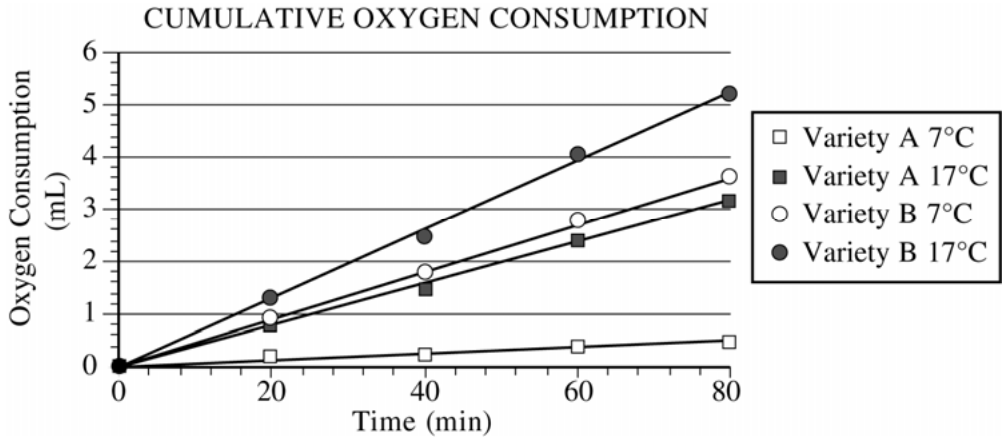
AP® BIOLOGY
2012 SCORING GUIDELINES

Question 2

An agricultural biologist was evaluating two newly developed varieties of wheat as potential crops. In an experiment, seedlings were germinated on moist paper towels at 20°C for 48 hours. Oxygen consumption of the two-day-old seedlings was measured at different temperatures. The data are shown in the graph below.



(a) **Calculate** the rates of oxygen consumption in mL/min for each variety of wheat at 7°C and at 17°C. **Show** your work (including your setup and calculation).
(3 points maximum)

- **1 point** for using the rate formula (D*y*/D*x*)
- **1 point** for using appropriate data to calculate the slope for at least three treatments
- **1 point** for giving answers in decimal format of mL/min

Note: Setup can choose <u>any</u> pair of points for the rise-over-run calculation of rate. The values used in the calculations can be greater or less than those shown in the examples below. Units of mL/min are implied by the question stem and need not be specifically shown.

Variety A at 7°C	(0.5 – 0 mL)/(80 – 0 min) = 0.0062 mL/min
Variety A at 17°C	(3.2 – 0 mL)/(80 – 0 min) = 0.040 mL/min
Variety B at 7°C	(3.6 – 0 mL)/(80 – 0 min) = 0.045 mL/min
Variety B at 17°C	(5.2 – 0 mL)/(80 – 0 min) = 0.065 mL/min

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Question 2 (continued)

(b) **Explain** the relationship between metabolism and oxygen consumption. **Discuss** the effect of temperature on metabolism for each variety of seedlings.
(4 points maximum)

Explanation of relationship (1 point)

- As metabolism increases, oxygen consumption increases.
  OR,
- As metabolism decreases, oxygen consumption decreases.

Discussion (1 point per bullet; 3 points maximum)

Interpretation of graph

- General statement that increasing temperature increases metabolic rate/oxygen consumption (no specific mention of variety A or B).
  OR,
- Variety A: rate of metabolism/oxygen consumption increases with an increase in temperature.
- Variety B: rate of metabolism/oxygen consumption increases with an increase in temperature.

Comparison of varieties

- Variety B has a higher metabolism/oxygen consumption than variety A at either temperature.
- Variety B has better metabolism/oxygen consumption at lower temperatures than variety A.

Elaboration of temperature

- Kinetic energy increases with temperature.
- Enzyme reaction rates increase with temperature.
- Effects on electron transport chain (ETC)/system.

(c) In a second experiment, variety A seedlings at both temperatures were treated with a chemical that prevents NADH from being oxidized to NAD^+. **Predict** the most likely effect of the chemical on metabolism and oxygen consumption of the treated seedlings. **Explain** your prediction.
(5 points maximum)

Prediction (1 point each; 2 points maximum)

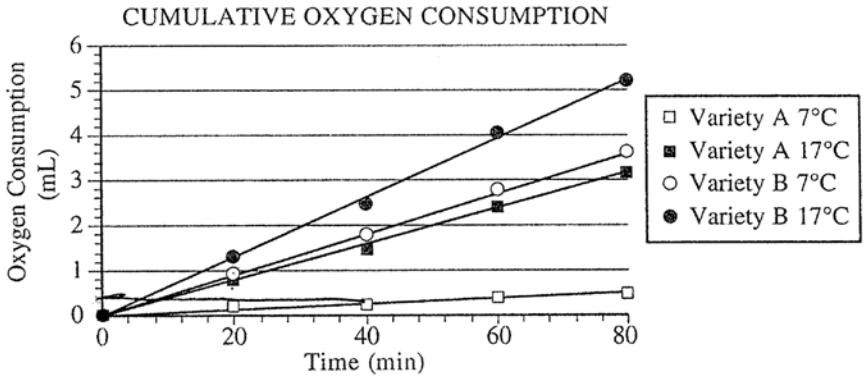
- Metabolism/respiration stops/declines/decreases/slows down.
- Oxygen consumption stops/declines/decreases/slows down.

Explanation (1 point each; 3 points maximum)

- Glycolysis/Krebs cycle/ETC will stop.
- ATP levels will drop/decline/decrease.
- Oxygen cannot accept electrons from ETC.

2-A-1

2. An agricultural biologist was evaluating two newly developed varieties of wheat as potential crops. In an experiment, seedlings were germinated on moist paper towels at 20°C for 48 hours. Oxygen consumption of the two-day-old seedlings was measured at different temperatures. The data are shown in the graph below.



(a) **Calculate** the rates of oxygen consumption in mL/min for each variety of wheat at 7°C and at 17°C. **Show** your work (including your setup and calculation).

(b) **Explain** the relationship between metabolism and oxygen consumption. **Discuss** the effect of temperature on metabolism for each variety of seedlings.

(c) In a second experiment, variety A seedlings at both temperatures were treated with a chemical that prevents NADH from being oxidized to NAD^+. **Predict** the most likely effect of the chemical on metabolism and oxygen consumption of the treated seedlings. **Explain** your prediction.

a) Variety A 7°C: $\frac{0.2-0}{40-0} = \frac{0.2}{40} = 0.005$ mL/min

Variety A 17°C: $\frac{3.2-0}{80-0} = \frac{3.2}{80} = 0.04$ mL/min

Variety B 7°C: $\frac{1-0}{20-0} = \frac{1}{20} = 0.05$ mL/min

Variety B 17°C: $\frac{4-0}{60-0} = \frac{4}{60} = \frac{2}{30} = 0.067$ mL/min

b) Metabolism is the total of all reactions in an organism. Many reactions require energy in order to occur. Oxygen consumption is necessary for cellular respiration to take place. Cellular respiration breaks down glucose to produce ATP for chemical reactions. In Variety A, 7°C dramatically decreases the rate of O_2 consumption which means that the rate of metabolism is also decreasing. At 17°C, Variety A has a significant increase in the rate of oxygen consumption and therefore the rate of metabolism.

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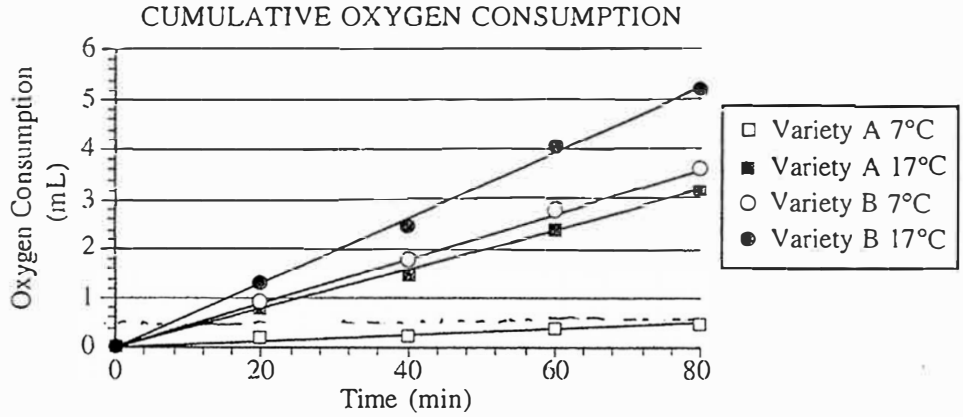
In Variety B, at 7°C the rate of oxygen consumption is less than the rate at 17°C but it is not as dramatic a change as in variety A. At 7°C the rate of metabolism is less than the rate at 17°C in Variety B.

c) The rate of oxygen consumption and metabolism will decrease significantly because the electrons in NADH need to go through the electron transport chain in order to create a H^+ gradient to produce ATP. Without oxidative phosphorylation, there is not enough ATP being produced to continue the chemical reactions in the plant.

2-B-1

2. An agricultural biologist was evaluating two newly developed varieties of wheat as potential crops. In an experiment, seedlings were germinated on moist paper towels at 20°C for 48 hours. Oxygen consumption of the two-day-old seedlings was measured at different temperatures. The data are shown in the graph below.



(2)

$\frac{1}{2}$

80

(a) **Calculate** the rates of oxygen consumption in mL/min for each variety of wheat at 7°C and at 17°C. **Show** your work (including your setup and calculation).

(b) **Explain** the relationship between metabolism and oxygen consumption. **Discuss** the effect of temperature on metabolism for each variety of seedlings.

(c) In a second experiment, variety A seedlings at both temperatures were treated with a chemical that prevents NADH from being oxidized to NAD^+. **Predict** the most likely effect of the chemical on metabolism and oxygen consumption of the treated seedlings. **Explain** your prediction.

a) Variety A at 7°C: .5 mL in 80 min

$\frac{.5\text{ mL}}{80\text{ min}} = \frac{1}{2}$ $\frac{1}{2} \cdot \frac{1}{80} = \frac{1}{160} \approx$ .006 mL/min

160 | 1.0000 .006

Variety A at 17°C: 3.2mL in 80 min

$\frac{3.2\text{mL}}{80\text{min}}$ 80 | 3.2000 .04 ≈ .04 mL/min

Variety B at 7°C: 4.6 mL in 80 min

$\frac{4.6\text{ mL}}{80\text{ min}}$ 80 | 4.6000 .05 ≈ .05 mL/min

Variety B at 17°C: 5.2 mL in 80 min

$\frac{5.2\text{mL}}{80\text{ min}}$ 80 | 5.2000 ≈ .065 mL/min

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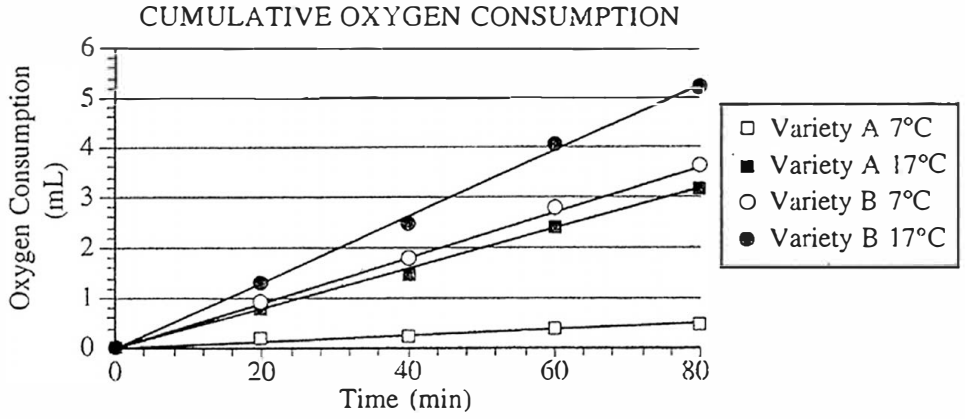
b) The more oxygen that is consumed, the more the seedling is metabolizing. This is because oxygen is needed for cell respiration. If the seed is consuming oxygen, at a faster rate, we know it is metabolizing at a faster rate. Temperature speeds up metabolism. This is because enzymes work more quickly and efficiently in warm temperatures, so the cells can metabolize more quickly.

c) The metabolism and oxygen consumption of both varieties would come to a halt. If the cells run out of O_2, they need to proceed to anaerobic respiration, or fermentation so they can continue glycolysis. Fermentat oxidizes NADH to NAD^+. NAD^+ is needed for glycolysis, so if the cell runs out of both oxygen and NAD^+, neither aerobic nor anaerobic respiration can continue and all metabolism will stop.

2-C-1

2. An agricultural biologist was evaluating two newly developed varieties of wheat as potential crops. In an experiment, seedlings were germinated on moist paper towels at 20°C for 48 hours. Oxygen consumption of the two-day-old seedlings was measured at different temperatures. The data are shown in the graph below.



(a) **Calculate** the rates of oxygen consumption in mL/min for each variety of wheat at 7°C and at 17°C. **Show** your work (including your setup and calculation).

(b) **Explain** the relationship between metabolism and oxygen consumption. **Discuss** the effect of temperature on metabolism for each variety of seedlings.

(c) In a second experiment, variety A seedlings at both temperatures were treated with a chemical that prevents NADH from being oxidized to NAD^+. **Predict** the most likely effect of the chemical on metabolism and oxygen consumption of the treated seedlings. **Explain** your prediction.

a) V.A at 17°C slope $\frac{4-0}{60-0} = \frac{4}{60} = \frac{1}{15}$ ml/min

V.B at 7°C $\frac{1-0}{20-0} = \frac{1}{20} = .05$ ml/min

V.A at 17°C $\frac{1.3-0}{40-0} = 3/80$ ml/min

V.A. at 7°C $\frac{1-0}{80-0} = \frac{1}{160}$ ml/min

3. Oxygen consumption and metabolism are directly linked to each other. The organisms level of metabolism depends on the oxygen availability. Because oxygen is necessary for the production of ATP and therefore energy.

As is evident from the experiment when temperature was lower for both varieties of seedlings oxygen consumption was lower. It would suggest that with higher temperatures metabolism increases, increasing the need for gas exchange. Availability of oxygen is necessary for the cell to make energy. Therefore, when metabolism increases therefore the need for energy increases, oxygen consumption would increase. Oxidation,

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which is a primary process during germination, needs oxygen. When the metabolism of the seedling increases, then, so does oxidation and the necessity for oxygen.

(c.) The chemical, which prevents NADH from being oxidized, would be harmful to the seedling. It would decrease oxygen consumption and become problematic for the metabolism levels. Without oxidation and the result of a slower or stagnant metabolism the seedling would fail to germinate, causing death of the plant

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AP® BIOLOGY
2012 SCORING COMMENTARY

Question 2

Overview

This question examined students' ability to apply mathematics to a biological process. Parts (a) and (b) focused on analyzing and interpreting graphs, with appropriate calculations. In part (a) students were asked to use the data in a graph to calculate the rate of oxygen consumption in two different varieties of wheat at two different temperatures. Part (b) asked them to demonstrate knowledge and understanding of the relationship between metabolism and oxygen consumption and to discuss the effect of temperature on metabolism. In part (c) students were expected to use a knowledge of intermediary metabolism to make and support a prediction about how the metabolism would be affected when a metabolic inhibitor that prevents the oxidation of NADH was present.

Sample: 2A
Score: 10

In part (a) 3 points were earned: 1 point for evidence of using the rate formula, 1 point for the use of appropriate data in the setup for calculations, and 1 point for presenting the correct final answers in decimal format. Four points were earned in part (b): 1 point for explaining that as metabolism increases, oxygen consumption increases; 1 point for indicating that the rate of oxygen consumption of variety A is lower at 7°C than at 17°C; 1 point for indicating that the rate of oxygen consumption of variety B is lower at 7°C than at 17°C; and 1 point for indicating that the change in oxygen consumption between 7°C and 17°C in variety B is not as dramatic as the change in oxygen consumption in variety A. In part (c) the response earned 3 points: 1 point for predicting that the chemical would result in reduced oxygen consumption, 1 point for predicting that it would result in reduced metabolism, and 1 point for explaining that "without oxidative phosphorylation, there is not enough ATP being produced."

Sample: 2B
Score: 8

In part (a) 1 point was earned for the use of appropriate data in the setup for calculations, and 1 point was earned for presenting the correct final answers in decimal format. In part (b) the response earned 1 point for the explanation that "[t]he more oxygen that is consumed, the more the seedling is metabolizing." The response earned 1 point for discussing how "[t]emperature speeds up metabolism." It earned 1 point for elaborating that "enzymes work more quickly and efficiently in warm temperatures." In part (c) the response earned 2 points for predicting that the chemical would cause "metabolism and oxygen consumption … [to] come to a halt." The response earned 1 point for explaining that NAD^+ is needed for glycolysis.

Sample: 2C
Score: 6

In part (a) 1 point was earned for giving evidence of using the rate formula, and 1 point was earned for the use of appropriate data in the setup for calculations. In part (b) the response earned 1 point for explaining, "Oxygen consumption and metabolism are directly linked to each other." The response earned 2 points for indicating that lower temperatures resulted in lower oxygen consumption for both varieties of seedlings. In part (c) 1 point was earned for predicting that the chemical "would decrease oxygen consumption."