2025

AP® Biology

Sample Student Responses and Scoring Commentary

Inside:

Free-Response Question 2

- ☑ **Scoring Guidelines**
- ☑ **Student Samples**
- ☑ **Scoring Commentary**

Question 2: Interpreting and Evaluating Experimental Results with Graphing — 9 points

Many insects rely on pheromones (chemical signals) that are released by the females to find mating partners. Scientists hypothesize that, in a certain type of moth, the behavior of male moths in response to pheromones is regulated by the extracellular signaling molecule 20E.

To investigate whether the binding of 20E to its receptor, DopEcR, affects behavior in moths, scientists injected male moths with saline (control solution) or with small interfering RNA molecules (siRNAs) that inhibit the expression of the gene encoding DopEcR. The scientists then exposed the moths to the pheromone and determined the percent of total time observed that the moths engaged in general activity, defined as movement in any direction. The scientists also determined the percent of the general activity time that the moths spent in oriented activity, defined as movement toward an area of high pheromone concentration (Table 1).

Table 1. Average General and Oriented Activity in Male Moths Injected With Saline or siRNA Molecules

Treatment	General Activity (percent of total time observed, average $\pm 2SE_{\bar{X}}$)	Oriented Activity (percent of general activity, average $\pm 2SE_{\bar{X}}$)
Male moths injected with saline (control solution)	95 ± 5	60 ± 4
Male moths injected with siRNAs that inhibit expression of the gene encoding DopEcR	90 ± 8	25 ± 6

DopEcR is a G protein-coupled receptor. When 20E binds to DopEcR, GTP displaces the GDP bound to the G protein, and a signaling pathway is activated. The scientists hypothesize that this leads to the transcription of genes associated with the oriented activity observed in the male moths (Figure 1).

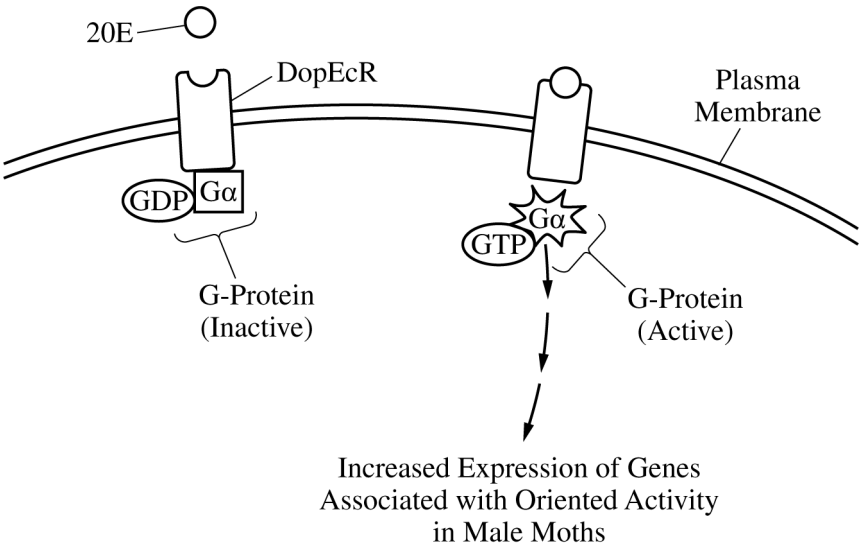
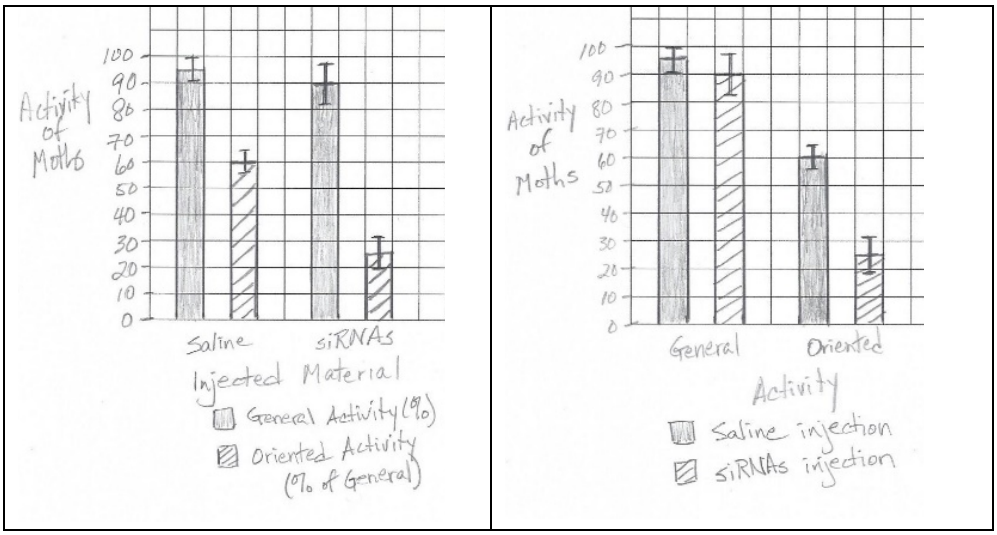


Figure 1. A simplified model of a signaling pathway activated by the binding of 20E to its receptor, DopEcR

A	Many receptors are embedded in the plasma membrane. **Describe** the polarity of the portion of the receptor that is inside the membrane. Examples of acceptable responses may include the following: • (The portion of the receptor inside the membrane) is nonpolar. • (The portion of the receptor inside the membrane) is hydrophobic.	**Point A1**
B	(i) Using the template in the space provided for your response, **construct** an appropriate type of graph that represents the data in Table 1. Your graph should be appropriately plotted and labeled. • Data are represented in a bar/modified bar graph. • Examples of acceptable responses may include the following: 	**Point B1**
	(i) Using the template in the space provided for your response, **construct** an appropriate type of graph that represents the data in Table 1. Your graph should be appropriately plotted and labeled. • Data and error bars are accurately plotted.	**Point B2**
	(i) Using the template in the space provided for your response, **construct** an appropriate type of graph that represents the data in Table 1. Your graph should be appropriately plotted and labeled. • Graph is appropriately labeled.	**Point B3**
	(ii) Based on the data in Table 1, **determine** the type of activity that was affected by inhibiting the expression of the DopEcR receptor. • Oriented activity (was affected).	**Point B4**

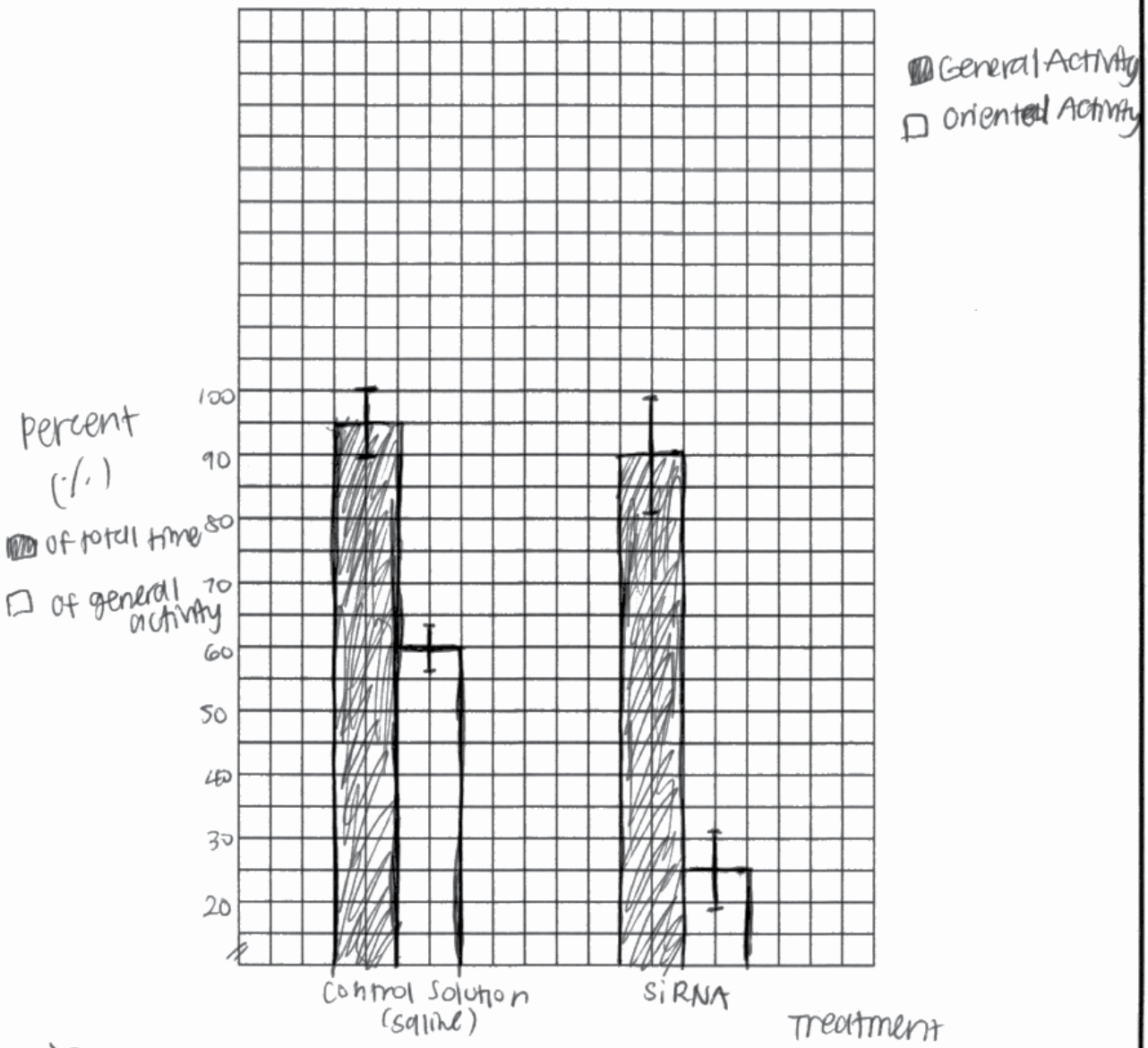
C	(i) Based on Table 1, identify the treatment group in which the oriented activity was greater than 50% of the general activity. Examples of acceptable responses may include the following: • The control/saline-treated group • Male moths injected with saline/control solution	**Point C1**
	(ii) The scientists studied some moths with a mutation in the gene encoding the G protein. The mutation prevents GTP from displacing the GDP bound to the G protein. Based on Figure 1, **predict** the effect of this mutation on the oriented activity in male moths exposed to the pheromone. • (The moths will show) decreased (oriented) activity.	**Point C2**
D	(i) Expression of the gene encoding DopEcR is low in the male moths during their first few days as adults, when they are sexually immature. Gene expression rapidly increases as the moths reach sexual maturity. The scientists claim that this increase in gene expression increases the likelihood of males finding females with whom to mate. Use evidence from the information provided to **support** the scientists' claim. Examples of acceptable responses may include the following: • (Increased expression of DopEcR) will increase oriented activity (and the moths' ability to find a mate). • (An increase in DopEcR expression) will enable the binding of 20E to more receptors. • (An increase in DopEcR expression) will make the males more sensitive to pheromones from the females. • (An increase in DopEcR expression) will enable the binding of 20E to more receptors and will make the males more sensitive to pheromones from the females.	**Point D1**
	(ii) Based on Figure 1, **explain** how an inhibitor of the DopEcR pathway might serve as an effective chemical to protect crops from moth damage. • (An inhibitor of the pathway) will reduce oriented activity/expression of genes associated with oriented activity and therefore decrease mating/population growth.	**Point D2**

BEGIN Question 2

Begin your response to **QUESTION 2** on this page. Do not skip lines.

Average General & Oriented Activity in Male Moths Injected with saline or siRNA

WHEN CONSTRUCTING A GRAPH, USE ONLY ONE COLOR.



A) The portion of the receptor that is inside the membrane is nonpolar, causing it to be hydrophobic.

Bii) Oriented activity was affected by inhibiting the expression of the DopEcR receptor.

GO ON TO THE NEXT PAGE.

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

0164804

Q5526/05

Additional page for answering Question 2

Continue your response to **QUESTION 2** on this page. Do not skip lines.

Ci) The male moths injected with saline (control solution) had oriented activity greater than 50% of general activity.

ii) The mutation prevents activation of the G-protein. This decreases expression of genes associated with oriented activity in male moths. The mutation decreases oriented activity in male moths exposed to the pheromone.

Di) Increase in gene expression of DopEcR means more of this ~~GPCR~~, G protein coupled receptor, which 20E binds to in order to activate a signaling pathway. This signaling pathway ultimately increases expression of genes associated with oriented activity. So more DopEcR increases oriented activity, which is movement towards areas of high pheromone concentration. Females release these pheromones to find mates, so increased oriented activity in males means they move towards females to mate.

ii) Inhibiting the DopEcR pathway ~~decreases~~ prevents expression of genes associated with oriented activity in male moths. Less oriented activity means less mating, so less offspring. Less moths means less crop damage.

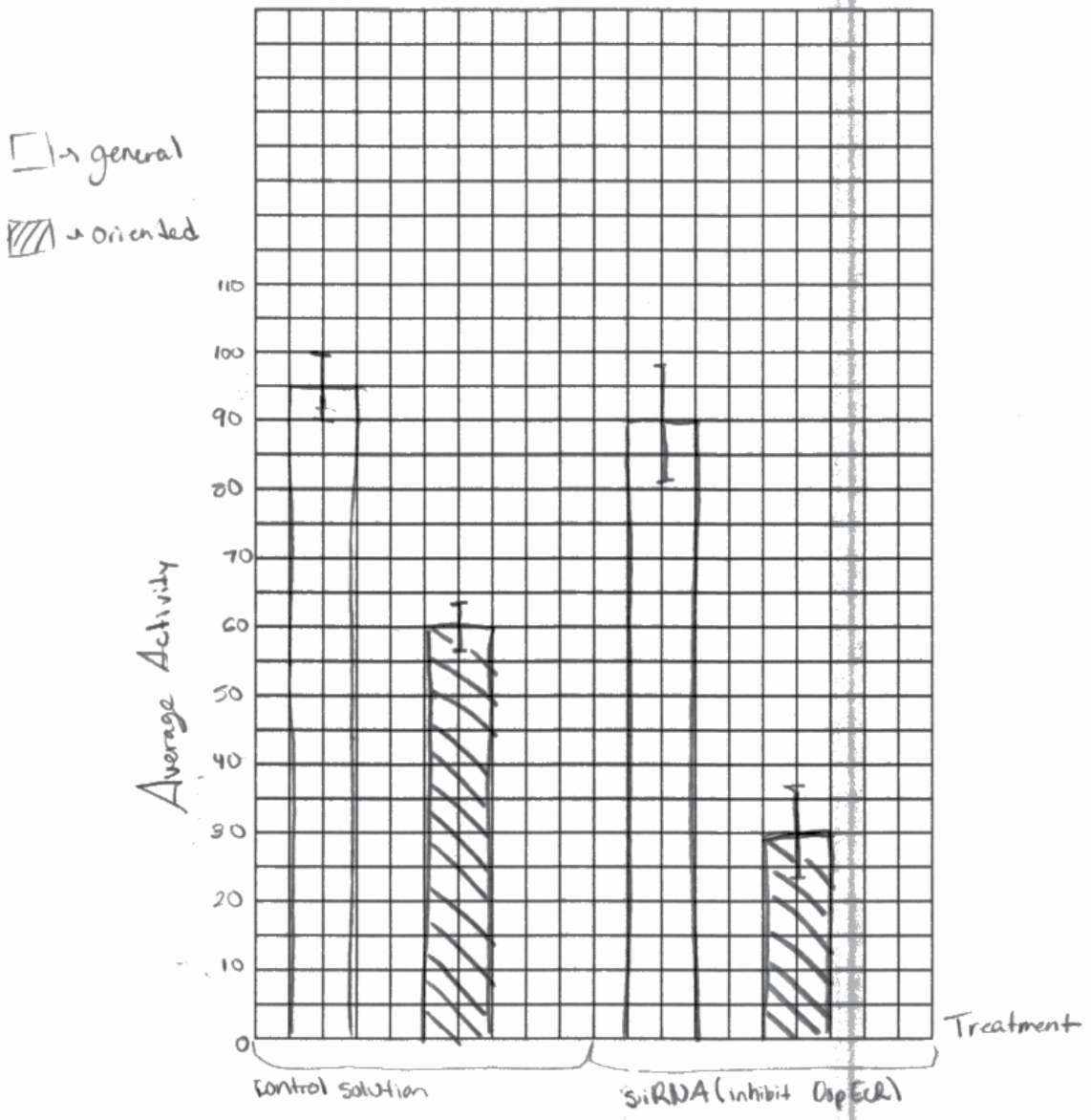
GO ON TO THE NEXT PAGE.

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

BEGIN Question 2

Begin your response to **QUESTION 2** on this page. Do not skip lines.

WHEN CONSTRUCTING A GRAPH, USE ONLY ONE COLOR.



A) The receptor inside the membrane is non polar

B) Oriented activity was affected. (i)

C) (i) The control solution group, oriented activity was greater than 50% of the general activity.

GO ON TO THE NEXT PAGE.

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

0278683

Q5526/05

Additional page for answering Question 2

Continue your response to **QUESTION 2** on this page. Do not skip lines.

ii) The mutation will decrease the expression of genes with Oriented activity. Oriented activity will decrease.

D) i) The gene expression increases the likelihood of males finding females to mate with, due to the increase of oriented activity and pheromones.

ii) An inhibitor of the DopEcR pathway serves as effective chemical protection for crops from moth damage since the moth's activity decreases when DopEcR is inhibited.

GO ON TO THE NEXT PAGE.

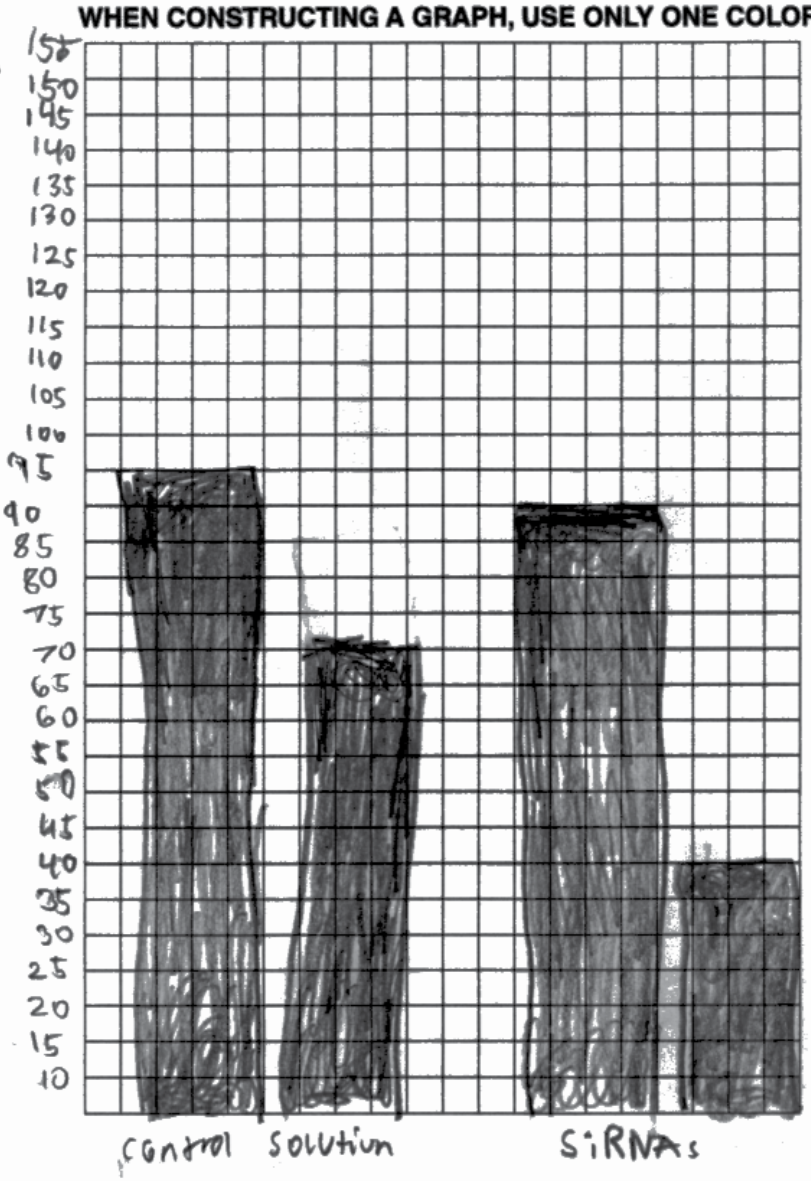
Use a pencil or pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

BEGIN Question 2

Begin your response to **QUESTION 2** on this page. Do not skip lines.

WHEN CONSTRUCTING A GRAPH, USE ONLY ONE COLOR.

(B) i.



(A). The polarity would be very high.

(B). ii. Their activity.

GO ON TO THE NEXT PAGE.

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

0256535

Q5526/05

Additional page for answering Question 2

Continue your response to **QUESTION 2** on this page. Do not skip lines.

(C.) i. The control solution.

ii. Their activity will decrease.

(D.) i. The activity shows to increase after sexual maturity has been reached.

ii. It will deactivat protiens crops give off which will make them useless to moths.

GO ON TO THE NEXT PAGE.

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

Question 2

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

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 2A
Score: 9

The response earned 1 point in part A for describing the portion of the receptor inside the membrane as "nonpolar."

The response earned 3 points in part B (i): 1 point for representing the data in a bar graph, 1 point for accurately plotting the data and error bars, and 1 point for appropriately labeling the graph. The response earned 1 point in part B (ii) for determining that oriented activity was the type of activity affected by inhibiting DopEcR expression

The response earned 1 point in part C (i) for identifying the "moths injected with saline" as the group with the oriented activity greater than 50% of general activity. The response earned 1 point for part C (ii) for predicting that the mutation would decrease oriented activity.

The response earned 1 point for part D (i) for stating that "more DopEcR increases oriented activity." The response earned 1 point for part D (ii) for explaining that the inhibitor prevents expression of genes associated with oriented activity, and "less oriented activity means less mating."

Sample: 2B
Score: 7

The response earned 1 point in part A for describing the portion of the receptor inside the membrane as "nonpolar."

The response earned 2 points in part B (i): 1 point for representing the data in a bar graph and 1 point for appropriately labeling the graph. The response did not earn the third point available for part B (i) because it does not accurately plot the data and error bars. The response earned 1 point in part B (ii) for determining that oriented activity was the type of activity affected by inhibiting DopEcR expression.

The response earned 1 point in part C (i) for identifying the control solution group as the group with the oriented activity greater than 50% of general activity. The response earned 1 point for part C (ii) for predicting that "oriented activity will decrease."

The response earned 1 point for part D (i) for stating that males are more likely to find females "due to the increase of oriented activity." The response did not earn a point for part D (ii) because it does not explain that reduced oriented behavior results in decreased moth reproduction.

Question 2 (continued)

Sample: 2C
Score: 3

The response did not earn a point in part A because it describes the polarity as "very high."

The response earned 1 point in part B (i) for representing the data in a bar graph. The response did not earn the second or third point available for part B (i) because it does not accurately plot the data and error bars and it does not appropriately label the graph (e.g., no *y*-axis label, no key). The response did not earn a point in part B (ii) because it does not determine that oriented activity was the type of activity affected by inhibiting DopEcR expression.

The response earned 1 point in part C (i) for identifying the moths injected with the control solution as the group with the oriented activity greater than 50% of general activity. The response earned 1 point for part C (ii) for predicting their "activity will decrease."

The response did not earn a point for part D (i) because it does not state that the increase in DopEcR gene activity will result in an increase in oriented activity. The response did not earn a point for part D (ii) because it does not explain the connection between decreased oriented activity and decreased mating/population growth.