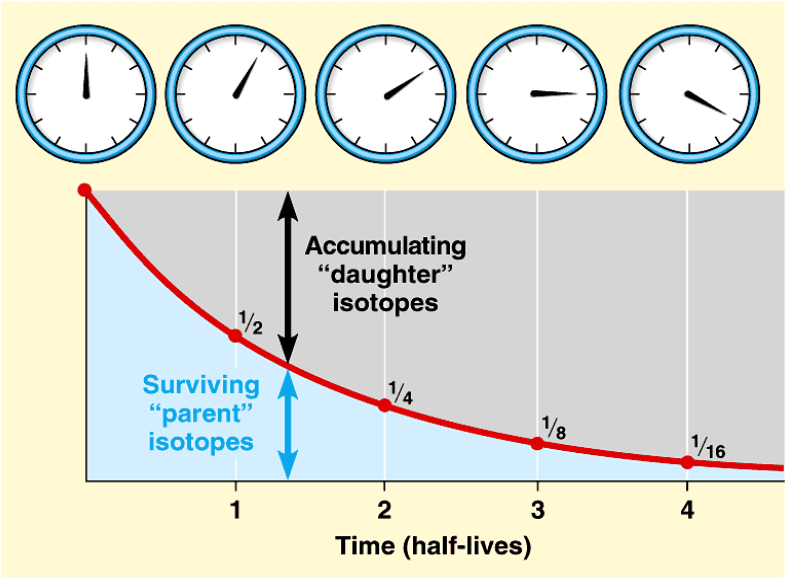
Phylogeny: *the evolutionary history of a species*

- *Systematics:*
  the study of biological diversity in an evolutionary context
- *The fossil record*: the ordered array of fossils, within layers, or strata, of sedimentary rock
- *Paleontologists*

The fossil record

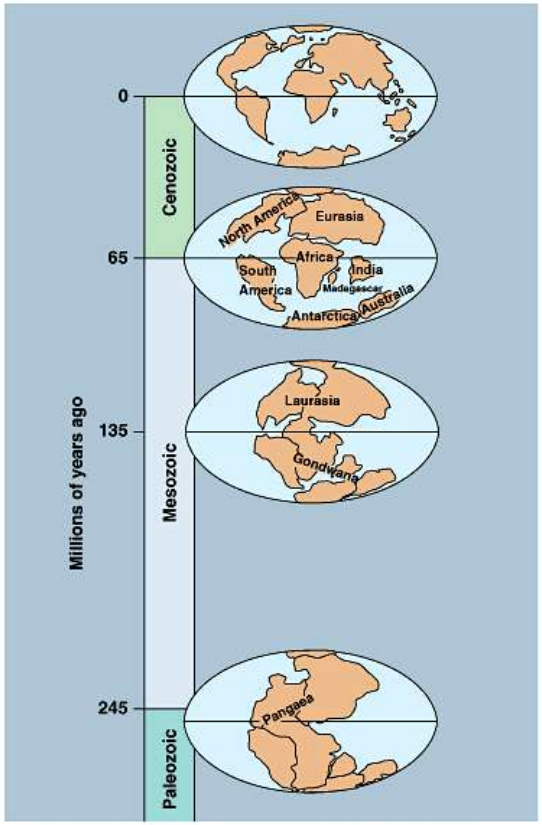
- *Sedimentary rock*: rock formed from sand and mud that once settled on the bottom of seas, lakes, and marshes

- *Dating:*
- 1- *Relative~* geologic time scale; sequence of species
- 2- *Absolute~* radiometric dating; age using half-lives of radioactive isotopes



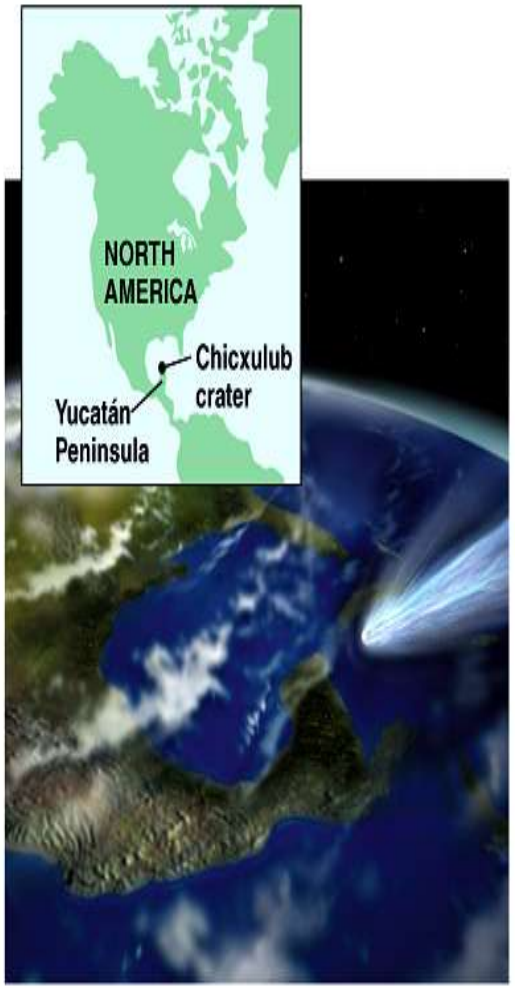
Biogeography: *the study of the past and present distribution of species*

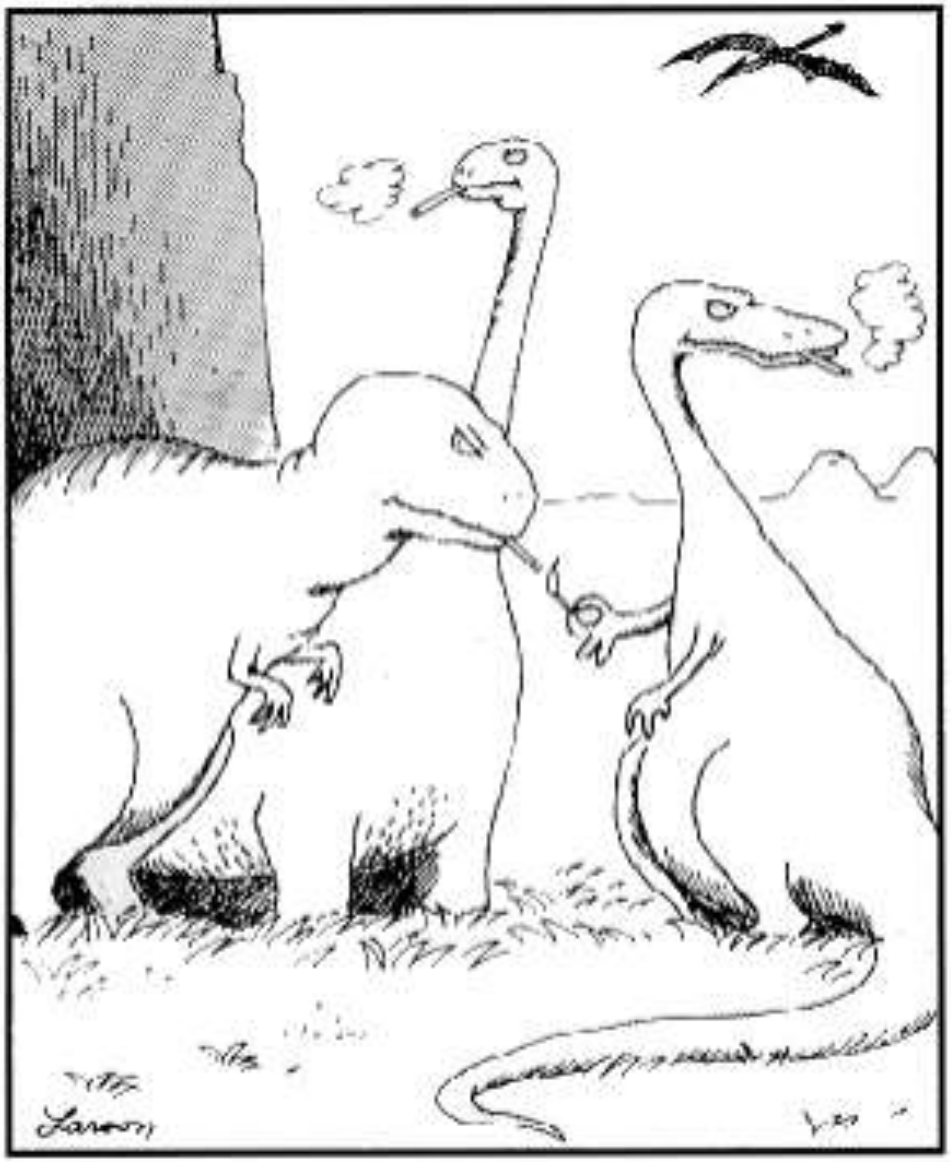
- *Pangaea*-250 mya
  - √ Permian extinction
- *Geographic isolation*-180 my
  - √ African/South America reptile fossil similar
  - √ Australian marsupials



Mass extinction

- *Permian* (250 million years ago): 90% of marine animals; Pangea merge
- *Cretaceous* (65 million years ago): death of dinosaurs, 50% of marine species; low angle comet

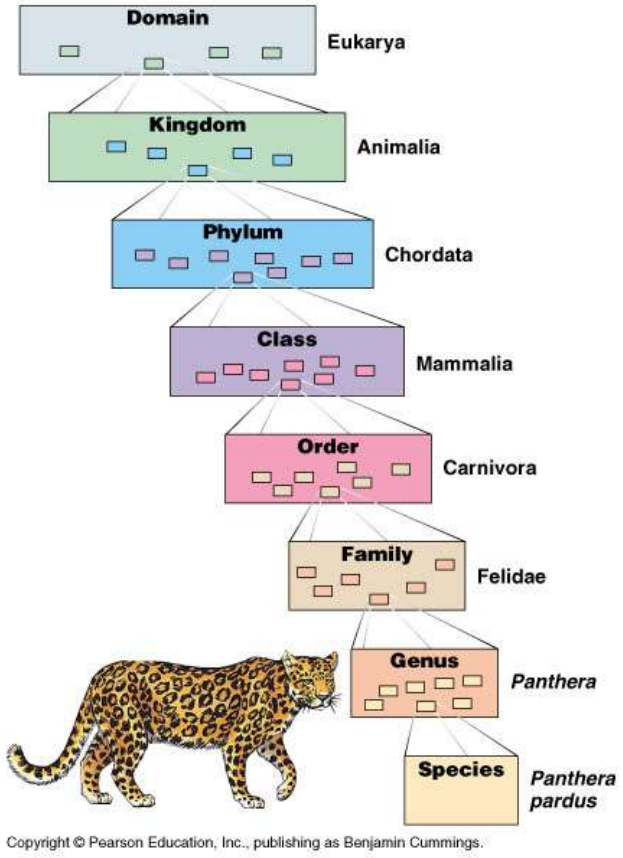




The real reason dinosaurs became extinct

Phylogenetics

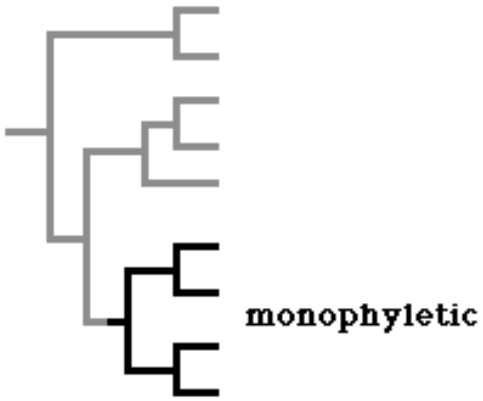
- The tracing of evolutionary relationships (*phylogenetic tree*)
- Linnaeus
- Binomial
- Genus, specific epithet
- *Homo sapiens*
- Taxon (taxa)

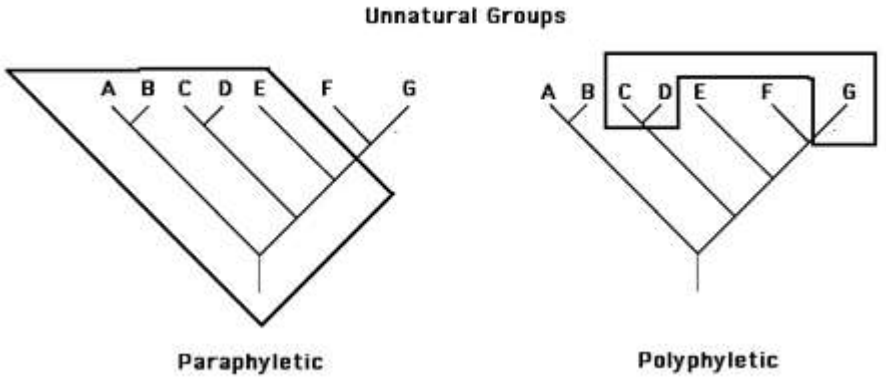


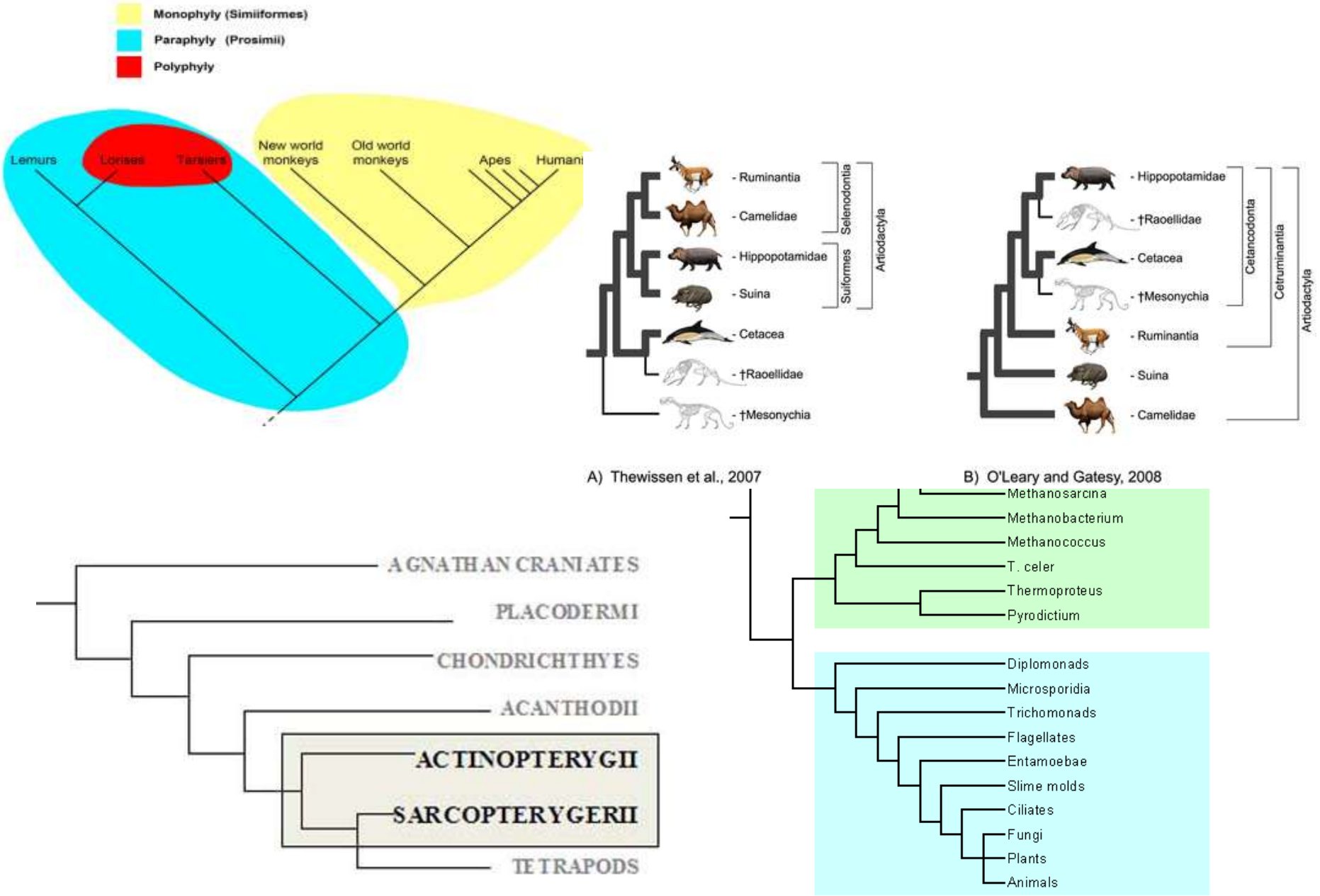
Phylogenetic Trees

<u>Clade</u>: each evolutionary branch in a cladogram

- ***Types:***
- **<u>1- Monophyletic</u> single ancestor that gives rise to all species in that taxon and to no species in any other taxon; legitimate cladogram**
- 2- Polyphyletic members of a taxa are derived from 2 or more ancestral forms (example – pachyderms - elephant – rhino – hippo - do not share a common ancestor)
- 3- Paraphyletic – includes some, but not all descendants of an ancestor (example dinosaurs but not birds



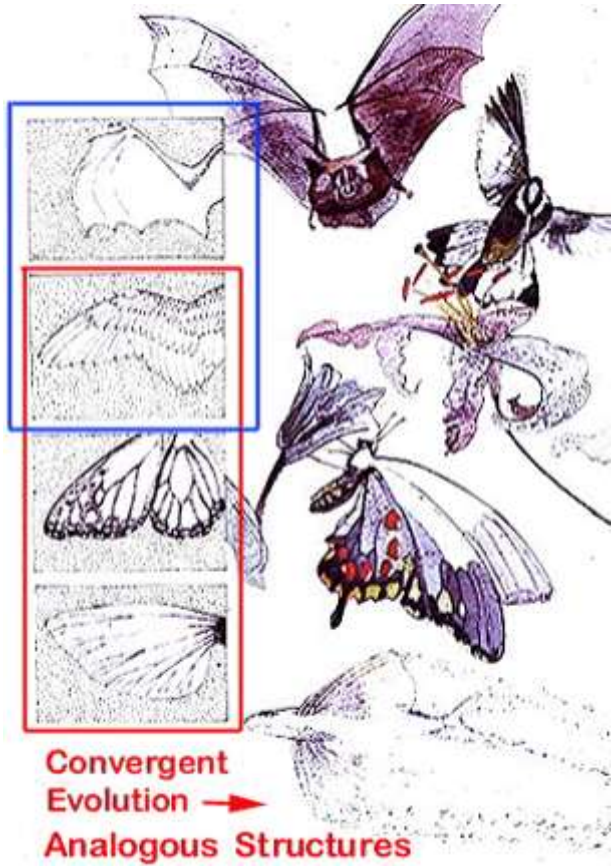




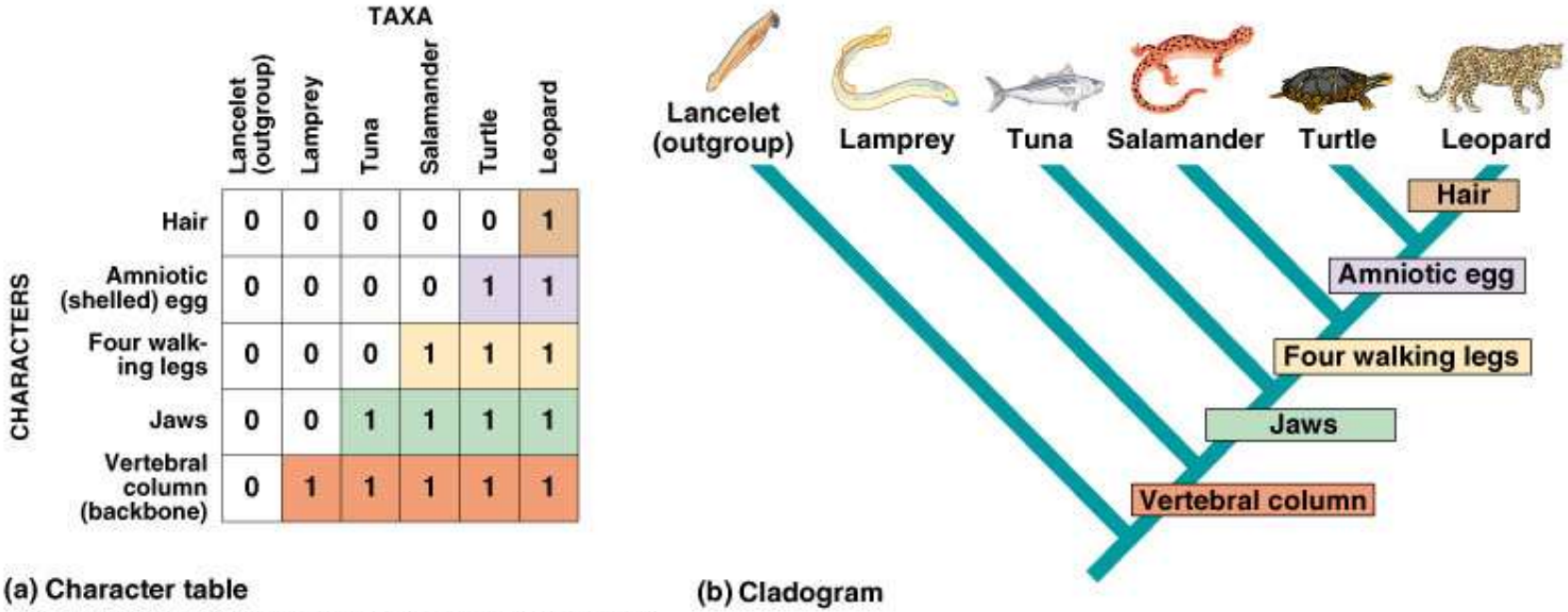
Bony fish include lungfish but not tetrapods

Constructing a Cladogram

- Sorting homology vs. analogy...
- Homology:
  likenesses attributed to common ancestry
- Analogy:
  likenesses attributed to similar ecological roles and natural selection
- Convergent evolution: species from different evolutionary branches that resemble one another due to similar ecological roles



A Cladogram – The basics



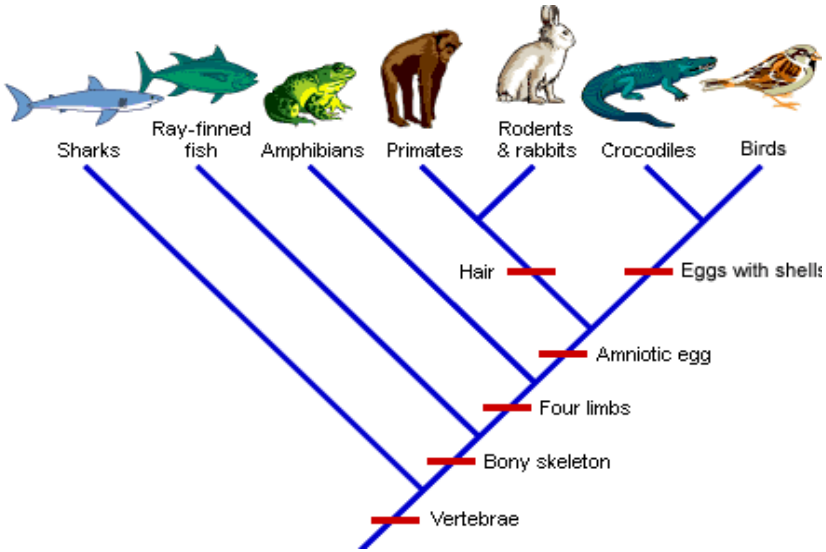
CHARACTERS	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Hair	0	0	0	0	0	1
Amniotic (shelled) egg	0	0	0	0	1	1
Four walking legs	0	0	0	1	1	1
Jaws	0	0	1	1	1	1
Vertebral column (backbone)	0	1	1	1	1	1

TAXA

(a) Character table

(b) Cladogram

Spot the difference



How would this table differ from the last?

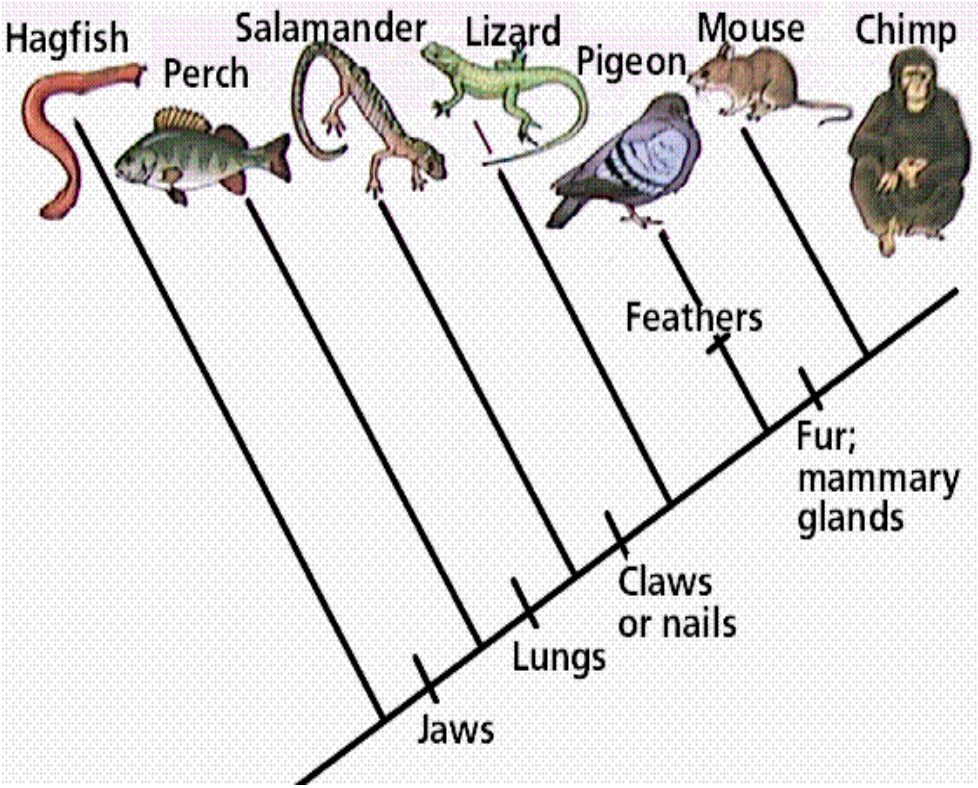
Make Your Own

To make a cladogram, you must first look at the animals you are studying and establish characteristics that they share and ones that are unique to each group. For the animals on the table, indicate whether the characteristic is present or not. Based on that chart, create a cladogram like the one pictured above.

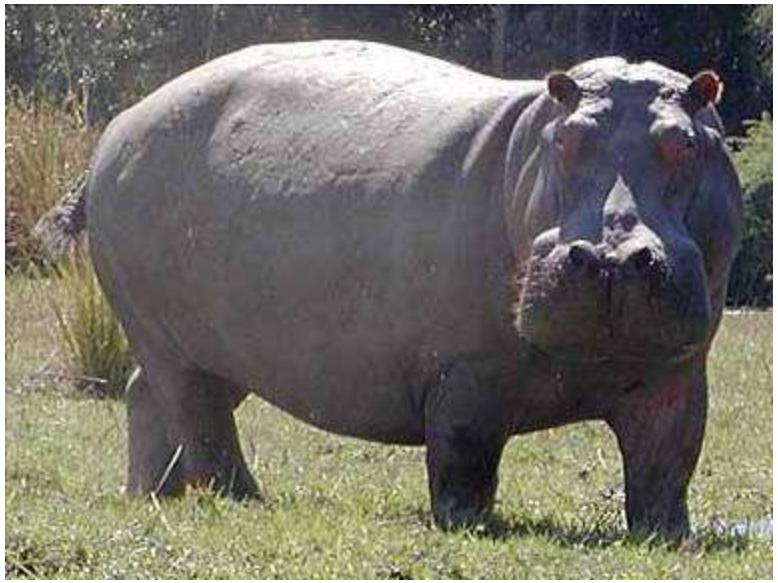
	Cells	Backbone	Legs	Hair	Opposable Thumbs
Slug					
Catfish					
Frog					
Tiger					
Human					

Warm-up

- What are the 2 parts that make up the Latin name of a species?
- Using the cladogram, which animals have claws/nails?
- Which animals have fur/mammary glands?
- To what is the chimp most closely related to?



Is a hippopotamus more closely related to a pig or to a whale? List 3 reasons to defend your answer.



HIPPO ⟶ WHALE

Based on physical comparisons (particularly dental structure and number of toes) it was originally thought that hippos were most closely related to pigs but DNA analysis indicates that hippos are more closely related to whales!

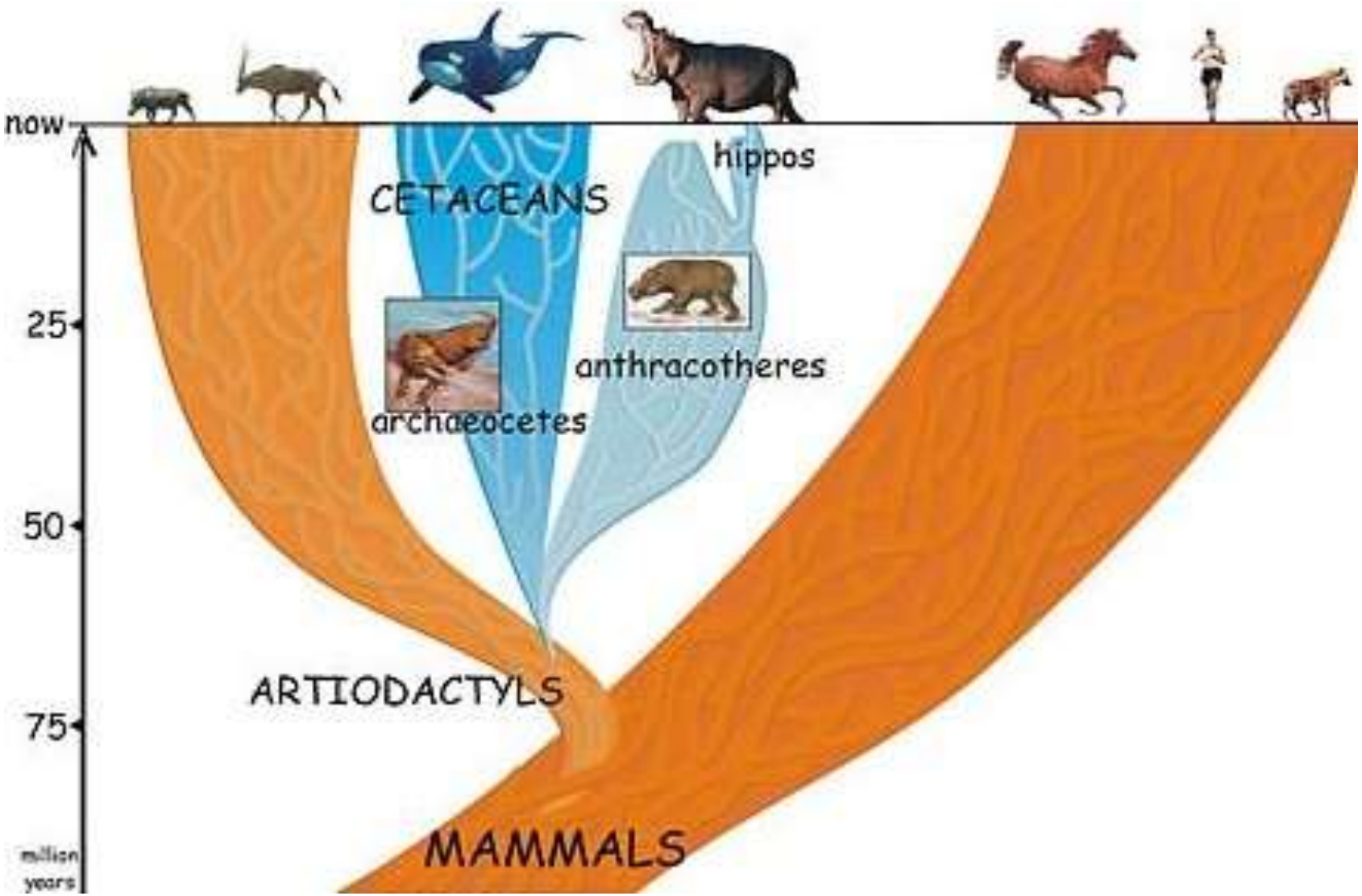
Evolutionary Link

- Whales and hippos had a common water-loving ancestor 50 to 60 million years ago that evolved and split into two groups:

The cetaceans (whales, dolphins, and porpoises)

The pig-like anthracotheres – died out less than 2.5 million years ago, leaving only the hippo as a descendent

Cladogram

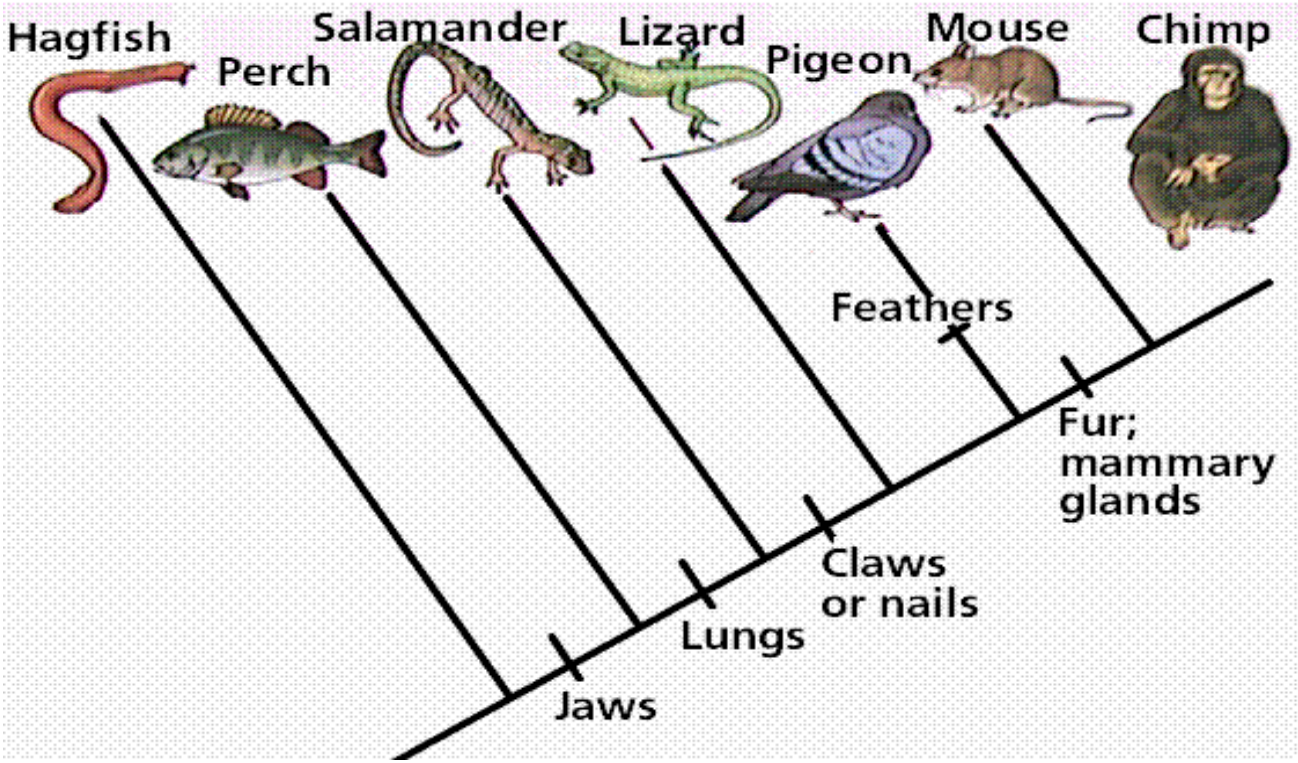

now
25
50
75
million years
hippos
CETACEANS
anthracotheres
archaeocetes
ARTIODACTYLS
MAMMALS

Cladograms are used to…

- Organize organisms based on evolutionary relationships (phylogeny).
- In other words… who is related to who and where did we come from…

How are cladograms constructed?

- Organisms are grouped together based on their shared derived characteristics (trait modified from the ancestral trait).



Cladogram construction

- Given a table of derived characters (traits), create a cladogram

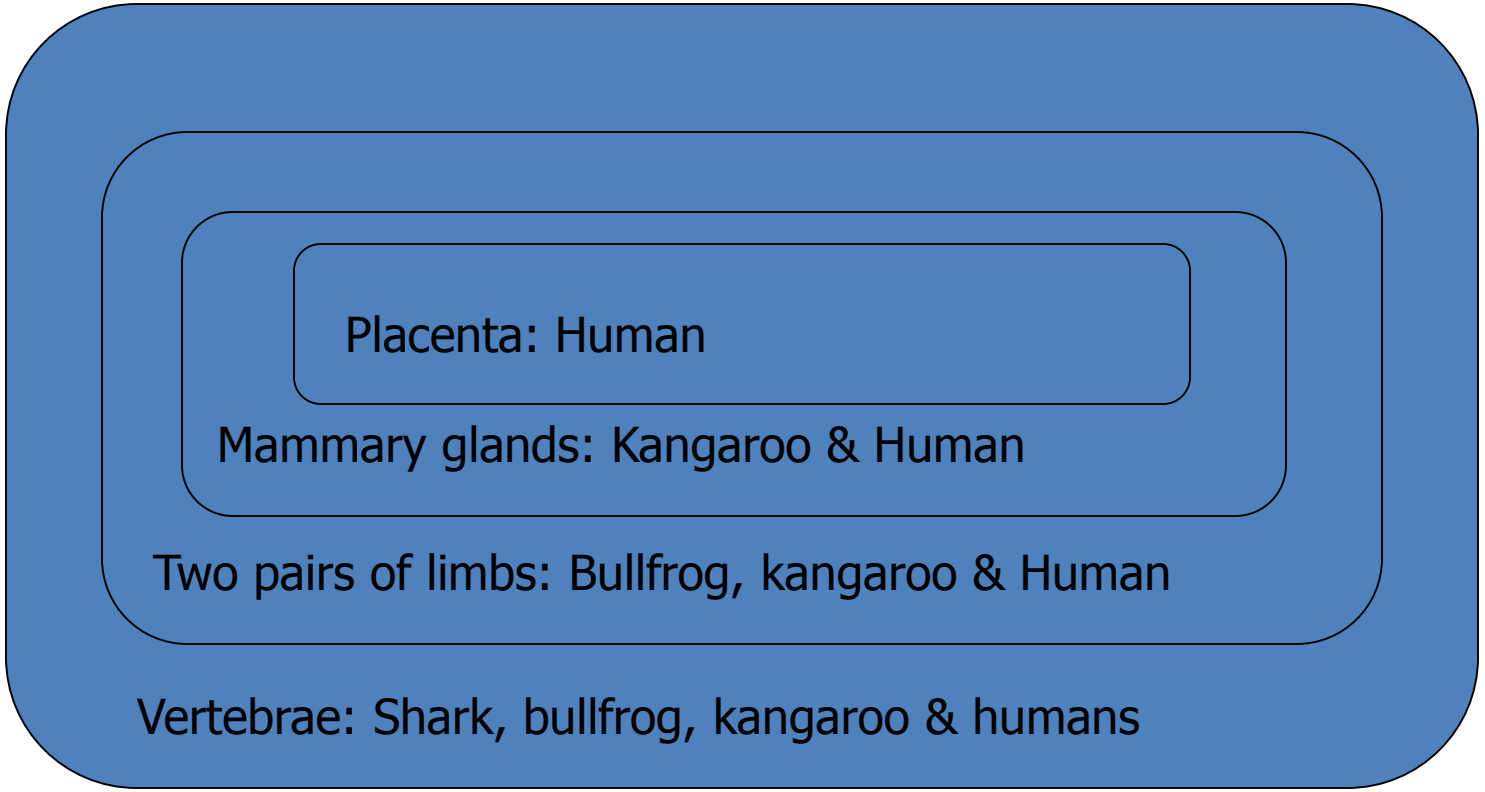
Taxa

Characters	Shark	Bullfrog	Kangaroo	Human
Vertebrae	X	X	X	X
Two pairs of limbs		X	X	X
Mammary glands			X	X
Placenta				X

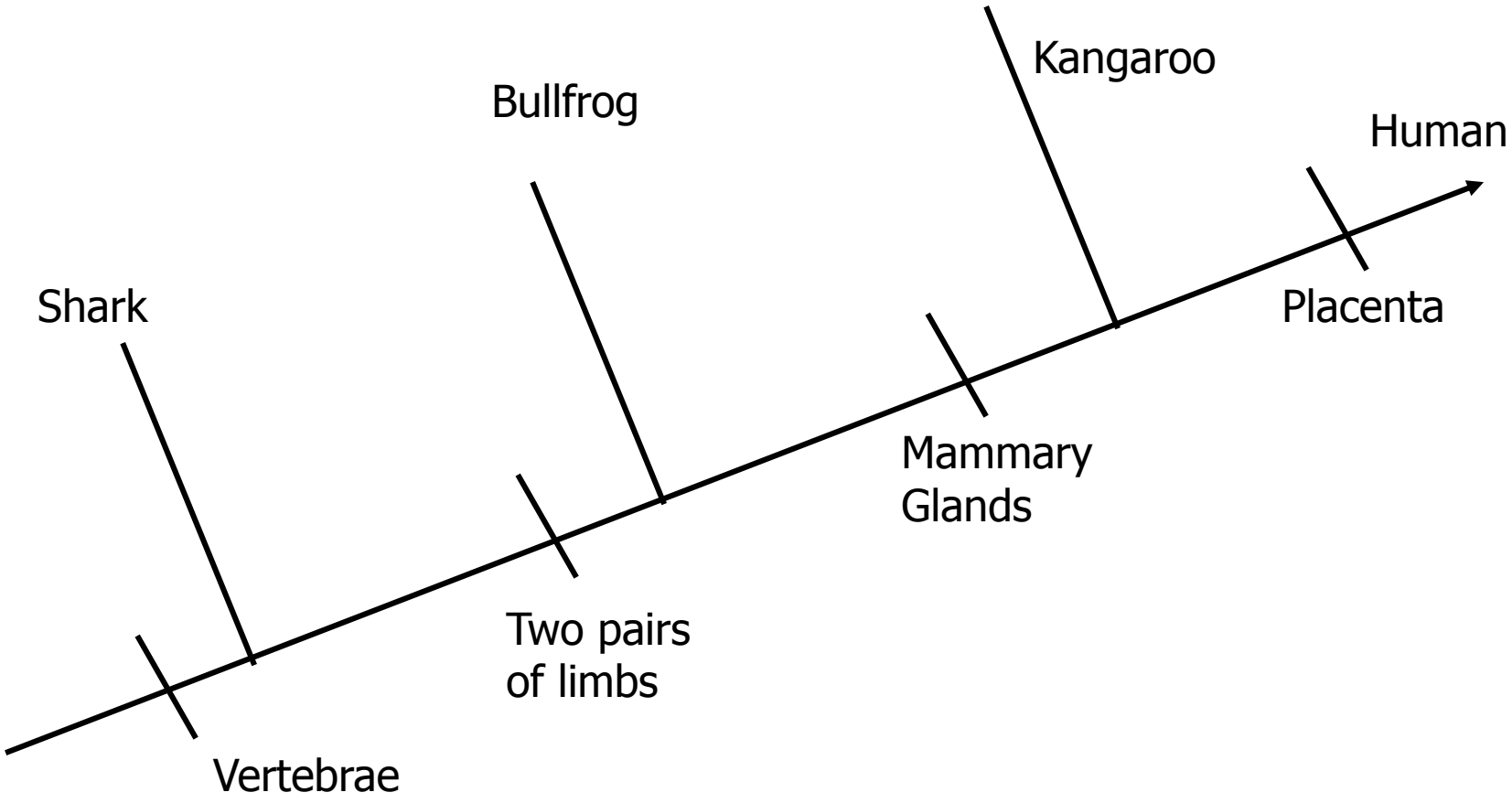
Step 1 – Create a Venn Diagram

- How many organisms are you comparing?
  - This number will equal the number of circles in your Venn diagram.
- Now count the number of characters each organism has.
  - This will be the order that you place the organisms in the Venn Diagram.

Venn Diagram



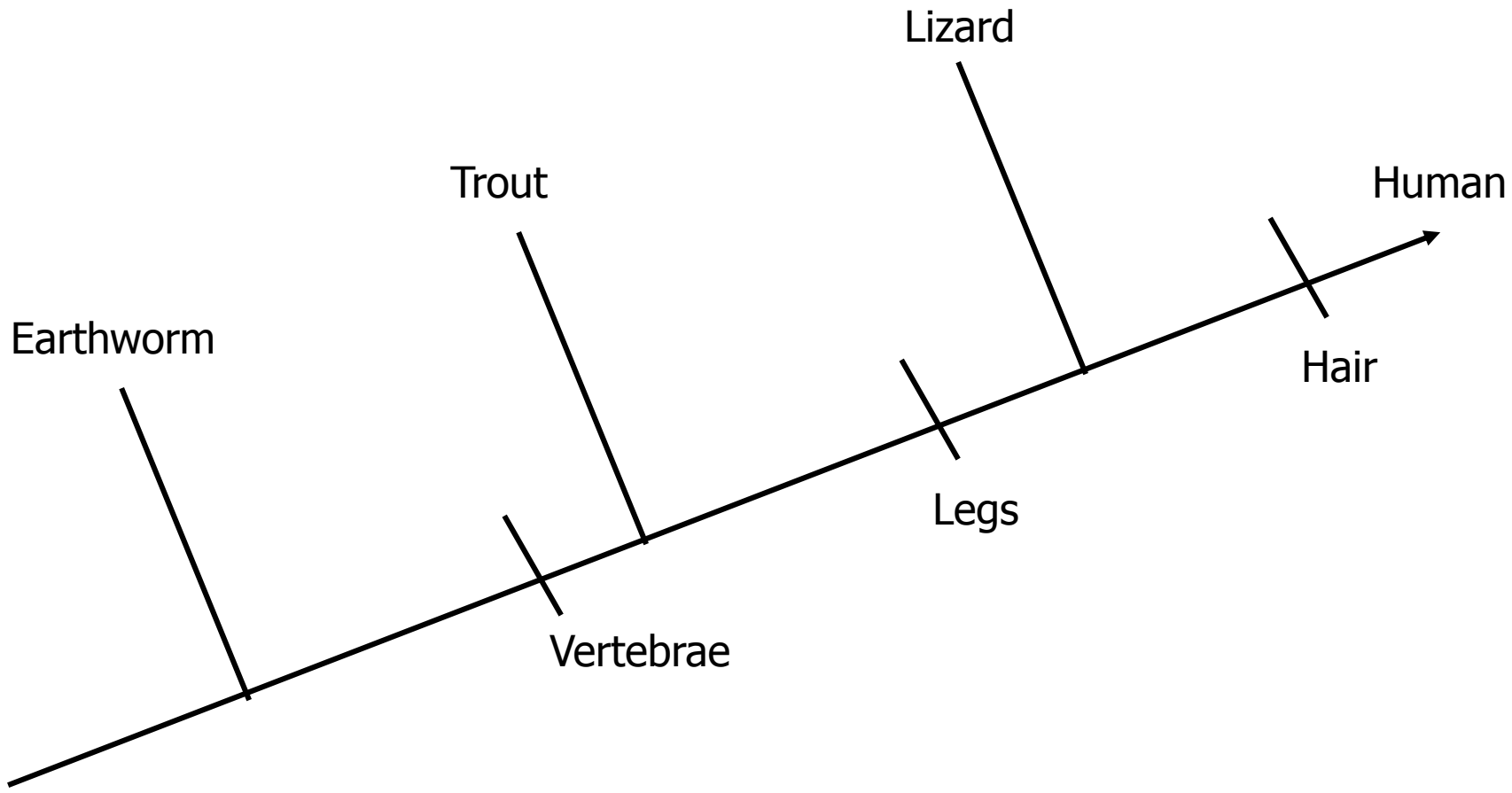
Step Two – Convert the Venn Diagram into a Cladogram



Character	Earthworm	Trout	Lizard	Human
Vertebrae		X	X	X
Legs			X	X
Hair				X

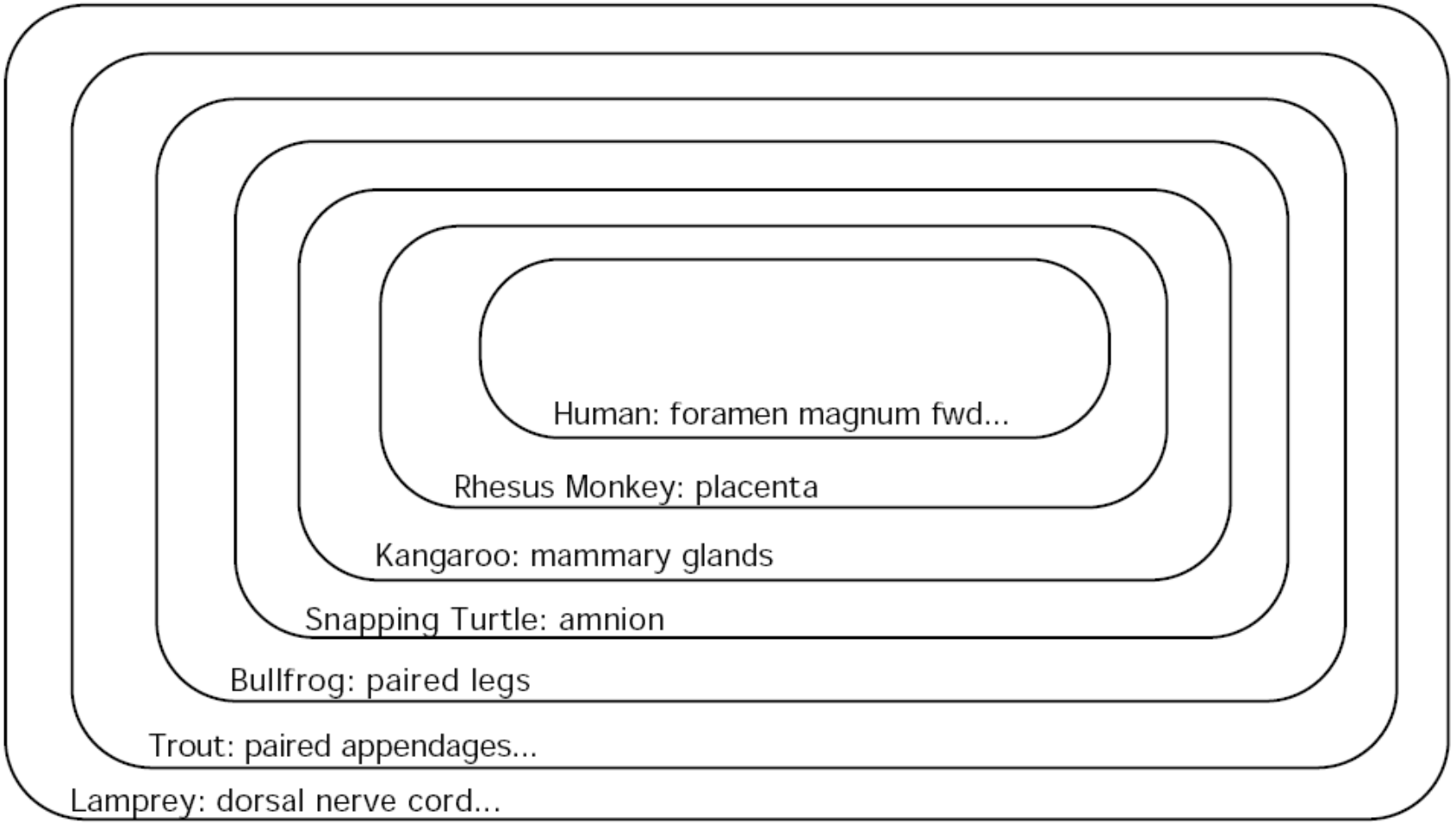
Character	Earthworm	Trout	Lizard	Human
Vertebrae		X	X	X
Legs			X	X
Hair				X

Convert the Venn Diagram into a Cladogram



- Independent Practice Problems:

SETS	TRAITS	Kangaroo	Lamprey	Rhesus Monkey	Bullfrog	Human	Snapping Turtle	Tuna
SET 1	Dorsal Nerve Cord Notochord	X	X	X	X	X	X	X
SET 2	Paired Appendages Vertebral column	X		X	X	X	X	X
SET 3	Paired legs	X		X	X	X	X	
SET 4	Amnion (Amniotic sac)	X		X		X	X	
SET 5	Mammary Glands	X		X		X		
SET 6	Placenta			X		X		
SET 7	Canine teeth short Foramen magnum fwd					X		
	TOTALS of Xs-------->	5	1	6	3	7	4	2


Human: foramen magnum fwd...
Rhesus Monkey: placenta
Kangaroo: mammary glands
Snapping Turtle: amnion
Bullfrog: paired legs
Trout: paired appendages...
Lamprey: dorsal nerve cord...