

2024



AP[®] Biology

Sample Student Responses and Scoring Commentary

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Question 6: Analyze Data

4 points

Scientists can quantify the rate of translation as ribosomes move along an mRNA from one codon to the next. Using a procedure called ribosome profiling, the scientists measured how long a ribosome remains stationary at each codon of each mRNA. They determined the average translation rate across all codons is 5.2 amino acids per second but that the average translation rate for specific codons in different mRNA sequences can vary widely. These variations in translation rates are thought to facilitate correct folding of the protein being produced. The rate at which three different codons were translated was measured in 100 different mRNAs. The scientists determined the distribution of rate (number of times each rate was recorded) for each of the three codons: GAC (Figure 1A), AUU (Figure 1B), and UGG (Figure 1C).

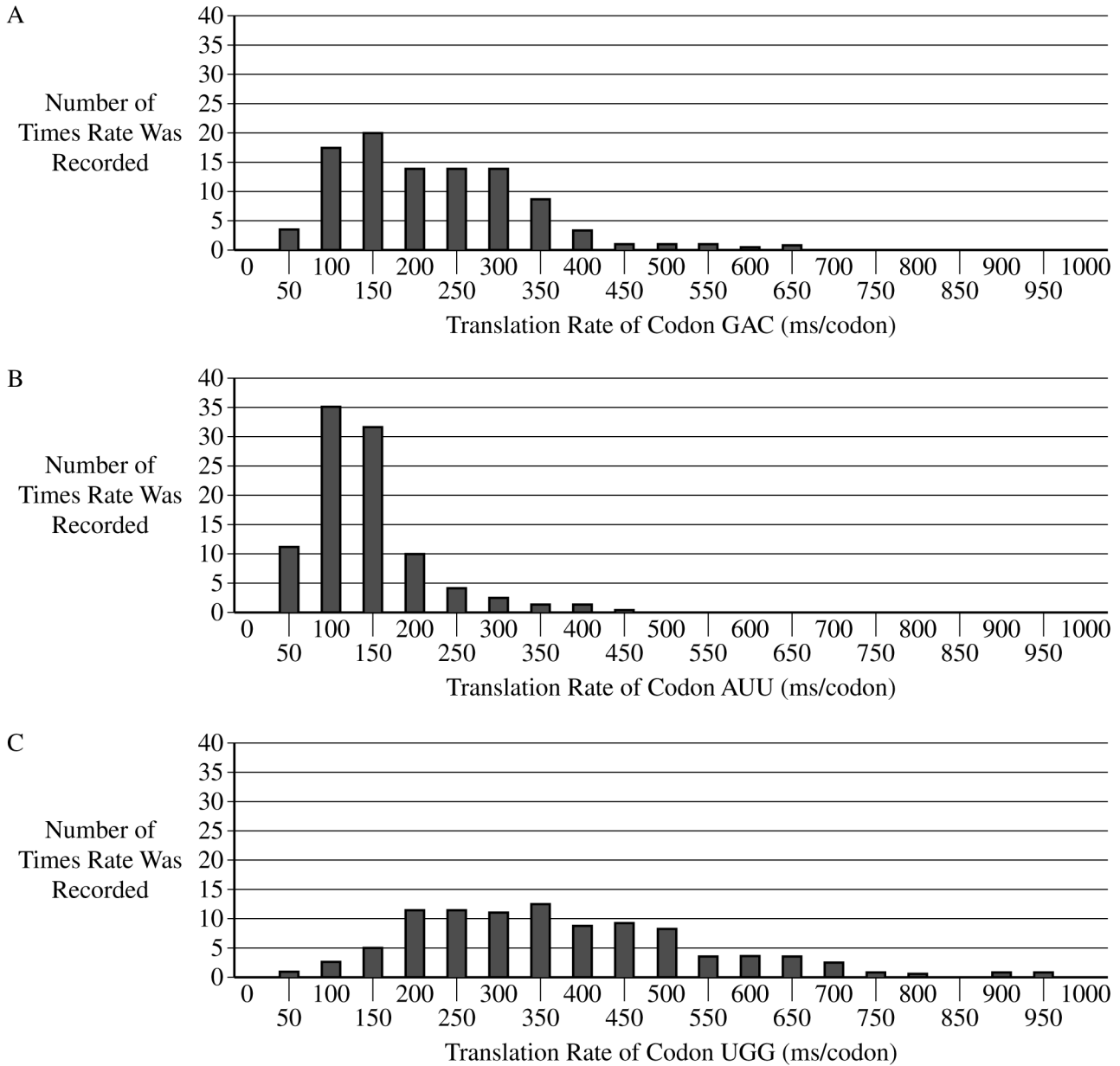


Figure 1. The distribution of translation rates for three different codons (A) GAC , (B) AUU , and (C) UGG

(a)	Using the data in <u>Figure 1</u> , graph A, identify the rate (in ms/codon) that was recorded the greatest number of times for the GAC codon. <ul style="list-style-type: none">• 150	1 point
(b)	Using the data in <u>Figure 1</u> , graphs B and C, describe the variation in translation rate of the AUU codon compared with that of the UGG codon. Accept one of the following: <ul style="list-style-type: none">• There is greater variation in (the translation rate of) UGG codons (than in the translation rate of AUU codons).• (The translation rate of) UGG ranges from 50 (ms/codon) to 950 (ms/codon), while (the translation rate of) AUU ranges from 50 (ms/codon) to 450 (ms/codon).	1 point
(c)	Scientists hypothesize that tRNA molecules that bind to UGG codons are available in lower abundance than are tRNAs that bind to AUU codons. Support the scientists' hypothesis using the data in <u>Figure 1</u> . Accept one of the following: <ul style="list-style-type: none">• The (average) translation rate of UGG is slower (than that of AUU).• Translation of UGG takes longer (per codon than does translation of AUU).• More of the UGG codons were translated at slower rates (than AUU codons were).	1 point
(d)	Amino acids can be encoded by multiple codons. In many organisms, certain codons for the same amino acid occur more frequently in an mRNA than do other codons. Based on the data provided, explain why the use of one codon over another for the same amino acid might result in increased levels of protein production from a particular mRNA. <ul style="list-style-type: none">• Certain codons are translated at faster rates than are others (and result in increased levels of protein production from a particular mRNA).	1 point
Total for question 6		4 points

BEGIN Question 6

Begin your response to **QUESTION 6** on this page. Do not skip lines.

- a) 150 ms/codon
- b) There is more variation in the UGG₃ codon than the AUU codon. because the numbers are more spread out.
- c) That is true because translation rate for UGG₃ codon took longer in general than AUU codon.
- d) The use of one codon might be faster to translate than another codon, causing an increased rate of protein production.

Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

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BEGIN Question 6

Begin your response to QUESTION 6 on this page. Do not skip lines.

6(a)- The rate that was recorded the most for the GAC codon was 150 ms/codons.

6(b)- The UGG codon has more variation than the AUU codon, because the translation rate of codon UGG goes from 50 ms/codon to 950 ms/codon, but the AUU codon goes from 50 ms/codon to 450 ms/codon.

6(c)- UGG codons have a lower abundance of tRNA than AUU, because UGG codons do different rates of translation fewer times and the most times it was recorded was 13 times, but AUU codons does translation rates more for a small amount of translation rates and the most times it was recorded was 35 times.

6(d)- Using one codon over another could have an increase in the levels of protein produced, because different codons have different translation rates, so some codons could have faster translation rates and can still be the same amino acid to create the proteins, but the production will increase.

BEGIN Question 6

Begin your response to **QUESTION 6** on this page. Do not skip lines.

6a: The rate that was recorded the greatest number of times for the GAC codon is 150 ms/codon.

6b: The variation in translation rate of the AUU codon is less than the variation in translation rate of the UGG codon. For the AUU codon, the only rates that were recorded, were from 50 ms/codon to 450 ms/codon. On the other hand, for the UGG codon, the rates that were recorded, were from 50 ms/codon to 950 ms/codon.

6c: The tRNA molecules that bind to UGG codons are available in lower abundance than rare tRNAs that bind to AUU codons because according to Figure 1, there were less times a rate was recorded for the UGG Codon, while for the AUU codon, there was a greater number of times the rates were recorded.

6d: The use of one codon over another for the same amino acid might result in increased levels of protein production from a particular mRNA because there will be a disruption in the rate of translation as ribosomes move along an mRNA from one codon to the next.

Question 6

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

Overview

Question 6 explained how scientists use ribosome profiling to measure translation rates and presented data in the form of frequency distributions of translation rates for three different codons.

Responses to part (a) were expected to identify the translation rate recorded most often for the GAC codon (Skill 4.B).

Responses to part (b) were expected to “describe the variation in translation rate of the AUU codon compared with that of the UGG codon,” based on the data (Skill 4.B).

Part (c) presented a hypothesis that “tRNA molecules that bind to UGG codons are available in lower abundance than are tRNAs that bind to AUU codons.” Responses were expected to support the hypothesis using the data in the frequency distributions (Skill 5.D).

Part (d) explained that “amino acids can be encoded by multiple codons,” and that “certain codons for the same amino acid occur more frequently in an mRNA than do other codons.” Responses were expected to explain that the use of codons that are translated at faster rates than others would result in increased levels of protein production (Skill 6.D; LO IST-1.O).

Sample: 6A

Score: 4

The response earned 1 point in part (a) because it correctly identifies the rate as 150. The response earned 1 point in part (b) because it describes UGG as having “more variation” than AUU has. The response earned 1 point in part (c) because it supports the hypothesis by indicating that UGG translation “took longer.” The response earned 1 point in part (d) because it explains that “one codon might be faster to translate than another codon.”

Sample: 6B

Score: 3

The response earned 1 point in part (a) because it correctly identifies the rate as 150. The response earned 1 point in part (b) because it describes UGG as having “more variation” than AUU. It also describes the larger range of translation rates for UGG than AUU, which is an alternate way to earn this point. The response did not earn a point in part (c) because it does not support the hypothesis based on the data that the (average) translation rate (X-axis: ms/codon) of UGG codons is slower (than that of AUU codons). The response earned 1 point in part (d) because it explains that “some codons could have faster translation rates.”

Question 6 (continued)

Sample: 6C

Score: 2

The response earned 1 point in part (a) because it correctly identifies the rate as 150. The response earned 1 point in part (b) because it describes the variation in AUU codons as being “less than the variation” in UGG codons. It also describes the larger range of translation rates for UGG than AUU, which is an alternate way to earn this point. The response did not earn a point in part (c) because it does not support the hypothesis based on the data that the (average) translation rate (X-axis: ms/codon) of UGG codons is slower (than that of AUU codons). The response did not earn a point in part (d) because it does not explain that certain codons are translated at faster rates than are others.