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TOPIC 7.9

Phylogeny

EVO-3.B.1

Phylogenetic trees and cladograms show evolutionary relationships among lineages–

a. Phylogenetic trees and cladograms both show relationships between lineages, but phylogenetic trees show the amount of change over time calibrated by fossils or a molecular clock.

c. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms.

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TOPIC 7.9

Phylogeny

EVO-3.B.1

Phylogenetic trees and cladograms show evolutionary relationships among lineages–

b. Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms–

i. Shared characters are present in more than one lineage.

ii. Shared, derived characters indicate common ancestry and are informative for
the construction of phylogenetic trees and cladograms.

iii. The out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram.

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TOPIC 7.9

Phylogeny

EVO-3.C.1

Phylogenetic trees and cladograms can be used to illustrate speciation that has occurred. The nodes on a tree represent the most recent common ancestor of any two groups or lineages.

EVO-3.C.2

Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities.

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Phylogeny

EVO-3.C.3

Phylogenetic trees and cladograms represent hypotheses and are constantly being revised, based on evidence.

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Phylogenetic trees & cladograms both show lineage.

A. True

B. False

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TOPIC 7.9

Phylogenetic trees & cladograms both show lineage.

A. True

A phylogenetic tree (also phylogeny or evolutionary tree) is a branching diagram or a tree showing the evolutionary relationships among various biological species or other entities based upon similarities and differences in their physical or genetic characteristics.

- Wikipedia

A cladogram is a diagram used to represent a hypothetical relationship between groups of animals, called a phylogeny.

- Biology Dictionary

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TOPIC 7.9

What does a phylogenetic tree show?

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TOPIC 7.9

What does a phylogenetic tree show?

Amount of change as determined by molecular clock or calibrated by fossils.

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TOPIC 7.9

Don't worry!

Since the 2013 redesign, the FRQs have always included the blank template cladogram or tree for you to fill in.

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TOPIC

7.9

What is the outgroup?

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TOPIC 7.9

What is the outgroup?

The lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram.

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TOPIC 7.9

What does a node represent?

A. A divergent event leading to two related lineages

B. A convergent event leading to two unrelated lineages

C. A divergent event leading to two unrelated lineages

D. A convergent event leading to two related lineages

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What does a node represent?

A. A divergent event leading to two related lineages

A node is a branch point on a cladogram or phylogenetic tree. This shows the common ancestor of organisms.

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TOPIC 7.9

Which two are most closely related?

TABLE 1. DIVERGENCE (IN PERCENT) OF MITOCHONDRIAL DNA SEQUENCES AMONG FIVE PRIMATE SPECIES

	Human	Gorilla	Orangutan	Gibbon	Chimpanzee
Human	-	10.3	16.1	18.1	8.8
Gorilla		-	16.7	18.9	10.6
Orangutan			-	18.9	17.2
Gibbon				-	18.9
Chimpanzee					-

A. Human & Gorilla

B. Human & Orangutan

C. Human & Gibbon

D. Human & Chimpanzee

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TOPIC 7.9

Which two are most closely related?

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Orangutan			-	18.9	17.2
Gibbon				-	18.9
Chimpanzee					-

D. Human & Chimpanzee

The two organisms with the least differences in their DNA sequences are most closely related. The human and the chimp have 8.8% difference, which is the smallest number in the chart.

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TOPIC 7.9

Justify the claim that the human & chimpanzee are most closely related.

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TOPIC 7.9

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Gorilla		-	16.7	18.9	10.6
Orangutan			-	18.9	17.2
Gibbon				-	18.9
Chimpanzee					-

Human and chimpanzee have 8.8% difference in their mitochondrial sequences.

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TOPIC 7.9

If human/chimp diverged 7 million years ago, calculate the rate of divergence per million years.

TABLE 1. DIVERGENCE (IN PERCENT) OF MITOCHONDRIAL DNA SEQUENCES AMONG FIVE PRIMATE SPECIES

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TOPIC 7.9

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Orangutan			-	18.9	17.2
Gibbon				-	18.9
Chimpanzee					-

8.8 divided by 7 million years

8.8/7 = 1.257

so... let's just say 1.26/million years

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TOPIC 7.9

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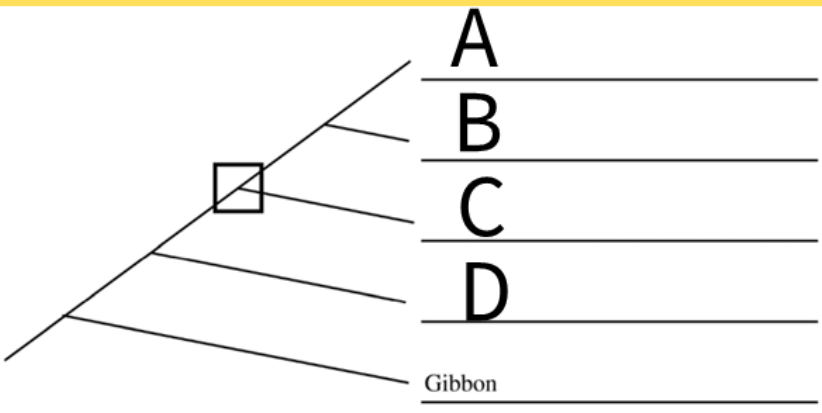

Which organism would be at position D on the cladogram?

A. Human

B. Gorilla

C. Orangutan

D. Chimpanzee

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TOPIC 7.9

Which organism would be at position D on the cladogram?

C. Orangutan

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Orangutan			-	18.9	17.2
Gibbon				-	18.9
Chimpanzee					-

If you look at the human, the gibbon (already on the diagram as the outgroup) has 18.1. The next number is 16.1, which belongs to the orangutan at position D. Position C is the gorilla with 10.3. Positions A/B is human/chimpanzee with 8.8.

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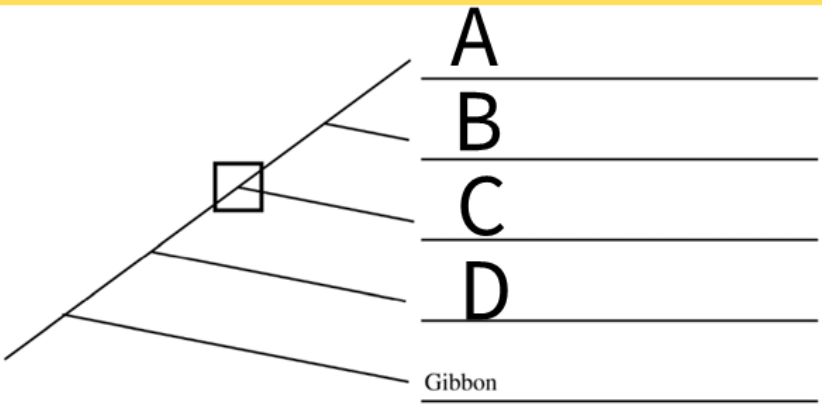

Which two organisms would be at positions A and B?

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Orangutan			-	18.9	17.2
Gibbon				-	18.9
Chimpanzee					-

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TOPIC 7.9

Which two organisms would be at positions A and B?

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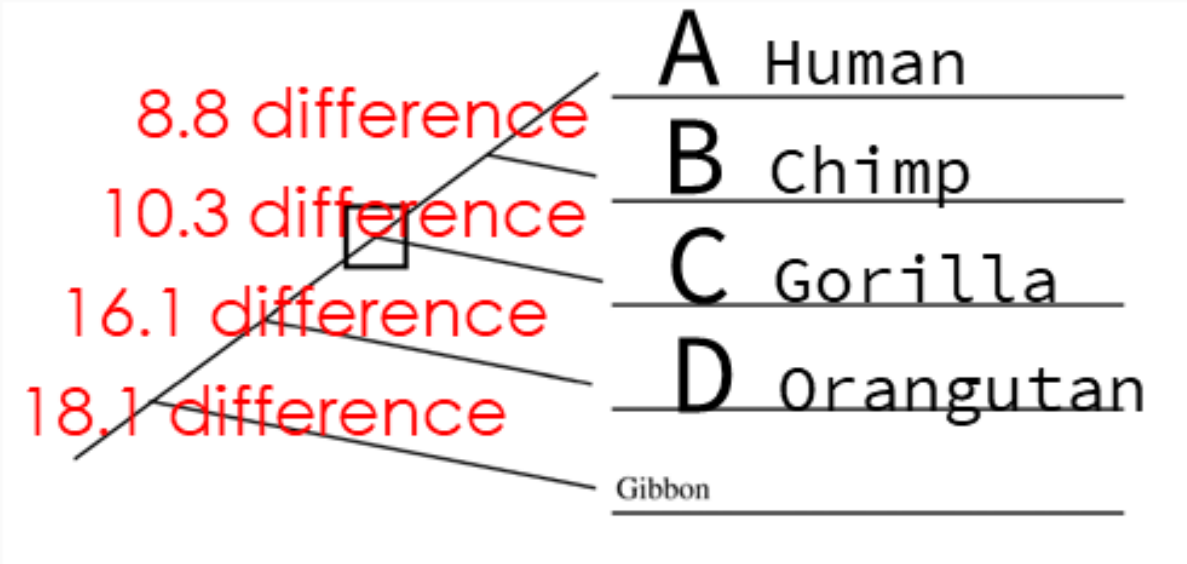
Orangutan			-	18.9	17.2
Gibbon				-	18.9
Chimpanzee					-

Human & Chimpanzee



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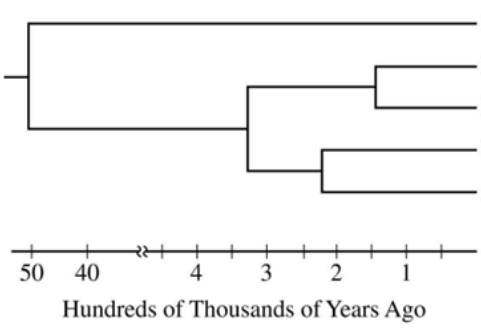

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

How many hundreds of thousands of years ago was the common ancestor of Brown Bears?

A. 2
B. 3
C. 4
D. 5

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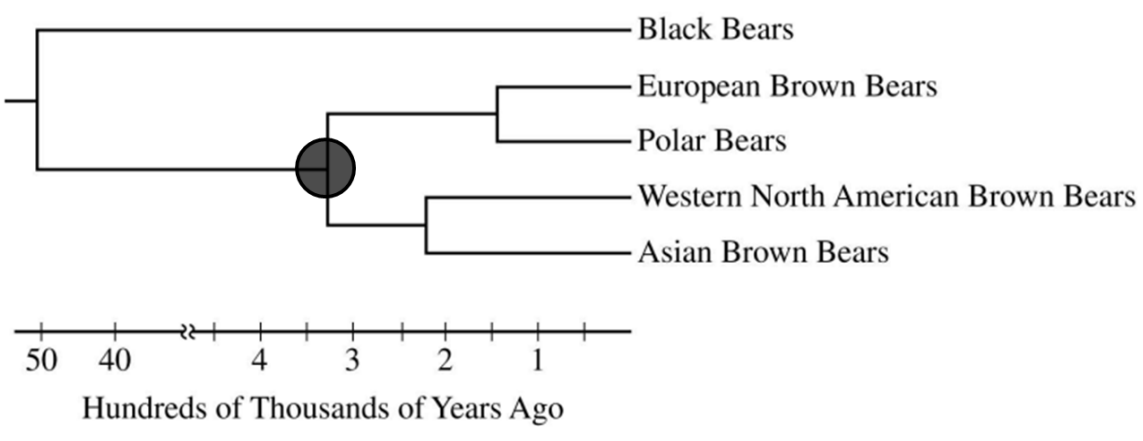
How many hundreds of thousands of years ago was the common ancestor of Brown Bears?

B. 3

That's where all of the brown bears diverged from so it's the most recent common ancestor of all brown bears.



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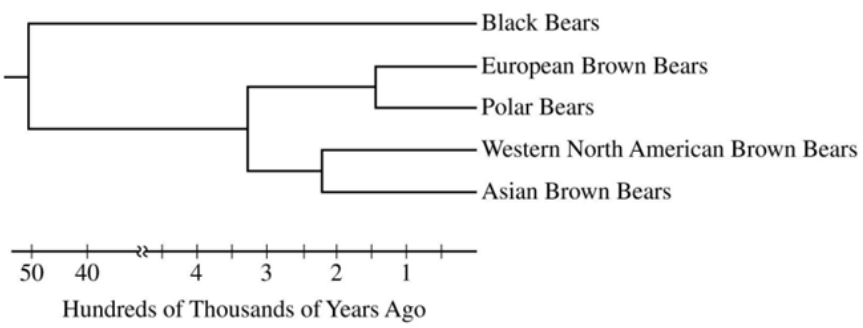

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

Which two bears can be rotated at ONE point?

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Which two bears can be rotated at ONE point?

European Bear & Polar

OR

Western North American Brown & Asian Brown

The branch point (node) is able to be rotated. Since the bears come from the same branch point, they can be rotated.

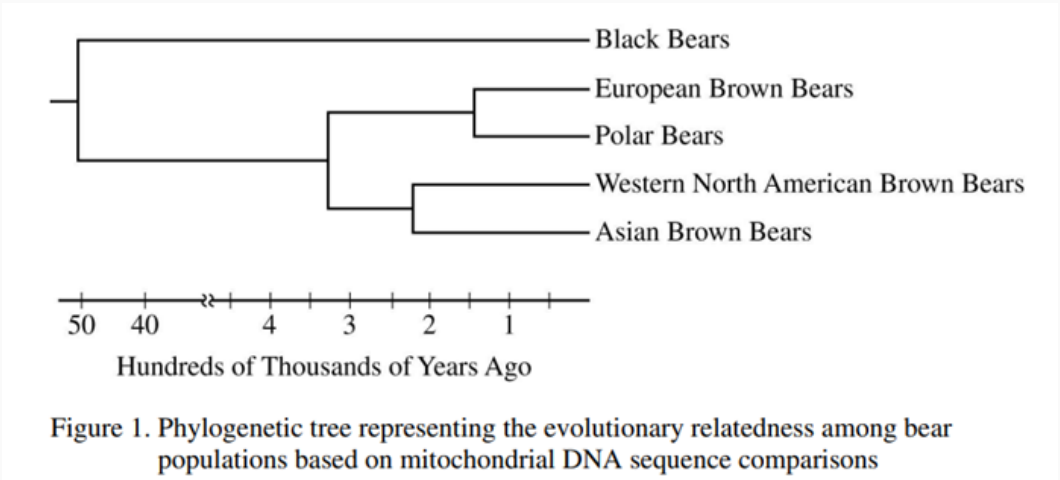

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

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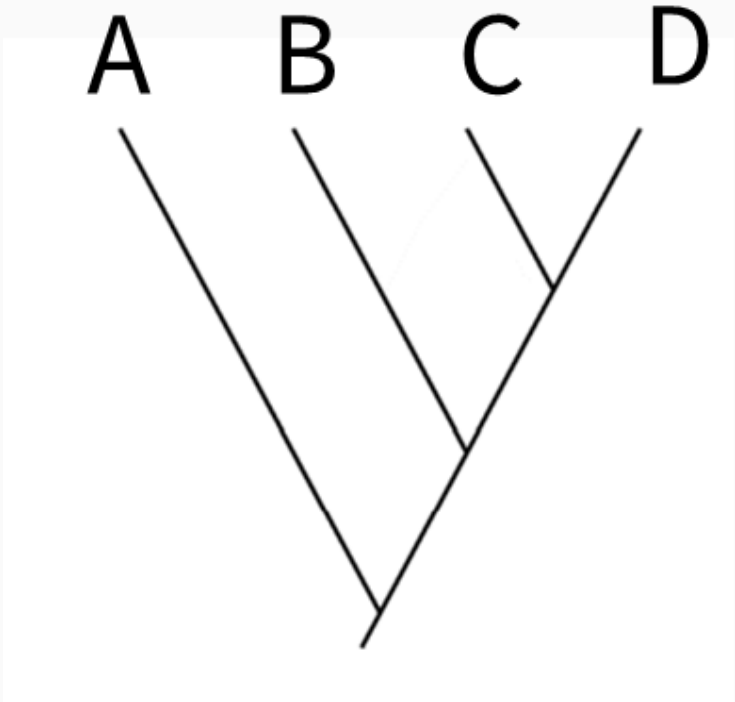
TOPIC 7.9

TABLE 1. AMINO ACID DIFFERENCES IN THE LYST PROTEIN AMONG BEAR SPECIES

	Panda	Black	Brown	Polar
Panda	–			
Black	33	–		
Brown	34	1	–	
Polar	40	7	8	–

Which position would you find the outgroup?



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Which position would you find the outgroup?

A

The outgroup is the organism that is the least related to the other organisms. Traditionally, it does not share any of the traits with the other organisms. The organism on branch A is the first to diverge and does not share traits with the others.

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	Panda	Black	Brown	Polar
Panda	–			
Black	33	–		
Brown	34	1	–	
Polar	40	7	8	–

Which organism would be the outgroup?

A. Black

B. Brown

C. Panda

D. Polar

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Which organism would be the outgroup?

C. Panda

When looking at the amino acid differences, the panda bear has the largest number of differences with each of the other bears.

Panda/Black - 33

Panda/Brown - 34

Panda/Polar - 40

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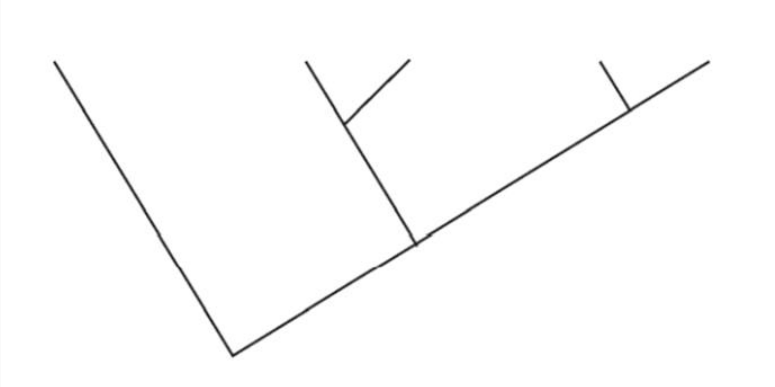
TOPIC

7.9

THE NUMBER OF AMINO ACID DIFFERENCES IN CYTOCHROME *c* AMONG FIVE SPECIES

	E. ferus	*D. polylepis*	*G. gallus*	*A. forsteri*	*E. africanus*
E. ferus	0	21	11	13	1
D. polylepis		0	18	17	20
G. gallus			0	3	10
A. forsteri				0	12
E. africanus					0

Starting from the left, identify the placement of organisms.



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Starting from the left, identify the placement of organisms.

There are multiple possible answers due to the ability to rotate upon a node.

DAGEE

DGAEE

DEEGA

DEEAG

(Note: I am just writing the first letter of the organism)

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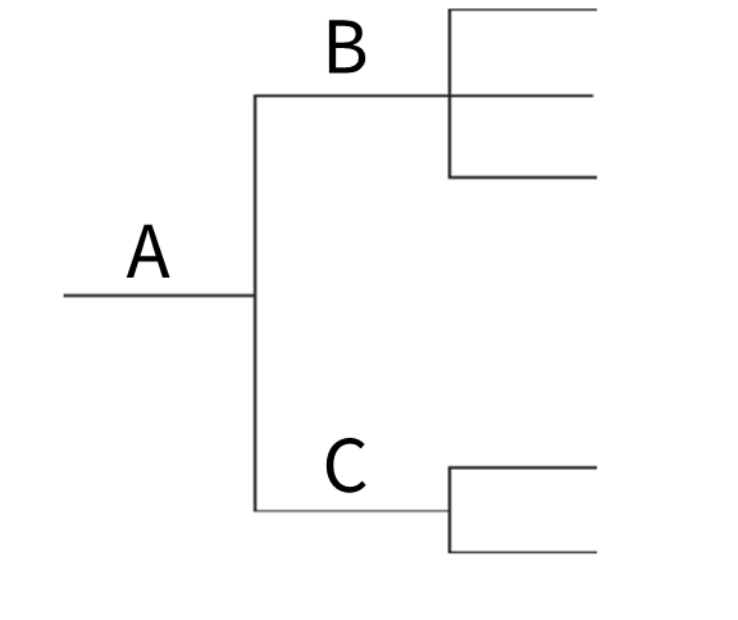
TOPIC 7.9

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

What position was the lactose and protein A traits gained?



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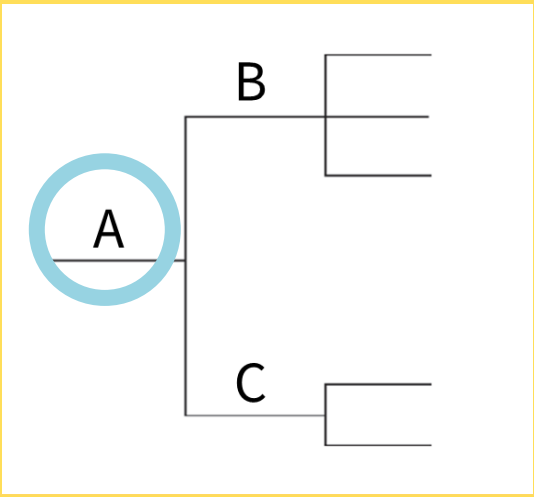
TOPIC 7.9

What position was the lactose & protein A traits gained?



Notice that all of the organisms have both of these traits. This trait must have emerged BEFORE the branch point.

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

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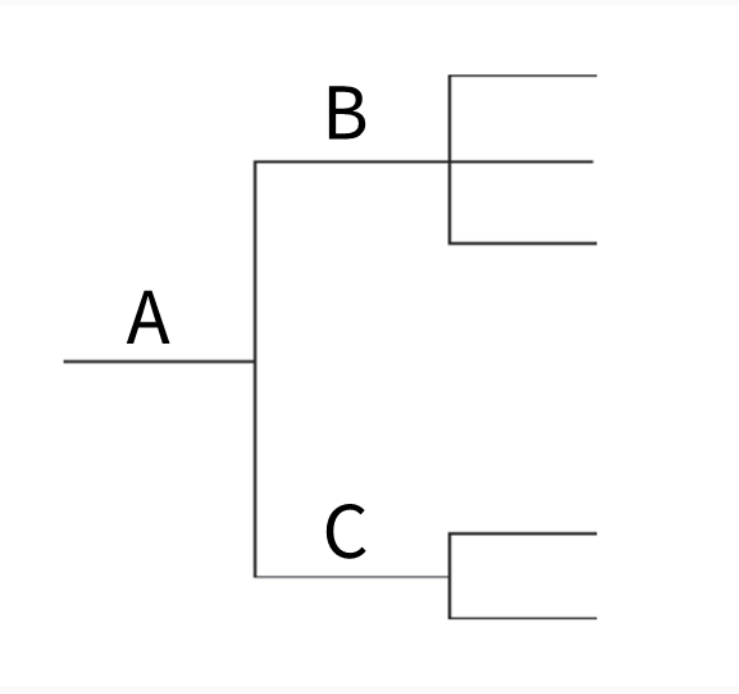
TOPIC 7.9

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

What position might the protein B trait been gained?



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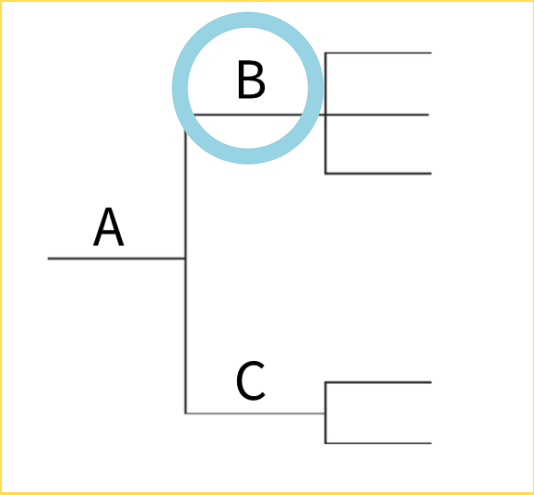
What position might the protein B trait been gained?



Notice that the cow, horse, and pig all have the trait for protein B, so the trait might have emerged on the branch with the three organisms that have the trait.

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

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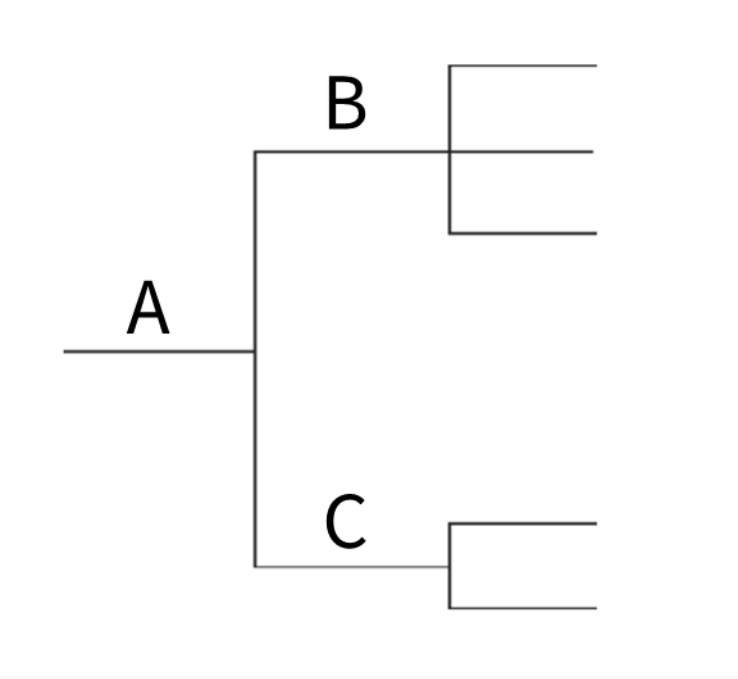
TOPIC
7.9

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

If casein was gained at position A, when was it lost?



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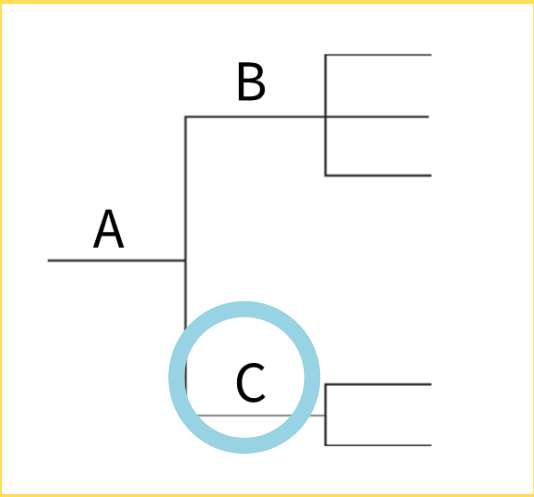
If casein was gained at position A, when was it lost?



Notice that cat and human do NOT have the trait for casein, so the trait might be lost on the branch with the two organisms that DO NOT have the trait.

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

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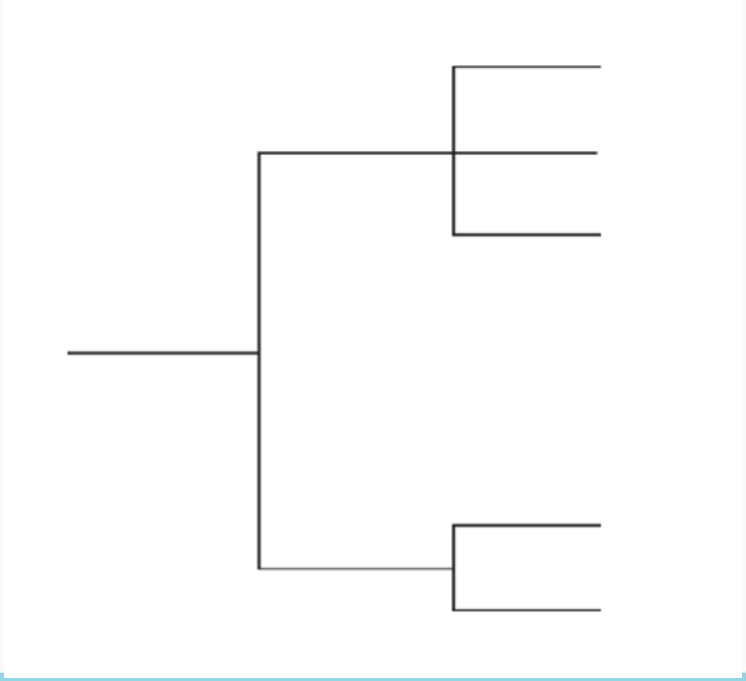
TOPIC 7.9

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

Which three organisms are placed together on the top branch?



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TOPIC 7.9

Which three organisms are placed together on the top branch?

Cow, Horse, & Pig

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

These three organisms share the same traits.

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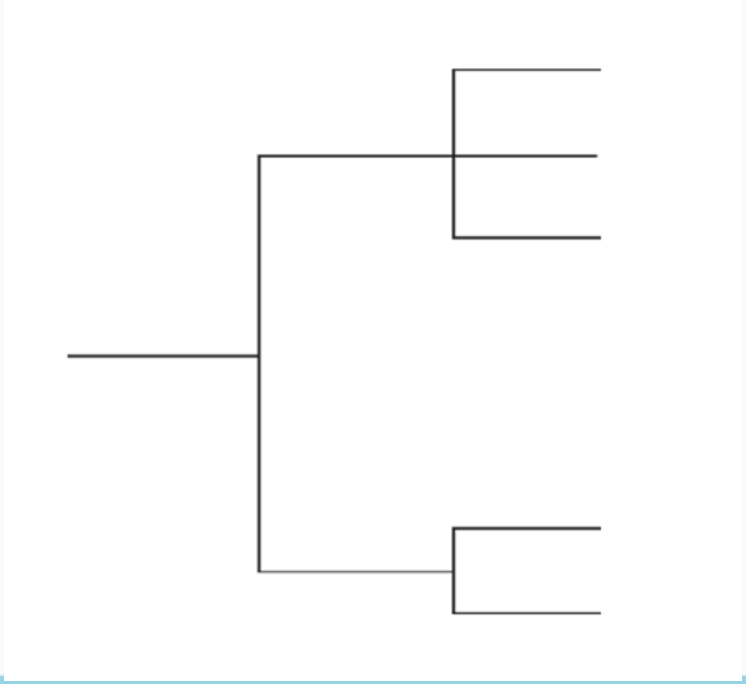
TOPIC
7.9

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

Which two organisms are placed together on the bottom branch?



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TOPIC 7.9

Which two organisms are placed together on the bottom branch?

Cat & Human

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

These two organisms share the same traits.

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TOPIC 7.9

What type of data is most effective to develop a tree?

A. Biogeography evidence

B. Ecological evidence

C. Fossil evidence

D. Molecular evidence

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TOPIC 7.9

What type of data is most effective to develop a tree?

D. Molecular evidence

Molecular evidence shows the differences in nucleotide sequence or protein sequences. It is the most effective to determine a tree.

Biogeography shows organisms living the same area. Ecological shows organisms living in the same environment. Fossil evidence shows organisms that lived in the same area. These do not show relatedness between organisms.

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TOPIC 7.9

Which molecular data is more accurate for relatedness?

A. DNA

B. Proteins

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TOPIC 7.9

Which molecular data is more accurate for relatedness?

A. DNA

DNA is able to have changes that are not observed in the amino acid sequence. Recall, a silent mutation involves different codon sequences that code for the same amino acid. So, if you are comparing DNA sequences, you are able to see the organisms with the least nucleotide differences and the most closely related.

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TOPIC 7.9

What change can occur in the DNA that would not be observed in the protein?

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TOPIC 7.9

What change can occur in the DNA that would not be observed in the protein?

Silent mutations will change the nucleotide pair without changing the amino acid

Any mutations in an intron will be removed/are not expressed

If the mutation takes place in a noncoding region of the genome, it is not expressed.

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TOPIC 7.9

Which is the outgroup?

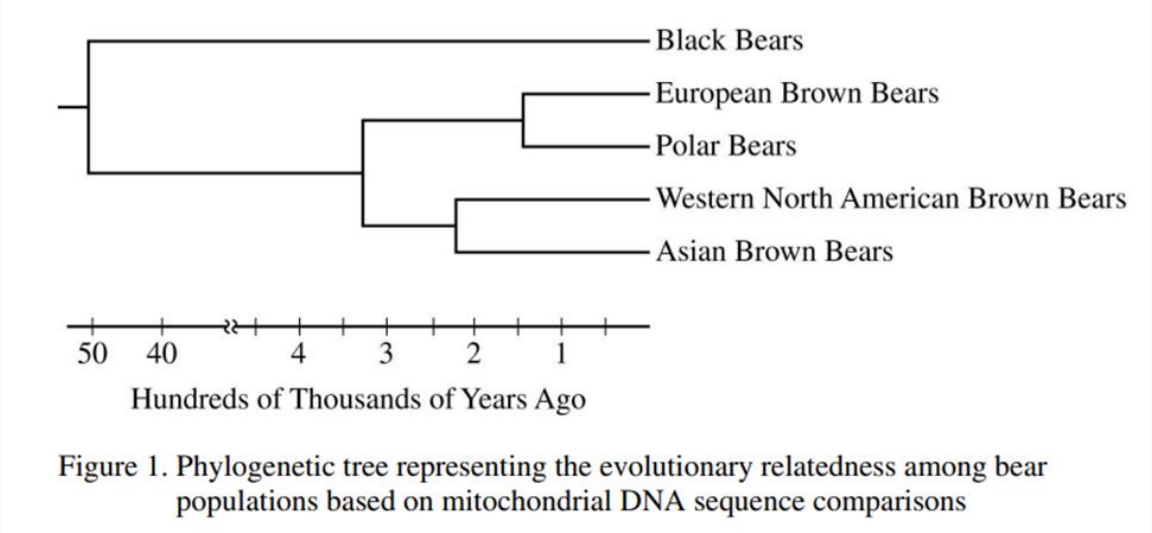

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

A. Asian Brown Bear

B. Black Bear

C. European Brown Bear

D. Polar Bear

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TOPIC 7.9

Which is the outgroup?

B. Black Bear

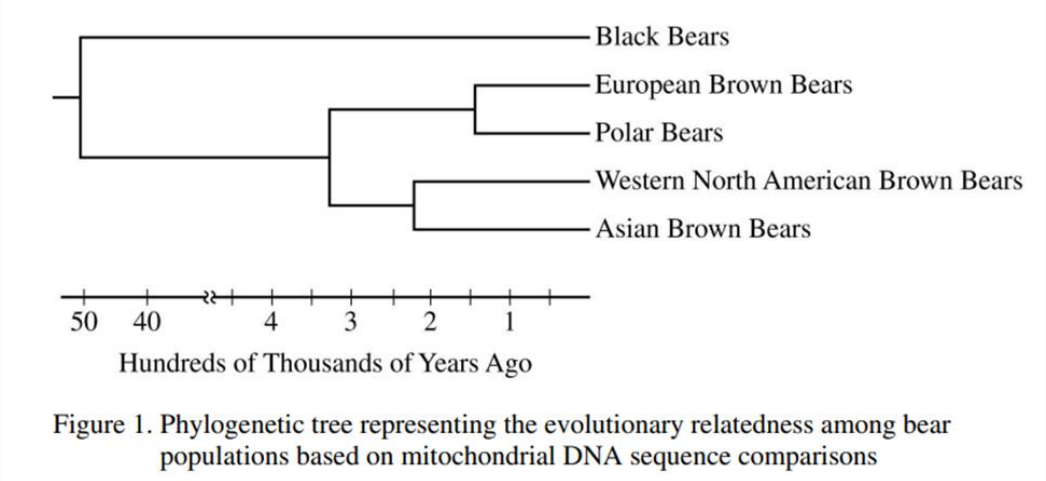

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

As seen in the phylogenetic tree, the black bear diverges from the other bears. The E. Brown and Polar Bears are closely related to each other AND Western North American Brown and Asian Brown Bears are closely related.

AP BIO INSTA-REVIEW

TOPIC
7.9

What is closely related to the polar bear?

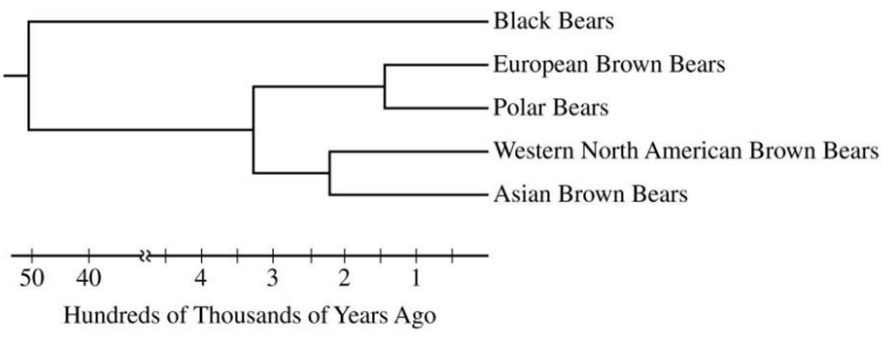

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

A. Asian Brown Bear

B. Black Bear

C. European Brown Bear

D. Western North American Brown Bear

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TOPIC 7.9

What is closely related to the polar bear?

C. European Brown Bear

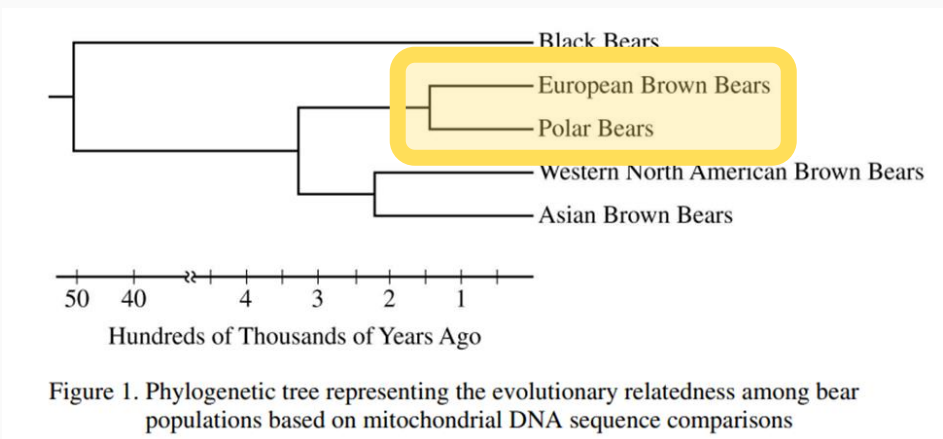

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

The two organisms that are most closely related share the most recent common ancestor (or branch point). If you look at Polar Bears, you will see that European Brown Bears share a recent branch point.

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TOPIC 7.9

The Western North American and Asian Brown Bears can rotate positions.

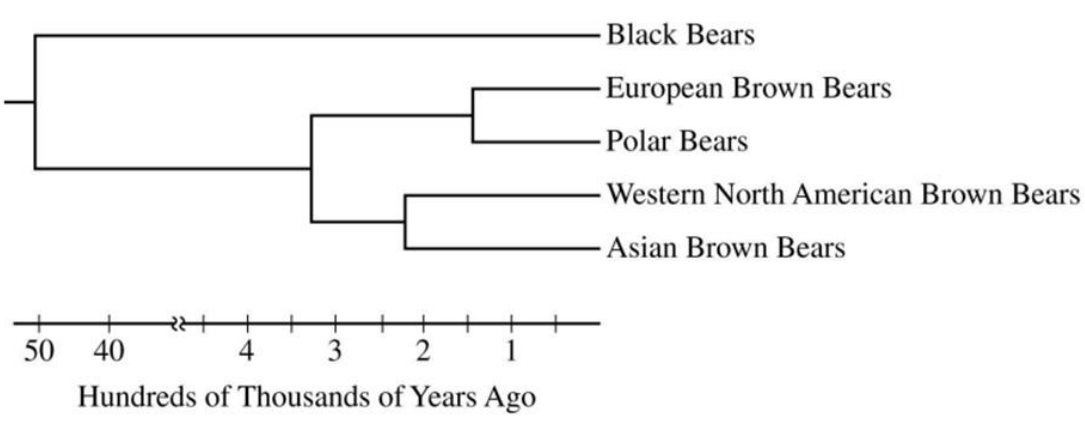

Figure 1. Phylogenetic tree representing the evolutionary relatedness among bear populations based on mitochondrial DNA sequence comparisons

A. True

B. False

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TOPIC 7.9

The Western North American and Asian Brown Bears can rotate positions.

A. True

The organisms can rotate on the node at the branch point.

So, the European Brown Bear & Polar Bear can also rotate.

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TOPIC 7.9

Note:
This was found on Google Images when I searched "phylogeny practice"

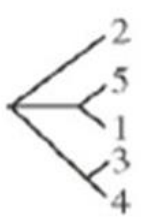
18. Five new species of bacteria were discovered in Antarctic ice core samples. The nucleotide (base) sequences of rRNA subunits were determined for the new species. The table below shows the number of nucleotide differences between the species.

NUCLEOTIDE DIFFERENCES

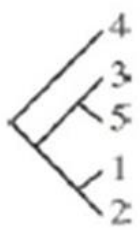
Species	1	2	3	4	5
1	--	3	19	18	27
2		--	19	18	26
3			--	1	27
4				--	27
5					--

Which of the following phylogenetic trees is most consistent with the data?

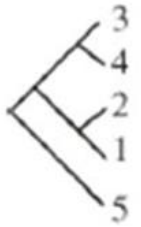
(A)



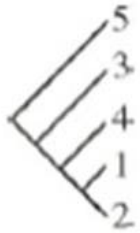
(B)



(C)



(D)



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NUCLEOTIDE DIFFERENCES

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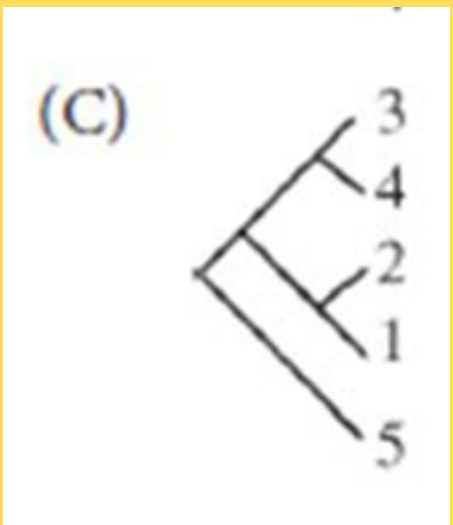

Since 1 & 2 only have 3 differences, we know they are closely related. Since 3 & 4 only have 1 difference, we know they are closely related. Since 5 has a large number of differences with everything, it is considered the "outgroup"

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TOPIC 7.9

Which two are closely related?

TABLE 1. AMINO ACID DIFFERENCES IN THE LYST PROTEIN AMONG BEAR SPECIES

	Panda	Black	Brown	Polar
Panda	–			
Black	33	–		
Brown	34	1	–	
Polar	40	7	8	–

A. Panda & Black

B. Black & Brown

C. Brown & Polar

D. Polar & Panda

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TOPIC 7.9

Which two are closely related?

B. Black & Brown

The Black & Brown bears only have 1 amino acid difference in their LYST protein. The two organisms with the least amino acids differences are most closely related.

TABLE 1. AMINO ACID DIFFERENCES IN THE LYST PROTEIN AMONG BEAR SPECIES

	Panda	Black	Brown	Polar
Panda	–			
Black	33	–		
Brown	34	1	–	
Polar	40	7	8	–

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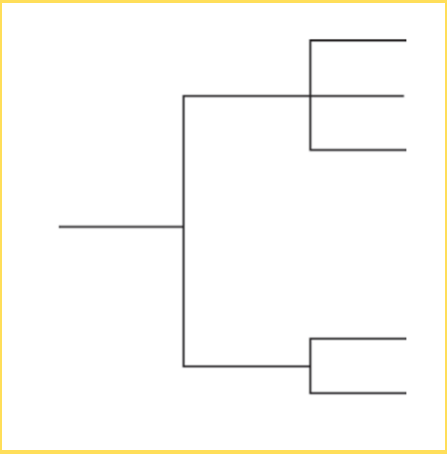
TOPIC 7.9

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character



Which two organisms would be grouped together on the branch with two placements?

A. Cat & Cow

B. Cow & Horse

C. Horse & Human

D. Human & Cat

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TOPIC 7.9

Which two organisms would be grouped together on the branch with two placements?

D. Human & Cat

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character

The human and the cat share the same characteristics.

+ : Lactose & Protein A

– : Protein B & Casein

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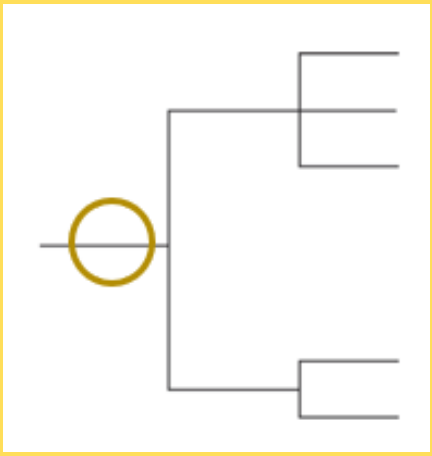
MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+

+ indicates the presence of the character, and – indicates the absence of the character



Which traits would be at the circled part of the phylogenetic tree?

A. Lactose & Protein A

B. Protein A & Protein B

C. Protein B & Casein

D. Casein & Lactose

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TOPIC 7.9

Which traits would be at the circled part of the phylogenetic tree?

A. Lactose & Protein A

The circle shows that the traits emerged in the common ancestor, so all of the descendants have the traits.

All four of the organisms have Lactose & Protein A, which means these two traits emerged before the branch point.