AP BIO Unit 3 Released FRQs

2017 #7

Question 7

Many species of bacteria grow in the mouths of animals and can form biofilms on teeth (plaque). Within plaque, the outer layers contain high levels of oxygen and the layers closest to the tooth contain low levels of oxygen. The surface of the tooth is covered in a hard layer of enamel, which can be dissolved under acidic conditions. When the enamel breaks down, the bacteria in plaque can extract nutrients from the tooth and cause cavities.

Certain types of bacteria (e.g., *Streptococcus mutans*) thrive in the innermost anaerobic layers of the plaque and are associated with cavities. Other types of bacteria (*Streptococcus sanguinis*) compete with *S. mutans* but are unable to thrive in acidic environments.

(a) **Identify** the biochemical pathway *S. mutans* uses for metabolizing sugar and **describe** how the pathway contributes to the low pH in the inner layers of plaque. **(2 points; both points must be earned from the same row.)**

Identification	**Description**
fermentation	(lactic) acid/lactate
anaerobic respiration	acid
glycolysis	(pyruvic) acid/pyruvate

(b) Normal tooth brushing effectively removes much of the plaque from the flat surfaces of teeth but cannot reach the surfaces between teeth. Many commercial toothpastes contain alkaline components, which raise the pH of the mouth. **Predict** how the population sizes of *S. mutans* AND *S. sanguinis* in the bacterial community in the plaque between the teeth are likely to change when these toothpastes are used. **(1 point)**

Prediction (1 point)

- *S. mutans* decreases AND *S. sanguinis* increases

2017 #7 Answer Key

Question 7

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Prediction (1 point)

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2015 #2

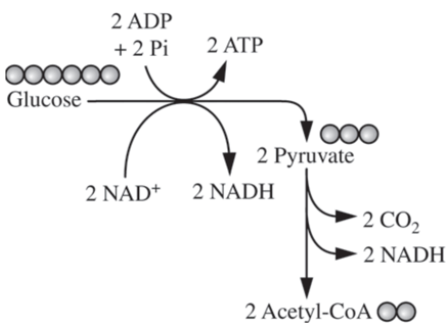


Figure 1. Glycolysis and pyruvate oxidation

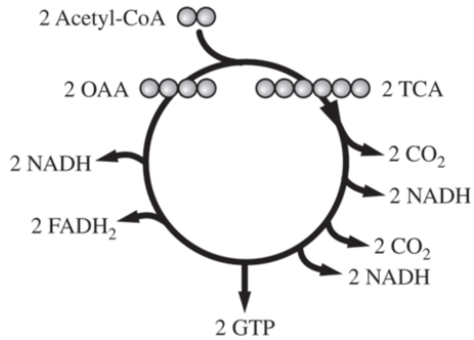


Figure 2. Krebs cycle

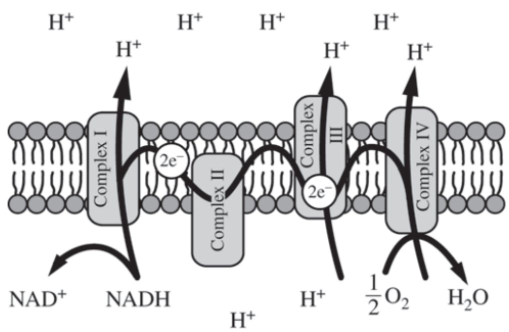


Figure 3. Electron transport chain

2. Cellular respiration includes the metabolic pathways of glycolysis, the Krebs cycle, and the electron transport chain, as represented in the figures. In cellular respiration, carbohydrates and other metabolites are oxidized, and the resulting energy-transfer reactions support the synthesis of ATP.

(a) Using the information above, **describe** ONE contribution of each of the following in ATP synthesis.

- Catabolism of glucose in glycolysis and pyruvate oxidation
- Oxidation of intermediates in the Krebs cycle
- Formation of a proton gradient by the electron transport chain

(b) Use each of the following observations to **justify** the claim that glycolysis first occurred in a common ancestor of all living organisms.

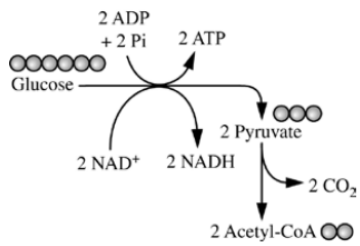
- Nearly all existing organisms perform glycolysis.
- Glycolysis occurs under anaerobic conditions.
- Glycolysis occurs only in the cytosol.

(c) A researcher estimates that, in a certain organism, the complete metabolism of glucose produces 30 molecules of ATP for each molecule of glucose. The energy released from the total oxidation of glucose under standard conditions is 686 kcal/mol. The energy released from the hydrolysis of ATP to ADP and inorganic phosphate under standard conditions is 7.3 kcal/mol. **Calculate** the amount of energy available from the hydrolysis of 30 moles of ATP. **Calculate** the efficiency of total ATP production from 1 mole of glucose in the organism. **Describe** what happens to the excess energy that is released from the metabolism of glucose.

(d) The enzymes of the Krebs cycle function in the cytosol of bacteria, but among eukaryotes the enzymes function mostly in the mitochondria. **Pose** a scientific question that connects the subcellular location of the enzymes in the Krebs cycle to the evolution of eukaryotes.

2015 #2 Answer Key

Question 2



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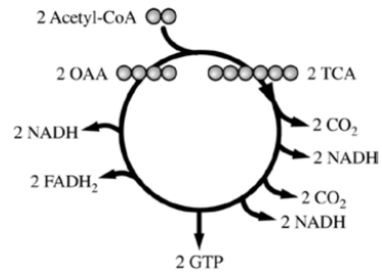

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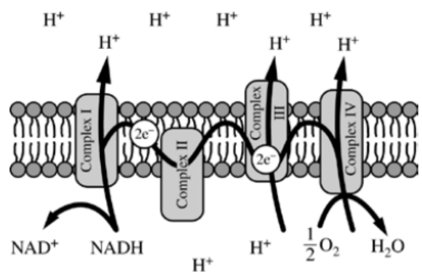


Figure 3. Electron transport chain

Cellular respiration includes the metabolic pathways of glycolysis, the Krebs cycle, and the electron transport chain, as represented in the figures. In cellular respiration, carbohydrates and other metabolites are oxidized, and the resulting energy-transfer reactions support the synthesis of ATP.

(a) Using the information above, **describe** ONE contribution of each of the following in ATP synthesis.

- Catabolism of glucose in glycolysis and pyruvate oxidation
- Oxidation of intermediates in the Krebs cycle
- Formation of a proton gradient by the electron transport chain

Process	**Description (1 point each box; 3 points maximum)**
Catabolism of glucose in glycolysis and pyruvate oxidation	• Produces NADH for use in ETC • Produces acetyl-CoA for entry into Krebs cycle • Provides energy for (substrate level) phosphorylation of ADP
Oxidation of intermediates in the Krebs cycle	• Produces NADH or FADH2 for use in ETC • Releases high energy electrons for use in ETC • Provides energy to pump protons against their concentration gradient • Produces GTP for (substrate level) phosphorylation of ADP
Formation of a proton gradient by the electron transport chain	• The flow of protons through membrane-bound ATP synthase generates ATP • Provides energy for (oxidative) phosphorylation of ADP

2015 #2 Answer Key Cont

Question 2 (continued)

(b) Use each of the following observations to **justify** the claim that glycolysis first occurred in a common ancestor of all living organisms.

- Nearly all existing organisms perform glycolysis.
- Glycolysis occurs under anaerobic conditions.
- Glycolysis occurs only in the cytosol.

Observation	**Justification (1 point each box; 3 points maximum)**
Nearly all existing organisms perform glycolysis	• Trait/gene/process originated early and was inherited/passed down/highly conserved • Glycolysis provided a selective advantage that was passed on to descendants
Glycolysis occurs under anaerobic conditions	Origin of glycolysis pre-dates free atmospheric oxygen/photosynthesis
Glycolysis occurs only in the cytosol	Origin of glycolysis pre-dates cell types with membrane-bound organelles/eukaryotes/endosymbiosis

(c) A researcher estimates that, in a certain organism, the complete metabolism of glucose produces 30 molecules of ATP for each molecule of glucose. The energy released from the total oxidation of glucose under standard conditions is 686 kcal/mol. The energy released from the hydrolysis of ATP to ADP and inorganic phosphate under standard conditions is 7.3 kcal/mol. **Calculate** the amount of energy available from the hydrolysis of 30 moles of ATP. **Calculate** the efficiency of total ATP production from 1 mole of glucose in the organism. **Describe** what happens to the excess energy that is released from the metabolism of glucose.

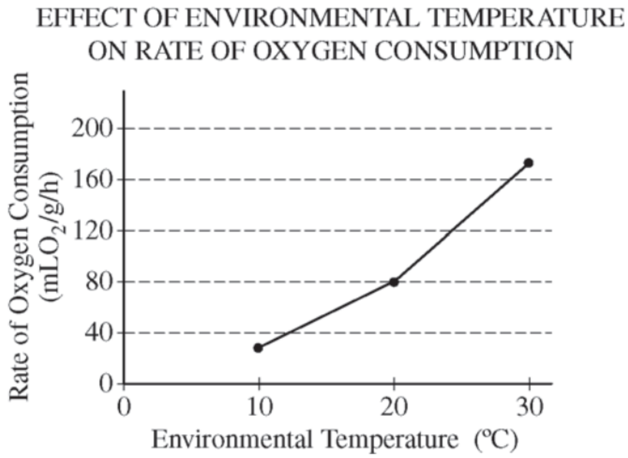
	Calculation/description (1 point each box; 3 points maximum)
Calculate available energy in ATP	219 kcal
Calculate efficiency	0.31 - 0.32 or 31 - 32%
Describe fate of excess energy	Released as heat/increases entropy

(d) The enzymes of the Krebs cycle function in the cytosol of bacteria, but among eukaryotes the enzymes function mostly in the mitochondria. **Pose** a scientific question that connects the subcellular location of the enzymes in the Krebs cycle to the evolution of eukaryotes.

Question (1 point)

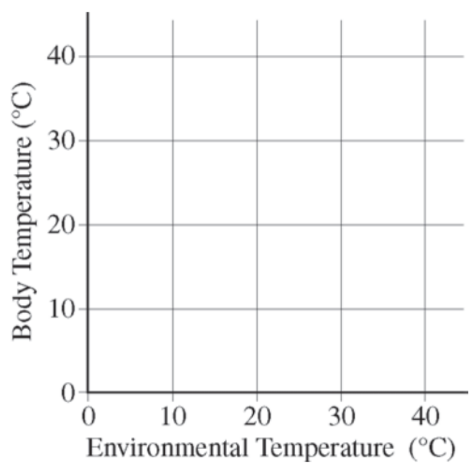
- A valid scientific question related to evolution of eukaryotes (e.g., Since the Krebs cycle occurs in the "cytoplasm" of the mitochondria (matrix), does it suggest that mitochondria were once prokaryotes?)

2014 #7



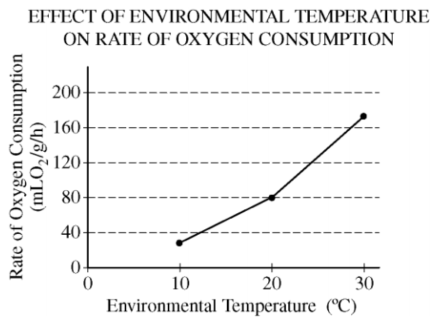
7. (a) Based on the graph, **describe** a specific method of thermoregulation used by the species of animal. **Provide** support for your answer using the data.

(b) On the labeled axis provided below, **draw** a line to indicate the most likely relationship between body temperature and environmental temperature in the species.



2014 #7 Answer Key

Question 7



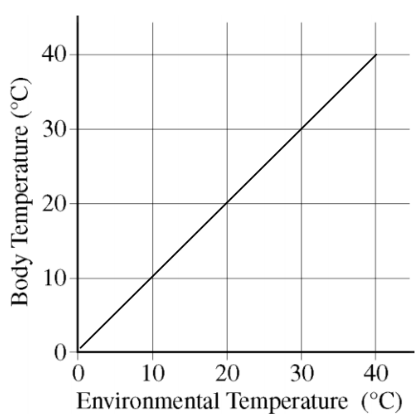
(a) Based on the graph, **describe** a specific method of thermoregulation used by the species of animal. **Provide** support for your answer using the data. (**2 points maximum**; LO 2.21, 2.24, 2.27)

NOTE: students may only earn points within one row.

Describe method (**1 point**)	Support (**1 point**)
This species is an ectotherm/incapable of endoregulation	• Increased metabolic rate/O_2 consumption rate/respiration rate with increased temperature • Decreased metabolic rate/O_2 consumption rate/respiration rate with decreased temperature • If the animal were endothermic, O_2 consumption rate/respiration rate/metabolic rate would increase with decreasing temperature
Behavior to adjust body temperature, i.e.,seeking shade, basking in the sun, burrowing in mud, evaporative cooling	• Increased metabolic rate/O_2 consumption rate/respiration rate with increased temperature • Decreased metabolic rate/O_2 consumption rate/respiration rate with decreased temperature • This species is ectothermic/incapable of endoregulation

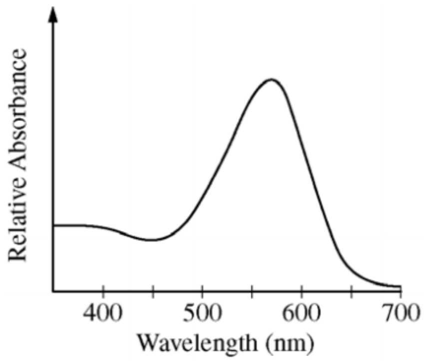
Question 7 (continued)

(b) On the labeled axis provided below, **draw** a line to indicate the most likely relationship between body temperature and environmental temperature in the species. (**1 point**; LO 2.22)

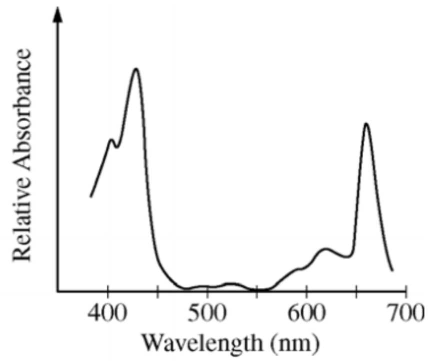


- Line/curve with positive slope

2013 #2



Graph I



Graph II

Color	Wavelength (nm)
Violet	380–450
Blue	450–475
Cyan	475–495
Green	495–570
Yellow	570–590
Orange	590–620
Red	620–750

2. An absorption spectrum indicates the relative amount of light absorbed across a range of wavelengths. The graphs above represent the absorption spectra of individual pigments isolated from two different organisms. One of the pigments is chlorophyll *a*, commonly found in green plants. The other pigment is bacteriorhodopsin, commonly found in purple photosynthetic bacteria. The table above shows the approximate ranges of wavelengths of different colors in the visible light spectrum.

   (a) **Identify** the pigment (chlorophyll *a* or bacteriorhodopsin) used to generate the absorption spectrum in each of the graphs above. **Explain** and **justify** your answer.

   (b) In an experiment, identical organisms containing the pigment from Graph II as the predominant light-capturing pigment are separated into three groups. The organisms in each group are illuminated with light of a single wavelength (650 nm for the first group, 550 nm for the second group, and 430 nm for the third group). The three light sources are of equal intensity, and all organisms are illuminated for equal lengths of time. **Predict** the relative rate of photosynthesis in each of the three groups. **Justify** your predictions.

   (c) Bacteriorhodopsin has been found in aquatic organisms whose ancestors existed before the ancestors of plants evolved in the same environment. **Propose** a possible evolutionary history of plants that could have resulted in a predominant photosynthetic system that uses only some of the colors of the visible light spectrum.

2013 #2 Answer Key

(a) **Identify** the pigment (chlorophyll *a* or bacteriorhodopsin) used to generate the absorption spectrum in each of the graphs above. **Explain** and **justify** your answer. (**3 points maximum**)

1 point per box
Identify BOTH pigments: Graph 1 = bacteriorhodopsin AND graph 2 = chlorophyll *a*
Explain that an organism containing bacteriorhodopsin appears purple because the pigment absorbs light in the green range of the light spectrum and/or reflects violet or red and blue light. The reflected red and blue light appears purple.
Explain that an organism containing chlorophyll *a* appears green because the pigment absorbs light in the red and blue ranges of the light spectrum and/or reflects green light.

(b) In an experiment, identical organisms containing the pigment from Graph II as the predominant light-capturing pigment are separated into three groups. The organisms in each group are illuminated with light of a single wavelength (650 nm for the first group, 550 nm for the second group, and 430 nm for the third group). The three light sources are of equal intensity, and all organisms are illuminated for equal lengths of time. **Predict** the relative rate of photosynthesis in each of the three groups. **Justify** your predictions. (**5 points maximum**)

Wavelength (Group)	Prediction (**1 point each box**)	Justification (**1 point each box**)
650 nm (1st Group)	Intermediate rate	An intermediate level of absorption occurs at 650 nm (compared to 430 nm and 550 nm); *therefore*, an intermediate amount of energy is available to drive photosynthesis.
550 nm (2nd Group)	Lowest rate	The lowest level of absorption occurs at 550 nm; *therefore*, the least amount of energy is available to drive photosynthesis.
430 nm (3rd Group)	Highest rate	The highest level of absorption occurs at 430 nm; *therefore*, the greatest amount of energy is available to drive photosynthesis.

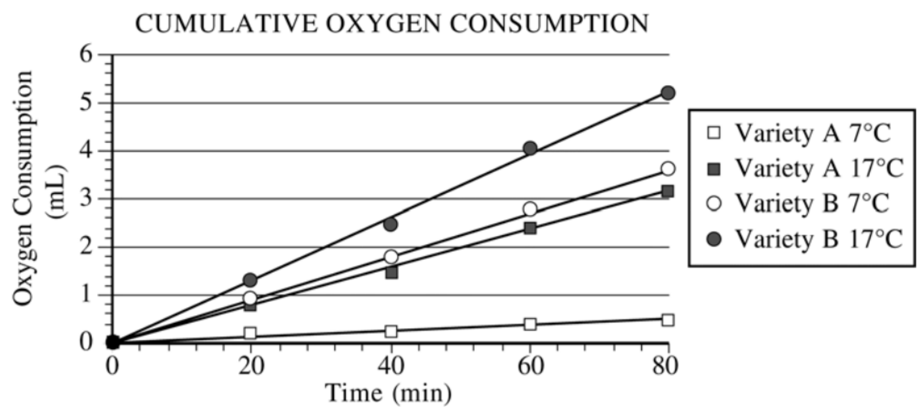
NOTE: A student who combines two groups (e.g., "the 650 nm and 430 nm groups have higher rates of photosynthesis compared to the 550 nm group") can earn a maximum of 4 points: up to 2 points for the prediction and up to 2 points for the justification.

(c) Bacteriorhodopsin has been found in aquatic organisms whose ancestors existed before the ancestors of plants evolved in the same environment. **Propose** a possible evolutionary history of plants that could have resulted in a predominant photosynthetic system that uses only some of the colors of the visible light spectrum. (**1 point per box; 2 points maximum**)

Proposal that includes an environmental selective pressure: • Green light was being absorbed by aquatic organisms using bacteriorhodopsin. • Unabsorbed wavelengths of light were available resources that organisms could exploit. • Absorbing visible light at all wavelengths may provide too much energy to the organism. • Absorbing light from ultraviolet wavelengths (shorter wavelengths = higher energy) could cause damage to the organism. • Absorbing light with longer wavelengths may not provide sufficient energy for the organism.
Appropriate reasoning to support the proposal: • Natural selection favored organisms that rely on pigments that absorb available wavelengths of light. • Endosymbiosis: chloroplasts evolved from cyanobacteria with pigments that used only certain wavelengths. • Genetic drift eliminated pigments that absorbed certain wavelengths of light. • Mutation(s) altered the pigment(s) used by organism.

2012 #2

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 20ºC 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.

2012 #2 Answer Key

(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

(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)

<u>Interpretation of graph</u>

- 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.

<u>Comparison of varieties</u>

- 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.

<u>Elaboration of temperature</u>

- 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.

2010 #2

2. An experiment was conducted to measure the reaction rate of the human salivary enzyme α-amylase. Ten mL of a concentrated starch solution and 1.0 mL of α-amylase solution were placed in a test tube. The test tube was inverted several times to mix the solution and then incubated at 25°C. The amount of product (maltose) present was measured every 10 minutes for an hour. The results are given in the table below.

Time (minutes)	Maltose Concentration (μM)
0	0
10	5.1
20	8.6
30	10.4
40	11.1
50	11.2
60	11.5

(a) **Graph** the data on the axes provided and **calculate** the rate of the reaction for the time period 0 to 30 minutes.

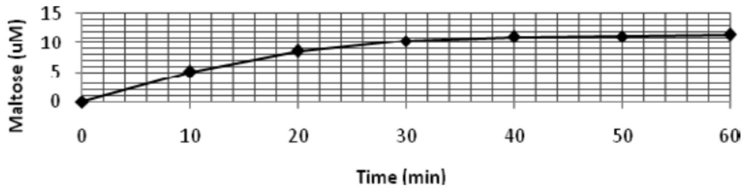
(b) **Explain** why a change in the reaction rate was observed after 30 minutes.

(c) **Draw** and **label** another line on the graph to predict the results if the concentration of α-amylase was doubled. **Explain** your predicted results.

(d) **Identify** TWO environmental factors that can change the rate of an enzyme-mediated reaction. **Discuss** how each of those two factors would affect the reaction rate of an enzyme.

2010 #2 Answer Key

(a) **Graph** the data on the axes provided and **calculate** the rate of the reaction for the time period 0 to 30 minutes. **(4 points maximum)**



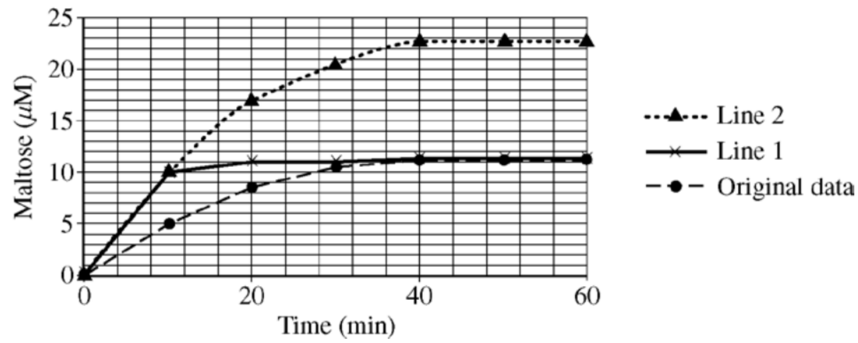
Graph **1 point each** **(3 points maximum)**	**Calculation** **(1 point maximum)**
• Correct orientation of the independent (time) and dependent (maltose) variables. • Correct display of units and intervals **(scale and labels)**. • Correct graphing of **all** data points on a properly scaled and oriented graph **(0–60 minutes)**.	• Correct setup **or** rate calculation (0.3–0.4 μM/min or, e.g., 1μM/3 min, 10.4 μM/30 min or 10.4–0.0 /30–0 μM/min), **with units**. (No points if setup is incorrect or if calculated number is wrong and contradicts a correct setup.)

(b) **Explain** why a change in the reaction rate was observed after 30 minutes. **(2 points maximum)**

Change **(1 point maximum)**	**Explanation of change** **(1 point maximum)**
• Reaction rate slows/levels off.	• Rate slows as substrate concentration declines (substrate used). • Enzyme inactive by about 40 minutes — enzyme loses activity over time (labile enzyme). • Product inhibition.

2010 #2 Answer Key Cont

(c) **Draw** and **label** another line on the graph to predict the results if the concentration of α-amylase was doubled. **Explain** your predicted results. **(2 points maximum)**

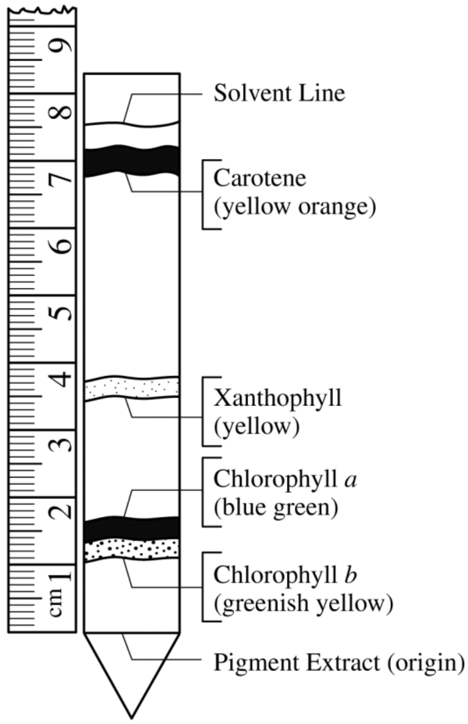


Drawing and labeling point (1 point maximum)	Explanation point (1 point maximum)
• Drawing and labeling of new line showing appropriate prediction (increased initial rate). o **Draw either line 1 OR line 2.**	• Line 1: Substrate is consumed more quickly because twice as much enzyme is present, but overall final product concentration remains the same. • Line 2: More product is formed at each time point because twice as much enzyme is present; product formation levels off as enzyme loses activity.

(d) **Identify** TWO environmental factors that can change the rate of an enzyme-mediated reaction. **Discuss** how each of those two factors would affect the reaction rate of an enzyme. **(4 points maximum including elaboration point)**

Identification point (1 point maximum)	Discussion points (3 points maximum)
• Identification of **TWO** environmental factors. (e.g., temperature, pH, salinity, inhibitors, stirring/mixing, pressure, O_2, light).	• Temperature factor — temperature ↑, rate ↑; temperature ↓, rate ↓; high temperature causes denaturation. • Other factors — how that factor changes the rate of the enzymatic reaction. • Detailed explanation point — description of temperature denaturation (improper folding, change of active site), altered kinetics (temperature alters rate of collisions) or pH inactivation or ionic (salinity) inactivation (active site charge changes).

2010B #1



1. Biological molecules can be separated by using chromatographic techniques. The diagram above shows the separation of several spinach leaf pigments by paper chromatography. Using the diagram above

   (a) **Explain** how paper chromatography can be used to separate pigments based on their chemical and physical properties.

   (b) **Discuss** the role of pigments both in capturing light energy and in converting it to the chemical energy of ATP and NADPH.

   (c) Use the ruler shown above to **determine** the R_f value of xanthophyll. **Show** your calculations.

2010B #1 Answer Key

Question 1

Biological molecules can be separated by using chromatographic techniques. The diagram shows the separation of several spinach leaf pigments by paper chromatography. Using the diagram,

(a) **Explain** how paper chromatography can be used to separate pigments based on their chemical and physical properties. **(4 points maximum)**

Separation property 2 points maximum	**Relationship to movement 2 points maximum**
Solubility in solvent used.	Greater solubility → further movement.
Molecular size/weight.	Smaller size → further movement.
Polarity/hydrophobicity/H-bonding.	Chemical similarity between solvent/pigment (solvent: pigment) → further movement.
Adhesion (affinity for paper).	Less adhesion → further movement.

- Description of chromatography protocol.

(b) **Discuss** the role of pigments both in capturing light energy and in converting it to the chemical energy of ATP and NADPH. **(3 points maximum for capturing; 3 points maximum for converting; 5 points maximum)**

Capturing
- Electromagnetic spectrum is described.
- Specific pigments absorb specific wavelength.
- Absorption/reflection (e.g., chlorophyll absorbs red/blue; reflects or transmits green).
- Pigments are embedded in thylakoid membranes.
- Antennae and/or accessory pigments.
- Electron energy level is boosted by absorption of photons (light).

Converting
- Photosynthesis is the process.
- Brief description of pathway through photosystems II and I.
- Electron transport or chemiosmosis, or both, transform light energy to chemical energy (produce NADPH/H^+/ATP).
- Brief description of electron transport or chemiosmosis, or both.
- Cyclic pathway.
- Splitting of water/photolysis.
  - H^+, e^-, O_2

(c) Use the ruler shown above to **determine** the R_f value of xanthophyll. **Show** your calculations. **(2 points maximum)**

- Formula or description $d_{pigment}/d_{solvent}$
- Calculation 3.5/7.5 ≈ 0.5

2009 #2

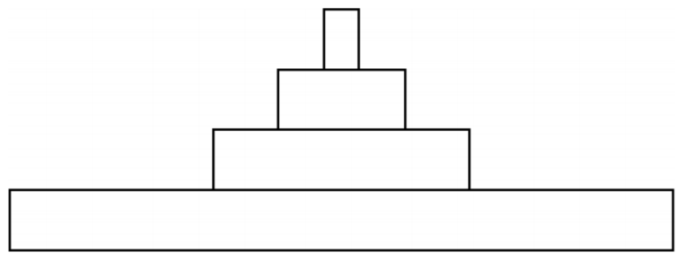
2. ATP and GTP are primary sources of energy for biochemical reactions.

   (a) **Describe** the structure of the ATP or the GTP molecule.

   (b) **Explain** how chemiosmosis produces ATP.

   (c) **Describe** TWO specific cell processes that require ATP and explain how ATP is used in each process.

   (d) An energy pyramid for a marine ecosystem is shown below. **Label** each trophic level of the pyramid and provide an example of a marine organism found at each level of this pyramid. **Explain** why the energy available at the top layer of the pyramid is a small percentage of the energy present at the bottom of the pyramid.



2009 #2 Answer Key

Question 2

ATP and GTP are primary sources of energy for biochemical reactions.

(a) **Describe** the structure of the ATP or the GTP molecule. **(1 point each; 2 points maximum)**

- Adenosine + 3 phosphates or guanosine + 3 phosphates.
- Elaborating on the phosphate bonds, e.g., unstable, negatively charged.
  Mentioning without explaining "high-energy bonds" is insufficient.
- Adenosine or guanosine described as adenine or guanine bound to ribose.

Note: adenine + ribose + 3 phosphates earns 2 points.

(b) **Explain** how chemiosmosis produces ATP. (**1 point each; 3 points maximum)**

- Electron transport, e.g., linked to proton pumps, coenzymes, NADH.
- H+ pumped to one side of the membrane, photosynthesis—inside thylakoid, respiration—outside cristae.
- Proton gradient established, has potential energy or capacity to do work.
- ATP synthases or channel proteins generate ATP.

(c) **Describe** TWO specific cell processes that require ATP and explain how ATP is used in each process. **(4 points maximum)**

	Description of process **(1 point per process; 2 points maximum)**	**How ATP is used** **(1 point per process; 2 points maximum)**
Mechanical	Muscle, sliding filament; cilia or flagella, propulsion; chromosome movement in mitosis or meiosis	ATP → ADP + P connected to process or energy coupling, e.g., conformational change in myosin head
Transport	Active transport or transport against gradient; sodium-potassium pump; endocytosis or exocytosis	ATP → ADP + P connected to process, e.g., phosphorylating the transport protein
Chemical	Hydrolysis or synthesis; specific chemical reaction, e.g., photosynthesis or glycolysis; kinase activity	ATP → ADP + P connected to process or energy coupling, e.g., phosphorylating glucose in glycolysis or PGA in Calvin cycle

(d) An energy pyramid for a marine ecosystem is shown below. **Label** each trophic level of the pyramid and provide an example of a marine organism found at each level of this pyramid. **Explain** why the energy available at the top layer of the pyramid is a small percentage of the energy present at the bottom of the pyramid. **(3 points maximum)**

	Explanation **(1 point per box; 3 points maximum)**
Label trophic levels	Producer or autotroph → 1° consumer or herbivore → 2° consumer or carnivore → 3° consumer; no point for mentioning detritivores or decomposers
Examples of <u>marine</u> organisms	Algae → zooplankton → small fish → shark Type of plankton must be specified if used above producer level; "fish" can be used <u>once</u> if unspecified; top level may include terrestrial organisms
Energy transfer	Energy transferred due to metabolic activities, heat, work, entropy Mentioning without explaining 10% energy transfer between trophic levels is insufficient

Note: Students must receive points in all four sections to earn a score of 10.

2008 B #1

1. Measurements of dissolved oxygen (DO) are used to determine primary productivity in bodies of water.

    - Explain the relationship of dissolved oxygen to primary productivity.
    - How would the predicted levels of DO differ in each of the following pairs of water samples? Provide support for your prediction. Be sure to include a discussion of net productivity and gross productivity in your answer.

    I. Pond water at 25°C vs. pond water at 15°C

    II. Pond water placed in the dark for 24 hours vs. pond water placed in light for 24 hours

2008 B #1 Answer Key

1. Measurements of dissolved oxygen (DO) are used to determine primary productivity in bodies of water.

- Explain the relationship of dissolved oxygen to primary productivity.

  Primary productivity **(4 points maximum)**
  - Primary productivity: rate at which autotrophs convert light energy into stored chemical energy
  - Increase in oxygen = increase in primary productivity
  - Rate of carbon compound formation measured indirectly through oxygen production
  - $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
  - Gross productivity\GPP = rate at which primary producer synthesizes O_2
  - Net productivity = GPP – producer respiration
  - Autotrophs produce/consume oxygen; heterotrophs consume oxygen

- How would the predicted levels of DO differ in each of the following pairs of water samples? Provide support for your prediction. Be sure to include a discussion of net productivity and gross productivity in your answer.

  I. Pond water at 25°C vs. pond water at 15°C **(4 points maximum)**
  - Prediction: DO at 15° greater than DO at 25°
  - Why: [saturation DO] 15° greater than [saturation DO] 25°
  - Example **(1 point maximum)**
    - Higher metabolic rate of aquatic organisms at warmer temperature = less available oxygen
    - Fish die in summer ponds/trout live in cold streams
    - Drinks at room temperature hold less dissolved gas than when cold
  - Elaboration of the example

  II. Pond water placed in the dark for 24 hours vs. pond water placed in light for 24 hours **(4 points maximum)**
  - Prediction: DO in light greater than DO in dark
  - Why: photosynthesis ↑ and oxygen ↑
    - Photosynthesis is light dependent
    - Light bottle is the NET productivity
    - Dark bottle uses O_2 /respiration

2005 #1

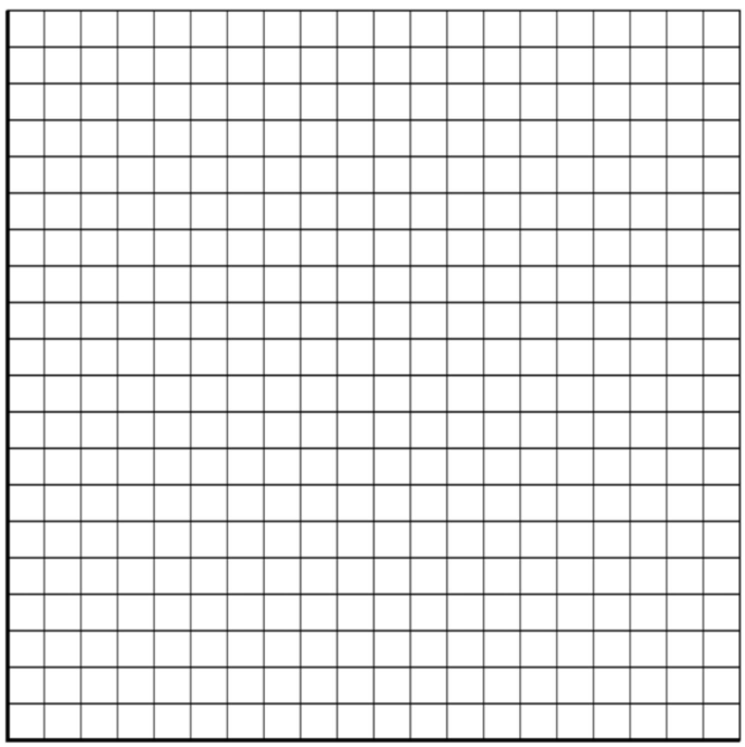
1. Yeast cells are placed in an apparatus with a solution of sugar (a major nutrient for yeast metabolism). The apparatus detects bubbles of gas released by the yeast cells. The rate of respiration varies with the surrounding temperatures as indicated by the data below.

Temperature (°C)	0	10	20	30	40	50	60	70
Number of bubbles of gas produced per minute	0	3	7	12	7	4	1	0

(a) **Graph** the results on the axes provided. **Determine** the optimum temperature for respiration in the yeast.

(b) Respiration is a series of enzyme-catalyzed reactions. Using your knowledge of enzymes and the data above, **analyze** and **explain** the results of this experiment.

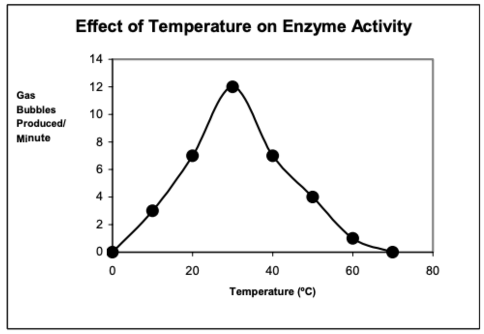
(c) **Design** an experiment to test the effect of varying the pH of the sugar solution on the rate of respiration. Include a prediction of the expected results.



2005 #1 Answer Key

Part A: Graph and Optimum Temperature (3 points maximum)

Graph Setup (1 point)
Must contain:
- Title/Legend and Y-axis [Bubbles of gas/Min]
- X-axis [Temperature (°C)]
- Correct measurement units and scaling for axes



Data Plotted (1 point)
- Correctly plotted points in proper orientation
- Points may or may not be connected with a line
- Bar graph acceptable

Optimum Temperature (1 point)
- 30° C, or between 20° C and 40° C either clearly indicated on the graph or in a sentence

Part B: Analyze and Explain the Results
(4 points maximum)

Analysis (1 point)
- Provide range of the change in respiration activity (increase and decrease) to temperature change (increase and decrease)

Explanations (1 point each)
- Below optimum—Increase in molecular movement leads to increase in reaction rate
- Above optimum—Denaturing of enzymes leads to decrease in reaction rate

Elaboration (2 points maximum, 1 point each)
- Relating enzyme function (effect on reaction rates) to allosteric site, active site, H^+ bond, R groups
- Gas production due to respiration (can use either aerobic respiration or fermentation)
- Induced fit
- Lowering energy of activation
- Enzyme specificity

Part C: Experimental Design (4 points maximum)

NOTE: Experiment must be feasible. Must include sugar solutions of varying pH and an organism. If experiment is not reasonable, no points are awarded in the design structure section below.

Design Structures (3 points maximum, 1 point each)
- Two experimental constants—constant amounts of yeast or sugar, or temperature held constant
- Independent variable tested—reasonable pH range must be stated, including acid through base

- Control—identification of a control treatment, e.g., no sugar, no yeast, pH 7
- Measurable product per unit of time—gas production, color change, etc.
- Multiple trials—repeat trials, several samples, stats, etc.

Prediction (1 point)
- Designate a pH at which enzymes will function optimally