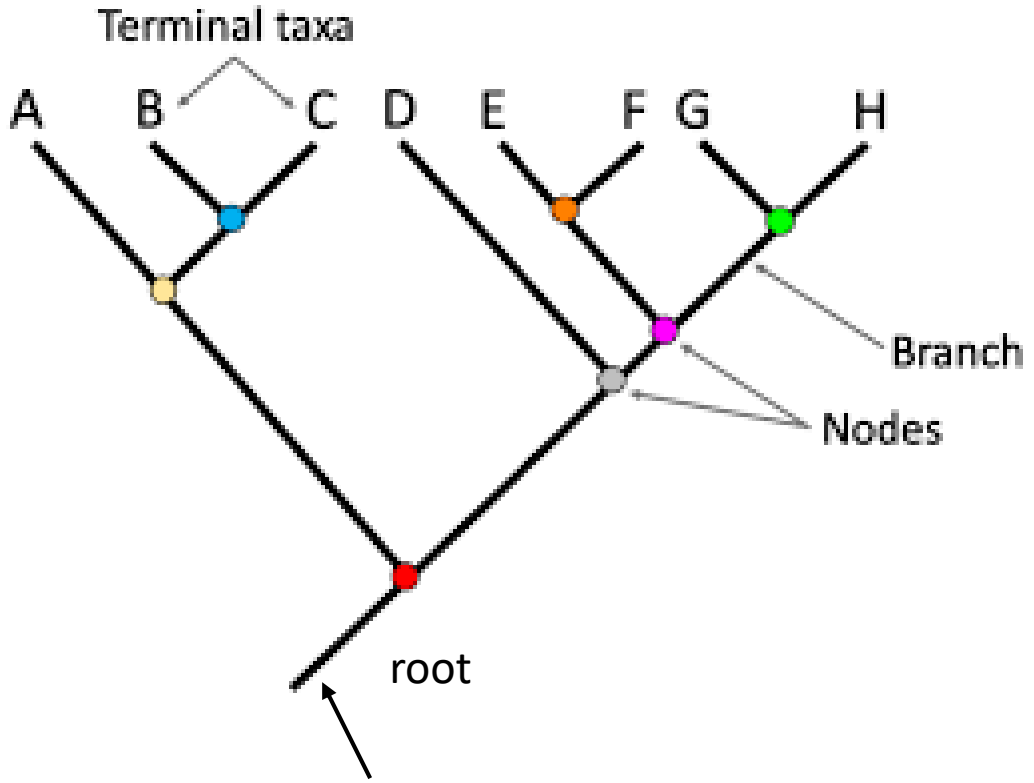
Evolution – Lecture 7: Finish Phylogenetic Trees, and start Species Concepts & Speciation

Housekeeping – Midterm #2 (20%)

- Next class (Tuesday)
- Start time: Section 224: 11:05 Section 221: 5:05 pm
- Testable content – All evolution lectures up to and including phylogenetic trees
- 4 major questions, plus one bonus questions (no total yet)
- Highly recommend bringing a calculator
- Same rules as midterm #1 with respect to study sheet, and implications if you write in pencil, erasable pen, and/or use white-out.
- Please see Canvas > Midterm #2 module for more details.
- Ruby & Christie's Review Session on Zoom: Saturday @ 2 pm. Office Hours link. Pre-review session slides will be posted Friday at the lasts > midterm #2 module and Important Dates
- Brett's study session is this Friday in SCRF 100, 5:00 pm – 6:50 pm (will be recorded)

Last class – started Phylogenetic Trees

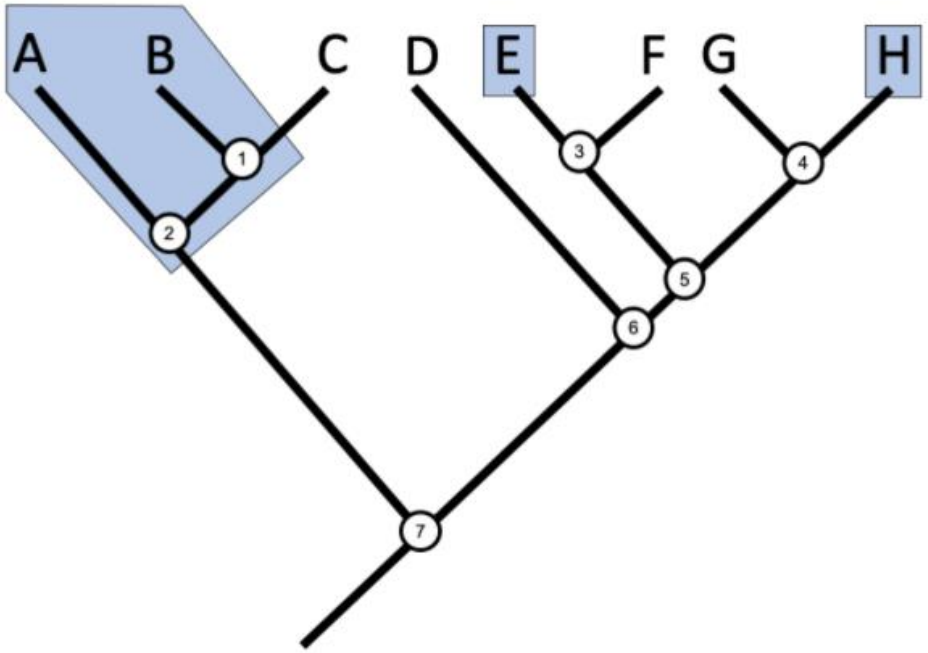
- Elements of a tree
- How to read a tree



Reading a tree - Learning objective #1

Be able to identify monophyletic, paraphyletic and polyphyletic groups in a tree.

iClicker Question



Are the species highlighted in blue (A, B, E, H, 1 & 2) an example of a:

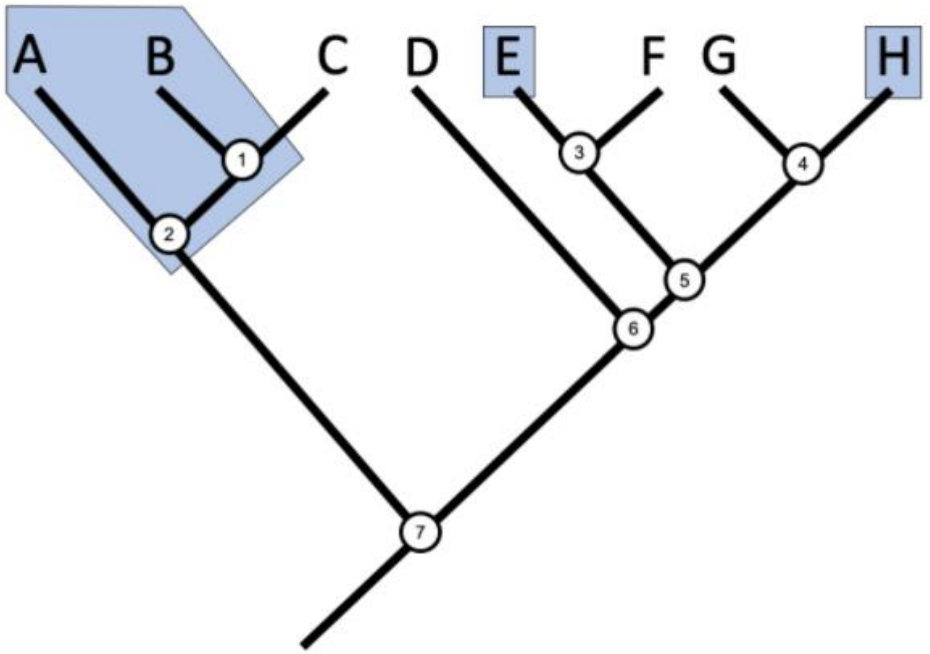
A. Monophyletic group

B. Paraphyletic group

C. Polyphyletic group

D. Not sure

Answer



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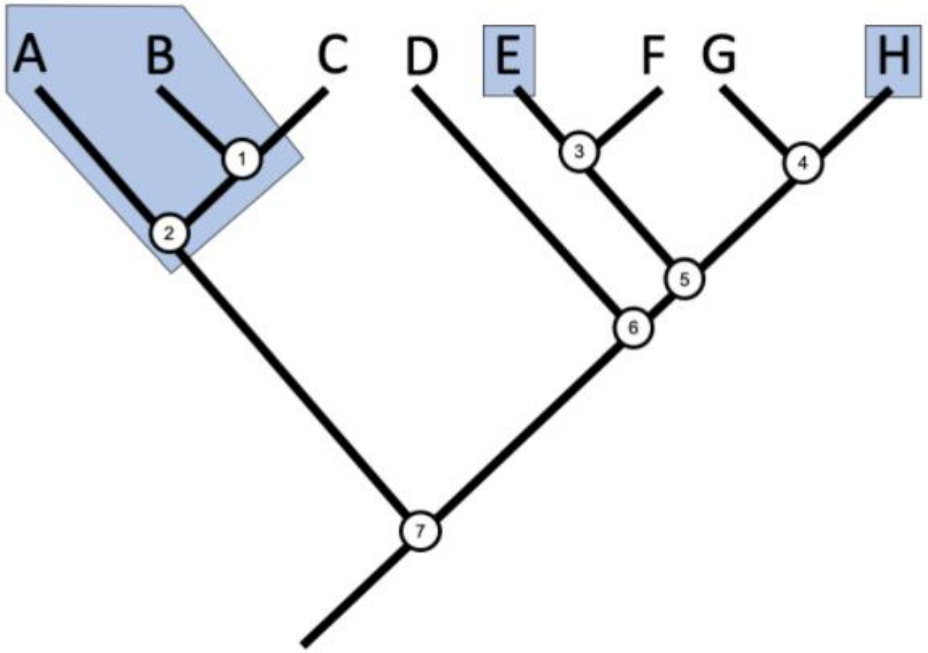
iClicker Question



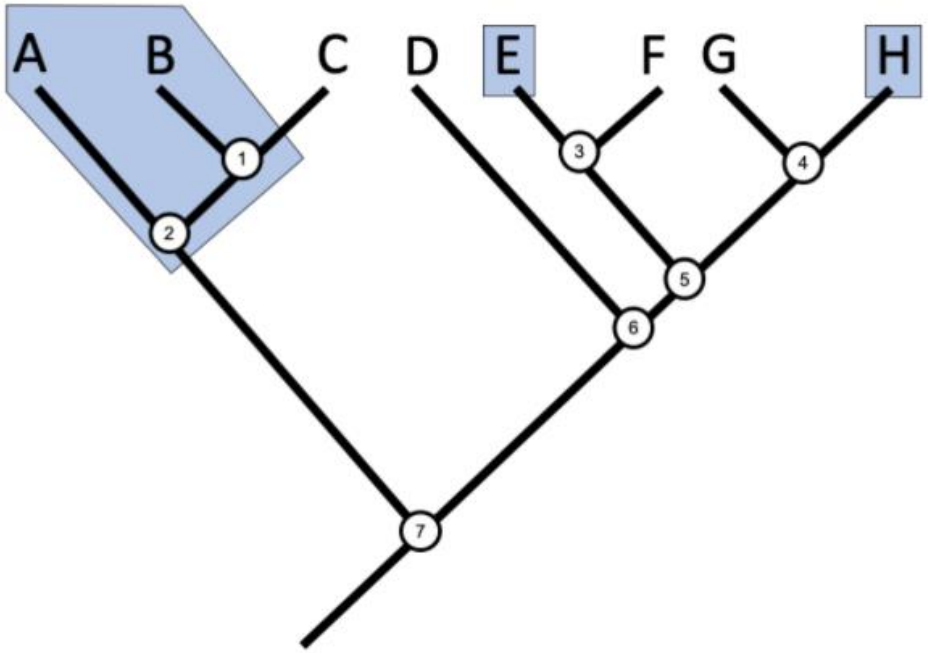
Would taxa A, B, C and 2 be considered a monophyletic group?

A. Yes

B. No

C. Not sure

Answer



Would taxa A, B, C and 2 be considered a monophyletic group?

A. Yes

B. No

C. Not sure

Species 1 (common ancestor of B and C) should also be included.

Synapomorphies

Monophyletic groups are typically distinguished by synapomorphies.

- (*syn*=shared; *morphe*=shape/form).

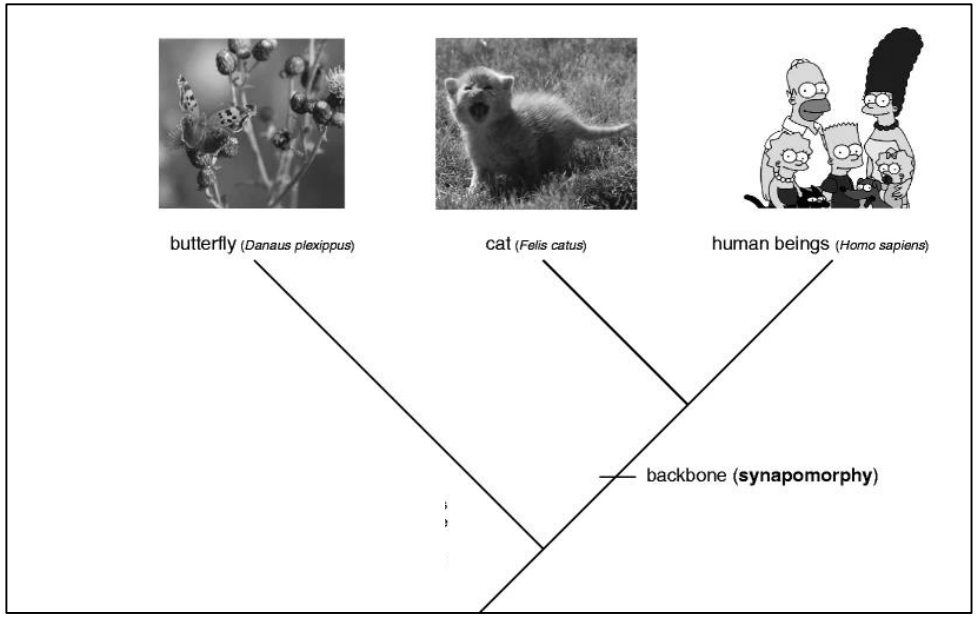
- these are shared homologous traits that were inherited from the most recent common ancestor to the group.

- they help distinguish one monophyletic group from another

- the term (synapomorphy) will become important when we discuss the phylogenetic species concept next class.

Synapomorphies

In this tree, having a backbone would be a synapomorphy for humans and cats. This trait can be used to distinguish the monophyletic group that includes cats, humans and their common ancestor from butterflies (which lack a backbone).



Symplesiomorphy (not testable)

Not all homologous traits are synapomorphies.

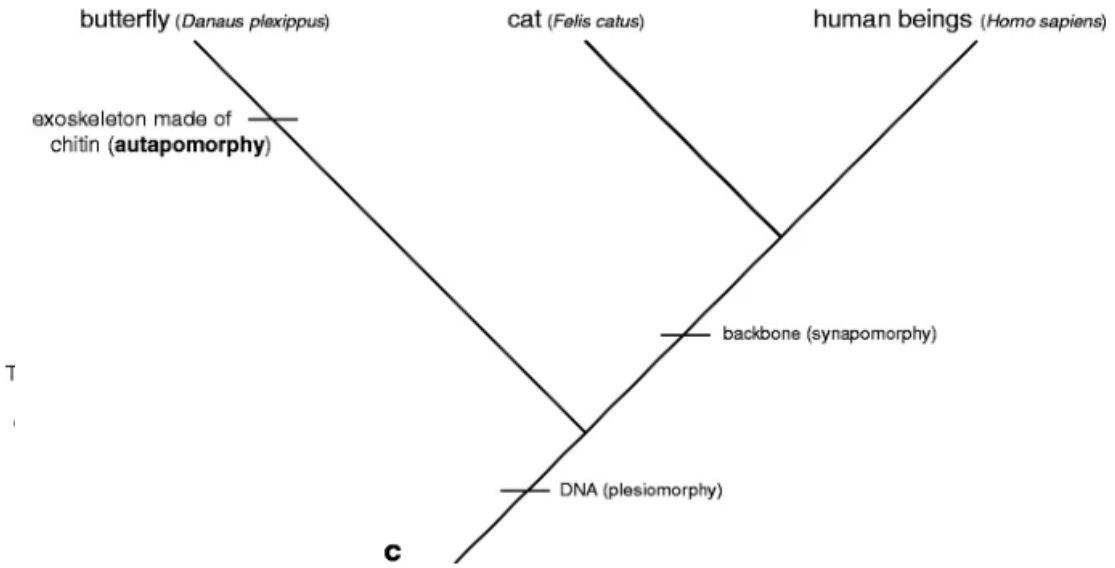
- synapomorphies are inherited from the most recent common ancestor to the group.

Symplesiomorphies are homologous traits that were inherited from a more distant ancestor (as opposed to the most recent common ancestor); so, not unique to a group.

Symplesiomorphy = a homologous trait that is shared by some or all members of a monophyletic groups, but is not unique to that group.

Symplesiomorphy (not testable)

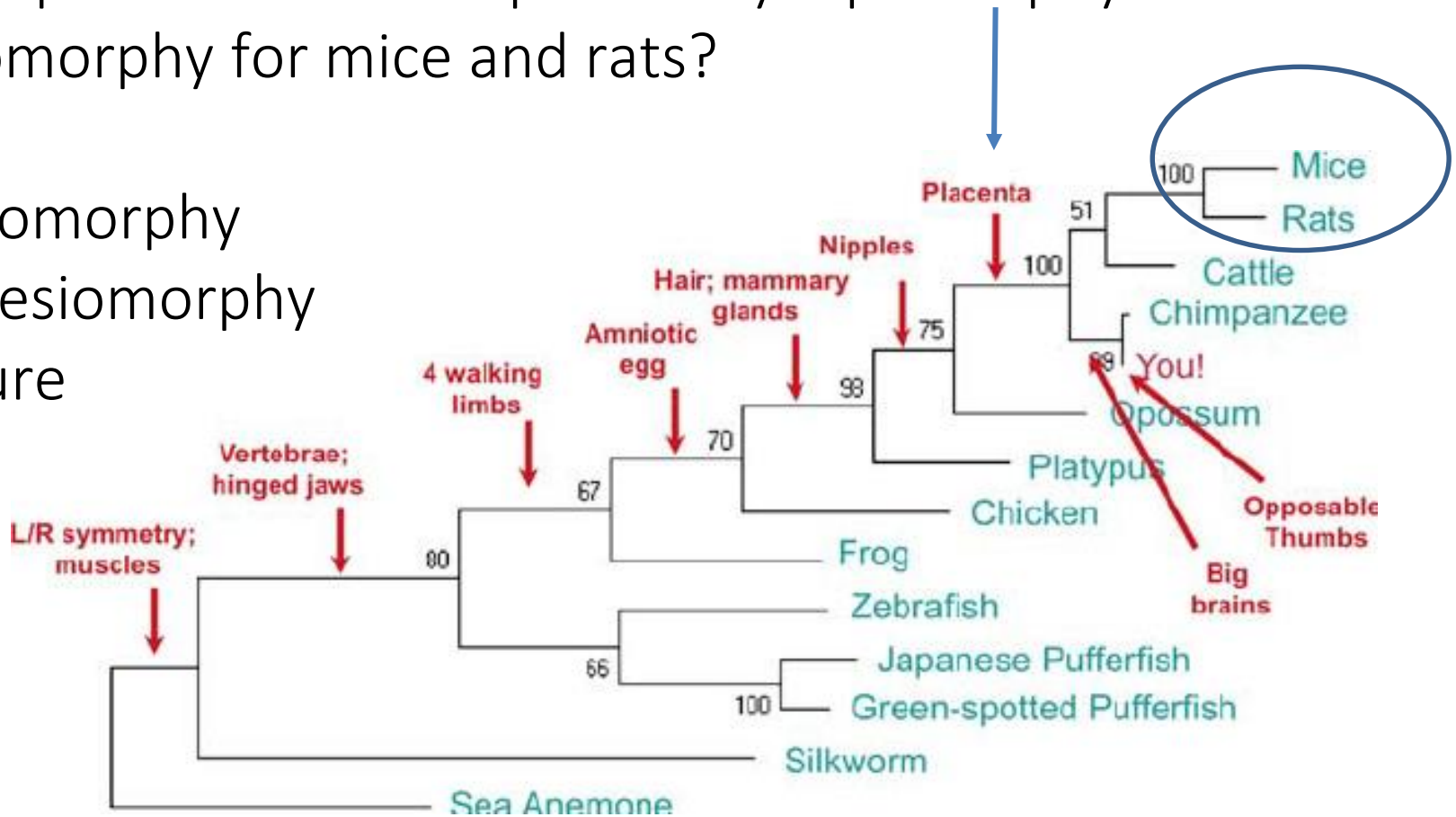
- The DNA in cats and humans is homologous. However, you would not classify DNA as a synapomorphy for cats and humans
- Why? Because it was inherited from a more distant ancestor (not from the most recent ancestor to cats and humans).
- DNA does not define cats and humans as a monophyletic group.
- Presence of DNA us that all 3 taxa are related
- But does not tell us who is more closely related to whom.



iClicker Question

Is having a placenta an example of a synapomorphy or a symplesiomorphy for mice and rats?

A. Synapomorphy
B. Symplesiomorphy
C. Not sure



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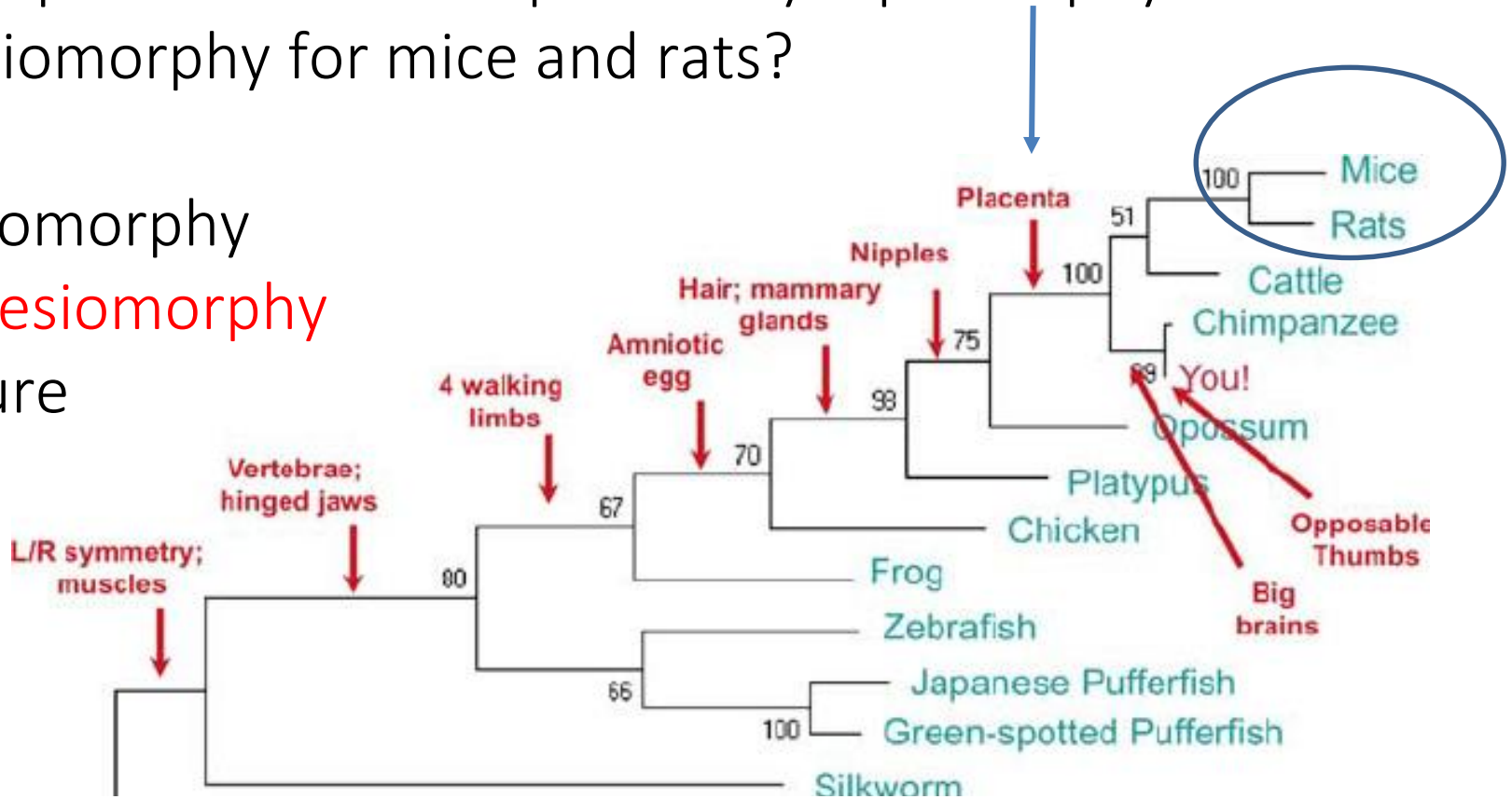


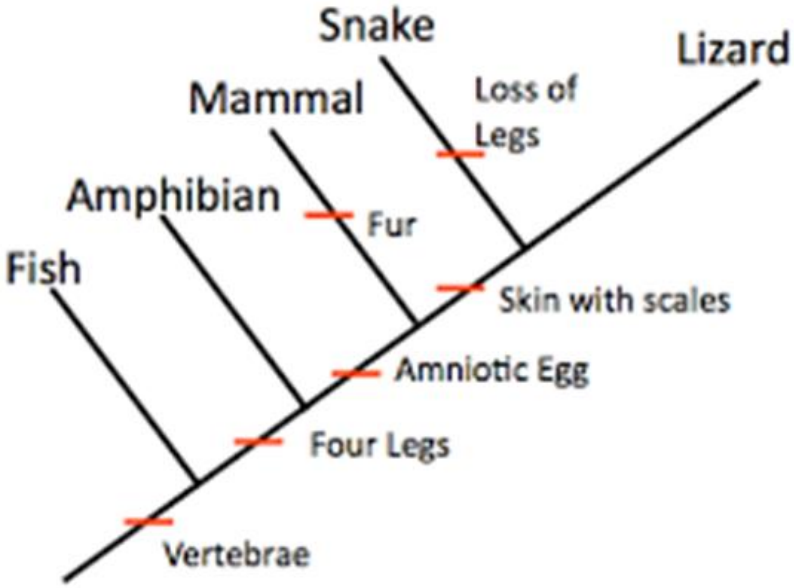
The placenta is a homologous structure for mice and rats. However:

- This trait was not inherited from the immediate common ancestor to mice and rats; it was inherited from a more distant ancestor
- And, this trait does not mice, rats and their common ancestor from other monophyletic groups.

iClicker Question

Is fur a synapomorphy for mammals?

A. Yes – it is a homologous structure that helps define the clade mammals.
B. No – it is a symplesiomorphy
C. Not sure



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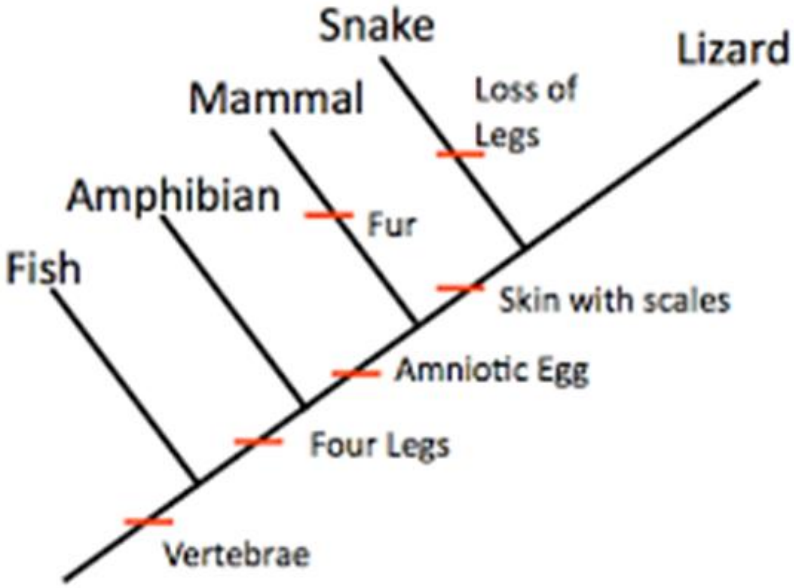
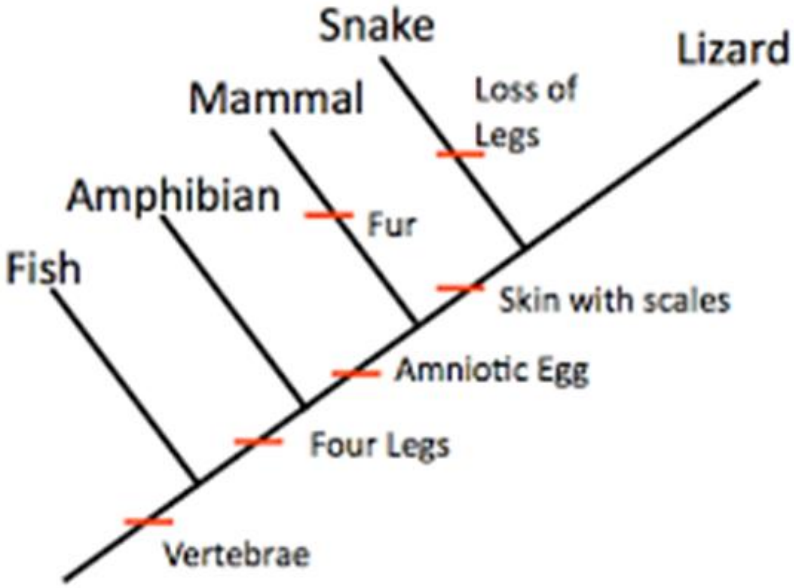


iClicker Question

Is having four legs a synapomorphy for mammals and lizards?

A. Yes – it is a homologous structure that helps define this clade.
B. No – it is a symplesiomorphy because it was not inherited from the immediate common ancestor of mammals and lizards.
C. Not sure



Answer

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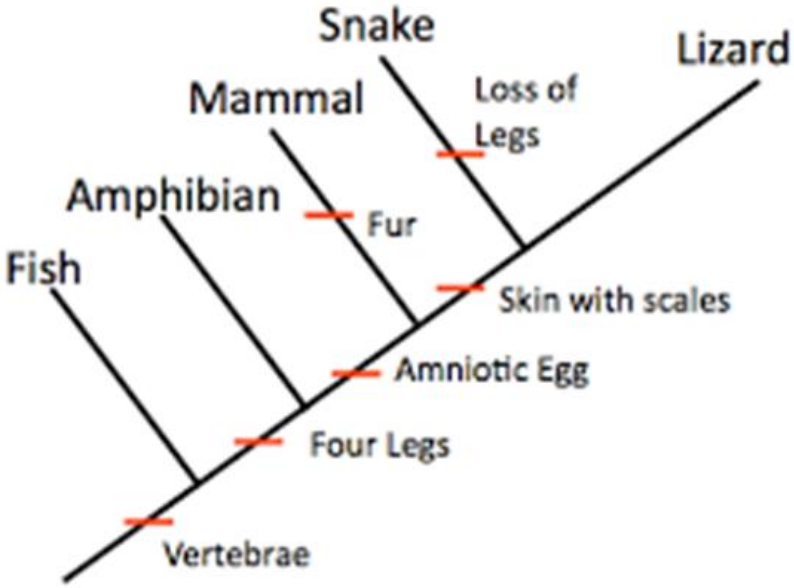


Learning objective #2

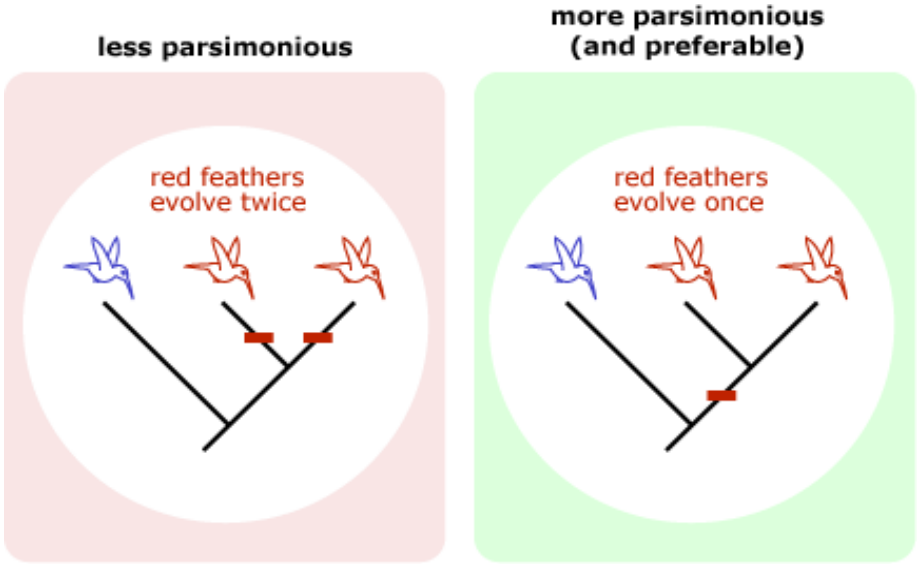
Predict the number of times a trait has been gained or lost based on a phylogeny using the principle of parsimony

Principle of Parsimony – character marks

- Often data can generate more than one phylogenetic tree
- Principle of Parsimony is used to determine which tree represents the "best hypothesis"
- Simply stated, parsimony is the assumption that the simplest explanation is most likely to be true

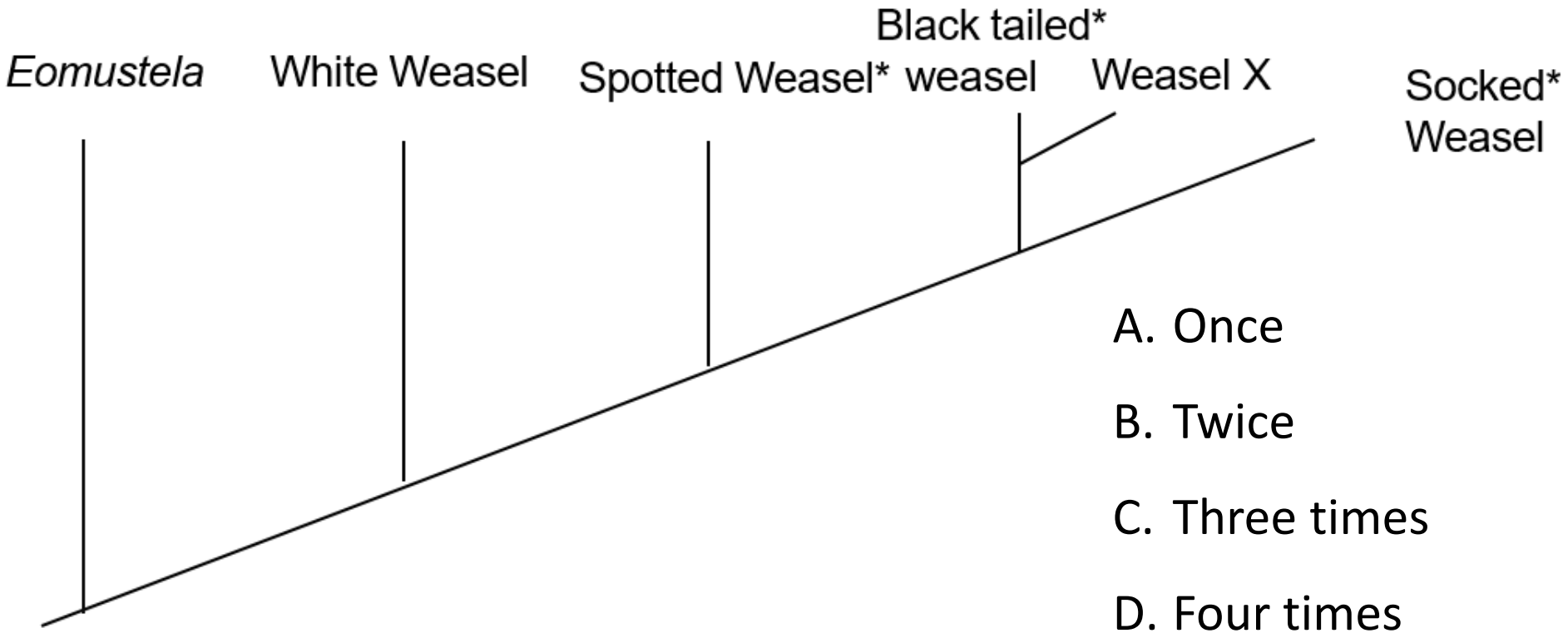
i.e. so a tree containing the fewest number of evolutionary changes is most likely to be correct.

Most parsimonious explanation
- the trait of red feathers arose once
- requires only one evolutionary change (not two evolutionary events)



iClicker Question

Assume spots can be gained and lost. How many times has spots been gained in weasels? (*=presence of spots)



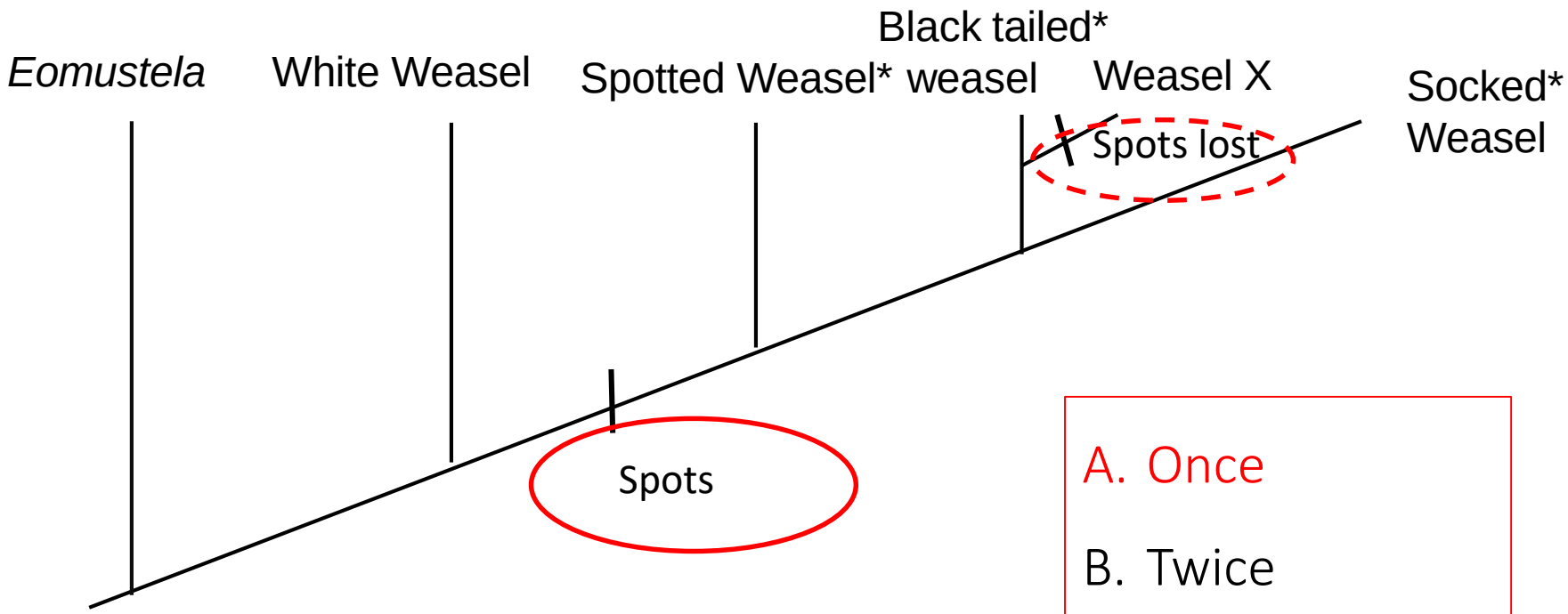
A. Once

B. Twice

C. Three times

D. Four times

E. Not sure



A. Once

B. Twice

C. Three times

D. Four times

E. Not sure

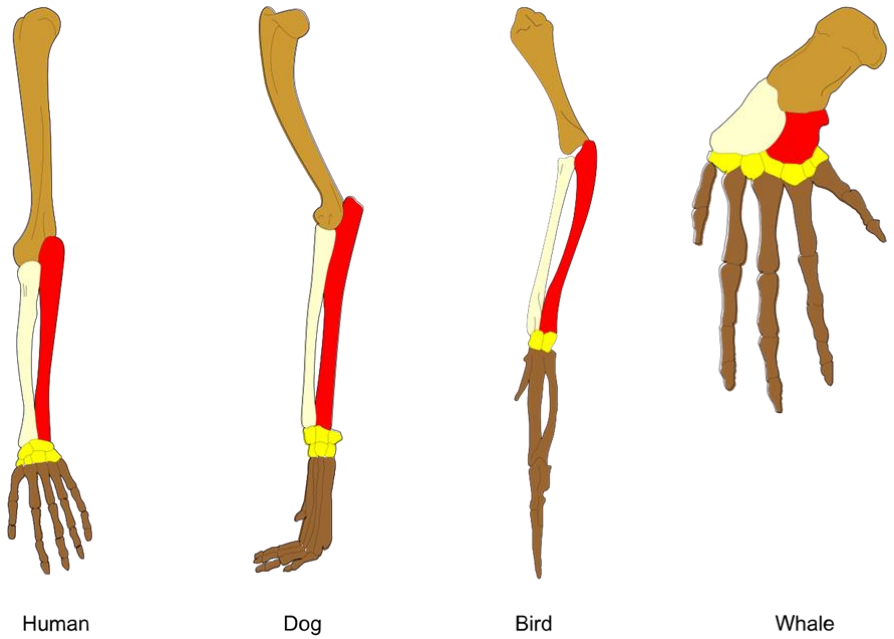
Learning objective #3

Be able to identify if a shared trait is homologous or analogous (homoplasy).

Homologous traits

Homologous traits are traits shared by 2 or more taxa because the trait was inherited from a common ancestor.

Biologists use homologous traits to construct phylogenetic trees because they indicate relatedness.



Analogous Traits (or Homoplasies) – testable

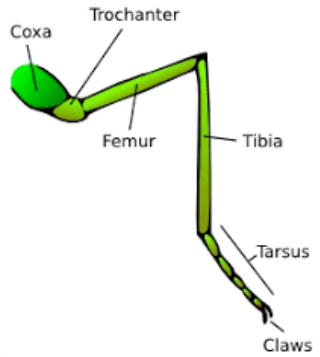
- Not all traits that look the same were necessarily inherited from a common ancestor.

- In a previous class, we discussed how fins and a streamline shape are not homologous traits in whales and sharks (remember - whale ancestor was terrestrial).

Analogous traits or homoplasies

- Analogous traits or homoplasies arise due to **convergent evolution (testable)**, i.e. independent solution to an environmental demand – not from a common ancestor

- The streamlined shape and fins represents a similar solution to the same environmental demand (moving efficiently through the water).



https://brainly.com/question/11735146

ADAM.

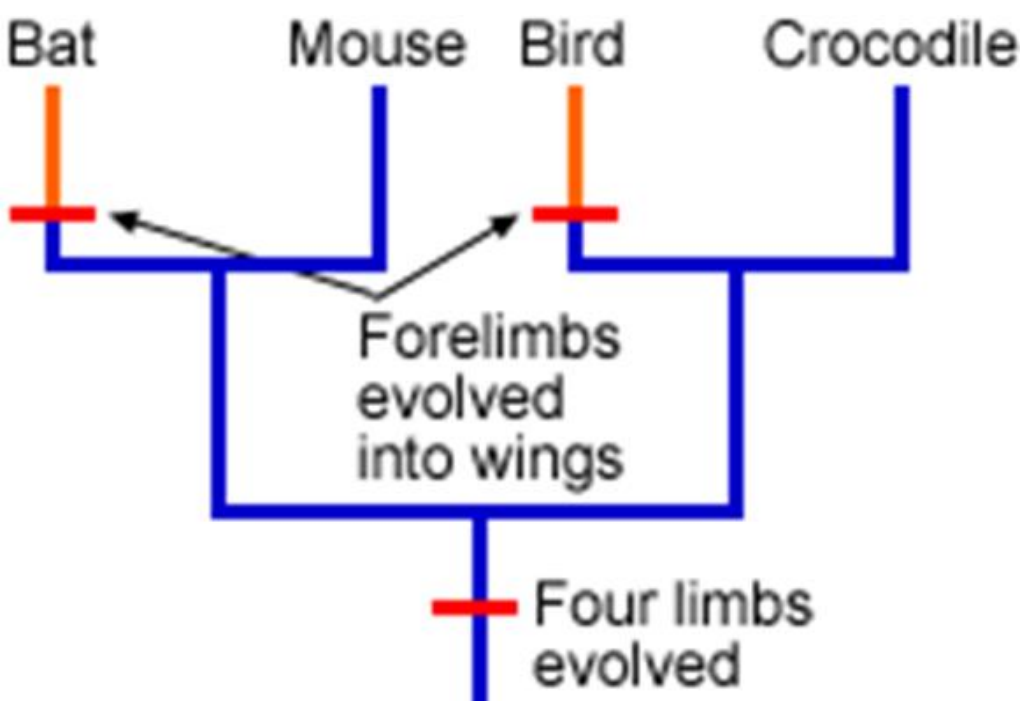
iClicker question

Is the presence of four limbs a homologous trait for bats, mice, birds and crocodiles?

A. Yes

B. No

C. Not sure



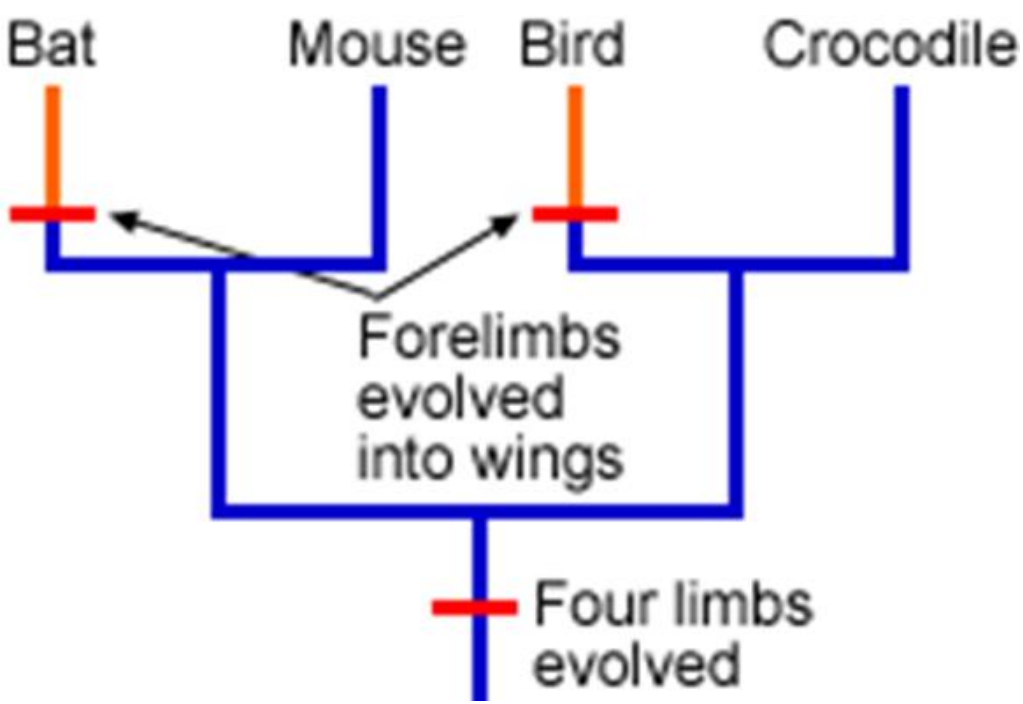
Answer

Is the presence of four limbs a homologous trait for bats, mice, birds and crocodiles?

A. Yes – arose in common ancestor to the 4 taxa

B. No

C. Not sure



iClicker Question

Are opposable thumbs of primates an example of:

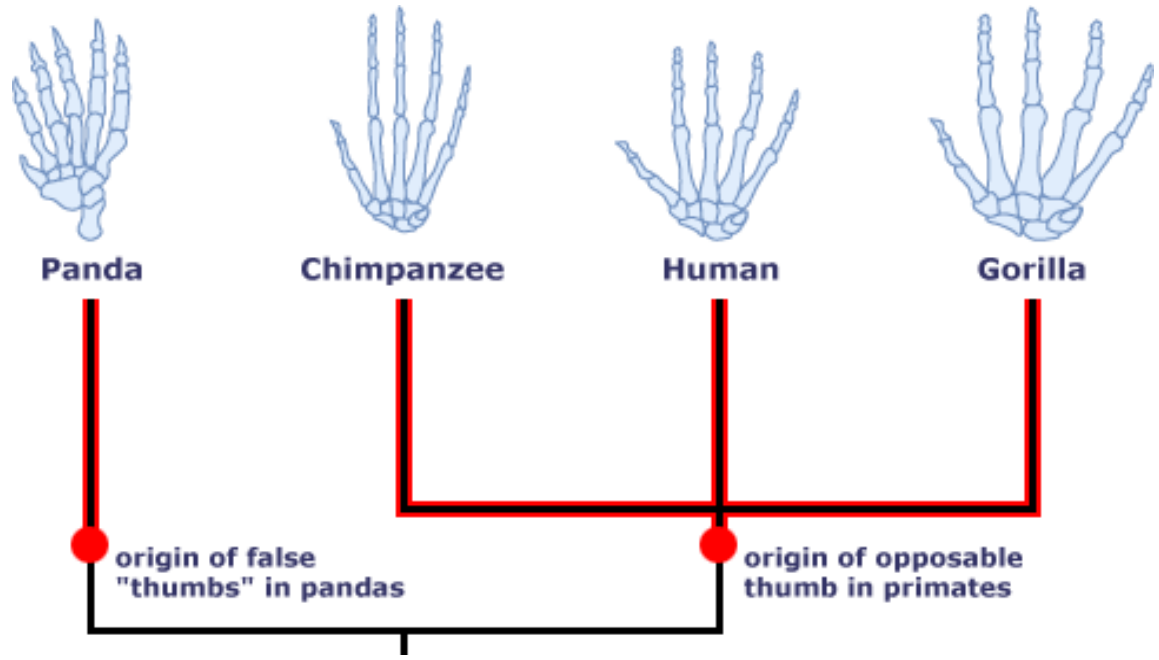
A. a Homologous trait

B. an Analogous trait (or homoplasy)

C. a Synapomorphy

D. Convergent evolution

E. A and C



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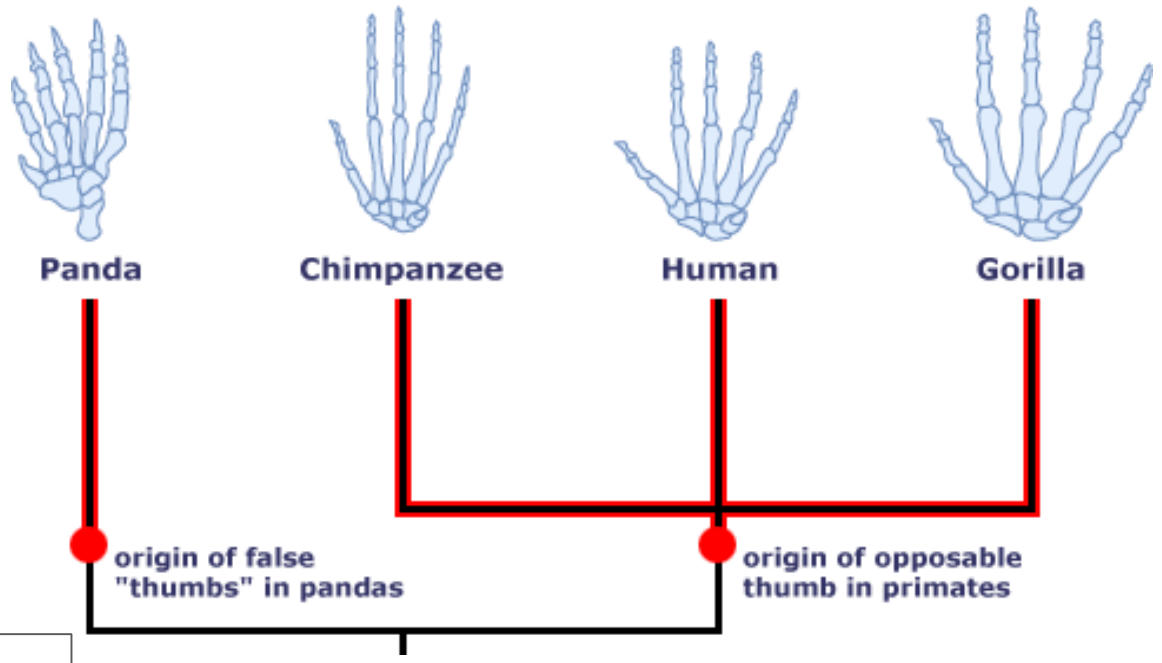


The opposable thumb in primates arose in the common ancestor to the primates (see red dot).
- Also note that red dot is on vertical line.

iClicker Question

Are opposable thumbs of primates and pandas an example of:

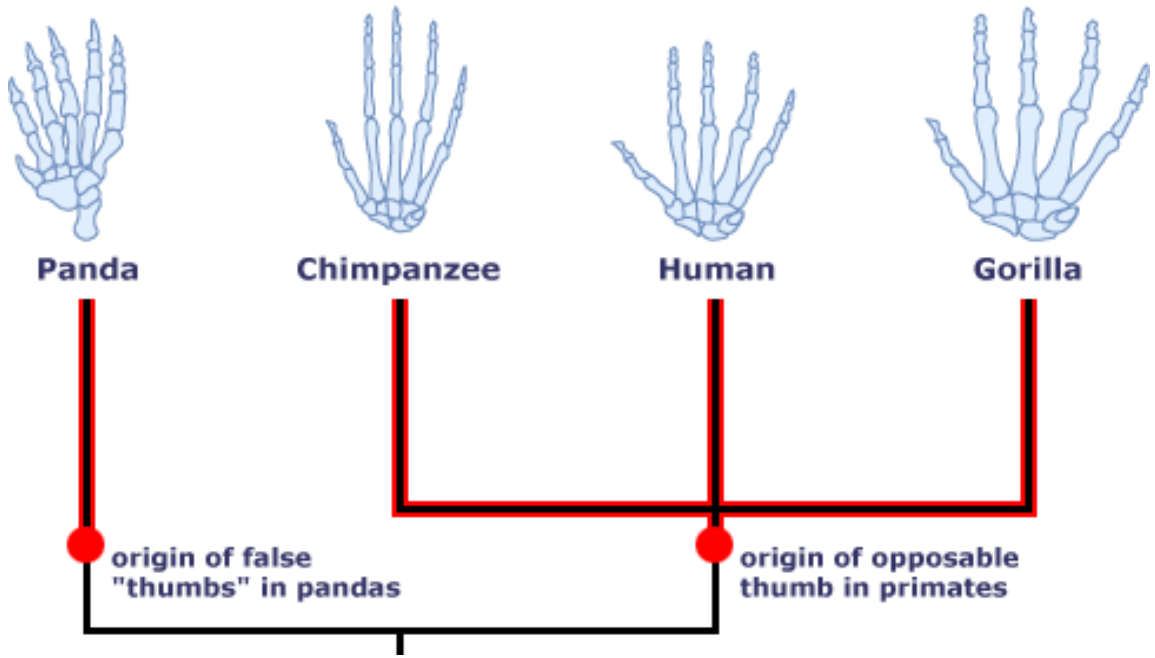
A. a Homologous trait

B. an Analogous trait (Homoplasy)

C. a Synapomorphy

D. Convergent evolution

E. B and D



Answer

Are opposable thumbs of primates and pandas an example of:

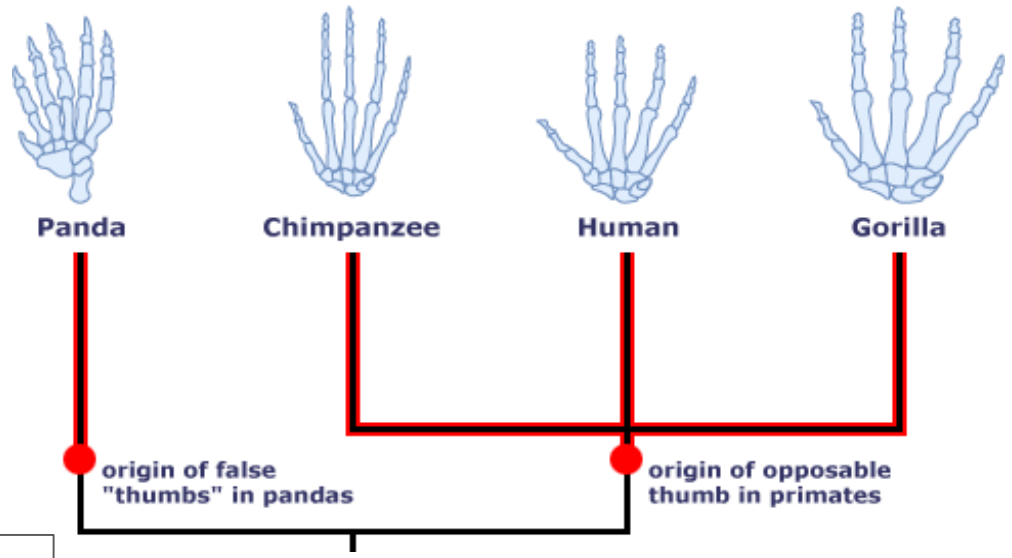
A. a Homologous trait

B. an Analogous trait (or homoplasy)

C. a Synapomorphy

D. Convergent evolution

E. B and D



The false thumb in pandas and the opposable thumbs of primates arose independently in the lineages leading to pandas and primates (see red dots). It is a result of convergent evolution, i.e. similar solution to the same environmental demand, e.g. how to manipulate objects such as food.

Learning objective #4

Given a phylogeny, identify the most closely related taxa to a particular taxon and justify your conclusion based on information from the phylogeny.

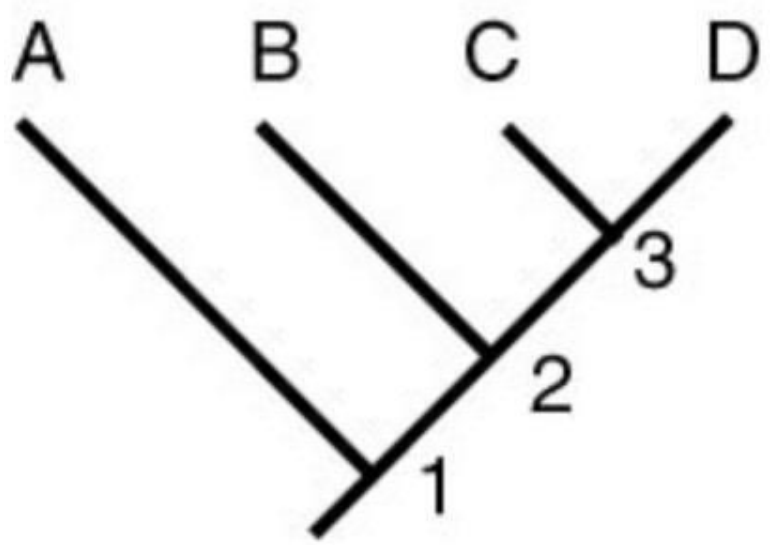
ONLY ACCEPTABLE CRITERIA - LOOK AT WHO SHARES THE MORE RECENT COMMON ANCESTOR

- More closely related taxa share a more recent common ancestor

iClicker Question

Which organism is B most closely related to – A or D?

A. Organism A
B. Organism D
C. Not sure



Answer

Which organism is B most closely related to – A or D?

A. Organism A
B. Organism D
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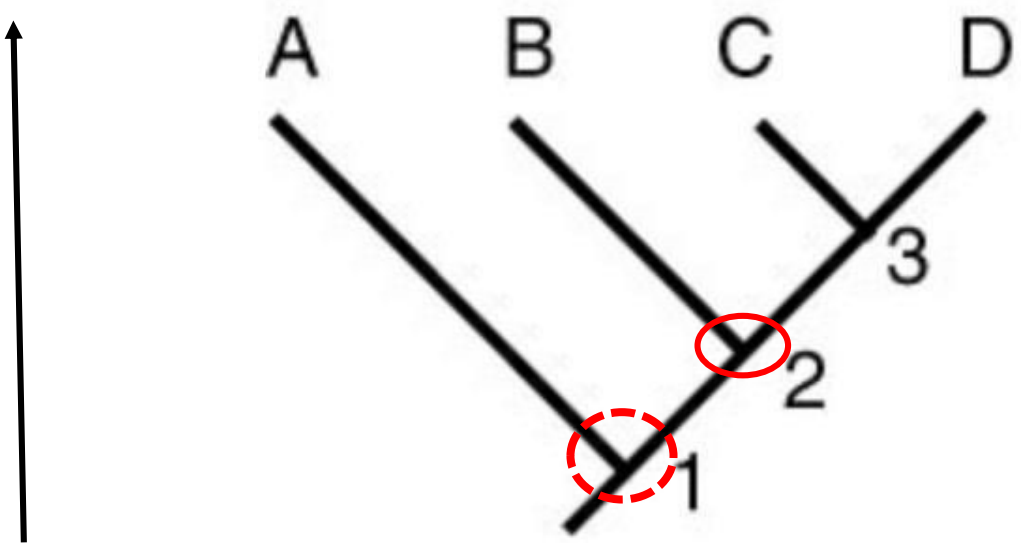
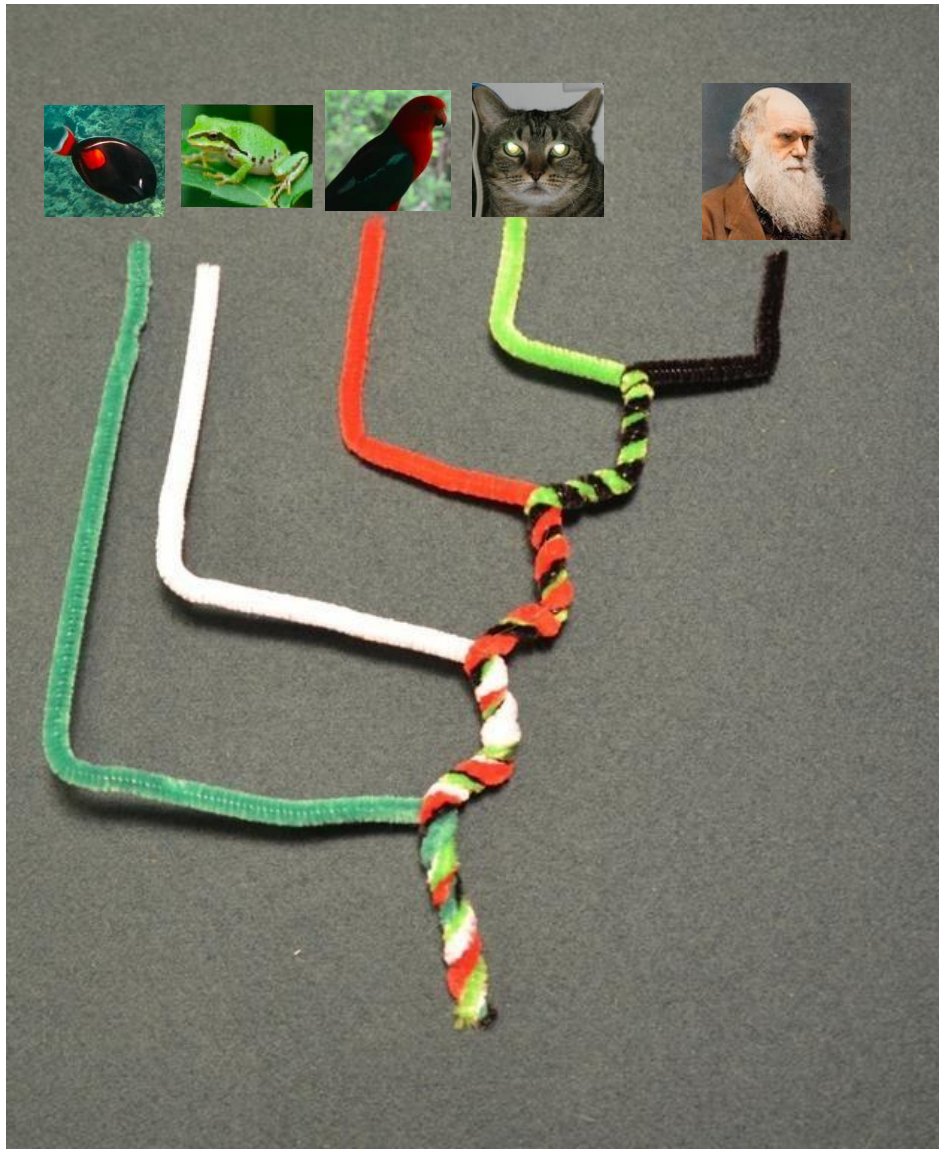
Time



Taxa B shared a more recent common ancestor with Taxa D (@ 2) than Taxa A (@1)

iClicker Question



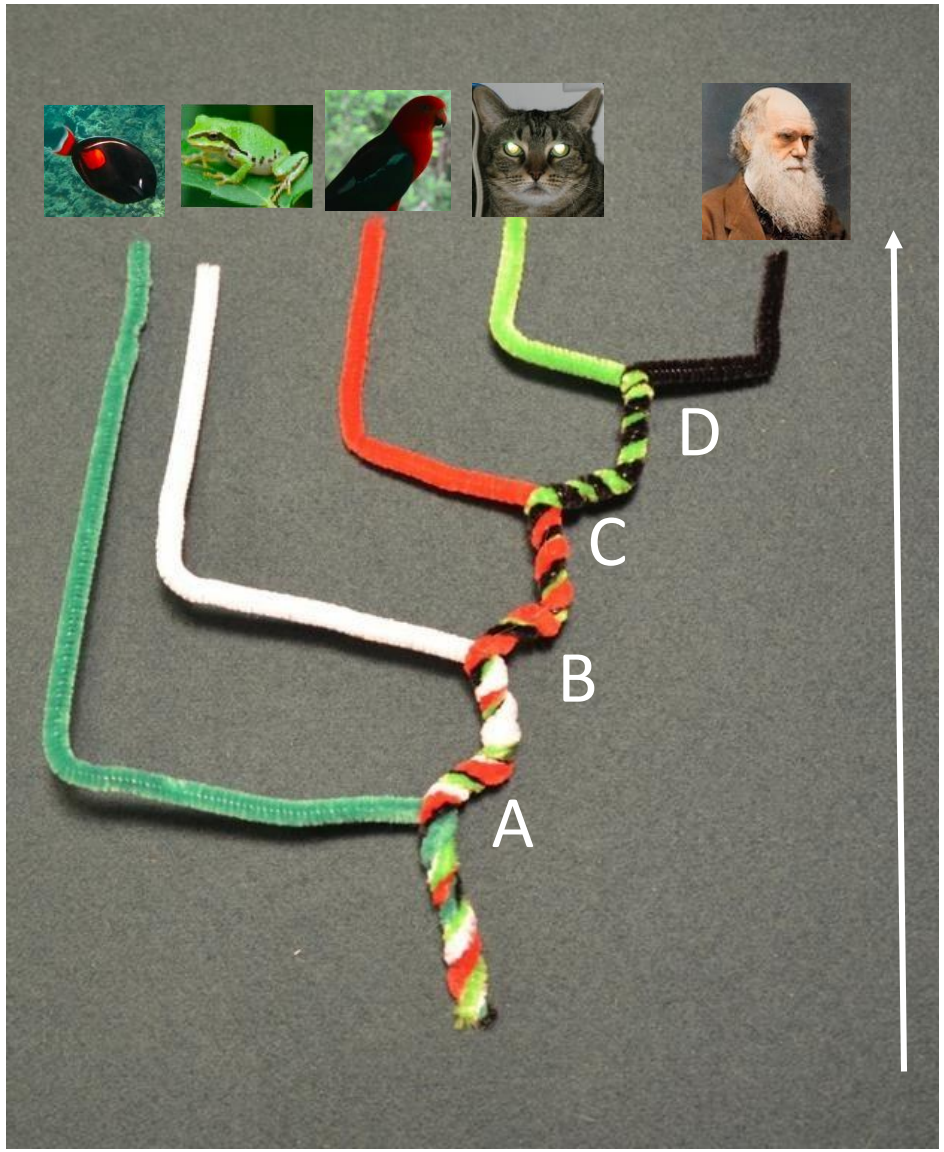
Frogs are more closely related to fish than frogs than to humans. Is this statement:

A. True

B. False

C. Not sure

Answer



Frogs are more closely related to fish than frogs than to humans. Is this statement:

A. True

B. False

C. Not sure

Look at the common ancestors – who shared a common ancestor more recently.

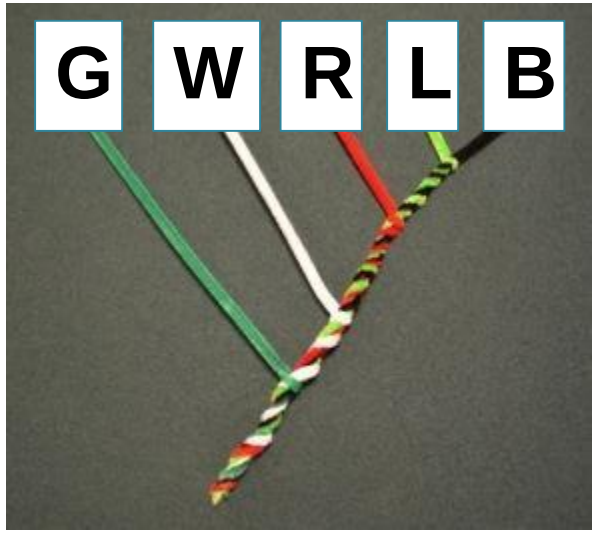
Learning objective #5

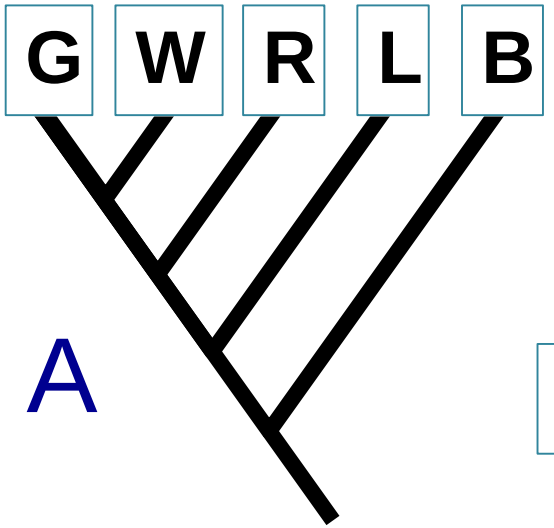
Determine if two trees for the same taxa show the same pattern of relationships among taxa and justify your conclusion with specific reference to trees.

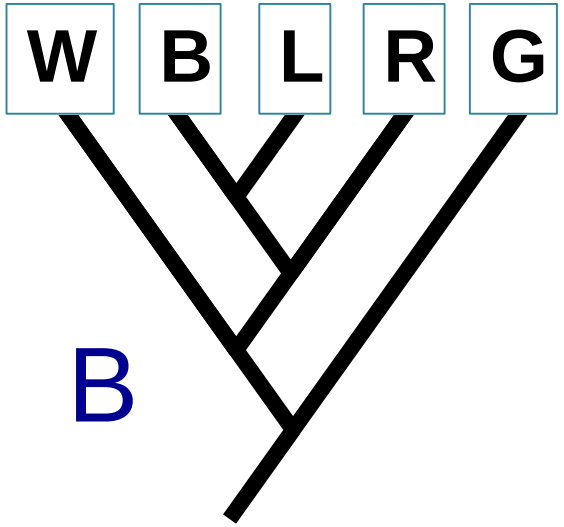
LOOK AT THE MONOPHYLETIC GROUPS – ARE THEY THE SAME OR NOT

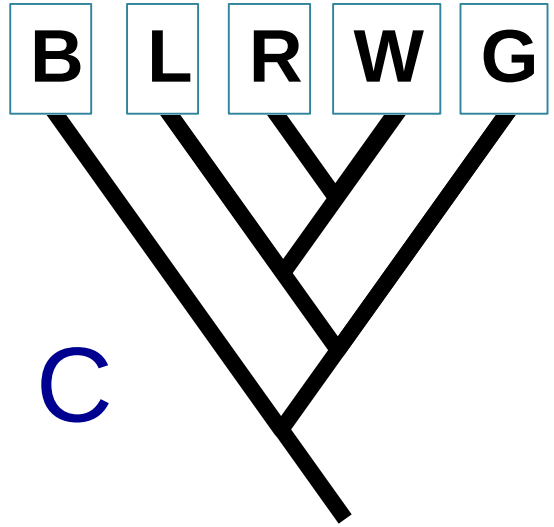
iClicker Question

Which phylogenetic tree shows the same relationships between taxa as the tree on the right? Hint – look at monophyletic groups









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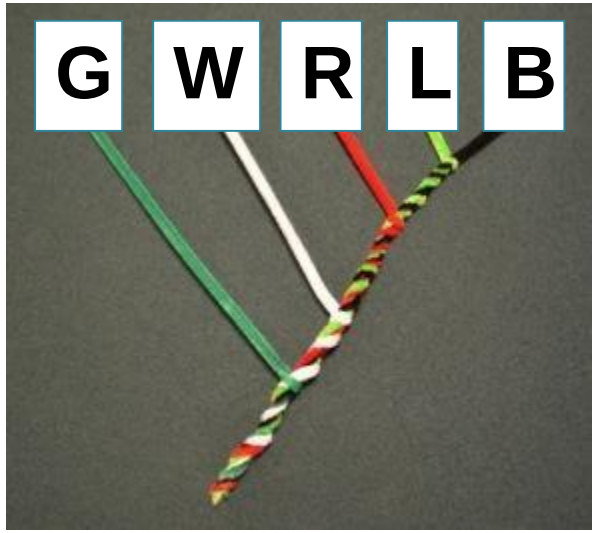
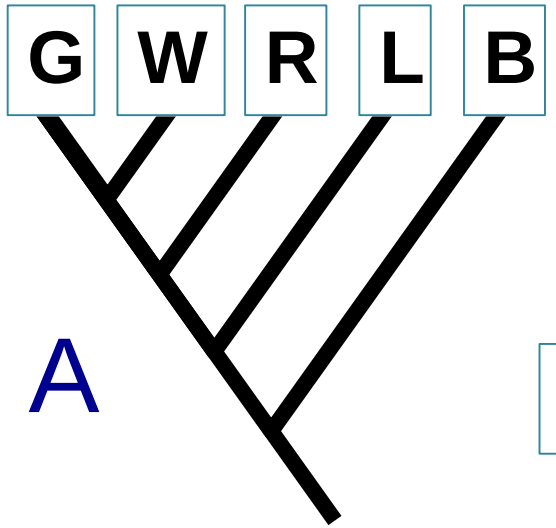
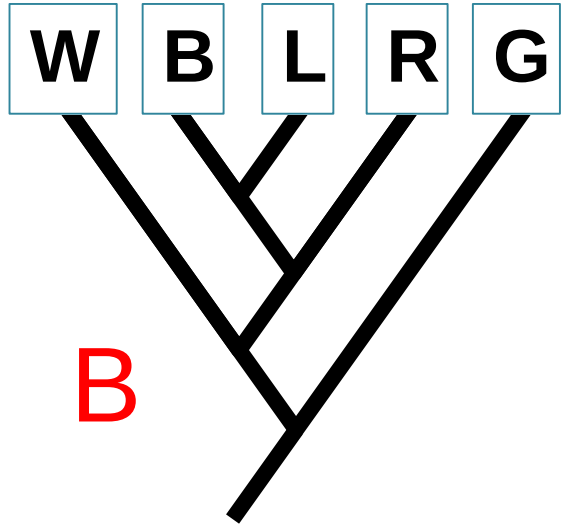
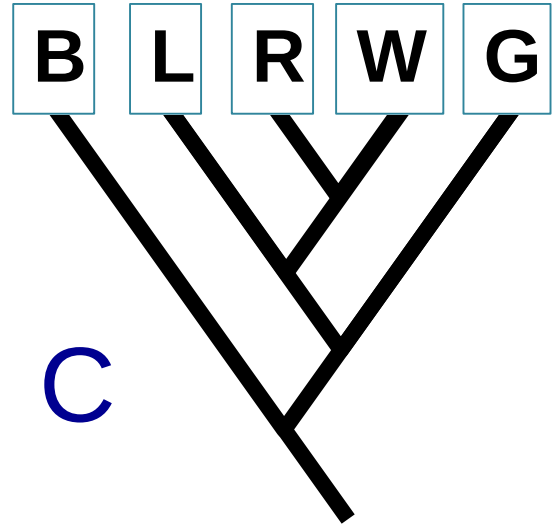




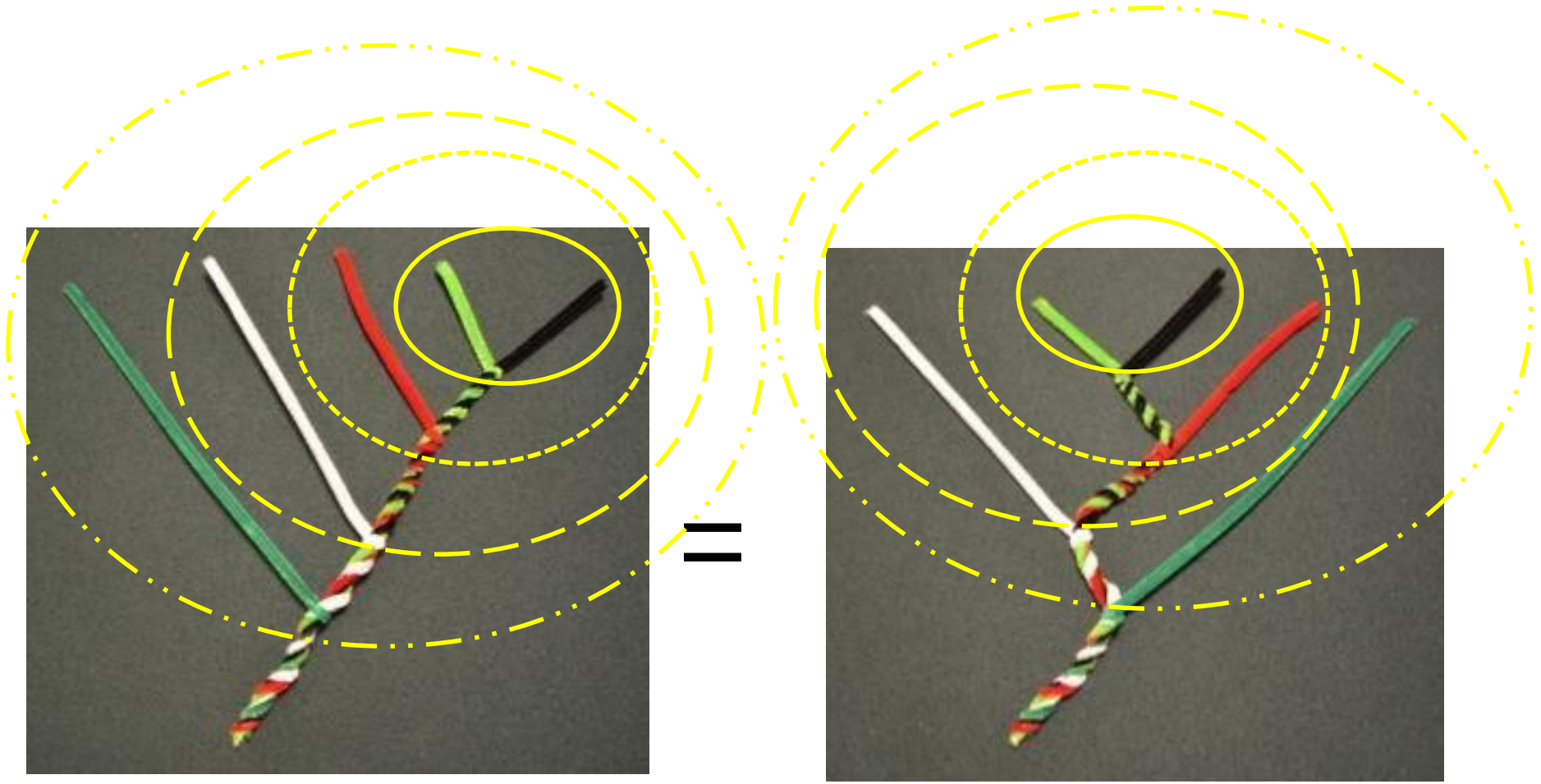




4 common mistakes in reading trees - testable

1. Degree of relatedness is indicated by the proximity of tips
2. Degree of relatedness is indicated by the number of nodes separating taxa.
3. Taxa at the tip of a branch are ancestors to other species on the tree.
4. Thinking one species is more evolved than another species.

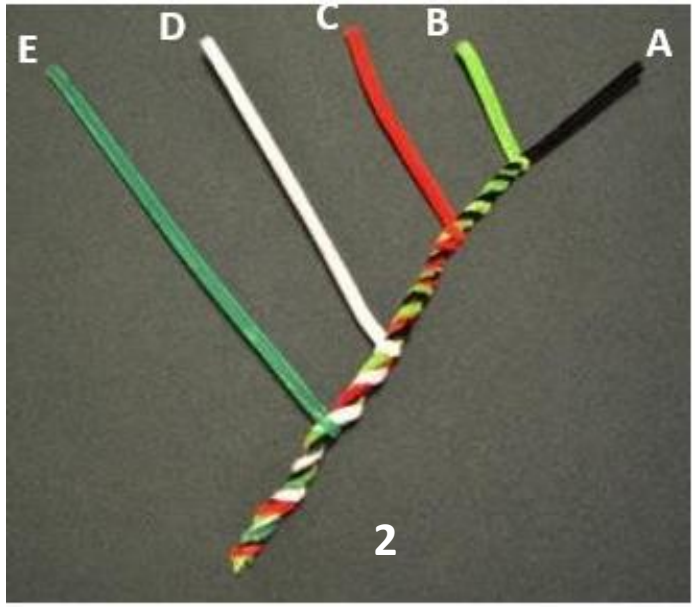
Mistake #1: Thinking proximity of tips is an indication of relatedness



These two figures show the same evolutionary relationships – look at the monophyletic groups

Mistake #2 – Thinking that degree of relatedness is indicated by the number of nodes separating taxa

It would be a mistake to conclude that D is more closely related to C (one node separation) than A or B (two node separation) because of the difference in node numbers.



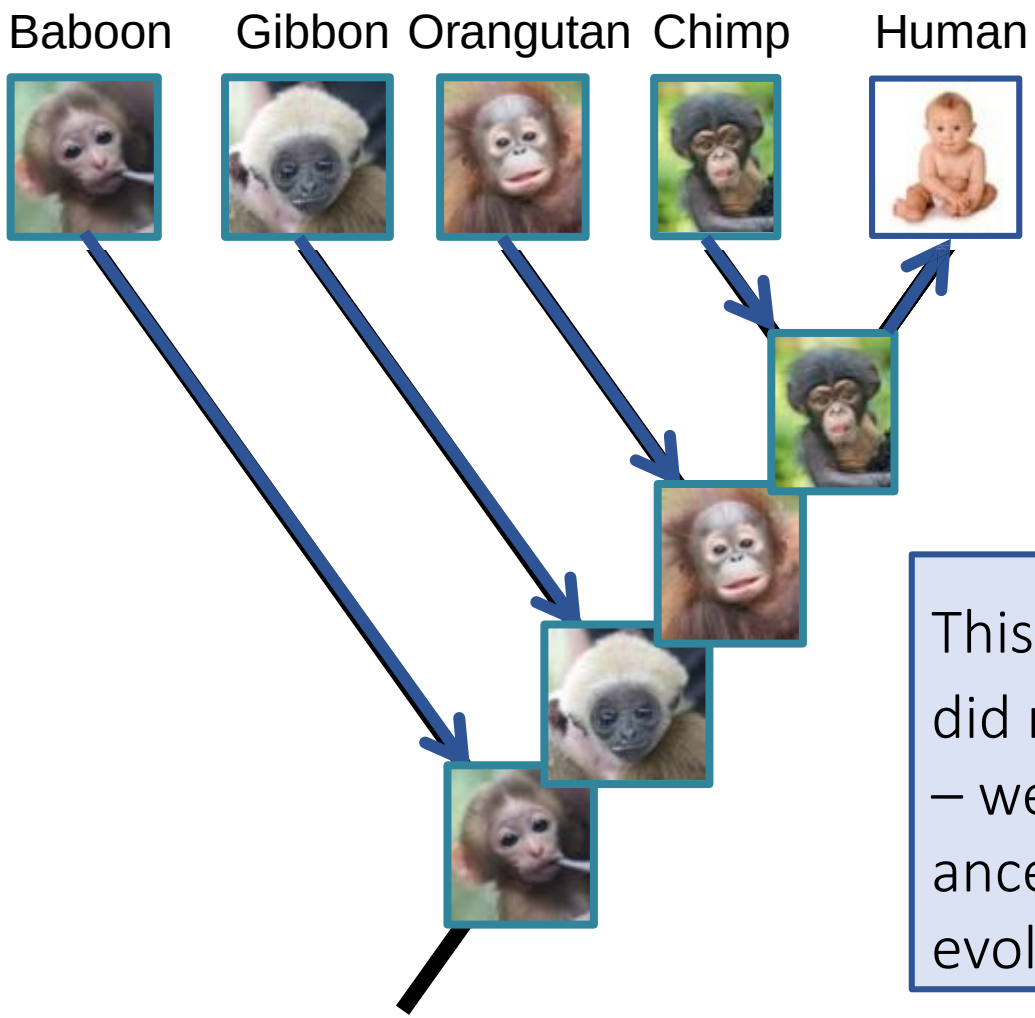
Taxa A, B, C are equally related to Taxa D because they (A, B, C, D) share a common ancestor at node "2".

After class note: Species A and B are more closely related to each other than to Species C and D (common ancestor of A & B at node 4).

A, B and C are more closely related to each other than to taxa D (common ancestor of A, B and C at node 3).

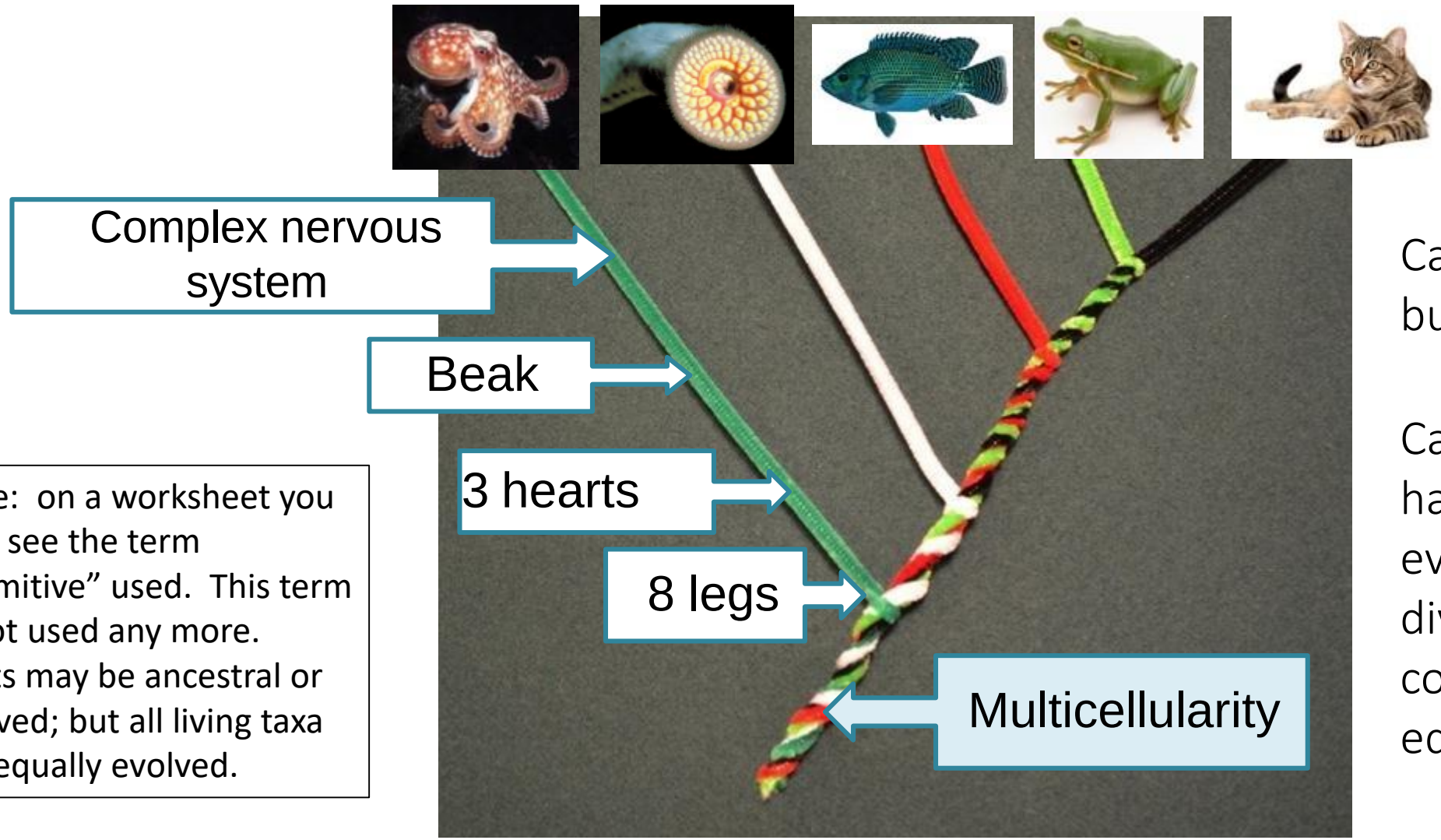
But Species A, B and C are equally related to D. The common ancestor at node 2 gave rise to the lineage to D and to the lineage that gave rise to A, B and C

Mistake #3: Thinking taxa at the tips are ancestors to other taxa on the tree



This is wrong – humans did not evolve from chimps – we share a common ancestor, i.e. we are evolutionary cousins

Mistakes #4 – Thinking some species on a tree are more evolved than other species (e.g. cats are more evolved than octopus).



Note: on a worksheet you may see the term "primitive" used. This term is not used any more. Traits may be ancestral or derived; but all living taxa are equally evolved.

Cats are advanced, but so are octopus.

Cats and octopuses have both been evolving since they diverged from a common ancestor; so, equally evolved.

iClicker Question

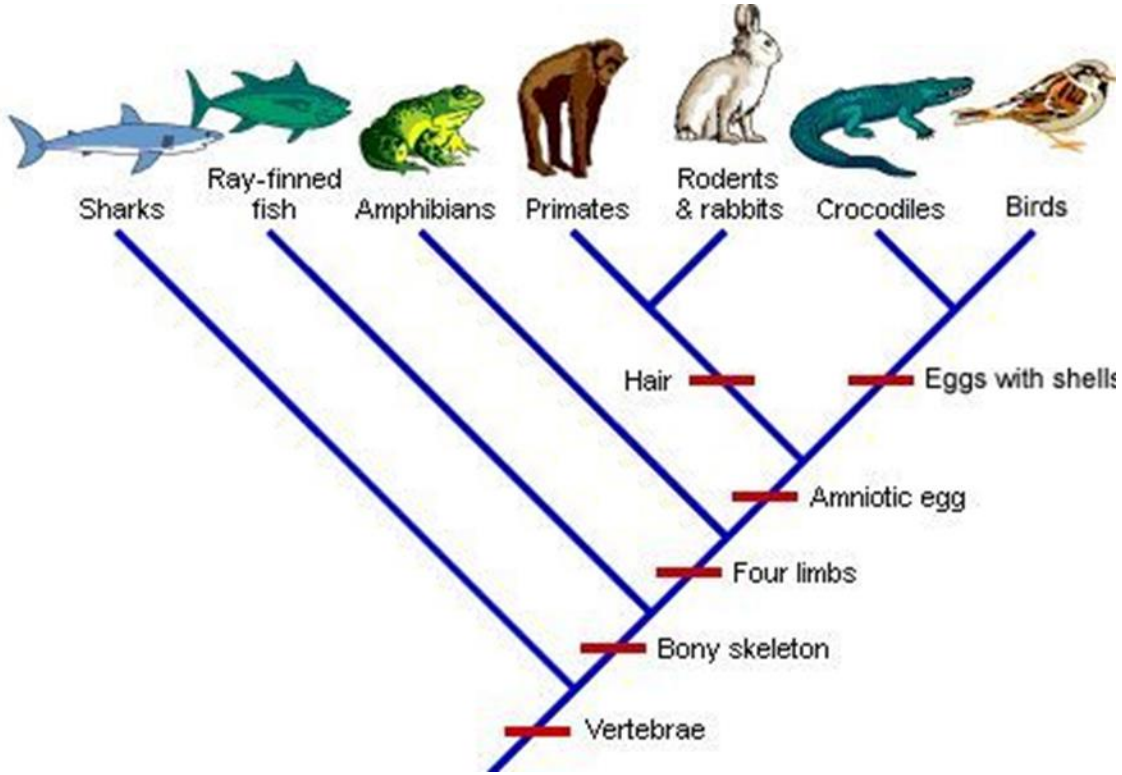
Based on this phylogenetic tree are ray-finned fishes more closely related to birds or to sharks?

A. Birds

B. Sharks

C. Neither

D. Not sure



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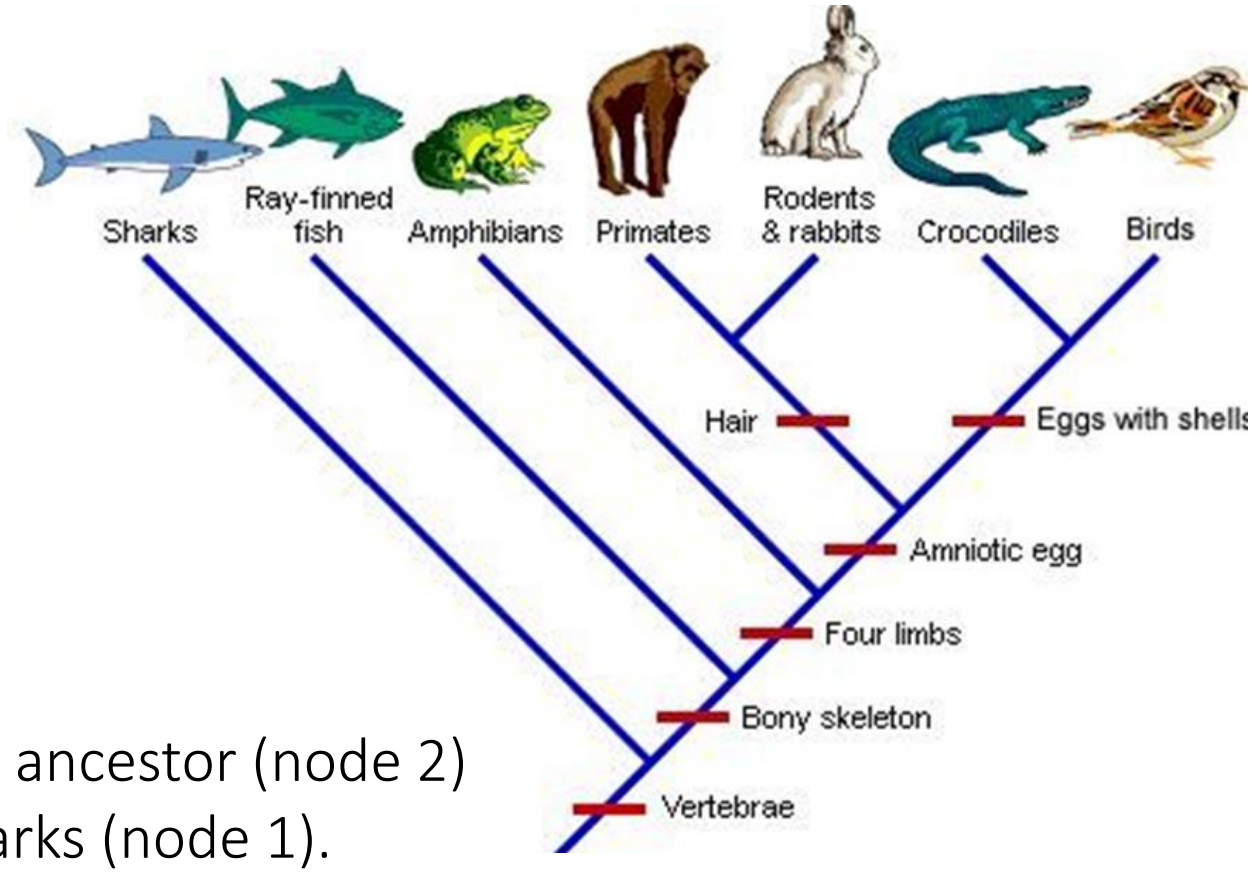
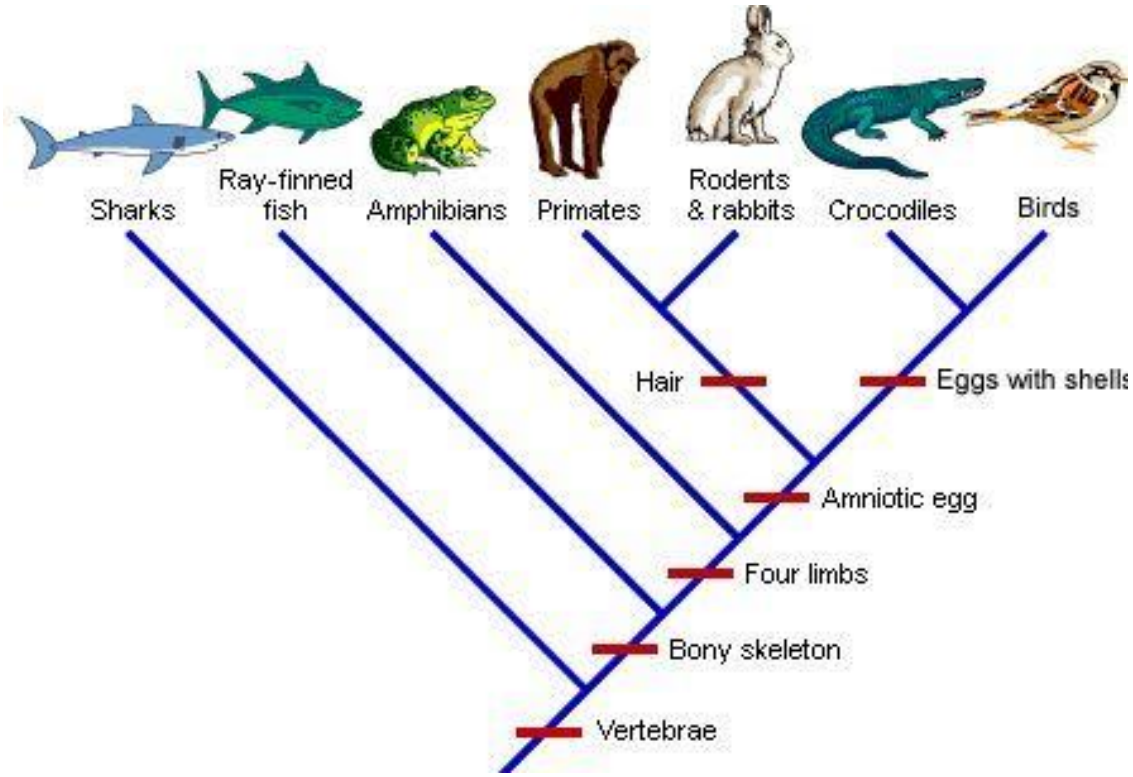


Birds and ray-finned fishes
share a more recent common ancestor (node 2)
than ray-finned fishes and sharks (node 1).

iClicker Question

Based on this phylogenetic tree are birds more evolved than sharks?

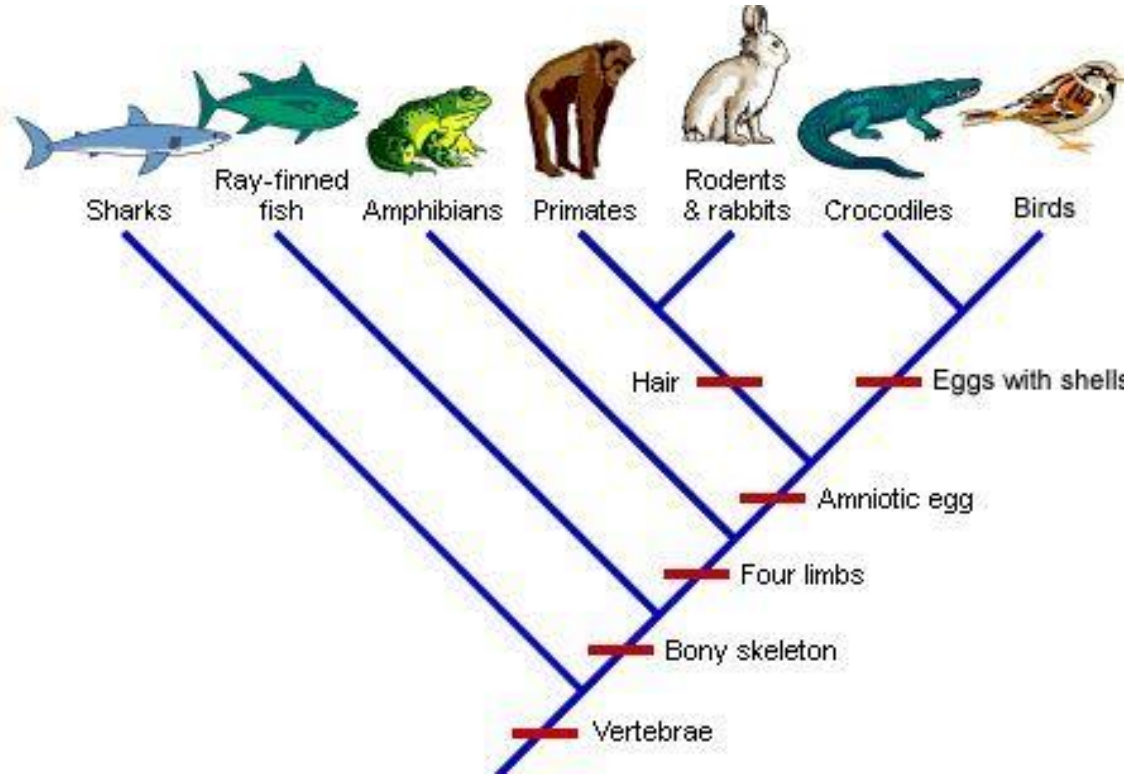
A. Yes
B. No
C. Not sure



Answer

Based on this phylogenetic tree are birds more evolved than sharks?

A. Yes
B. No
C. Not sure



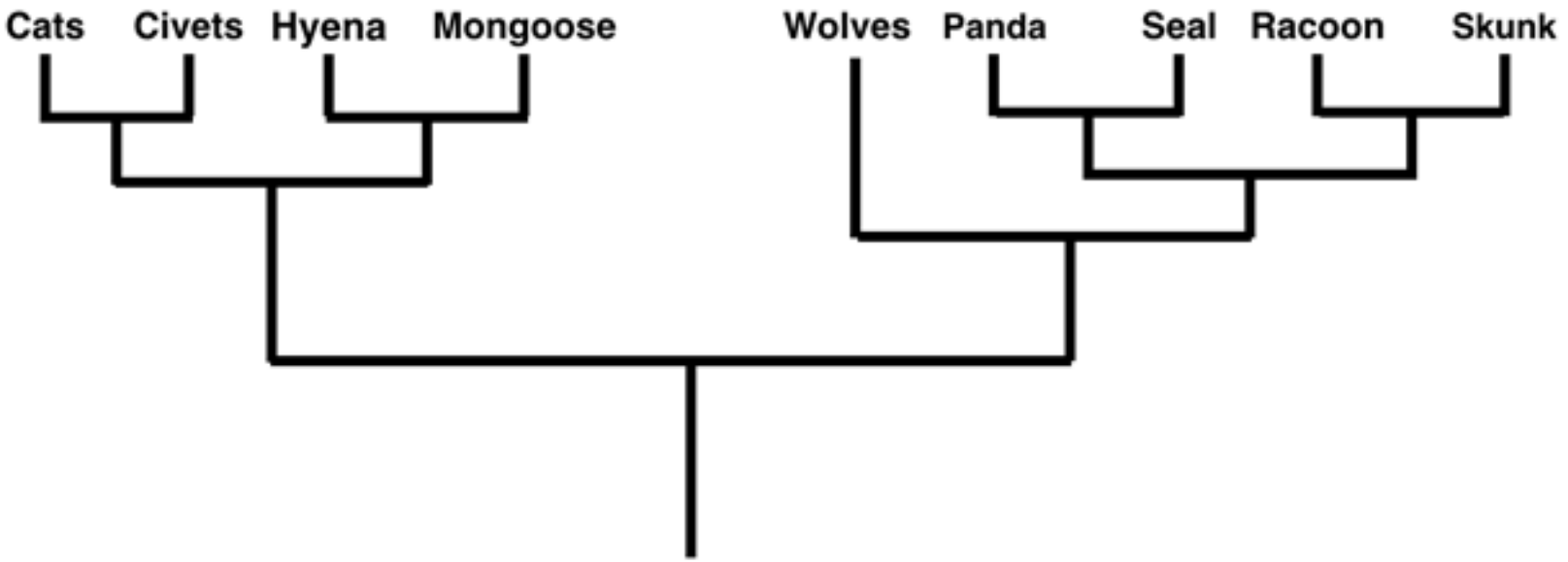
Birds and sharks have both been evolving since they diverged from their common ancestor (at node 1)

iClicker Question – for home, if interested

Cats, Civets, Hyena and Skunks are resistant to a new virus (Virus Z). The common ancestor of all nine taxa on this tree was not resistant to Virus Z. Using the principle of parsimony, how many times has resistance to virus Z been gained, and how many times has it been lost?

(Gain, Loss)

A. 1, 1
B. 2, 1
C. 1, 3
D. 3, 0
E. 0, 3



Answer

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(Gain, Loss)

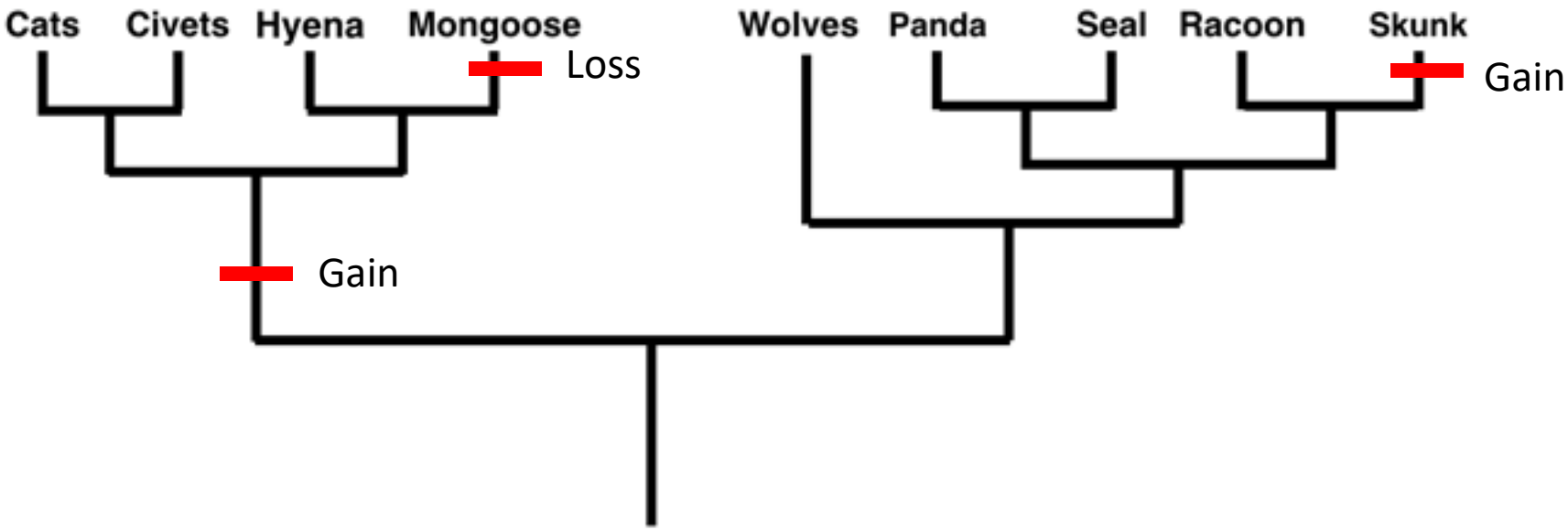
A. 1, 1

B. 2, 1

C. 1, 3

D. 3, 0 (if no losses)

E. Not sure



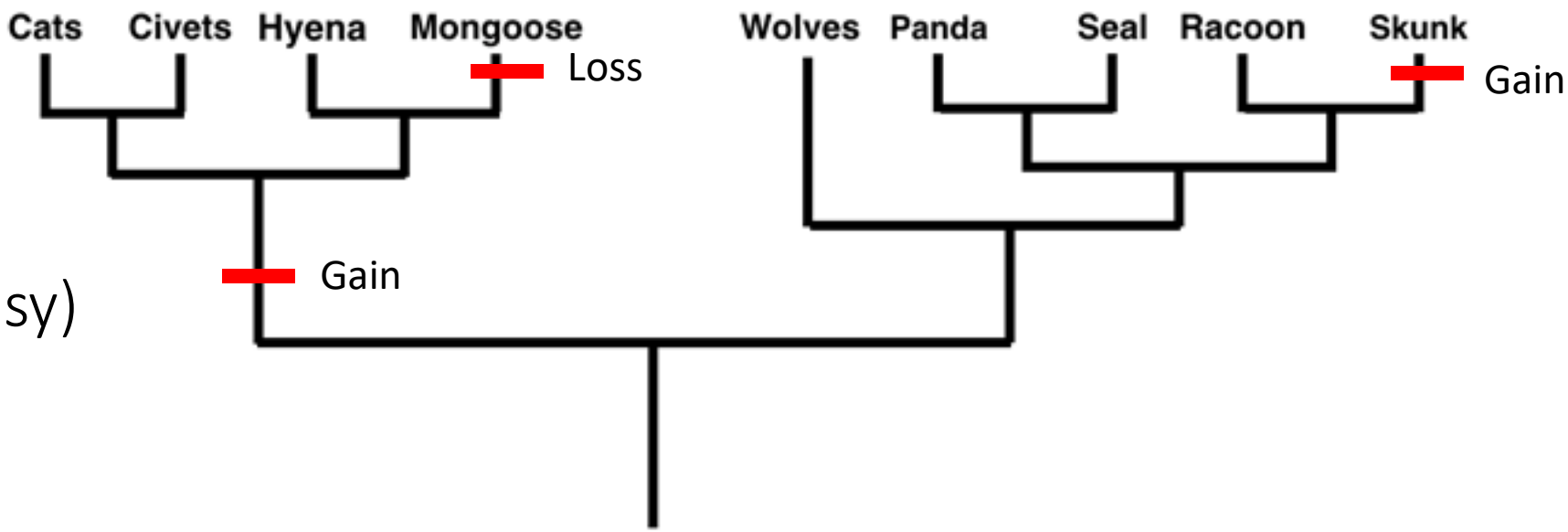
iClicker Question

Cats, Civets, Hyena and Skunks are resistant to a new virus (Virus Z). Is the presence of Virus Z resistance in skunks homologous or analagous to the presence of Virus Z resistance in cats, civets, and hyena?

A. Homologous

B. Analagous (homoplasy)

C. Not sure



Answer

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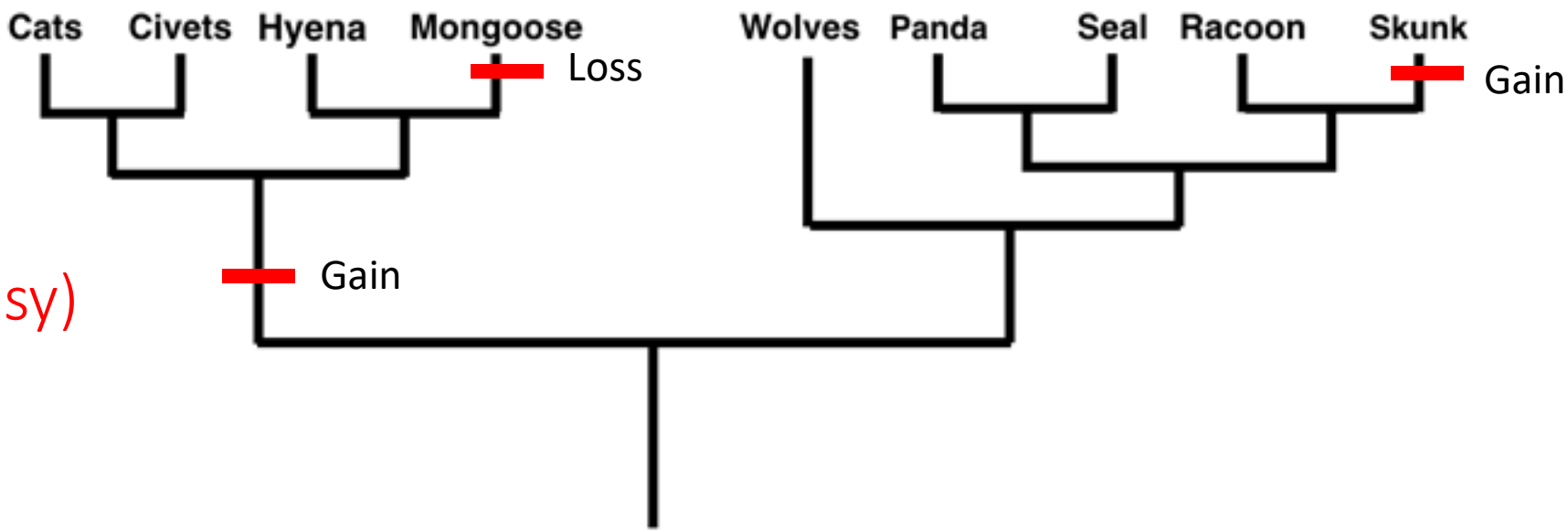

Questions about Phylogenetic Trees

End of testable material for next week's midterm

Species concepts and speciation will be tested on final exam

http://www.uucamp.org/

Learning objectives

	D2 Interpret phylogenetic trees in order to describe the evolutionary relationships among the organisms or taxa represented and infer the evolutionary history of specific traits and when they arose within the tree	• **Identify** a clade, sister taxa, and most closely related taxa on a phylogeny and provide a logical justification explaining your reasoning. • **Identify** homologous and analogous characteristics based on a phylogeny and make predictions about the number of times a trait has evolved and where it evolved. • **Determine** if two trees for the same taxa show the same pattern of relationship among taxa and **justify** your conclusion with specific reference to trees.	• Terms and concepts related to phylogenies (taxa, taxon, sister taxa, clades, nodes, branches, tips, common ancestor, most recent common ancestor, synapomorphy, shared derived character, homology, analogy, homoplasy, trait, character, parsimony).

Also:

Be able to identify monophyletic, paraphyletic and polyphyletic groups, and be able to justify your answer.

Be familiar with common misconceptions when reading phylogenetic trees so that you know how to interpret a tree correctly

Next Thursday

Finish Evolution Unit: Species Concepts & Speciation

Start Ecology Unit (if time) – my favourite ☺