AP® Biology

Sample Student Responses and Scoring Commentary

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Free-Response Question 5

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Question 5: Analyze Model or Visual Representation of a Biological Concept or Process   4 points

Ruminants are hoofed animals, including cattle and sheep, that have a unique four-chambered stomach specialized to digest tough, fiber-filled grasses. Researchers studying ruminants are investigating the morphological and molecular characteristics of different ruminant families in order to determine the evolutionary relationships among the families. Cladograms of several ruminant families were constructed based on morphological data (Figure 1A) and molecular data (Figure 1B). Table 1 shows a sample of the morphological characteristics present in each family used to construct the cladogram in Figure 1A.

A

Tragulidae Giraffidae Bovidae Moschidae Antilocapridae Cervidae

B

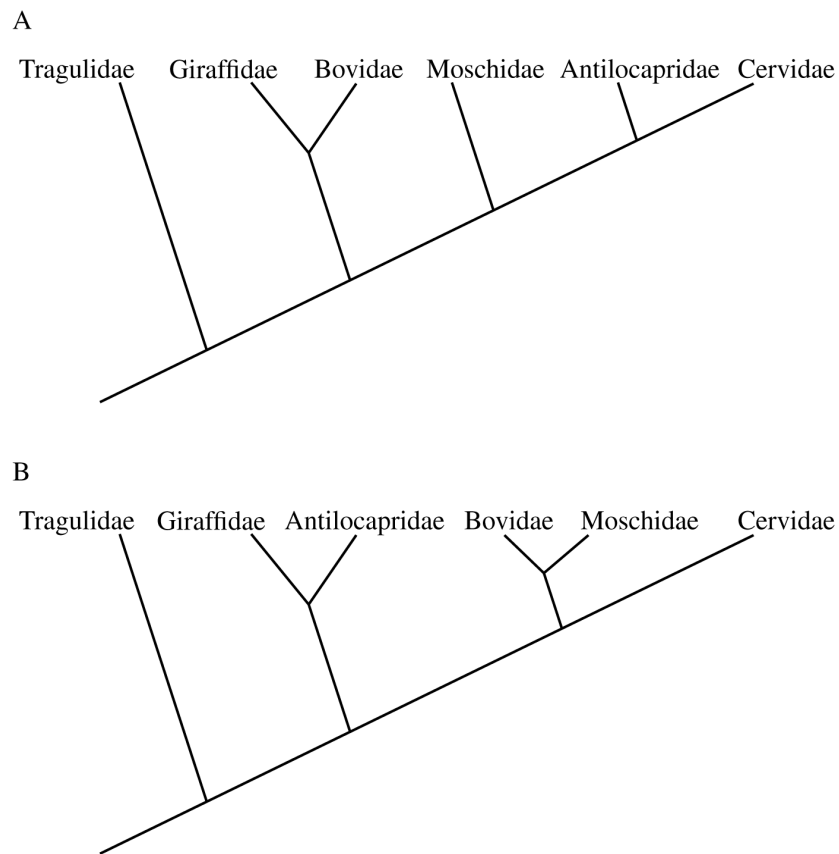Tragulidae Giraffidae Antilocapridae Bovidae Moschidae Cervidae

Figure 1. Cladogram of six ruminant families based on (A) morphological data and (B) molecular data

TABLE 1. MORPHOLOGICAL CHARACTERISTICS FOUND IN EACH RUMINANT FAMILY

Characteristic Number	Morphological Characteristic	Tragulidae	Giraffidae	Bovidae	Moschidae	Antilocapridae	Cervidae
1	Extra tooth material			X		X	
2	Third stomach		X	X	X	X	X
3	Double opening for tear ducts					X	X

| (a)	**Describe** how a scientist would use a comparison of the DNA sequences of different organisms to suggest the most likely evolutionary relationship among the organisms.	**1 point**
	• The (DNA) sequences of organisms that are more closely related are more similar (than those of organisms that are less closely related).	
(b)	Based on Figure 1, **explain** why Bovidae is likely to be more closely related to Moschidae than it is to Giraffidae. Accept one of the following: • (The molecular data/Figure 1B support(s) this relationship, and) molecular data are more reliable (than are morphological data). • (The molecular data/Figure 1B support(s) this relationship.) Morphological similarities may not reliably indicate evolutionary relatedness.	**1 point**
(c)	Using the template in the space provided for your response, **represent** the point(s) at which characteristic 1, listed in Table 1, evolved by marking "X" on the line(s) of the cladogram in the correct location(s). Sample Response:	**1 point**
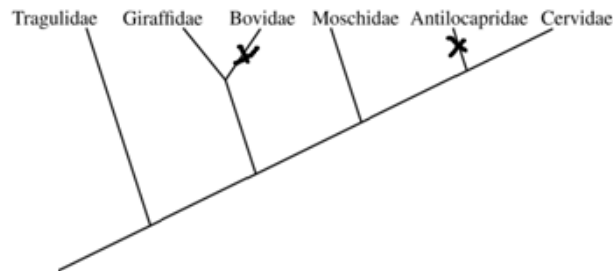
|		
	• Response must show an X placed on the line leading to Bovidae and an X placed on the line leading to Antilocapridae.	
(d)	Based on Figure 1A, **explain** why a characteristic found only in the Cervidae and Bovidae families is more likely evidence of convergent evolution than it is of common ancestry. Accept one of the following: • There are other families that have the same common ancestor as the Bovidae and Cervidae families but do not have the characteristic. • It is more likely that the characteristic arose independently in Cervidae and Bovidae than it arose in their common ancestor and was lost in Giraffidae, Moschidae, and Antilocapridae.	**1 point**

Total for question 5   4 points

BEGIN Question 5

Begin your response to **QUESTION 5** on this page. Do not skip lines.

Tragulidae   Giraffidae   Bovidae   Moschidae   Antilocapridae   Cervidae
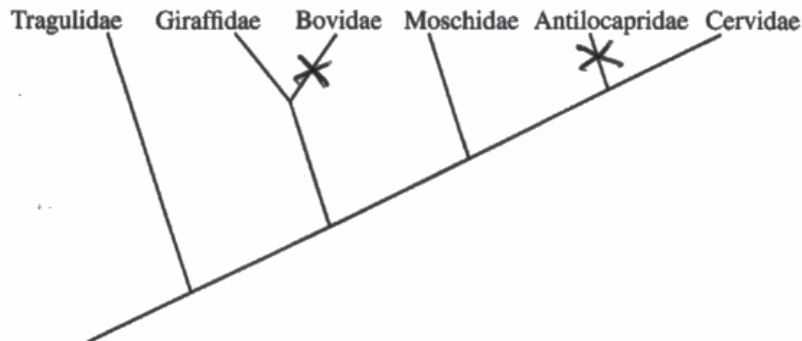
a) They would Compare the number of differences in the base Seqence. Then they would determine relationship by seeing that fewer differences means a ~~reduced~~ more recent Common ancestor and a closer relationship that compared to more differences.

b) Bovidae shares fewer molecular differces with Moschidae than with Giraffide as ~~suggested~~ shown by figure 1B.
Molecular ~~dat~~ comperisas are a more accurate representation of evolutionary closeness that morphological.

d) If a characteristic was only found in Cervidae and Bovidae due to common ancestroy, it would mean it has to evolue before their Common ancestor; then be removed in Moschidae and Giraffidae. This would require 3 independant

Page 12   **GO ON TO THE NEXT PAGE.**

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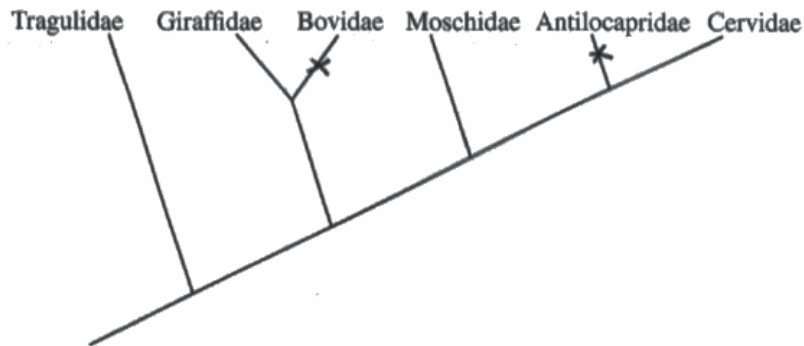
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Q5164/12

Additional page for answering Question 5

Continue your response to **QUESTION 5** on this page. Do not skip lines.

evolutionary events. Compare this to two evolutionary events due to convergent evolution in Bovidae and Cervidae. Typically, the reason with fewer evolutionary events is ~~the~~ more likely which in this case is convergent evolution evolving the characteristic twice.

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Q5164/13

BEGIN Question 5

Begin your response to **QUESTION 5** on this page. Do not skip lines.

Tragulidae Giraffidae Bovidae Moschidae Antilocapridae Cervidae

A) A scientist would use a comparison of DNA sequences to see how related organisms are. The more similarities in the DNA, the closer they are evolutionary and the more recent a common ancestor of the two organisms lived

B) The cladogram shows that Bovidae is likely more closely related to Moschidae than to Giraffidae. Bovidae is closer and on the same clade as Moschidae an Figure 1B. Figure 1B shows evolution based on molecular data, which is much stronger in showing evolutionary relatedness than morphological data like in Figure 1A. This is why Figure 1B proves their relatedness

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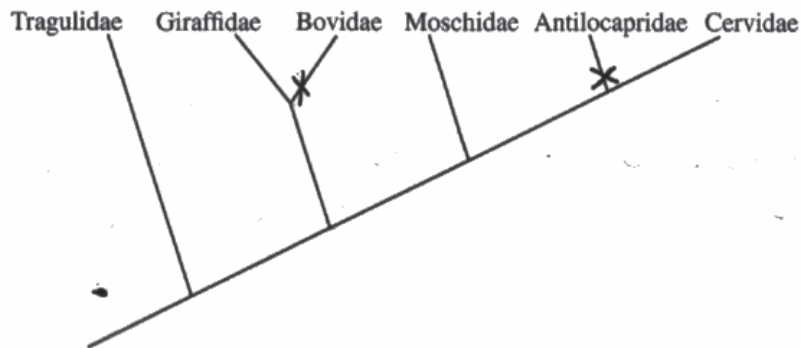
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over ~~Bovia~~ Bovidae and Girraerdae.

D) A characteristic found in Cervidae and Bovidae was most likely due to convergent evolution rather than common ancestry due to their lack of morphological relatedness. This characteristic is probably similar in function but different in ~~shape~~ structure, which shows how the traits are not related. Thes traits evolved in each organism as an adaptation to their niche in the environment.

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Q5184/13

BEGIN Question 5

Begin your response to **QUESTION 5** on this page. Do not skip lines.

Tragulidae Giraffidae Bovidae Moschidae Antilocapridae Cervidae

a) A scientist would compare DNA sequences of different organisms to determine genetic ~~simila~~ similarities ~~in~~ between the organisms' DNA to suggest the most likely evolutionary relationship.

b) Bovidae is likely more closely related to Moschidae because both are on the same branch ~~at roof molecular~~ diverging off, ~~of Cervidae~~ ~~from the common ancestor~~, on the cladogram of molecular data, whereas Bovidae and Giraffidae evolved ~~from Cervidae~~ on different branches at different times.

d) A characteristic found only in Cervidae and Bovidae families is more likely evidence of convergent evolution due to the two families living in similar environmental circumstances. If this characteristic was

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evidence of common ancestry, then it would likely appear in more than only the Cervidae and Bovidae families, since there are several other families that share the same common ancestor. Plus, morphological char

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Q5164/13

Question 5

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

Question 5 presented two cladograms of several ruminant families, one based on morphological data and another based on molecular data. The stimulus also presented a table of morphological characteristics for the ruminants.

In part (a) students were asked to describe how scientists would use comparisons of DNA sequences to determine the evolutionary relatedness of different organisms (Skill 1.A; Learning Objective [LO] EVO-1.N from the AP Biology Course and Exam Description [CED]).

In part (b) students were expected to interpret the cladograms to "explain why Bovidae is likely to be more closely related to Moschidae than it is to Giraffidae" (Skill 2.B; LO EVO-3.C).

In part (c) students were expected to use a cladogram template to represent the points at which a particular morphologic characteristic evolved (Skill 2.D; LO EVO-3.B).

In part (d) students were asked to explain why a trait found in only two families in the cladogram is likely evidence of convergent evolution. This question required students to apply their understanding of cladograms to the idea that selective pressures can result in the evolution of similar phenotypes in unrelated species (Skill 2.C; LO EVO-1.G).

Sample: 5A
Score: 4

The response earned 1 point in part (a) for describing that "fewer differences means a more recent common ancestor and a closer relationship." The response earned 1 point in part (b) for explaining that molecular comparisons are more accurate. The response earned 1 point in part (c) for representing an X on the line leading to Bovidae and an X on the line leading to Antilocapridae. The response earned 1 point in part (d) for explaining why the two families convergently evolved by stating that it is more likely for convergent evolution events to occur than for multiple families to lose a characteristic from a common ancestor.

Sample: 5B
Score: 3

The response earned 1 point in part (a) for describing that more similarities in the DNA means the closer is the evolutionary relatedness of the organisms. The response earned 1 point in part (b) for explaining that molecular data are "much stronger" than morphological data. The response earned 1 point in part (c) for representing an X on the line leading to Bovidae and an X on the line leading to Antilocapridae. The response did not earn a point in part (d) because it does not explain why the two families are more likely to have convergently evolved rather than having had a common ancestor, because the families who share a common ancestor either lack the trait or lost the trait.

Sample: 5C
Score: 2

The response did not earn a point in part (a) because it does not describe the evolutionary relationship by stating that more DNA sequence similarities means the organisms are more closely related. The response did not earn a point in part (b) because it does not explain that molecular data/Figure 1B are (is) more accurate than morphological data. The response earned 1 point in part (c) for representing an X on the line leading to Bovidae and an X on the line leading to Antilocapridae. The response earned 1 point in part (d) for explaining that "several other families that share the same common ancestor" (with Bovidae and Cervidae) do not have the trait.