2019

AP® CollegeBoard

# AP® Biology

## Sample Student Responses and Scoring Commentary

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# AP® BIOLOGY
# 2019 SCORING GUIDELINES

## Question 3

The pyruvate dehydrogenase complex (PDC) catalyzes the conversion of pyruvate to acetyl-CoA, a substrate for the Krebs (citric acid) cycle. The rate of pyruvate conversion is greatly reduced in individuals with PDC deficiency, a rare disorder.

(a) **Identify** the cellular location where PDC is most active.

**Identification (1 point)**

- Mitochondria
- Mitochondrial matrix

(b) **Make a claim** about how PDC deficiency affects the amount of NADH produced by glycolysis AND the amount of NADH produced by the Krebs (citric acid) cycle in a cell. **Provide reasoning** to support your claims based on the position of the PDC-catalyzed reaction in the sequence of the cellular respiration pathway.

**(1 point per row; 2 points max.)**

| | Claim | Reasoning |
|---|---|---|
| Glycolysis | No change | • Glycolysis continues; PDC is not needed.<br>• Glycolysis occurs before conversion of pyruvate to acetyl-CoA. |
| Krebs cycle | Decrease | • The Krebs cycle is greatly reduced/slowed down if there is no/less acetyl-CoA.<br>• The Krebs cycle occurs after conversion of pyruvate to acetyl-CoA. |

(c) PDC deficiency is caused by mutations in the *PDHA1* gene, which is located on the X chromosome. A male with PDC deficiency and a homozygous female with no family history of PDC deficiency have a male offspring. **Calculate** the probability that the male offspring will have PDC deficiency.

**Calculation (1 point)**

- The probability of inheritance is 0.
- The offspring cannot/will not have PDC deficiency.

3. The pyruvate dehydrogenase complex (PDC) catalyzes the conversion of pyruvate to acetyl-CoA, a substrate for the Krebs (citric acid) cycle. The rate of pyruvate conversion is greatly reduced in individuals with PDC deficiency, a rare disorder.

   (a) **Identify** the cellular location where PDC is most active.

   (b) **Make a claim** about how PDC deficiency affects the amount of NADH produced by glycolysis AND the amount of NADH produced by the Krebs (citric acid) cycle in a cell. **Provide reasoning** to support your claims based on the position of the PDC-catalyzed reaction in the sequence of the cellular respiration pathway.

   (c) PDC deficiency is caused by mutations in the *PDHA1* gene, which is located on the X chromosome. A male with PDC deficiency and a homozygous female with no family history of PDC deficiency have a male offspring. **Calculate** the probability that the male offspring will have PDC deficiency.

PAGE FOR ANSWERING QUESTION 3

a. PDC is most active in a cell's mitochondria.

b. A PDC deficiency does not change the amount of NADH produced [redacted] by glycolysis, but it decreases the amount of NADH produced in the Krebs cycle to make acetyl CoA. This occurs because the PDC-catalyzed reaction occurs after glycolysis, leading to no impact, and before the Krebs cycle. Without acetyl CoA, the Krebs cycle cannot occur, so a PDC deficiency would halt all NADH production in this step.

c. Male – $X^mY$, where m = mutation

Female – XX

| | X | X |
|---|---|---|
| $X^m$ | $X^mX$ | $X^mX$ |
| Y | XY | XY |

There is a 0% probability that a male offspring will have PDC deficiency.

3. The pyruvate dehydrogenase complex (PDC) catalyzes the conversion of pyruvate to acetyl-CoA, a substrate for the Krebs (citric acid) cycle. The rate of pyruvate conversion is greatly reduced in individuals with PDC deficiency, a rare disorder.

   (a) **Identify** the cellular location where PDC is most active.

   (b) **Make a claim** about how PDC deficiency affects the amount of NADH produced by glycolysis AND the amount of NADH produced by the Krebs (citric acid) cycle in a cell. **Provide reasoning** to support your claims based on the position of the PDC-catalyzed reaction in the sequence of the cellular respiration pathway.

   (c) PDC deficiency is caused by mutations in the *PDHA1* gene, which is located on the X chromosome. A male with PDC deficiency and a homozygous female with no family history of PDC deficiency have a male offspring. **Calculate** the probability that the male offspring will have PDC deficiency.

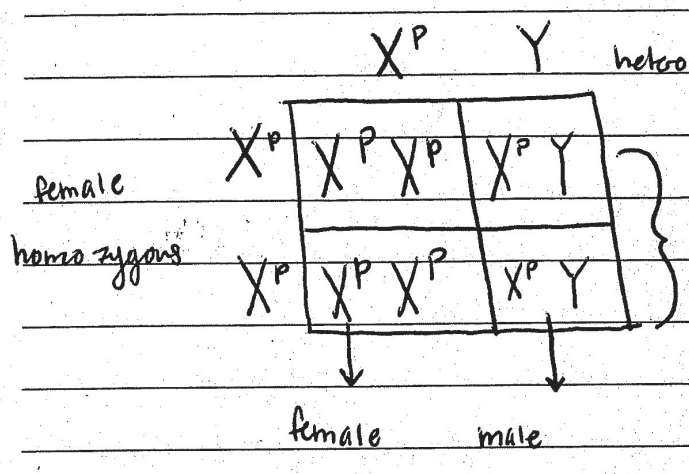
PAGE FOR ANSWERING QUESTION 3

a. It is most active in the cytoplasm of eukaryotic cells.

b. The PDC catalyzed reaction occurs at the end of glycolysis, prior to entering the Krebs cycle so a deficiency would not affect the amount of NADH produced by glycolysis. However, a deficiency would decrease the amount of NADH produced by the Krebs cycle because it would prevent the conversion, or significantly decrease, the ~~the~~ amount of acetyl-CoA which is a necessary substrate to trigger the Krebs cycle. If the Krebs cycle is not activated, the production of NADH during cellular respiration would be reduced, though it would not affect the existing amounts produced by glycolysis earlier in the overall process.

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

C. probability = 0




$X^P$ = dominant sex-linked trait for PDHA1 mutation.

$X^p$ = recessive

Y = y-chromosome

3C

3. The pyruvate dehydrogenase complex (PDC) catalyzes the conversion of pyruvate to acetyl-CoA, a substrate for the Krebs (citric acid) cycle. The rate of pyruvate conversion is greatly reduced in individuals with PDC deficiency, a rare disorder.

   (a) **Identify** the cellular location where PDC is most active.

   (b) **Make a claim** about how PDC deficiency affects the amount of NADH produced by glycolysis AND the amount of NADH produced by the Krebs (citric acid) cycle in a cell. **Provide reasoning** to support your claims based on the position of the PDC-catalyzed reaction in the sequence of the cellular respiration pathway.

   (c) PDC deficiency is caused by mutations in the *PDHA1* gene, which is located on the X chromosome. A male with PDC deficiency and a homozygous female with no family history of PDC deficiency have a male offspring. **Calculate** the probability that the male offspring will have PDC deficiency.

PAGE FOR ANSWERING QUESTION 3

A: PDC is most active in the mitochondria.
B: PDC deficiency will cause NADH production to decrease because there will be less energy.
C: $X^h$ Y The male offspring have
$X^H$ $X^HX^h$ $X^HY$ a 0% chance of
$X^H$ $X^HX^h$ $X^HY$ having a PDC deficiency.



GO ON TO THE NEXT PAGE.

# AP® BIOLOGY
# 2019 SCORING COMMENTARY

## Question 3

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

**Overview**

Students were asked to consider the cellular location of pyruvate dehydrogenase complex (PDC), the enzyme that converts pyruvate to acetyl-CoA, and describe the consequences in the cell when the activity of the enzyme is greatly reduced in the genetic disorder PDC deficiency. Students used their understanding of cellular organelles to identify the location of the enzyme. They also used their understanding of glycolysis and aerobic respiration to make a claim (and justify it) about how PDC deficiency affects the amount of NADH produced by these two processes. Lastly, they used their knowledge of the inheritance of X-linked traits to determine the probability of a child inheriting PDC deficiency given information about the genotypes of the parents. Within the question, students needed to provide claims and reasonings as well as calculate a probability.

**Sample: 3A**
**Score: 4**

The response earned 1 point in part (a) for identifying the mitochondria. The response earned 1 point in part (b) for making a claim that PDC deficiency does not change the amount of NADH produced by glycolysis and providing reasoning that "the PDC-catalyzed reaction occurs after glycolysis." The response earned 1 point in part (b) for making a claim that PDC deficiency decreases the amount of NADH produced in the Krebs cycle and providing reasoning that the PDC-catalyzed reaction occurs before the Krebs cycle. The response earned 1 point in part (c) for calculating that "[t]here is a 0% probability."

**Sample: 3B**
**Score: 3**

The response earned 1 point in part (b) for providing reasoning that the PDC-catalyzed reaction occurs at the end of glycolysis and making a claim that deficiency would not affect the amount of NADH produced by glycolysis. The response earned 1 point in part (b) for making a claim that a deficiency would decrease the amount of NADH produced by the Krebs cycle and providing reasoning that "it would prevent the conversion, or significantly decrease, the amount of acetyl-CoA which is a necessary substrate to … the Krebs cycle." The response earned 1 point in part (c) for calculating that the "probability = 0."

**Sample: 3C**
**Score: 2**

The response earned 1 point in part (a) for identifying that PDC is most active in the mitochondria. The response earned 1 point in part (c) for calculating that "[t]he male offspring have a 0% chance of having a PDC deficiency."