
AP[®] Biology

Sample Student Responses and Scoring Commentary

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AP[®] BIOLOGY

2019 SCORING GUIDELINES

Question 5

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					-

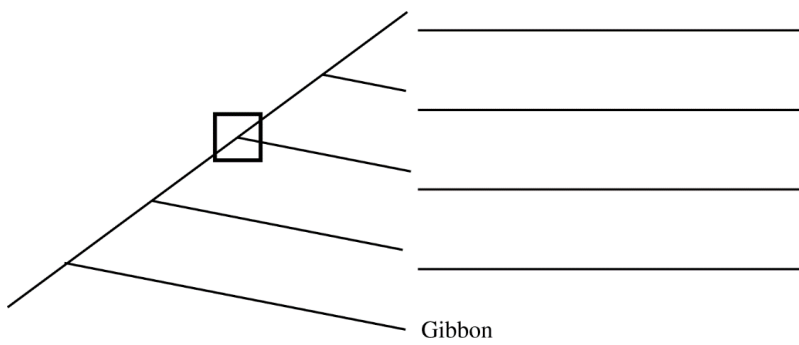
A researcher studying the evolutionary relationship among five primate species obtained data from a sequence of mitochondrial DNA (mtDNA) from a representative individual of each species. The researcher then calculated the percent divergence in the sequences between each pair of primate species (Table 1).

(a) Based on fossil data, the researcher estimates that humans and their most closely related species in the data set diverged approximately seven million years ago. Using these data, **calculate** the rate of mtDNA percent divergence per million years between humans and their most closely related species in the data set. Round your answer to two decimal places.

Calculation (1 point)

- 1.25 OR 1.26

(b) Using the data in the table, **construct** a cladogram on the template provided. **Provide reasoning** for the placement of gibbons as the outgroup on the cladogram.



Construction (1 point)

- From top to bottom: Human/Chimpanzee (interchangeable), Gorilla, Orangutan

Reasoning (1 point)

- Gibbon mtDNA is the least similar (to all of the other species)/most different (from all of the other species).
- Gibbon mtDNA is the most divergent (from all of the other species).

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2019 SCORING GUIDELINES

Question 5 (continued)

(c) On the cladogram, **draw** a circle around all of the species that are descended from the species indicated by the node within the square.

Circle (1 point)

- Circle species 1, 2, and 3, as numbered from the top.

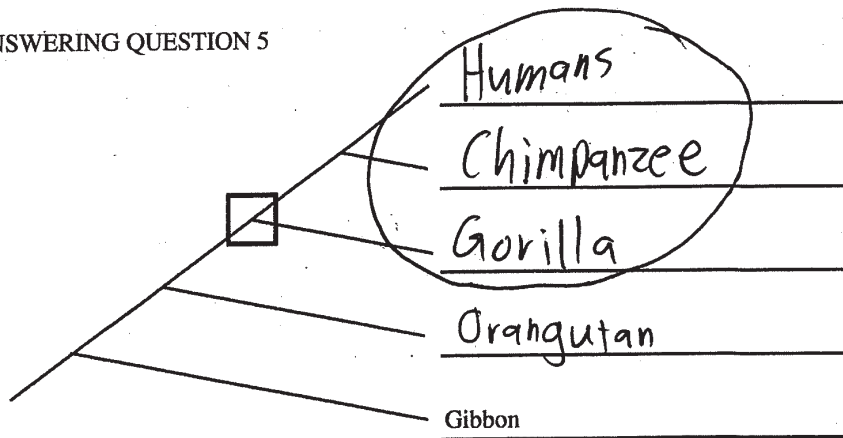
5A1

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

5. A researcher studying the evolutionary relationship among five primate species obtained data from a sequence of mitochondrial DNA (mtDNA) from a representative individual of each species. The researcher then calculated the percent divergence in the sequences between each pair of primate species (Table 1).
- Based on fossil data, the researcher estimates that humans and their most closely related species in the data set diverged approximately seven million years ago. Using these data, **calculate** the rate of mtDNA percent divergence per million years between humans and their most closely related species in the data set. Round your answer to two decimal places.
 - Using the data in the table, **construct** a cladogram on the template provided. **Provide reasoning** for the placement of gibbons as the outgroup on the cladogram.
 - On the cladogram, **draw** a circle around all of the species that are descended from the species indicated by the node within the square.

PAGE FOR ANSWERING QUESTION 5



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ADDITIONAL PAGE FOR ANSWERING QUESTION 5

- a. The rate of mtDNA percent divergence per million years is ≈ 1.26 per million years.
- b. Gibbons are the outgroup on the cladogram because it has the greatest/largest divergence of mitochondrial DNA among the 5 primate species.

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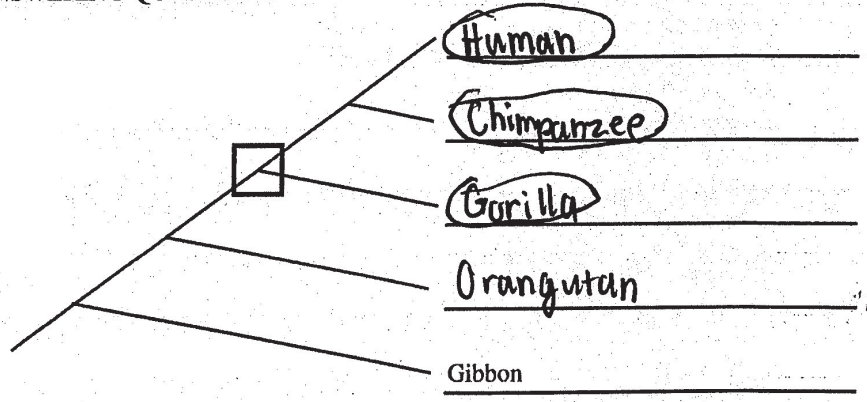
TABLE 1. DIVERGENCE (IN PERCENT) OF MITOCHONDRIAL DNA SEQUENCES AMONG FIVE PRIMATE SPECIES

Human, Chimpanzee, Gorilla, Orangutan

	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					-

5. A researcher studying the evolutionary relationship among five primate species obtained data from a sequence of mitochondrial DNA (mtDNA) from a representative individual of each species. The researcher then calculated the percent divergence in the sequences between each pair of primate species (Table 1).
- (a) Based on fossil data, the researcher estimates that humans and their most closely related species in the data set diverged approximately seven million years ago. Using these data, **calculate** the rate of mtDNA percent divergence per million years between humans and their most closely related species in the data set. Round your answer to two decimal places. *8.8 / 7*
 - (b) Using the data in the table, **construct** a cladogram on the template provided. **Provide reasoning** for the placement of gibbons as the outgroup on the cladogram.
 - (c) On the cladogram, **draw** a circle around all of the species that are descended from the species indicated by the node within the square.

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5B2

ADDITIONAL PAGE FOR ANSWERING QUESTION 5

a. ~~8.8~~ 8.8% Divergence / 7 \approx 1.26% per million years

The rate of mtDNA percent divergence per million years is around 1.26% / million years.

b. Gibbuts are the outgroup since it was the species to diverge first from the ancestral line.

c. see cladogram.

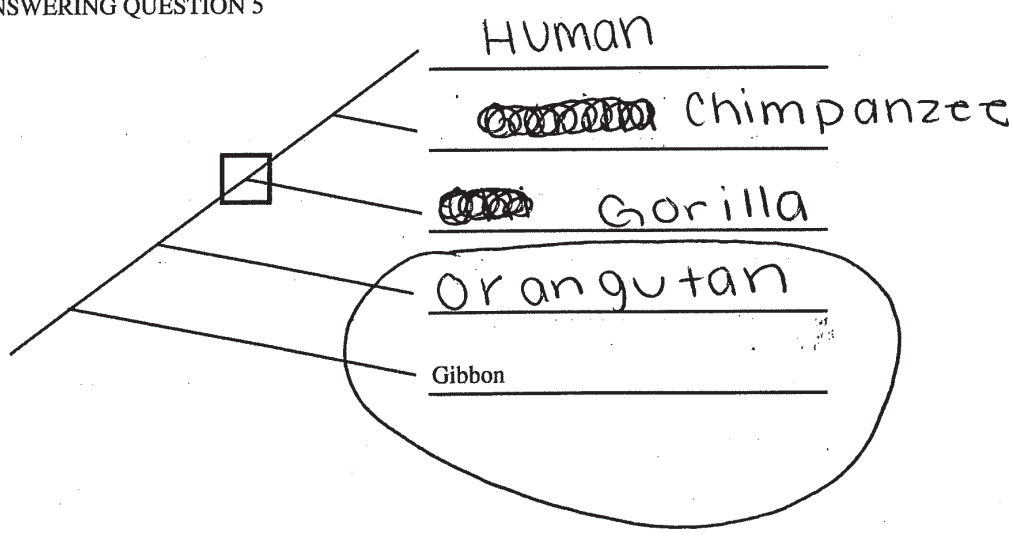
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TABLE 1. DIVERGENCE (IN PERCENT) OF MITOCHONDRIAL DNA SEQUENCES AMONG FIVE PRIMATE SPECIES

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Chimpanzee					-

5. A researcher studying the evolutionary relationship among five primate species obtained data from a sequence of mitochondrial DNA (mtDNA) from a representative individual of each species. The researcher then calculated the percent divergence in the sequences between each pair of primate species (Table 1).
- ✓ (a) Based on fossil data, the researcher estimates that humans and their most closely related species in the data set diverged approximately seven million years ago. Using these data, **calculate** the rate of mtDNA percent divergence per million years between humans and their most closely related species in the data set. Round your answer to two decimal places.
 - ✓ (b) Using the data in the table, **construct** a cladogram on the template provided. **Provide reasoning** for the placement of gibbons as the outgroup on the cladogram.
 - ✓ (c) On the cladogram, **draw** a circle around all of the species that are descended from the species indicated by the node within the square.

PAGE FOR ANSWERING QUESTION 5



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ADDITIONAL PAGE FOR ANSWERING QUESTION 5

a) According to the data, humans are most closely related to ~~gorillas~~^{chimpanzees}. The rate of mtDNA divergence per million years between humans and ~~gorillas~~^{chimpanzees} is ~~1.76%~~ 1.76%.

b) Gibbons are the outgroup in the cladogram because they have the most divergence from humans.

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2019 SCORING COMMENTARY

Question 5

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

Overview

This question provided a data table indicating the percent divergence of mitochondrial DNA sequences among five primate species. Students were asked to use the data to calculate the rate of mtDNA percent divergence per million years between humans and their most closely related species (chimpanzee). Then they were asked to construct a cladogram on a template and provide reasoning for the placement of one of the primate species (gibbon) that had been pre-populated as the outgroup on the cladogram. Lastly, students were asked to identify (by circling on the cladogram) all of the species that were descended from the species represented by a specific node on the cladogram. This demonstrated an understanding of evolutionary relationships as represented in a cladogram.

Sample: 5A

Score: 4

The response earned 1 point in part (a) for calculating that the rate of mtDNA percent divergence per million years is 1.26. The response earned 1 point in part (b) for constructing a cladogram showing in sequence from top to bottom: Humans, Chimpanzee, Gorilla, Orangutan. The response earned 1 point in part (b) for reasoning that Gibbon is the outgroup “because it has the greatest/largest divergence of mitochondrial DNA among the 5 primate species.” The response earned 1 point in part (c) for drawing a circle around the top three species in the cladogram.

Sample: 5B

Score: 3

The response earned 1 point in part (a) for calculating 1.26% per million years. The response earned 1 point in part (b) for constructing a cladogram showing in sequence from top to bottom: Human, Chimpanzee, Gorilla, Orangutan. The response earned 1 point in part (c) for drawing circles around the top three species in the cladogram.

Sample: 5C

Score: 2

The response earned 1 point in part (a) for calculating that the rate of mtDNA percent divergence per million years between humans and chimpanzees is 1.26%. The response earned 1 point in part (b) for constructing a cladogram showing in sequence from top to bottom: Human, Chimpanzee, Gorilla, Orangutan.