Chapter 4- An Introduction to Phylogenetic Trees

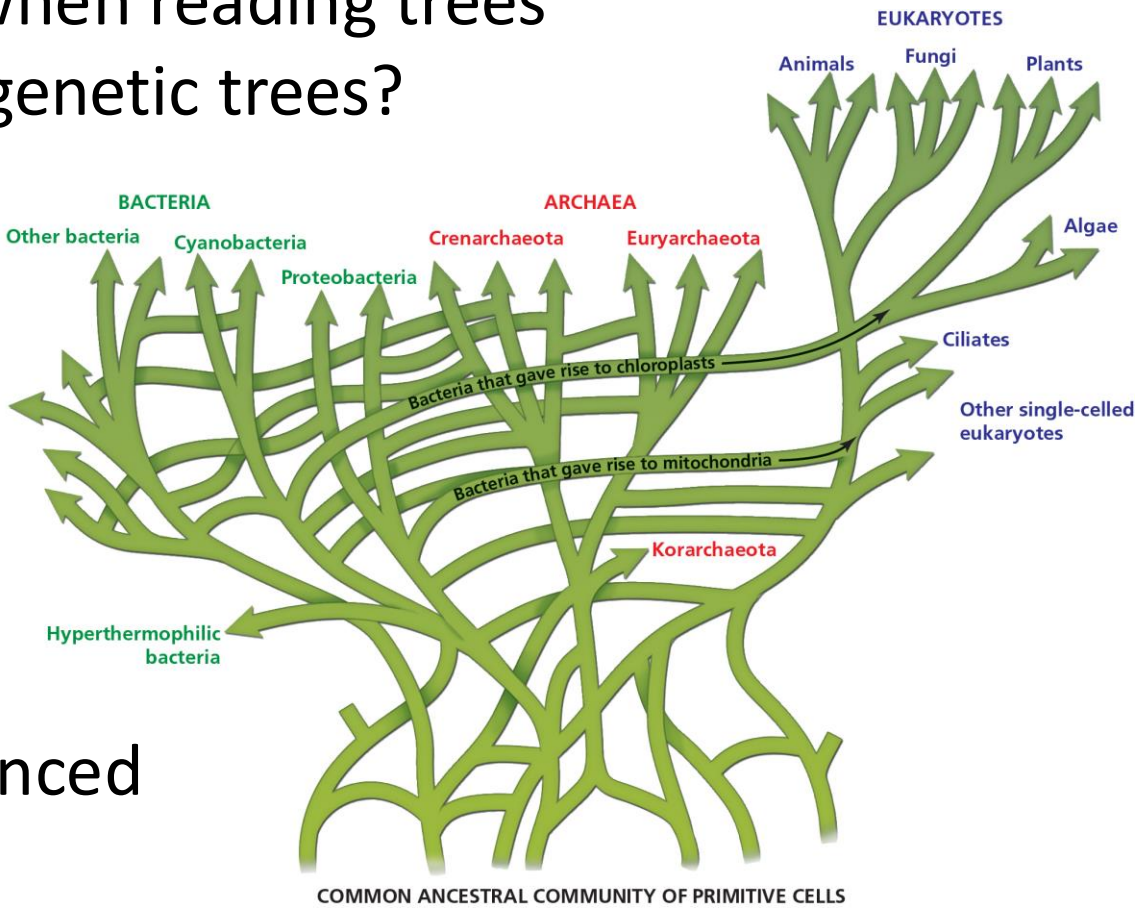
Language/Terms

Background (who are the Cladists?)

Mistakes that need fixing (clades, monophyletic groups, homologous, analogous)

Things to remember when reading trees

How do we use phylogenetic trees?



Who on this tree had ancestors that experienced Endosymbiosis!!!!

Language/Terms

Class*ification* is…..
*Taxo**nom**y* is….
Phylogeny is…
Systematics is……

A. Is the study of making trees

B. Putting things in classes or groups. Humans seem unable to resist the urge to classify. It's one of the most basic activities of any science, because it's easier to think about a few groups of things than about lots of separate things.

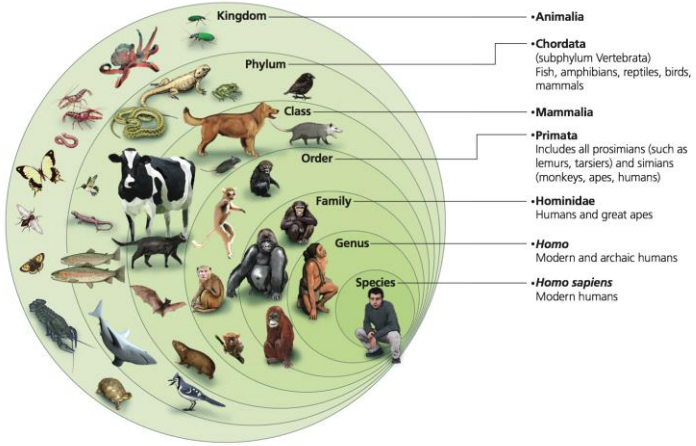
C. Evolutionary tree of life, the hierarchical structure by which every life-form is related to every other life-form.

D. Giving names to things. It tends to go hand in hand with classification, but need not. You can arrange things without naming them, or name them without arranging them, but the most helpful schemes name things in a way the reflects their classification.

Background (who are the Cladists?)

We had a sorting (classification) and naming (taxonomy) scheme developed by who?

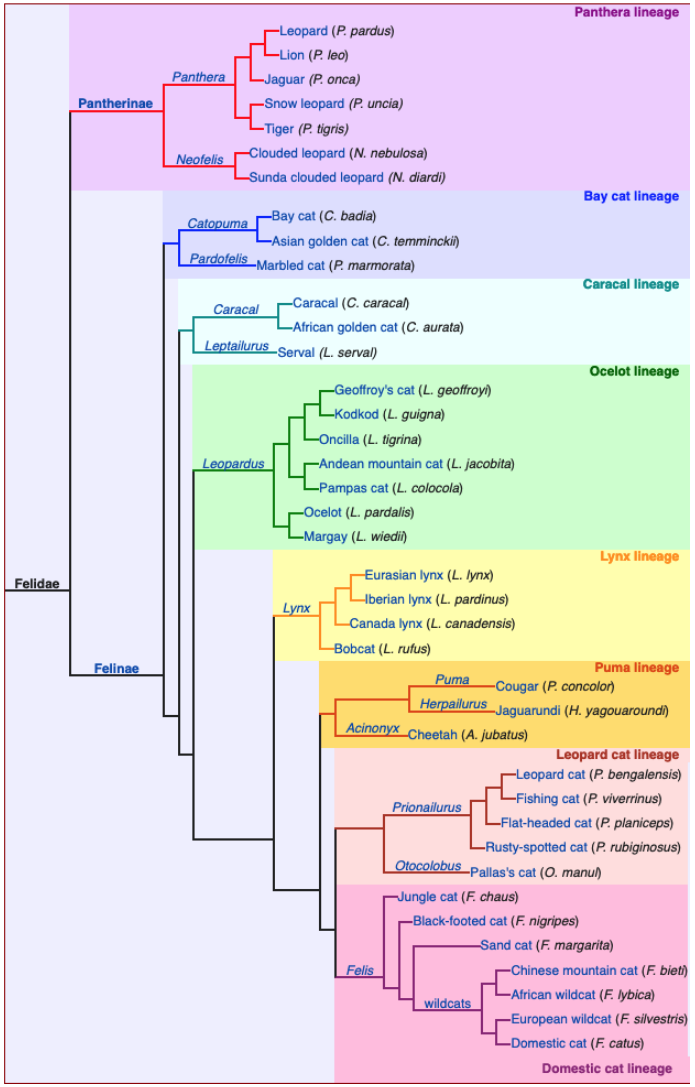
Once we realized all lineages of life evolved from previous lineages we realized that Linnaeus' way of sorting organisms (based on their morphology or shapes) and naming **often** reflected their true evolutionary relationships (or phylogenies). Yay!



EX. Felidae

In 1800's Linnaeus proposed animals that have certain characteristics (retractable claws, specific teeth arrangements etc..) should be put in the cat family!

When we dug deeper and asked are they all truly evolutionarily related we found out they are! ✅ (good job Linnaeus)



(FYI: First cats-about 25 mya)

While Linnaeus' approach often happened to reflect the true evolutionary relationships of different organisms, it did not **always reflect their true evolutionary relationships. (Darn!)**

EX. "Fish" Lets imagine Linnaeus put all these aquatic things with fins into a group called Fish.
Later after a bit more research we began to figure out that they are probably not all closely related to one another.

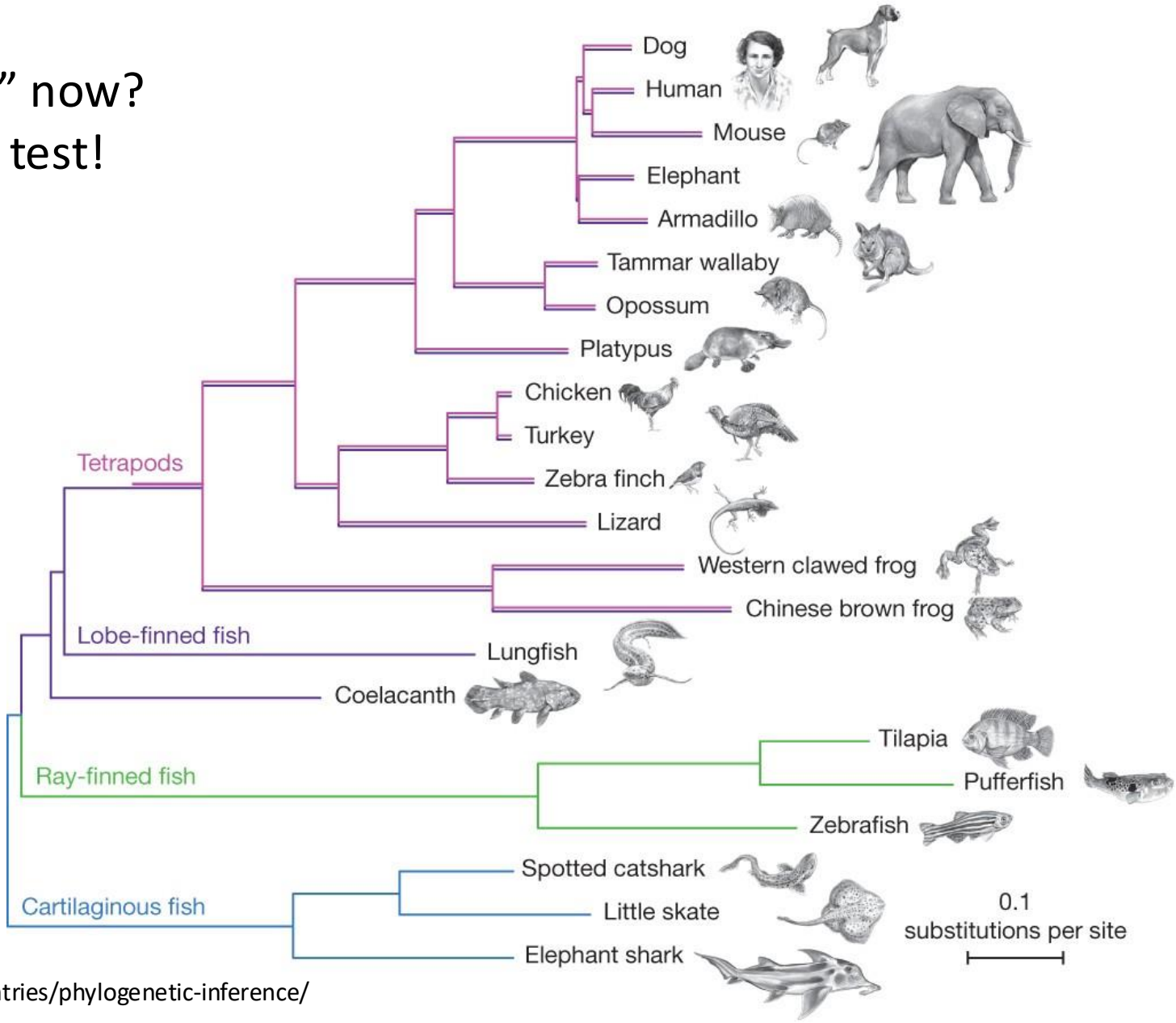
"Cladists" demanded we fix this!

Cladists bugged us and so we fixed the tree (after doing a bunch of research looking at genetic data).

Where are "fish" now?
Do the snip/clip test!

Can you cut this tree once and get all the "fish" to drop off the tree all at once?

Are fish a "good" evolutionary group?



https://plato.stanford.edu/entries/phylogenetic-inference/

Our goal today (because the Cladists kept us focused on cleaning up our messes and made clear rules) is to make our classification (sorting) system and our naming system (taxonomic system) align and reflect the organisms' evolutionary history.

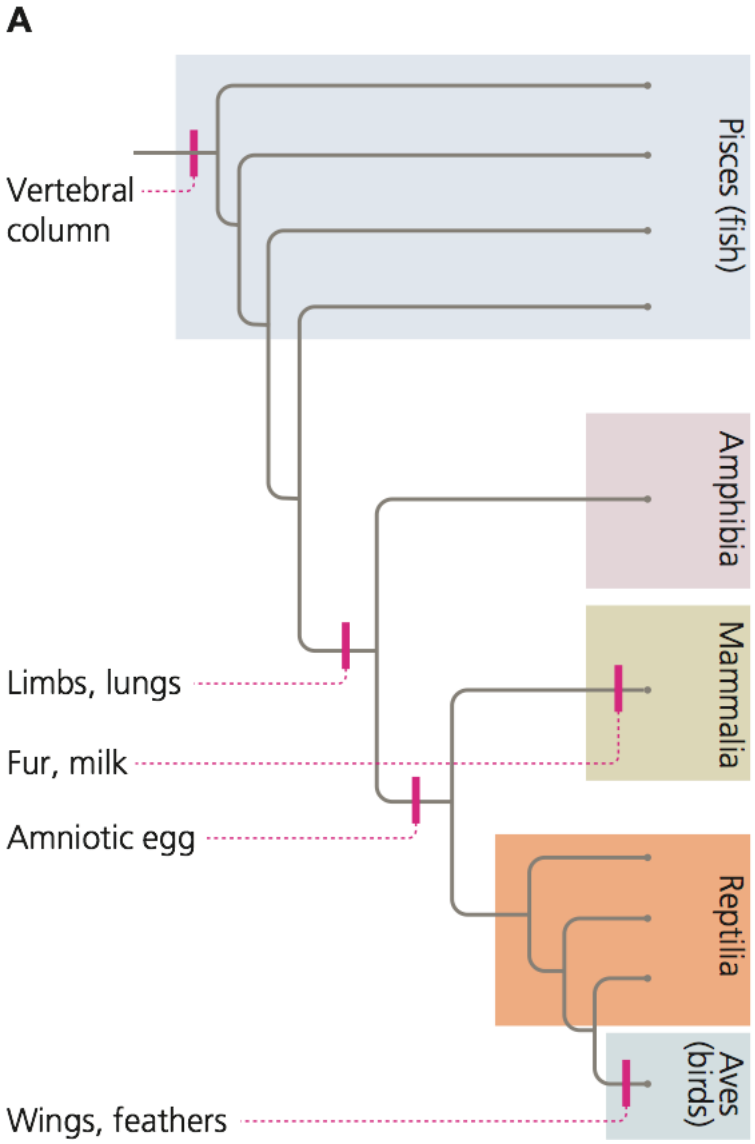
Why?

(It would be bad practice and messy to have a bunch of organisms in a Family, one of which does not have shared ancestry with the others.)

Since our goal today is to make our classification (sorting) system and our naming system (taxonomic system) reflect the organisms' evolutionary history……**we are constantly working to fix a whole variety of mistakes where sorting and naming are not "aligned."**

We will step through several kinds of mistakes we make!

Mistakes that need fixing



What named groups (shaded boxes) are not legal or "legitimate" here according to Cladists (and modern biologists)!

In other words….

- Which original "Linnaean classifications" are not good evolutionary groups or **clades**?

- Which groups are not **monophyletic and why**?

- Hint-Do the clip test!

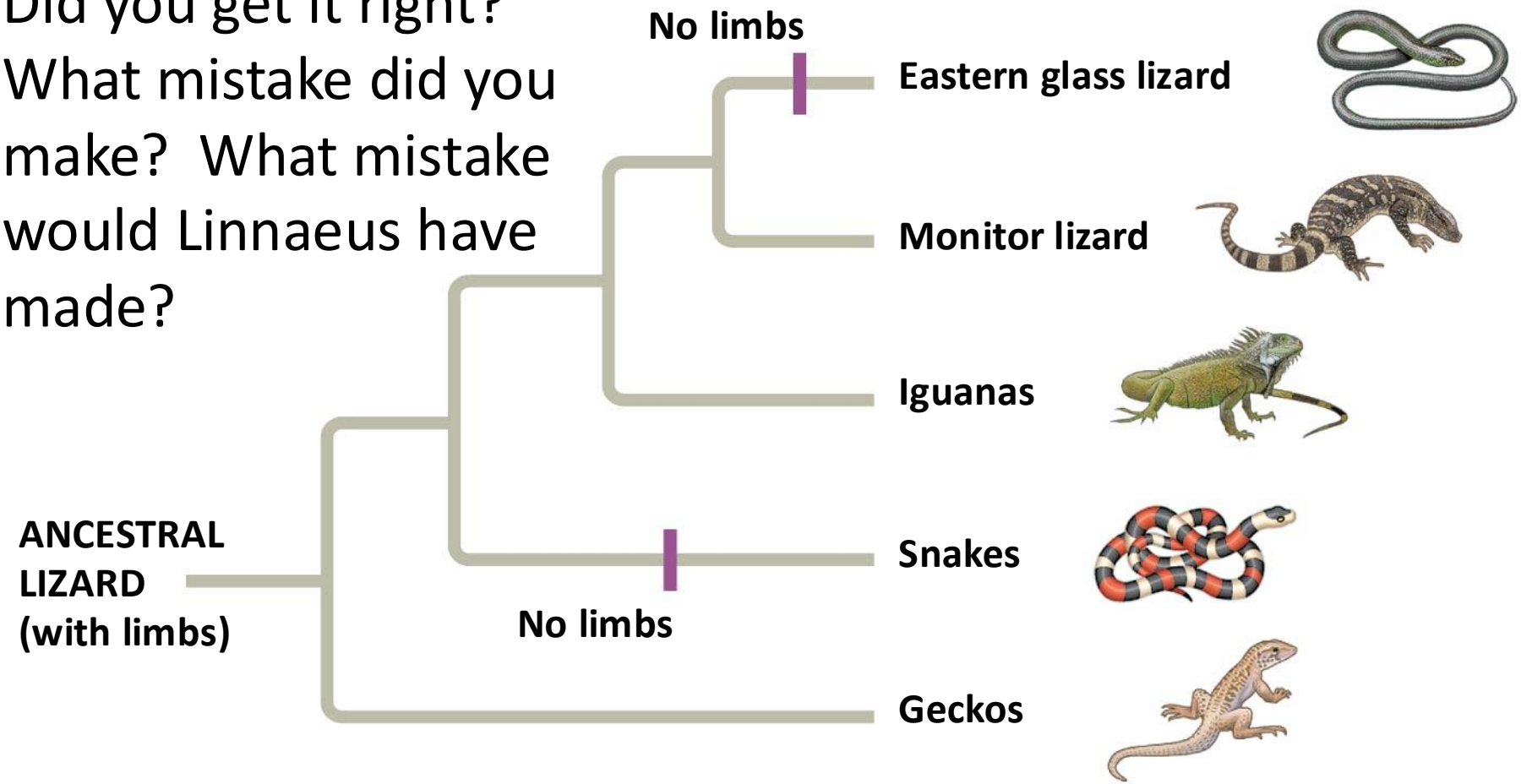
This is Mistake #1 not including all descendants!

Other kinds of mistakes….

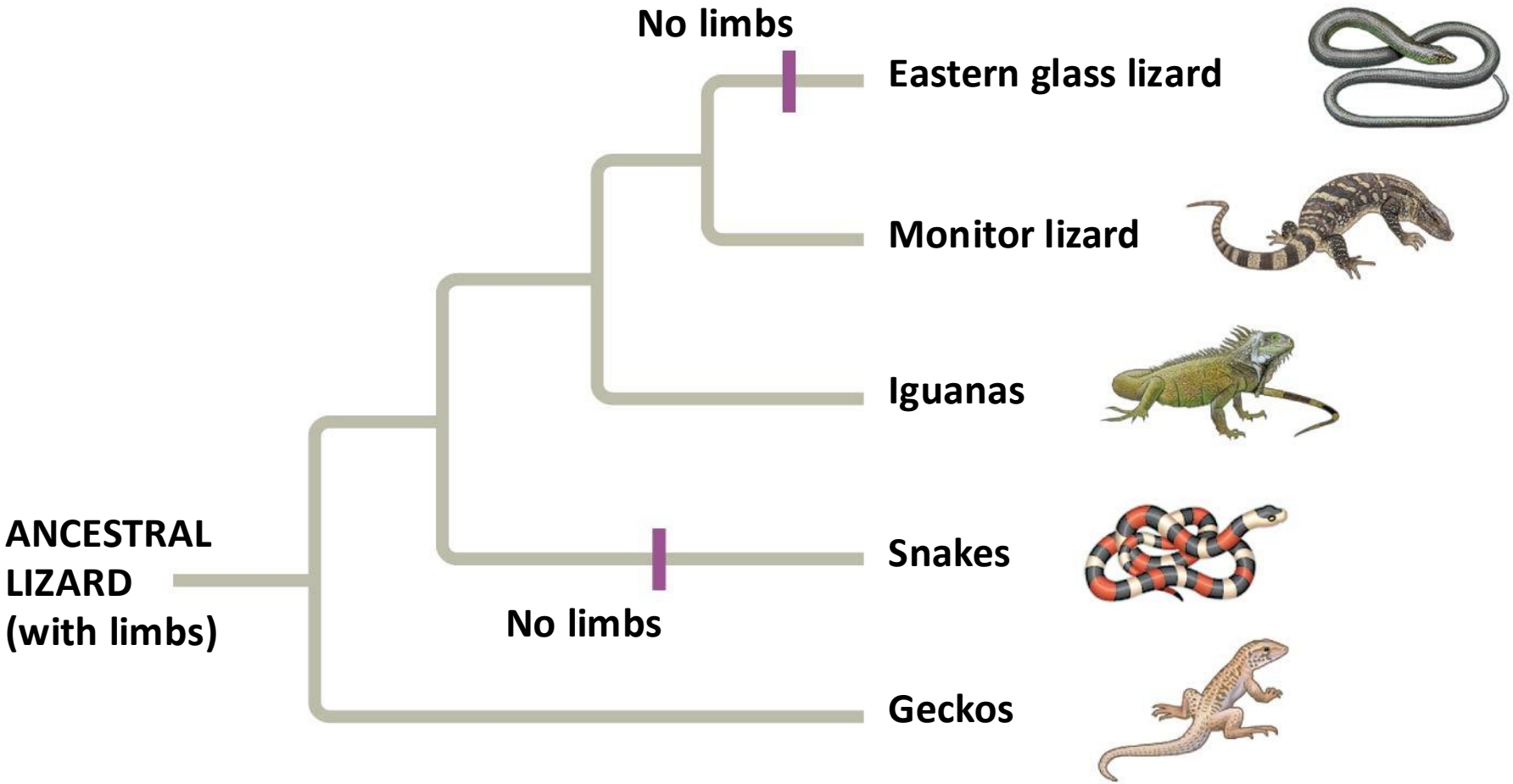
Which group/lineage/clade should this organism be put in?

If Linnaeus had placed with one of these 4 groups which do you think he would have selected?

Did you get it right? What mistake did you make? What mistake would Linnaeus have made?



Mistake #2 is accidently thinking two groups are related because they look similar morphologically when they are really evolutionarily not that closely related!

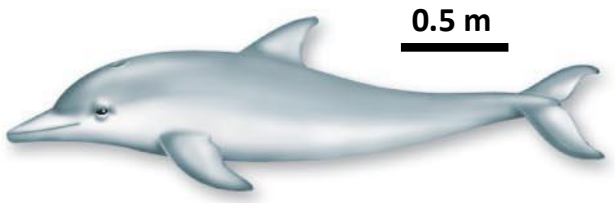


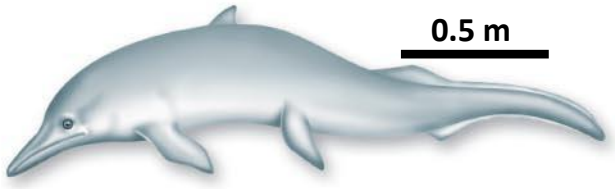
More terms….

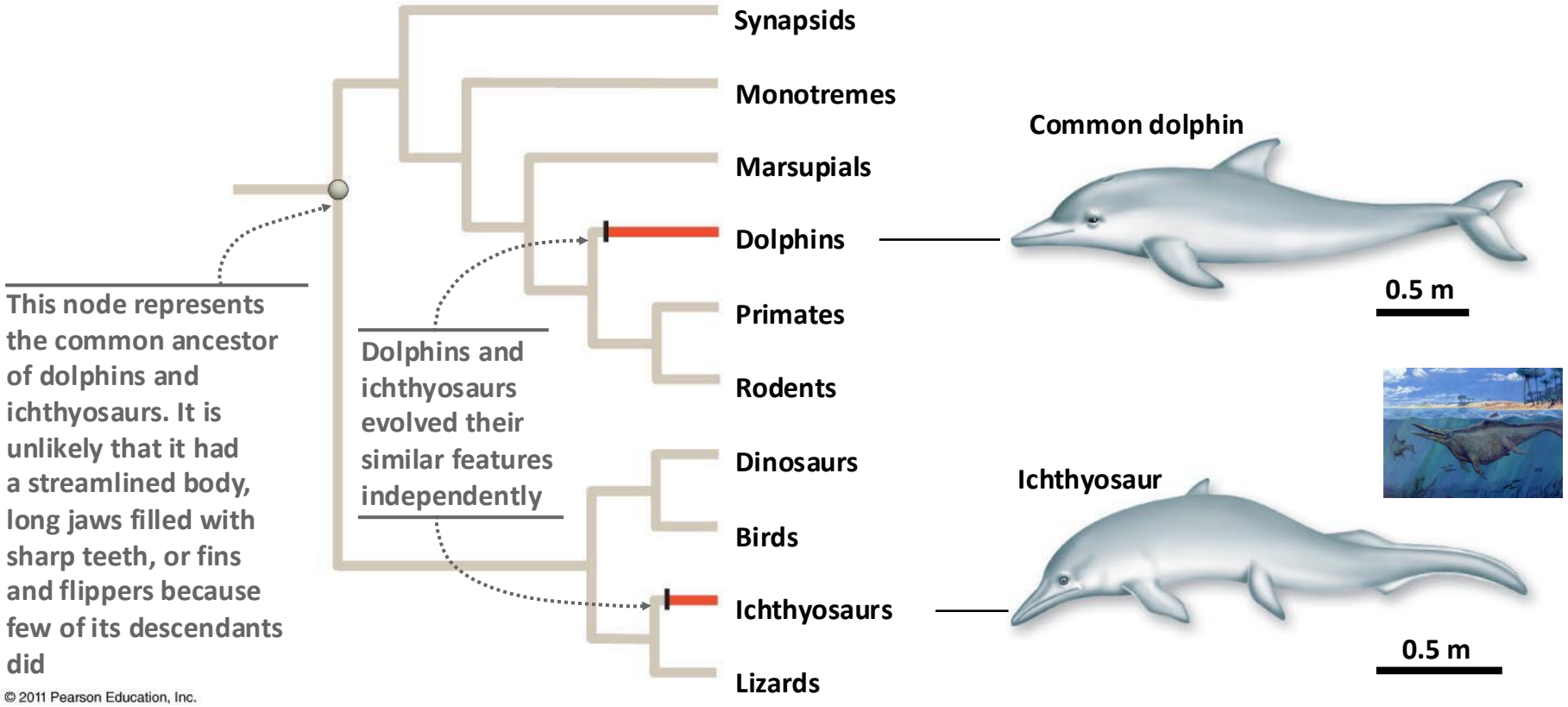
In this case, is a long skinny, legless body a **homologous** or **analogous** trait?

Analogous traits mean organisms look same due to a similar way of life, not because of shared ancestry!

Ex. Icthyosaurs and Dolphins- Both evolved a streamlined shape-aquatic predators.

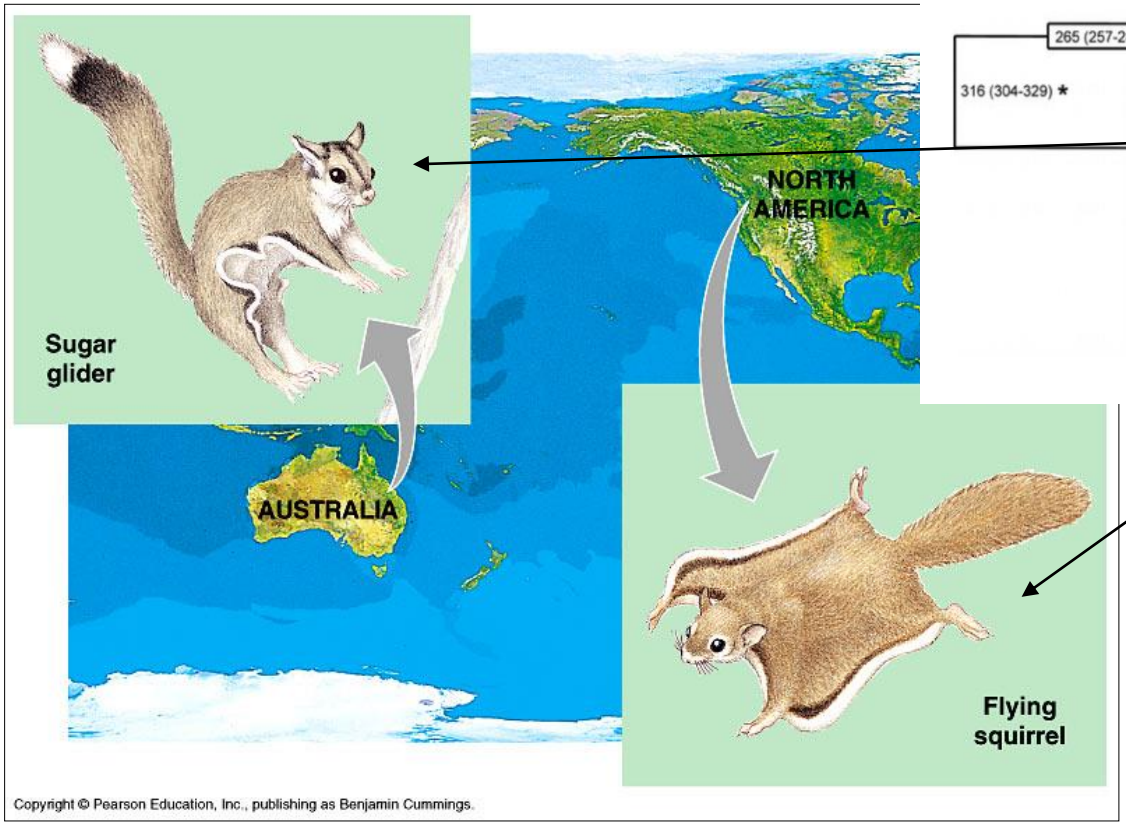


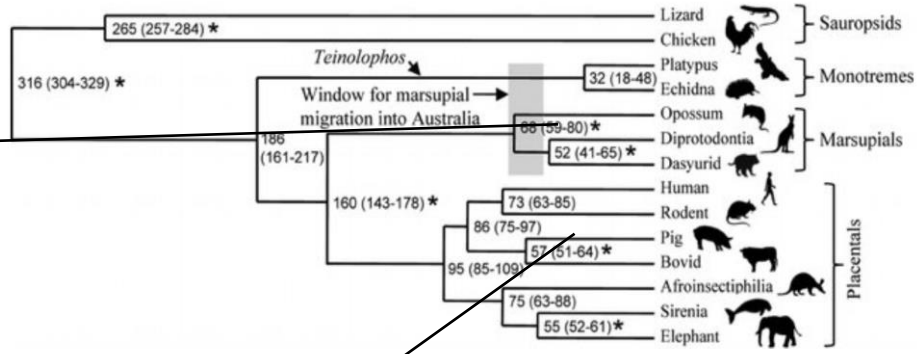




A streamlined shape evolved **convergently** in both due to selection for rapid swimming in water.

Analogous traits are also traits that experienced convergent evolution





What lineage of mammals lives in Australia vs the rest of the world??

So..Are gliding flaps between front and back limbs a homologous or analogous trait?

Molecules, morphology, and ecology indicate a recent, amphibious ancestry for echidnas

Oct 2009 · Proceedings of the ... 106(40):17089-94
DOI: 10.1073/pnas.0904649106
Source · PubMed

Matthew J Phillips · Thomas H Bennett · Michael S Y Lee

Homologous characters="really shared"=shared due to shared ancestry

Analogous characters=look same but really are not the same from an evolutionary standpoint

We would say that analogous traits show **homoplasy**

Again…
Mistake #2 is accidently thinking two groups are related because they look similar when they are really not!

(the traits you were using to sort were analogous and not homologous)

To avoid making both these mistakes this guy Hennig (A Cladist) said…..

Groups (**clades**) should share only very specific morphological traits that are **evolutionarily new or novel** (also called shared **derived traits** or **synapomorphies**)

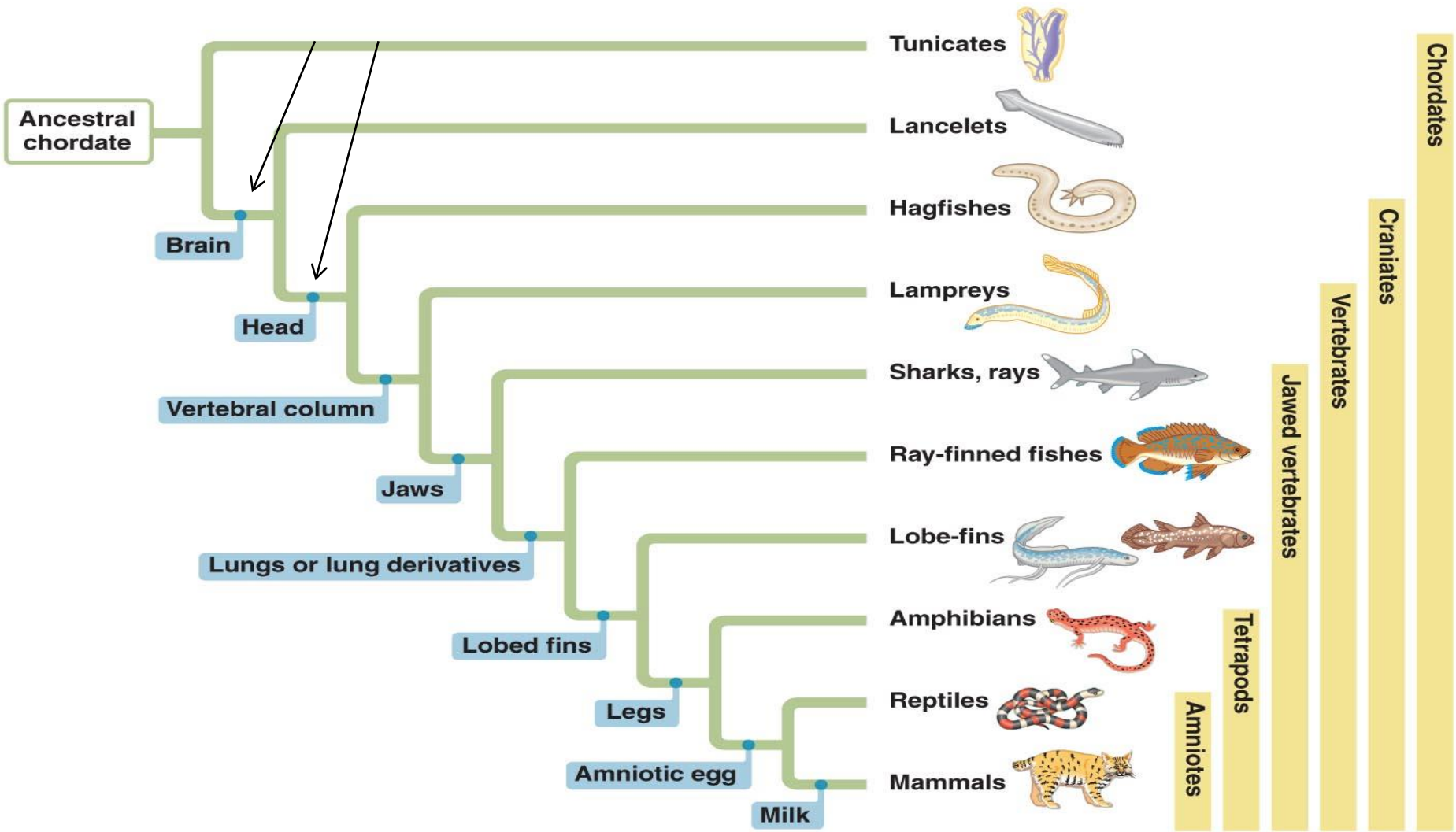
These are shared characteristics that no one else has.

Like the **astragalus** from Chapter 1!

BUT the astragalus is an odd synapomorphy because….

Synapomorphies give us clues about shared ancestry!

What do synapomorphies look like on a phylogenetic tree?



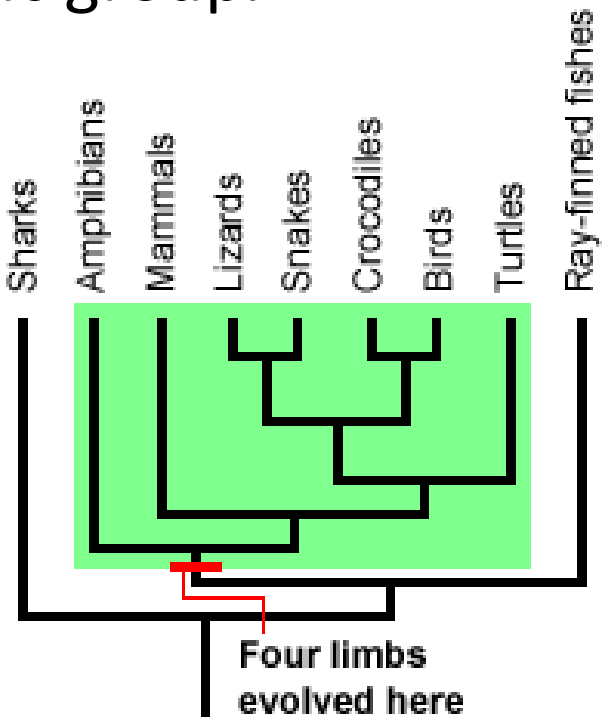
In summary, Cladists said…

All groups should be **monophyletic and based on a shared synapomorphy.**

(a monophyletic group includes an ancestor with all descendent species)

A clade is.. really just any monophyletic group.

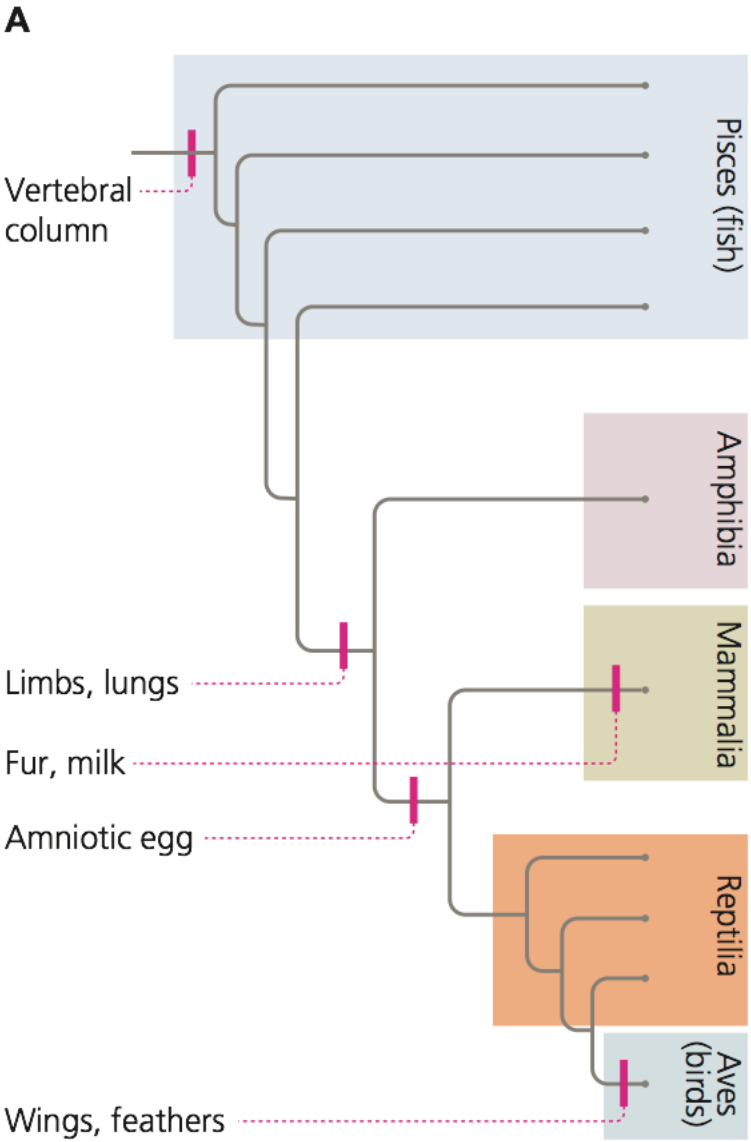
Cladistics!

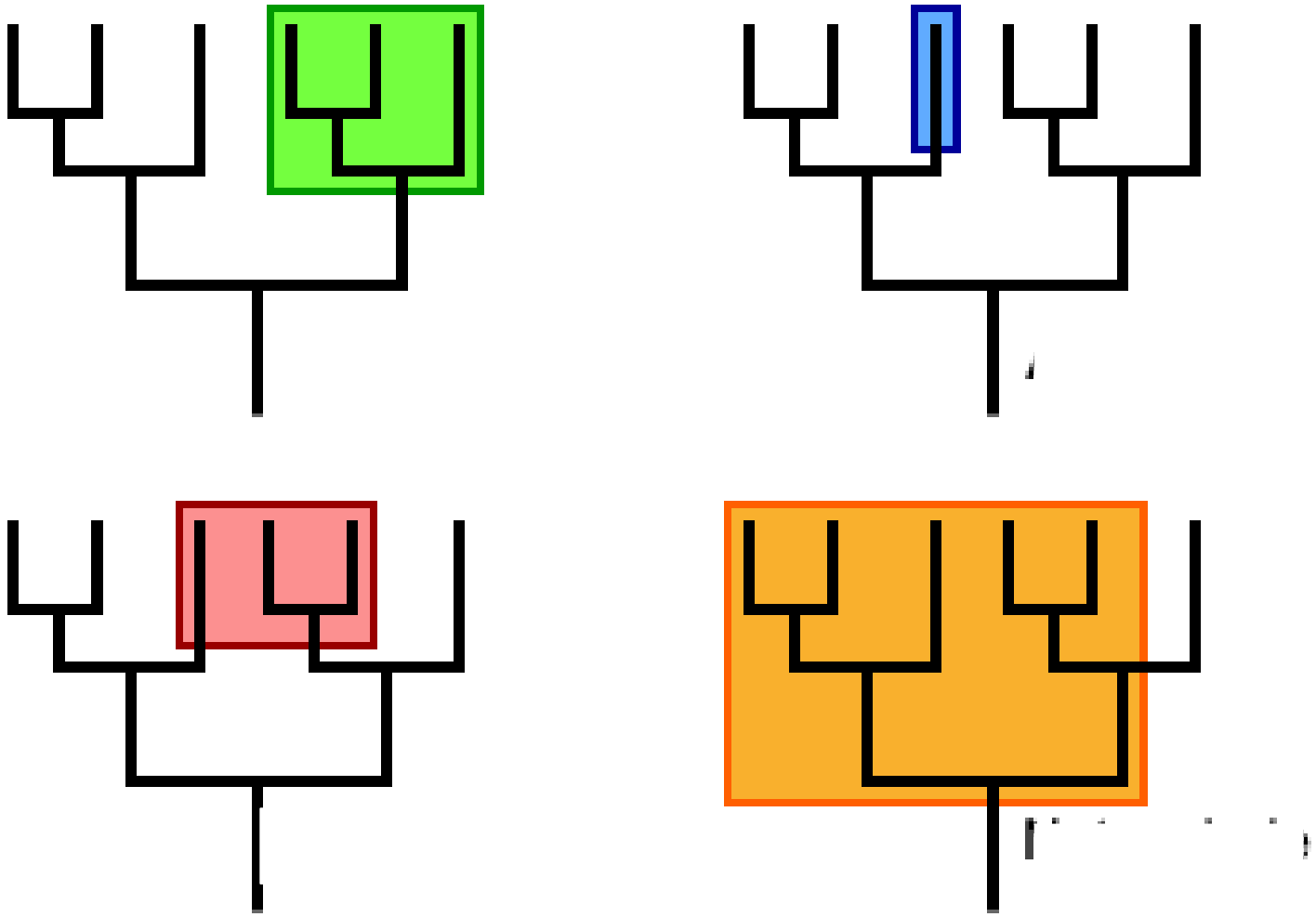


ucmp berkeley

You already saw this one….

Which boxes (which groups) show clades or monophyletic groups?





Which boxes (which groups) show clades or monophyletic groups?

Things to remember when reading trees!

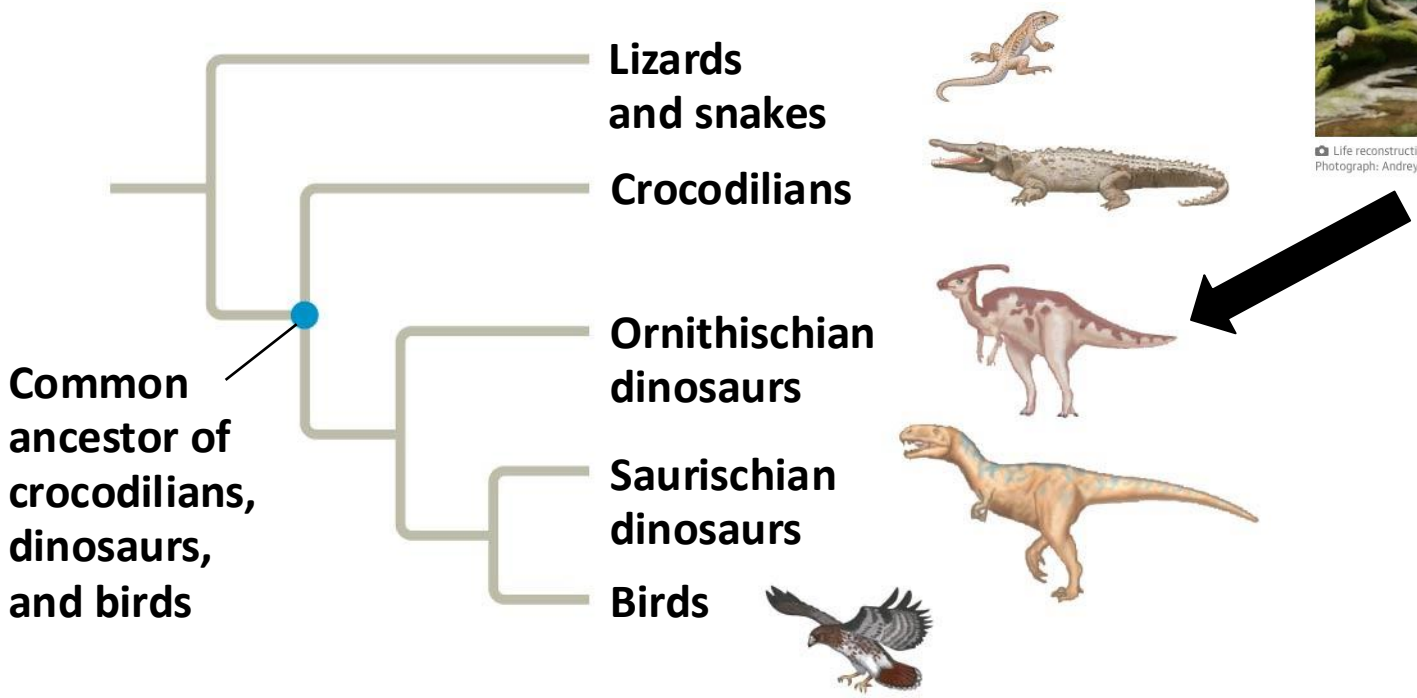
1. Will “neighbors” at the tips of a tree always look phenotypically or morphologically similar?

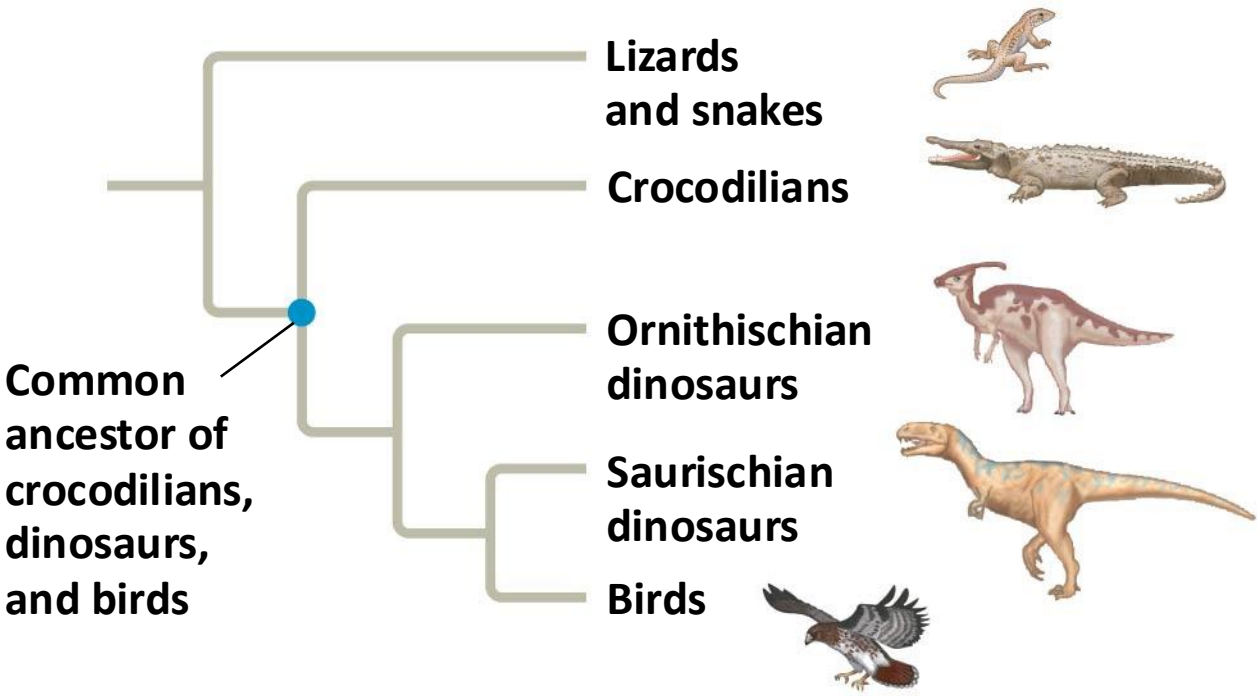
Why or Why not?

Siberian dinosaur spreads feathers around the dinosaur tree

Newly discovered *Kulindadromeus* opens up the possibility of many more dinosaurs having been coated in feather-like structures

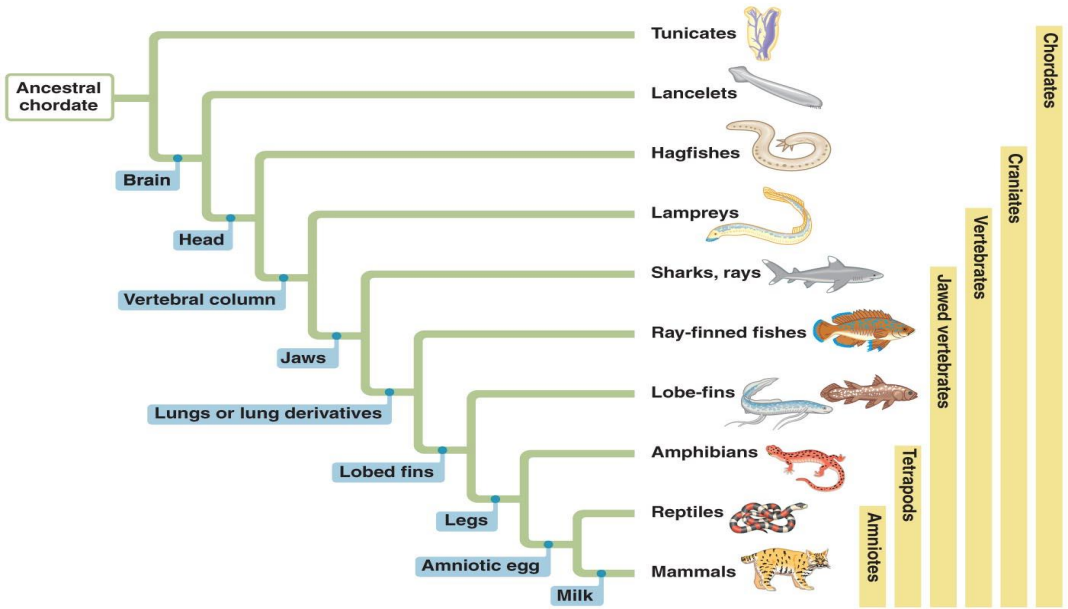
Life reconstruction of new dinosaur *Kulindadromeus* showing various scales and feather-like structures. Photograph: Andrey Atuchin





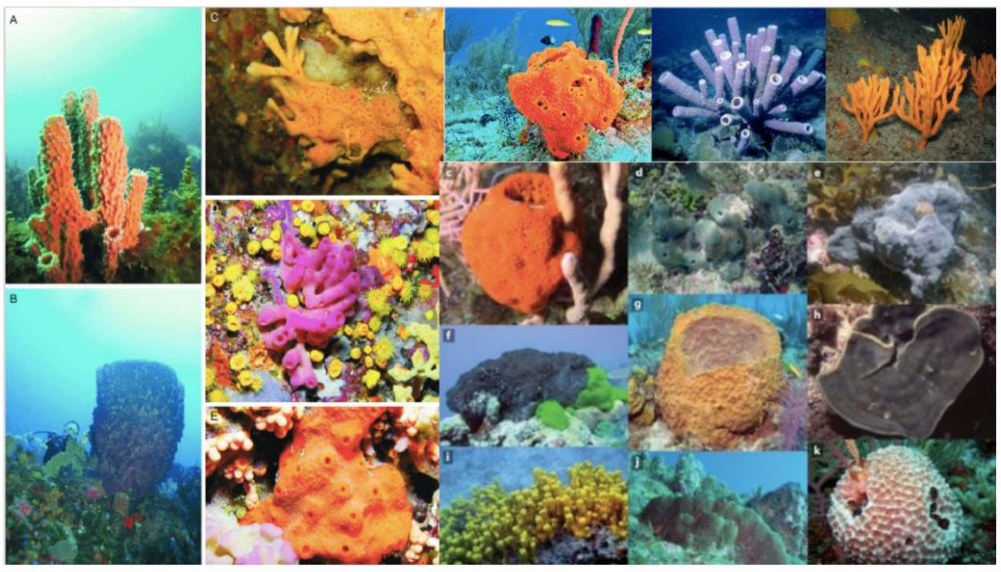
2. Have lizards and snakes evolved less than birds?

Have lampreys evolved less than mammals?



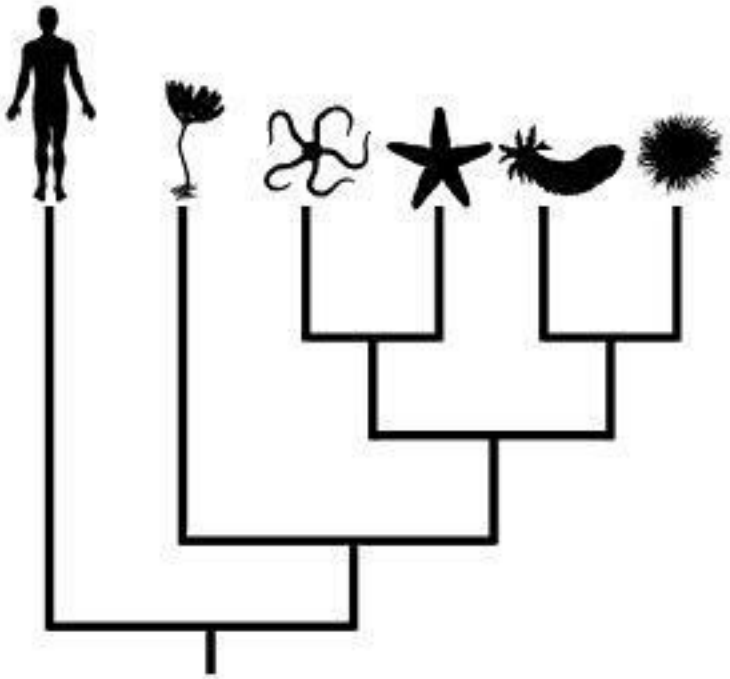
From the link I shared…

"While sponges first appeared before humans did, genes in the line leading to modern sponges and the line leading to modern humans have been evolving for just as long. Sponges did not freeze their genomes. Even when there is little obvious physical change there is much genetic change. Every extant species is just as evolved as every other extant species."



https://blogs.ubc.ca/mrpletsch/2019/01/10/phylum-porifera/

3. Did humans evolve from sea stars (and their friends)?



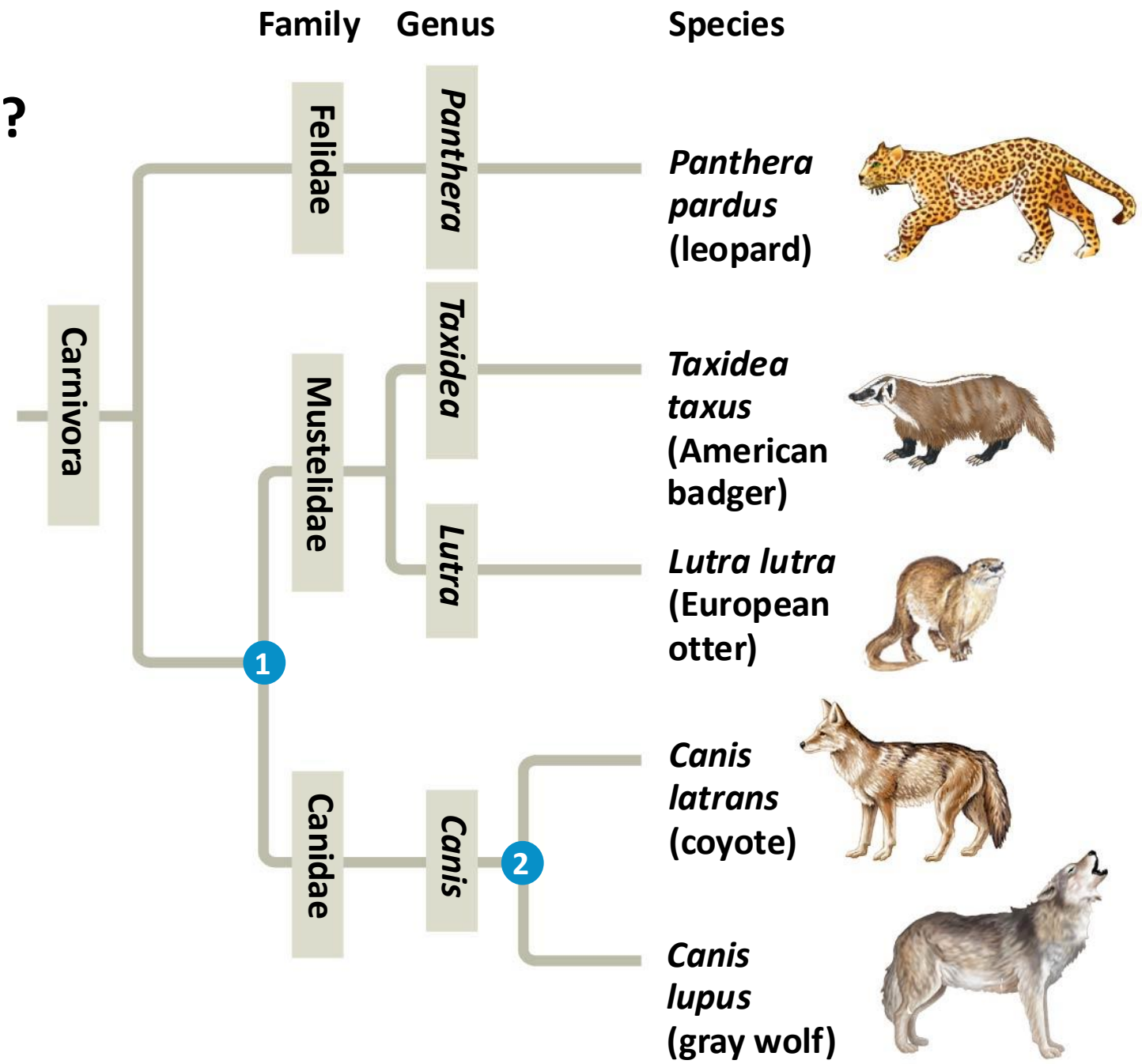
Did sea stars evolve from humans?

Sometimes a group is mistaken as being descended from its sister group instead of the **two sharing a common ancestor**. For instance, a person might think that birds are descended from crocodilians. In actuality neither crocodilians nor birds are descended from the other, but both are descended from a common ancestor at the node.

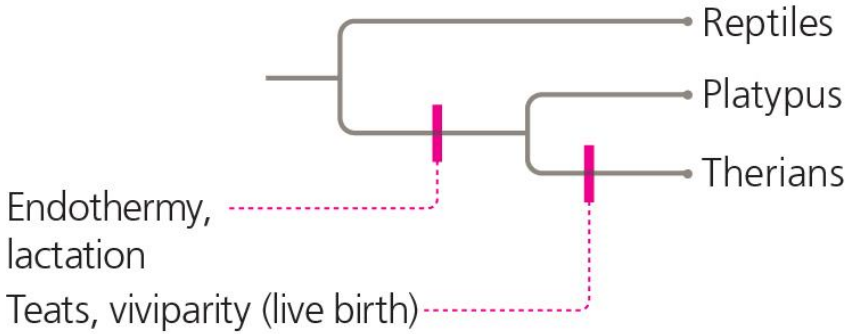
4. Does order at tips matter?

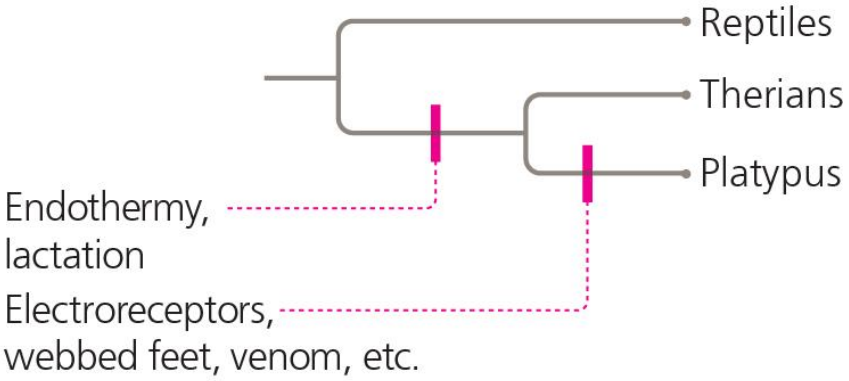
Meaning is only conveyed through branching order!

Rotate at nodes….



Order at tips is not meaningful but can affect our understanding!





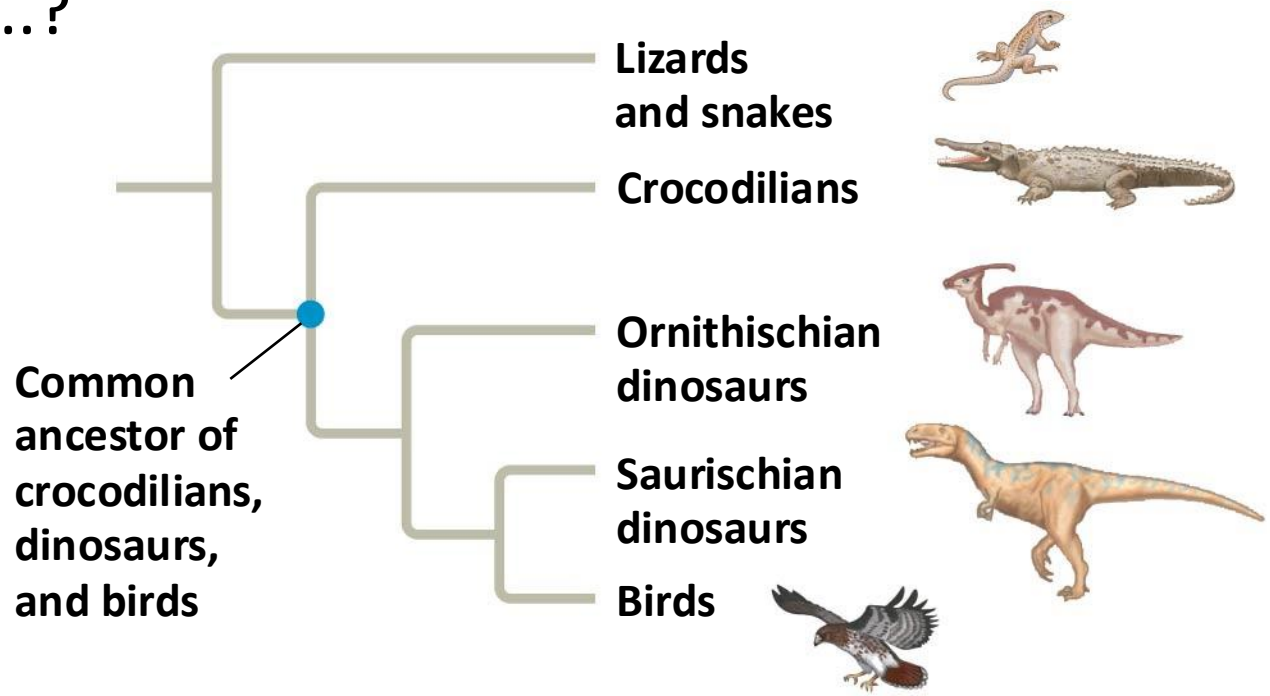
Which is the Platypus centric tree?

Note: Platypus are not viviparous, they lay eggs!!

How do we use phylogenetic trees?

We can make predictions about behavior of extinct dinos!

If crocodiles brood eggs (sit on to keep warm) and birds do too then the most **parsimonious** conclusion is that dinos….?



By: WPXI.com News Staff
Updated: January 11, 2021 - 1:09 PM

A multinational team of researchers has announced a first for the world of paleontology: A dinosaur preserved sitting atop a nest of its own eggs that include fossilized babies inside.

Researchers have preserved a dinosaur sitting atop a nest of its own eggs

https://www.wpxi.com/news/top-stories/researchers-have-preserved-dinosaur-sitting-atop-nest-its-own-eggs/XRXHSG3CYRGMNDPWCFZI4AFWSE/

We can use trees to understand the evolution of viruses and where they come from.

http://evolution.berkeley.edu/evolibrary/news/060101_batsars

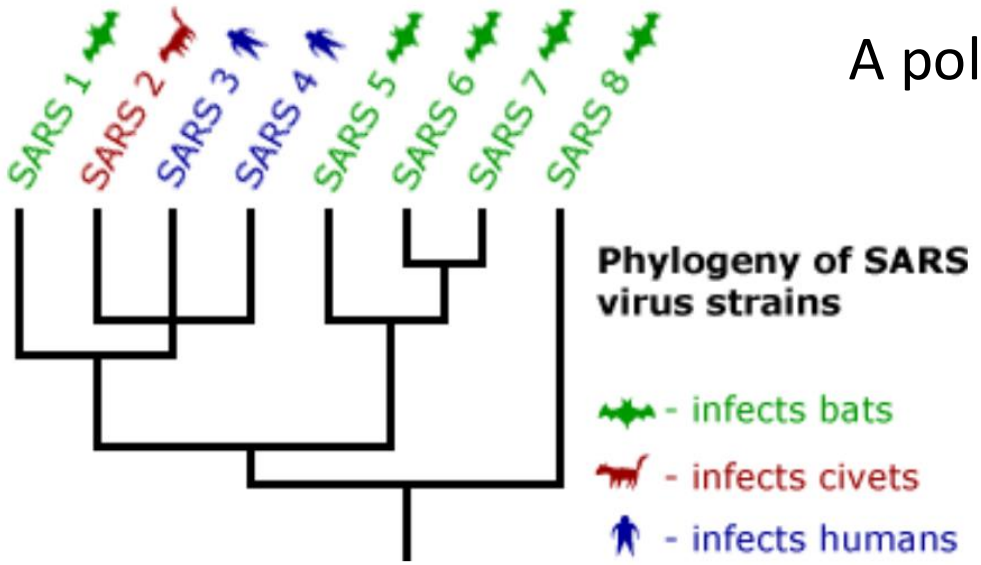
SARS virus 2002, 2003 (**SARS CoV 1**)
Where did it come from?

More than 8000 cases of illness and 774 deaths.

Jumped from a wild species (remember influenza).

Infected civets were discovered at a live animal market in southern China (where they are occasionally eaten).

Made a phylogenetic tree of various isolated viruses!



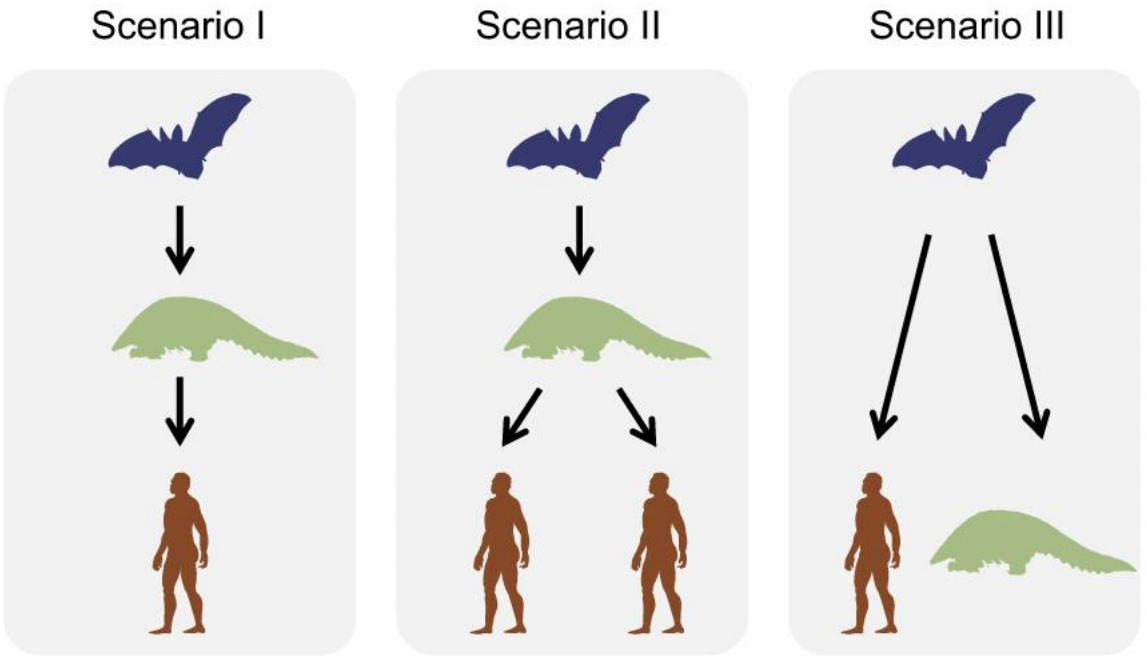
A polytomy

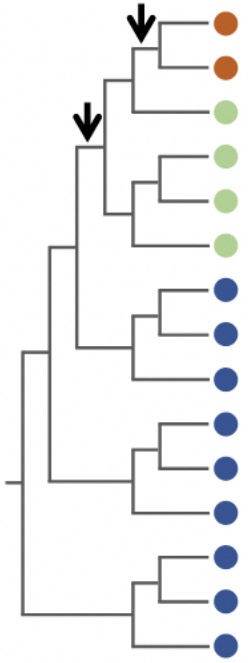
https://evolution.berkeley.edu/evolibrary/news/060101_batsars

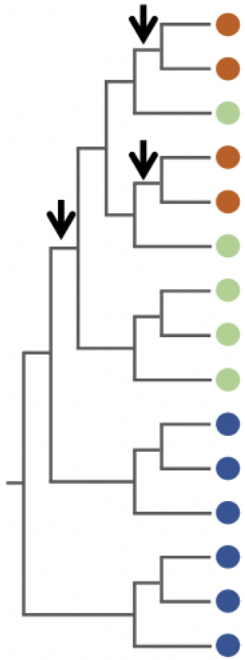
What does this phylogenetic tree suggest about **SARS Co-V1**?

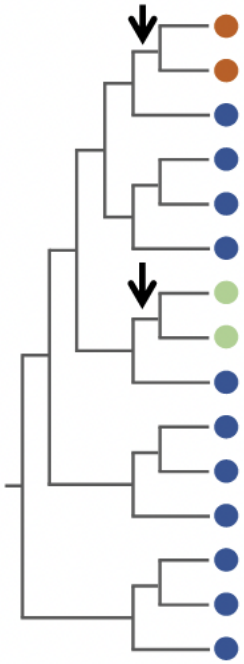
Where did the virus "come from"?

- Found infected horseshoe bats in wild
- We know bats, civets and people came into contact at a market





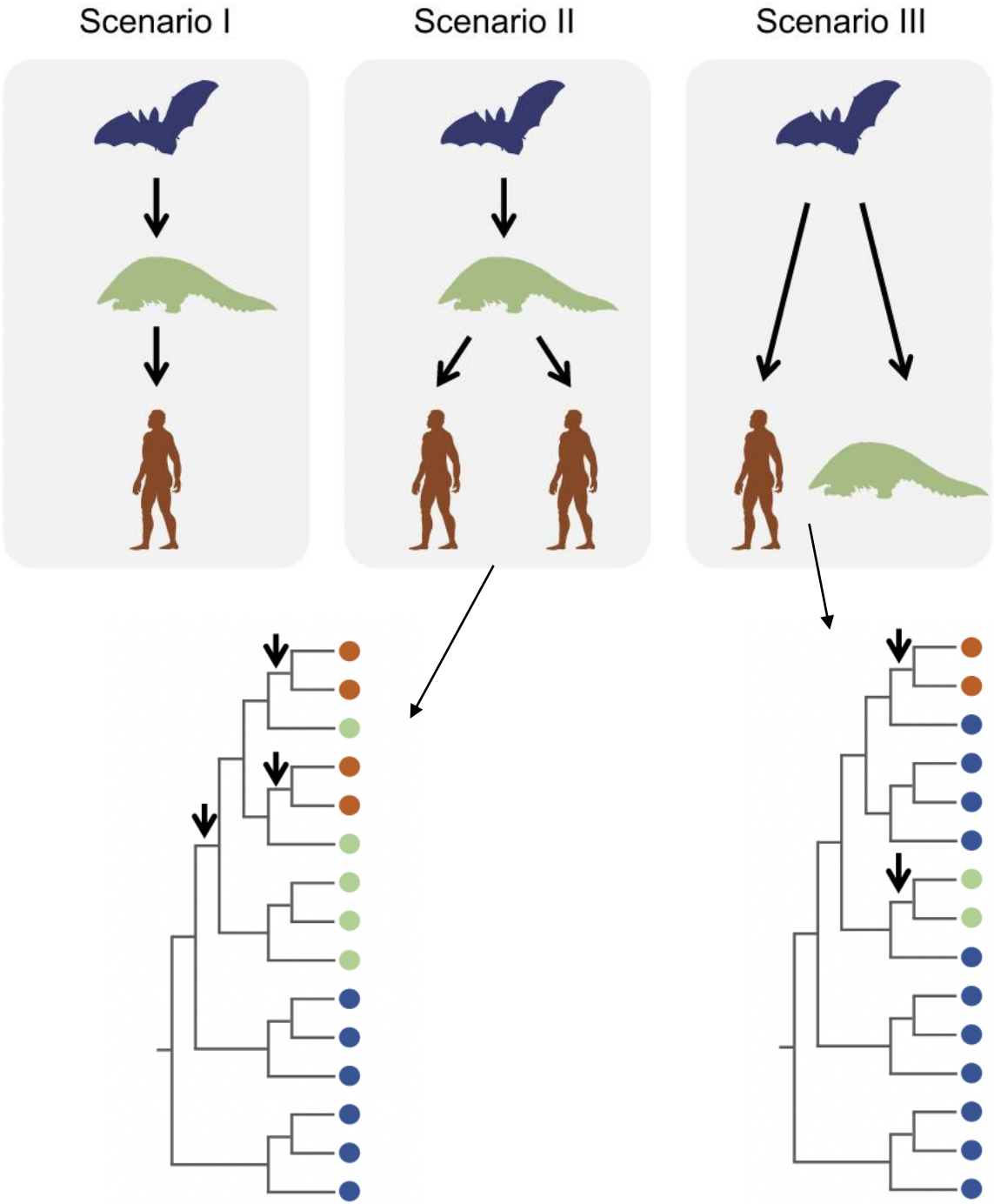




More tree reading practice with **SARS CoV 2**!

Match the phylogeny with the image.

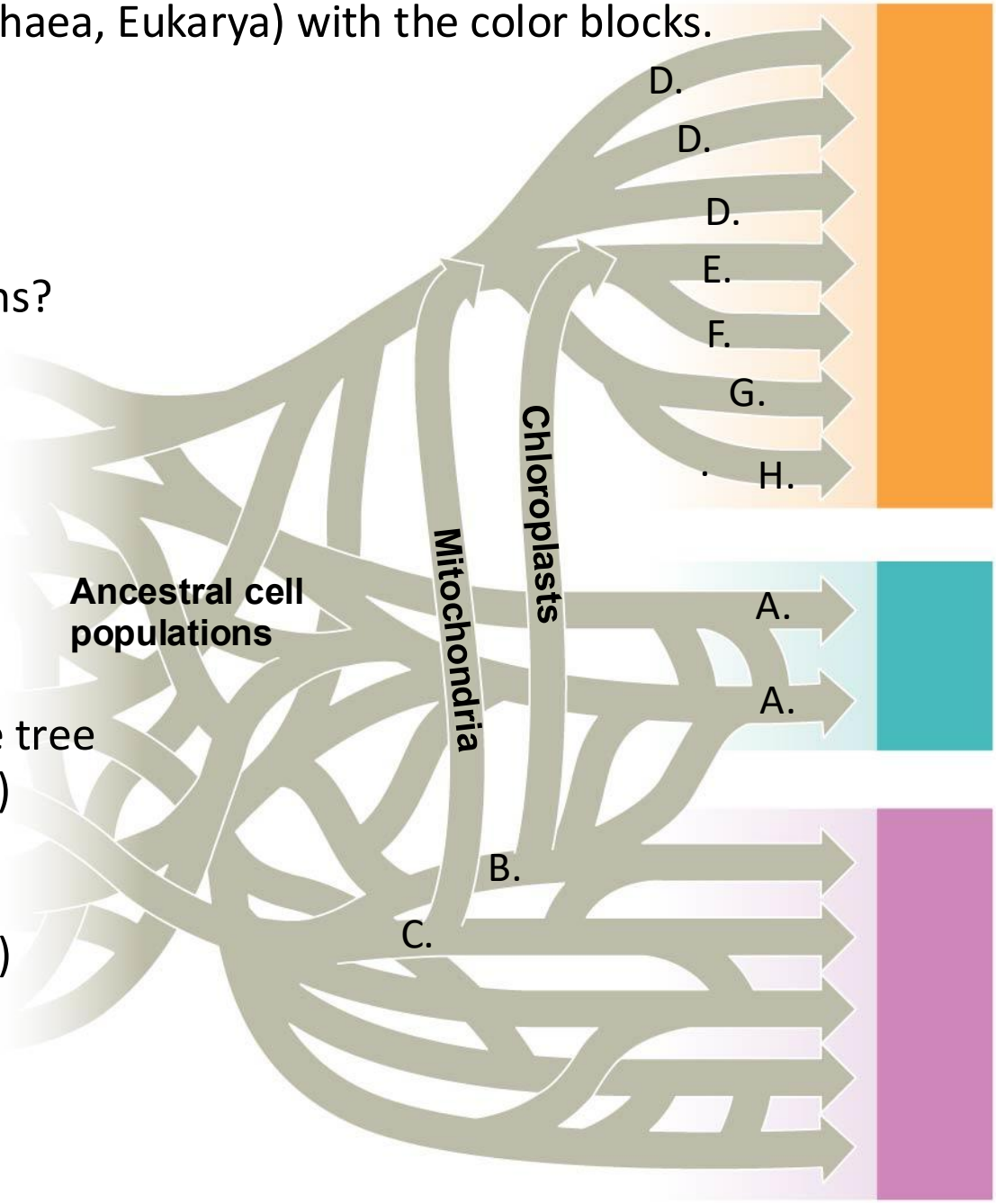
Trends in Microbiology, July 2020, Vol. 28, No. 7



Trends in Microbiology, July 2020, Vol. 28, No. 7

1. Match the Domains (Bacteria, Archaea, Eukarya) with the color blocks.
Orange=
Teal=
Purple=

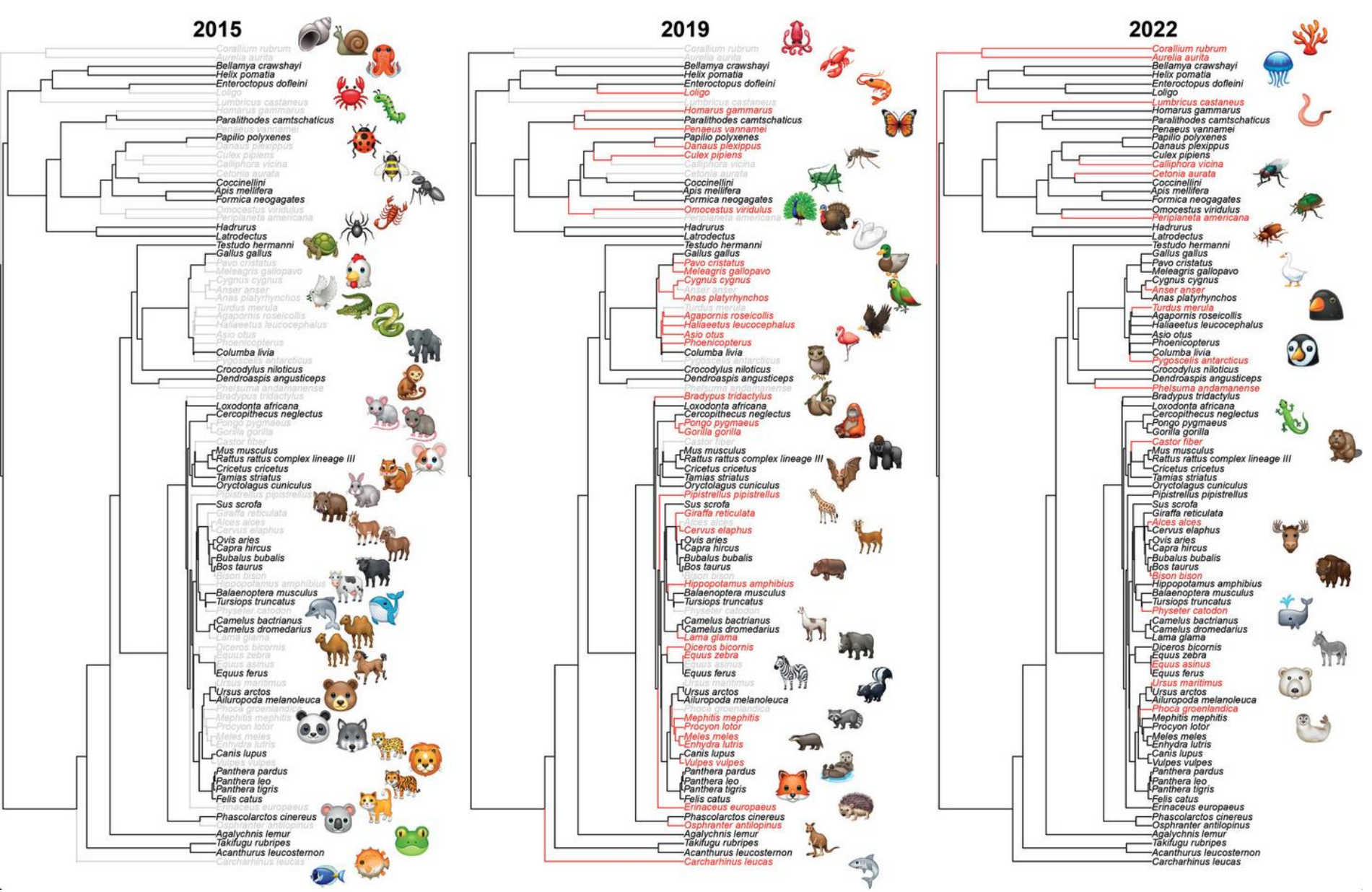
2. Which are the Prokaryotic Domains?



3. Match the lineages (A-H) onto the tree

Methanogens (or “Eury” group)
Fungi
Cyanobacteria
Thermophiles (or “Cren” group)
Animals
Proteobacteria
Plants
Photosynthetic protists
Other protists

Emoji Tree of Life
For Fun!



- Each tree has the same structure or architecture.
- The 3 versions show the emojis that have been created in the intervening years with branches for those in red.

Biodiversity communication in the digital era through the Emoji Tree of Life, *iScience* (2023). DOI: 10.1016/j.isci.2023.108569. www.cell.com/iscience/fulltext … 2589-0042(23)02646-9

Next, the researchers examined the biodiversity characteristics of the animal emojis in more detail. In some cases, they were able to identify individual animal species (for example, the bald eagle and giant panda emojis), while other emojis were only identifiable to the genus or family level (for example, emojis that represent ants or crocodilians).

Overall, 76% of the animal emojis represented vertebrates, 16% represented arthropods, and 4%, 2%, and 1% represented mollusks, cnidarians, and annelids, respectively. Given that there are 1,302,809 described species of arthropod and only 85,423 described species of vertebrate, this means that the current emoji catalog under-represents arthropod biodiversity and over-represents vertebrates.

The researchers also noted that there were no emojis representing either platyhelminths (i.e., flatworms, including tapeworms) or nematodes, despite there being more than 20,000 platyhelminth species and almost 20,000 nematode species. These biases in the emoji representation of animal biodiversity reflect known biases in biodiversity assessments and conservation analyses, including the IUCN Red List, the researchers write.