Question 5: Analyze Model or Visual Representation of a Biological Concept or Process — 4 points

Figure 1 shows the reactions of the metabolic pathway used to synthesize amino acid B from amino acid A in cells.

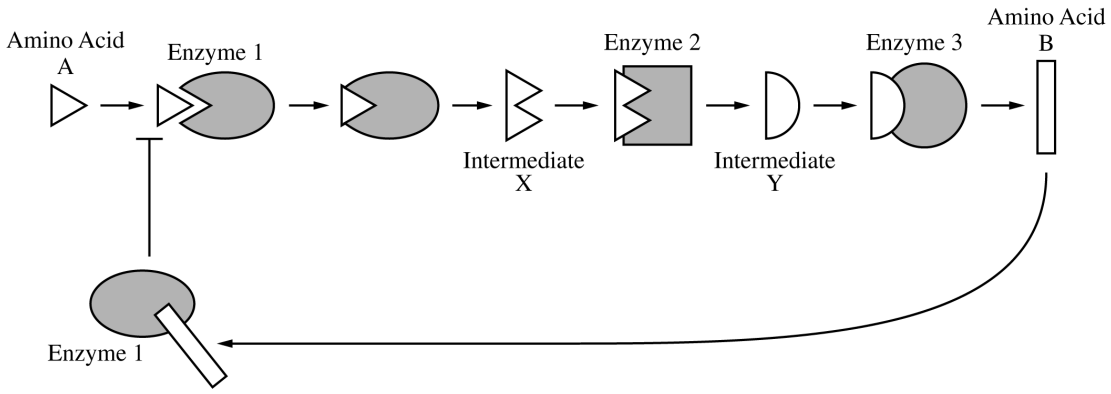


Figure 1. Synthesis of amino acid B from amino acid A

A	**Describe** a characteristic of an enzyme's active site that allows it to catalyze a specific chemical reaction. Examples of acceptable responses may include the following: • (The active site) is able to bind to a (specific) substrate/amino acid. • The shape/charge of the active site of an enzyme is compatible with a (specific) substrate/amino acid. • (The active site) positions the substrate/amino acid in a way that makes the reaction more likely. • Induced fit stresses bonds so that a reaction is more likely to occur.	**1 point**
B	Based on Figure 1, **explain** how the binding of amino acid A to enzyme 1 is regulated by amino acid B. Examples of acceptable responses may include the following: • Amino acid B inhibits the binding of amino acid A to enzyme 1. • Amino acid B binds to an allosteric site of enzyme 1 and prevents amino acid A from binding to enzyme 1. • The binding of amino acid B causes the enzyme to change shape and prevents amino acid A from binding to enzyme 1.	**1 point**
C	Using the information in Figure 1, **identify** the product of the reaction catalyzed by enzyme 2: intermediate X, intermediate Y, or amino acid B. • (Intermediate) Y	**1 point**
D	Based on Figure 1, **explain** how a change in pH could affect enzyme 3 in such a way that amino acid B cannot be produced. Examples of acceptable responses may include the following: • (A change in pH) could change the structure/active site/enzyme so that intermediate Y/the substrate cannot bind. • (A change in pH) could denature (enzyme 3) so that intermediate Y/the substrate cannot bind.	**1 point**

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

To investigate how increases in environmental temperatures affect the metabolism of certain organisms, researchers incubated liver cells from toads at different temperatures and measured two markers of metabolic activity (Table 1): the rate of oxygen consumption and the rate of ATP synthesis.

TABLE 1. RATE OF OXYGEN CONSUMPTION AND ATP SYNTHESIS AT DIFFERENT TEMPERATURES

Metabolic Marker	20°C	25°C	30°C
Rate of Oxygen Consumption (nmol/min/mg of mitochondrial protein $\pm 2SE_{\bar{X}}$)	12.8 ± 2.2	16.5 ± 2.0	22.1 ± 0.7
Rate of ATP Synthesis (nmol/min/mg of mitochondrial protein $\pm 2SE_{\bar{X}}$)	12.6 ± 1.6	16.8 ± 2.0	21.07 ± 0.8

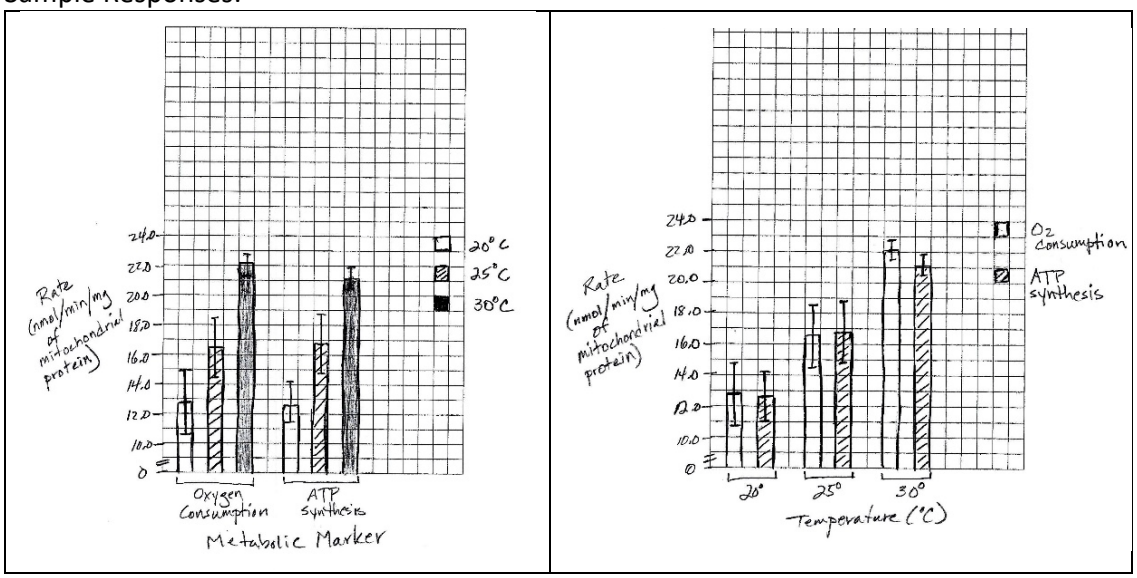
(a) **Describe** the role of water in the hydrolysis of ATP. **1 point**

Accept one of the following:

- Water is added in the process of cleaving/splitting (a phosphate from) ATP.
- Water breaks down/splits ATP.

(b) Using the template in the space provided for your response, **construct** a bar graph that represents the data shown in Table 1. Your graph should be appropriately plotted and labeled. **1 point**

Sample Responses:



- Data are represented in a bar graph.

Using the template in the space provided for your response, **construct** a bar graph that represents the data shown in Table 1. Your graph should be appropriately plotted and labeled. **1 point**

	Using the template in the space provided for your response, **construct** a bar graph that represents the data shown in Table 1. Your graph should be appropriately plotted and labeled. • Data points and error bars are correctly plotted.	**1 point**
	Based on the data provided, **determine** the temperature in $°C$ at which the rate of oxygen consumption is different from the rate of oxygen consumption at $25°C$. • 30	**1 point**
		Total for part (b) 4 points
(c)	Based on the data in Table 1, **describe** the effect of temperature on the rate of ATP synthesis in liver cells from toads. Accept one of the following: • As the temperature increases, the rate of ATP synthesis also increases. • There is a positive relationship (between temperature and ATP synthesis). • Temperature and ATP synthesis are directly correlated.	**1 point**
	Based on the data in Table 1**, calculate** the average amount of oxygen consumed, in $nmol$, for 10 mg of mitochondrial protein after 10 minutes at $25°C$. 1,650 [$16.5\ nmol/min/mg \times 10\ mg \times 10\ min$]	**1 point**
		Total for part (c) 2 points
(d)	Oligomycin is a compound that can block the channel protein function of ATP synthase. **Predict** the effects of using oligomycin on the proton gradient across the inner mitochondrial membrane. Accept one of the following: • (The proton gradient) will increase/become steeper (and may eventually plateau). • The difference in the concentration of protons/pH (across the inner mitochondrial membrane) will increase. • There will be an increase in the concentration of protons/a decrease in pH in the intermembrane space relative to that found within the mitochondrial matrix.	**1 point**
	Justify your prediction. Accept one of the following: • (Without protons being able to flow back into the matrix through ATP synthase), more protons will accumulate in the intermembrane space/between the two mitochondrial membranes. • (Without protons being able to flow back into the matrix through ATP synthase), there will be a lower pH in the intermembrane space/between the two mitochondrial membranes. • Protons will not be able to flow across the membrane (through ATP synthase), but the electron transport chain will still pump protons into the intermembrane space.	**1 point**
		Total for part (d) 2 points
		Total for question 2 9 points

Question 4: Conceptual Analysis — 4 points

Noncyclic electron flow and cyclic electron flow are two major pathways of the light-dependent reactions of photosynthesis. In noncyclic electron flow, electrons pass through photosystem II, then components of a chloroplast electron transport chain, and then photosystem I before finally reducing $NADP^+$ to NADPH. In cyclic electron flow, electrons cycle through photosystem I and some components of the electron transport chain (Figure 1).

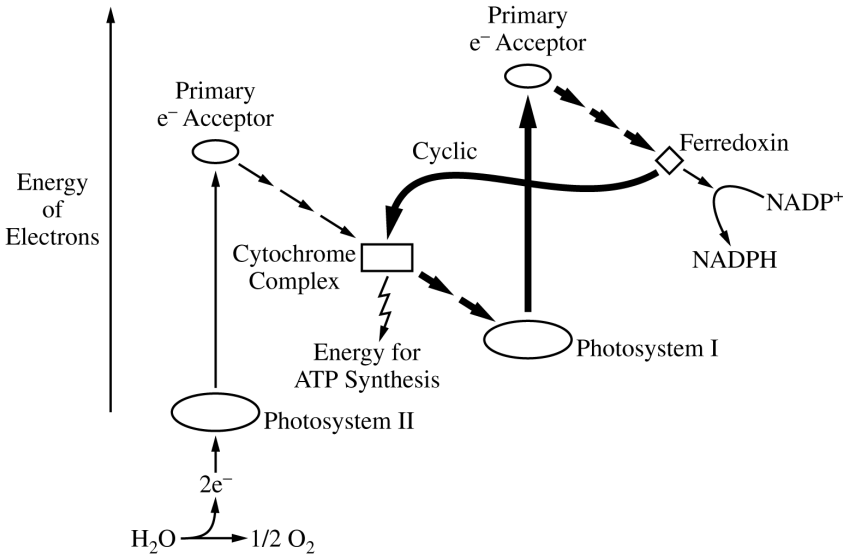


Figure 1. The pathways of noncyclic and cyclic (heavy arrows) electron flow. The cytochrome complex is a component of the electron transport chain between the two photosystems.

(a) **Describe** the role of chlorophyll in the photosystems of plant cells. **1 point**

Accept one of the following:

- Chlorophyll captures/absorbs light (energy).
- Chlorophyll receives electrons (from water)/receives electrons (from an electron transport chain)/transfers electrons (to an electron transport chain).

(b) Based on Figure 1, **explain** why an increase in the ratio of NADPH to $NADP^+$ will cause an increase in the flow of electrons through the cyclic pathway. **1 point**

- There is less/no $NADP^+$ to accept the electrons, so the electrons pass (instead) to the cyclic pathway/from ferredoxin to the cytochrome complex.

(c) Using rice plants, scientists examined the effect of a mutation that results in the loss of the protein CRR6. CRR6 is a part of the photosystem I complex, and its absence reduces the activity of photosystem I. **Predict** the effect of the mutation on the rate of biomass (dry weight) accumulation. **1 point**

- The rate (of biomass accumulation)/Biomass/It will be lower (in comparison with plants without the mutation).

(d) **Justify** your prediction in part (c). **1 point**

- There will be insufficient ATP/NADPH produced for the synthesis of carbohydrates/the Calvin cycle.

Total for question 4 — 4 points