2018

AP CollegeBoard

AP Biology

Sample Student Responses and Scoring Commentary

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Free Response Question 4

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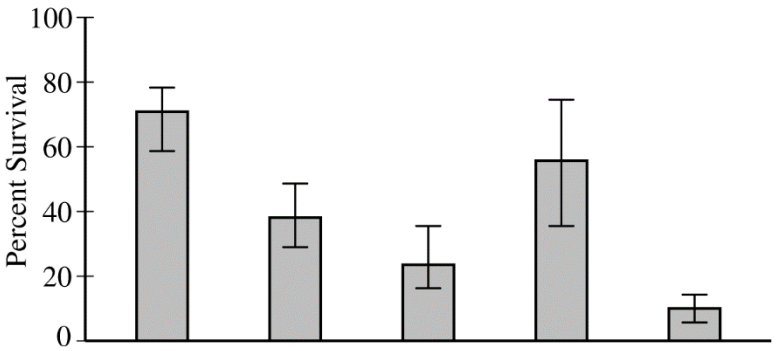
AP® BIOLOGY
2018 SCORING GUIDELINES

Question 4



Strain	I	II	III	IV	V
P450	+	–	+	+	–
Abc8	+	+	–	+	–
Cps	+	+	+	–	+

+ = Wildtype
– = Deletion

Figure 1. Percent survival of five strains of bedbugs treated with beta-cyfluthrin. A (+) indicates the gene is present; a (–) indicates the gene is deleted. Error bars represent the 95% confidence interval.

The common bedbug (*Cimex lectularius*) is a species of insect that is becoming increasingly resistant to insecticides. Bedbugs possess several genes suspected of contributing to the resistance, including *P450*, *Abc8*, and *Cps*. To investigate the role of these genes in insecticide resistance, researchers deleted one or more of these genes in different strains of bedbugs, as indicated in Figure 1, and treated the strains with the insecticide beta-cyfluthrin. Each strain was genetically identical except for the deleted gene(s) and was equally fit in the absence of beta-cyfluthrin. The percent survival of each strain following beta-cyfluthrin treatment is shown in Figure 1.

(a) **Identify** the control strain in the experiment. Use the means and confidence intervals in Figure 1 to **justify** the claim that *Abc8* is effective at providing resistance to beta-cyfluthrin.

Identification (1 point)

- Strain I

Justification (1 point)

- Error bars/CIs from strain I/control/WT do not overlap with strain III/*Abc8* deleted strain.
- Mean % survival of strain III/*Abc8* deletion falls outside the 95% confidence interval of strain I/control/WT.
- Strain III/*Abc8* deletion shows a statistically significant difference from strain I/control.

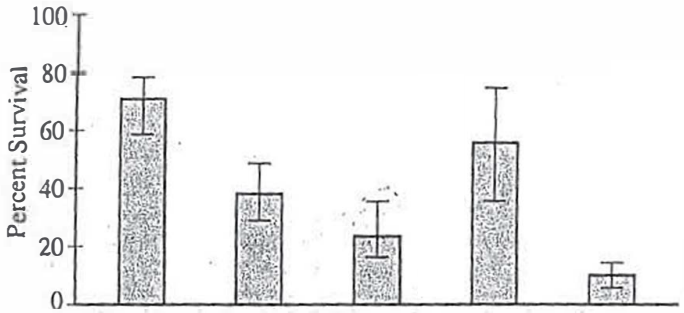
Question 4 (continued)

(b) *P450* encodes an enzyme that detoxifies insecticides. *Abc8* encodes a transporter protein that pumps insecticides out of cells. *Cps* encodes an external structural protein located in the exoskeleton that greatly reduces the absorption of insecticides. Based on this information and the data in Figure 1, **explain** how a deletion of both *P450* and *Abc8* results in lower survival in bedbugs compared with a deletion of *Cps* only.

Explanation (1 point per row; 2 points maximum)

Strain	*P450* and *Abc8*	*Cps* only	Explanation
V	Deleted	Present	Bedbugs can neither detoxify nor pump out insecticide, which results in a lower chance of bedbug survival.
IV	Present	Deleted	Bedbugs can detoxify and pump out insecticide, which results in a higher chance of bedbug survival.

4A1



Strain	I	II	III	IV	V
P450	+	–	+	+	–
Abc8	+	+	–	+	–
Cps	+	+	+	–	+

+ = Wildtype
– = Deletion

. Percent survival of five strains of bedbugs treated with beta-cyfluthrin. A (+) indicates the gene is present; a (–) indicates the gene is deleted. Error bars represent the 95% confidence interval.

ommon bedbug (*Cimex lectularius*) is a species of insect that is becoming increasingly resistant to insecticides. Bedbugs possess several genes suspected of contributing to the resistance, including *P450*, *Abc8*, and *Cps*. To investigate the role of these genes in insecticide resistance, researchers deleted one or more of these genes in different strains of bedbugs, as indicated in Figure 1, and treated the strains with the insecticide beta-cyfluthrin. Each strain was genetically identical except for the deleted gene(s) and was equally fit in the absence of beta-cyfluthrin. The percent survival of each strain following beta-cyfluthrin treatment is shown in Figure 1.

(a) **Identify** the control strain in the experiment. Use the means and confidence intervals in Figure 1 to **justify** the claim that *Abc8* is effective at providing resistance to beta-cyfluthrin.

(b) *P450* encodes an enzyme that detoxifies insecticides. *Abc8* encodes a transporter protein that pumps insecticides out of cells. *Cps* encodes an external structural protein located in the exoskeleton that greatly reduces the absorption of insecticides. Based on this information and the data in Figure 1, **explain** how a deletion of both *P450* and *Abc8* results in lower survival in bedbugs compared with a deletion of *Cps* only.

PAGE FOR ANSWERING QUESTION 4

a, Strain I was the control strain, Abc8 is effective at providing resistance because when Abc8 was deleted on 20% survives, and the confidance intervales between the strain without Abc8 (III) and the

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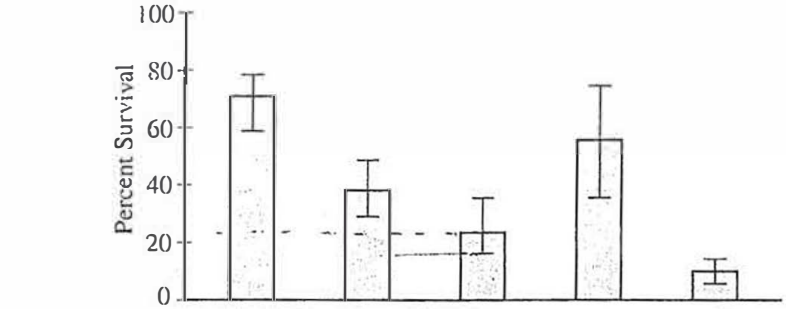
ADDITIONAL PAGE FOR ANSWERING QUESTION 4

control (CT) did not overlap, meaning there is a reliable statistical difference between having the Abc8 gene and not having it.
b. When both Abc8 and p450 are deleted the cell cannot get rid of the insecticide that has been absorbed. So because CPS doesn't encode for an exoskeleton that completly stops the insecticide from getting into the cell, any insecticide that does get into the cell remains toxic and has no way of leaving. When just CPS is deleted the survival rate is much higher because although a higher concentration of insecticide is getting into the cell it is getting detoxified and being removed through the transporter pumps encoded by Abc8.

4B,



Strain	I	II	III	IV	V
P450	+	−	+	+	−
Abc8	+	+	−	+	−
Cps	+	+	+	−	+

Most effect

+ = Wildtype
− = Deletion

Figure 1. Percent survival of five strains of bedbugs treated with beta-cyfluthrin. A (+) indicates the gene is present; a (−) indicates the gene is deleted. Error bars represent the 95% confidence interval.

4. The common bedbug (*Cimex lectularius*) is a species of insect that is becoming increasingly resistant to insecticides. Bedbugs possess several genes suspected of contributing to the resistance, including *P450*, *Abc8*, and *Cps*. To investigate the role of these genes in insecticide resistance, researchers deleted one or more of these genes in different strains of bedbugs, as indicated in Figure 1, and treated the strains with the insecticide beta-cyfluthrin. Each strain was genetically identical except for the deleted gene(s) and was equally fit in the absence of beta-cyfluthrin. The percent survival of each strain following beta-cyfluthrin treatment is shown in Figure 1.

✓(a) **Identify** the control strain in the experiment. Use the means and confidence intervals in Figure 1 to **justify** the claim that *Abc8* is effective at providing resistance to beta-cyfluthrin.

✓(b) *P450* encodes an enzyme that detoxifies insecticides. *Abc8* encodes a transporter protein that pumps insecticides out of cells. *Cps* encodes an external structural protein located in the exoskeleton that greatly reduces the absorption of insecticides. Based on this information and the data in Figure 1, **explain** how a deletion of both *P450* and *Abc8* results in lower survival in bedbugs compared with a deletion of *Cps* only.

PAGE FOR ANSWERING QUESTION 4

(a) The control strain in the experiment is Strain I. Due to the 95% confidence interval seen in Figure 1 it would be accurate to claim that Abc8 is effective at providing resistance to beta-cyfluthrin. When Abc8 is deleted from strain III you can observe ~~one of~~ the

4B2

ADDITIONAL PAGE FOR ANSWERING QUESTION 4

lowest survival rate when only one gene is deleted with a survival rate of about 15% to 40%.

(b) With the deletion of P450 the ~~insecticc~~ insecticides would be toxic and with the deletion of Abc8, the transporter protein would not be able to pump the insecticides out of the cell. Even though the Cps would reduce the absorption of the insectides, two of the main genes would not be present to combat the amount that did get through which leads to a lower survival rate which can be seen on strain V. However, when only Cps ~~it~~ is deleted the remaining genes, P450 and Abc8, can effectively (mostly) fight off the insecticed that have reached the cell by pumping it out of the cell and detoxifying it. This can be seen in Strain IV that shows a higher survival rate than Strain V.

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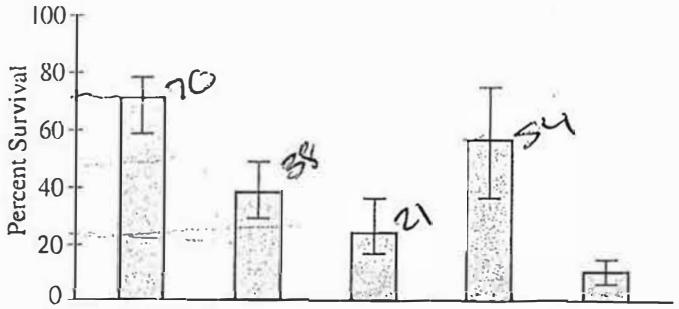
4C1



Strain	I	II	III	IV	V
P450	+	–	+	+	–
Abc8	+	+	–	+	–
Cps	+	+	+	–	+

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Figure 1. Percent survival of five strains of bedbugs treated with beta-cyfluthrin. A (+) indicates the gene is present; a (–) indicates the gene is deleted. Error bars represent the 95% confidence interval.

4. The common bedbug (*Cimex lectularius*) is a species of insect that is becoming increasingly resistant to insecticides. Bedbugs possess several genes suspected of contributing to the resistance, including *P450*, *Abc8*, and *Cps*. To investigate the role of these genes in insecticide resistance, researchers deleted one or more of these genes in different strains of bedbugs, as indicated in Figure 1, and treated the strains with the insecticide beta-cyfluthrin. Each strain was genetically identical except for the deleted gene(s) and was equally fit in the absence of beta-cyfluthrin. The percent survival of each strain following beta-cyfluthrin treatment is shown in Figure 1.

   (a) **Identify** the control strain in the experiment. Use the means and confidence intervals in Figure 1 to **justify** the claim that *Abc8* is effective at providing resistance to beta-cyfluthrin.

   (b) *P450* encodes an enzyme that detoxifies insecticides. *Abc8* encodes a transporter protein that pumps insecticides out of cells. *Cps* encodes an external structural protein located in the exoskeleton that greatly reduces the absorption of insecticides. Based on this information and the data in Figure 1, **explain** how a deletion of both *P450* and *Abc8* results in lower survival in bedbugs compared with a deletion of *Cps* only.

PAGE FOR ANSWERING QUESTION 4

a.) The control strain in the experiment is Strain I. Abc8 is effective at providing resistance to beta-cyfluthrin because without Abc8 we can see that the average percent of survival is

ADDITIONAL PAGE FOR ANSWERING QUESTION 4

only 15.5%. With a small confidence interval. However, with Abc8 the average percent of survival is around 54% with a larger confidence interval.

b.) The deletion of both PyS0 and ABC8 results in lower survival in bedbugs compared with a deletion of Cps only because without PyS0 and Abc8, there is no mechanism inside the cell that detoxifies or pumps out the insecticides. Cps only protects some of the outside of the cell which means that if the insecticides gets into the cell, the cell will automatically die.

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Question 4

Overview

The first part of the question focused on the interpretation of data presented both in graphic and tabular form. Students were provided with the results of an experiment involving five different strains of genetically altered bedbugs. The presence or absence of three different genes, *P450*, *Abc8*, and *Cps*, was given for each strain. The corresponding graph showed the average percent survival, with corresponding 95 percent confidence intervals, when each of the strains was exposed to the insecticide beta-cyfluthrin. Students were asked to identify the control strain and to justify the claim that *Abc8* is effective at providing resistance to the insecticide. Next, the students were provided with information on how each gene product functions in contributing to insecticide resistance. The students were then asked to explain the relationships among the functions of the gene products in providing resistance when either: 1) *P450* and *Abc8* are both deleted, or 2) when only *Cps* is deleted.

The key understandings and skills students were expected to demonstrate included the following:

- Knowledge of how organisms are affected by abiotic factors was used to investigate insecticide resistance.
- The understanding that expression, or lack thereof, of genes can alter phenotypes was used in an experimental investigation to help determine the function of the gene products in a biological process (insecticide resistance).
- Knowledge of experimental design and statistics was used to interpret the results of an experiment.

Sample: 4A
Score: 4

The response earned 1 point in part (a) for correctly identifying the control strain in the experiment as Strain I. The response earned 1 point in part (a) for correctly justifying the claim by stating that "the confidence intervals between the strain without *Abc8* (III) and the control (I) did not overlap." The response earned 1 point in part (b) for correctly explaining that when both *P450* and *Abc8* are deleted the insecticide "remains toxic and has no way of leaving." Lower survival is implied because the response specifies a higher survival rate when just *Cps* is deleted. The response earned 1 point in part (b) for correctly explaining that "when just *Cps* is deleted the survival rate is much higher" because insecticide "is getting detoxified and being removed through the transporter pumps."

Sample: 4B
Score: 3

The response earned 1 point in part (a) for correctly identifying the control strain in the experiment as Strain I. The response earned 1 point in part (b) for correctly explaining that "with the deletion of *P450* the insecticides would be toxic and with the deletion of *Abc8*, the transporter protein would not be able to pump the insecticides out … which leads to a lower survival rate." The response earned 1 point in part (b) for correctly explaining "when only *Cps* is deleted … *P450* and *Abc8* ... fight off the insecticide ... by pumping it out of the cell and detoxifying it," resulting in a higher survival rate.

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Question 4 (continued)

Sample: 4C
Score: 2

The response earned 1 point in part (a) for correctly identifying the control strain in the experiment as Strain I. The response earned 1 point in part (b) for correctly explaining that the "deletion of both *P450* and *Abc8* results in lower survival … because … there is no mechanism … that detoxifies or pumps out the insecticides."