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AP Bio Semester 1 Review, Practice FRQs

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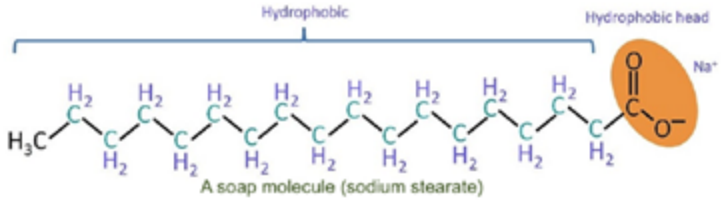
Unit 1 FRQs

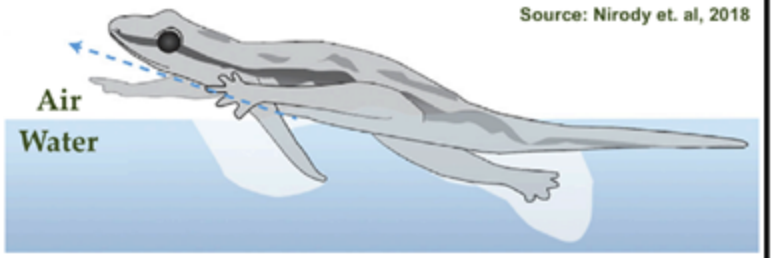
DM # 47: Geckos Running on water

47. Scientists studying Geckos have recently determined that Geckos can run across water at close to the same speed they run across land.

Soap molecules are hydrophobic on one side and hydrophilic on the other, as shown below.



A soap molecule (sodium stearate)



Source: Nirody et. al, 2018

A student wants to design an experiment that tests the ability of Geckos to transverse water with different concentrations of soap added.

- ☐ PART 1: **Describe** a property of water that allows Geckos to transverse pools at the same speed they run across land.
- ☐ PART 2: **Predict** the effect of adding soap to the water on the Gecko's ability to transverse the pool. **Justify** your prediction
- ☐ PART 3: **Describe** two variables that should remain constant between the student's experimental groups.

PART 1:

Water has a high surface tension, which allows Geckos to cross the water on the surface.

PART 2:

- **Prediction:** As more soap is added to the water, the ability of the Geckos to cross is decreased.
- **Justification:** Soap molecules will disrupt the hydrogen bonds that make surface tension possible.

PART 3:

Any combination of two of the variables below is acceptable:

- Same size of the tank/experimental apparatus
- The same source of water given to each lizard
- The same Gecko or population of Geckos challenged in different experimental trials
- Same water/air temperature

2008 #1

1. The physical structure of a protein often reflects and affects its function.

   (a) **Describe** THREE types of chemical bonds/interactions found in proteins. For each type, **describe** its role in determining protein structure.

   (b) **Discuss** how the structure of a protein affects the function of TWO of the following.

   - Regulation of enzyme activity
   - Cell signaling

   (c) Abnormal hemoglobin is the identifying characteristic of sickle cell anemia. **Explain** the genetic basis of the abnormal hemoglobin. **Explain** why the sickle cell allele is selected for in certain areas of the world.

(a) **Describe** THREE types of chemical bonds/interactions found in proteins. For each type, **describe** its role in determining protein structure. **(6 points; 1 point for bond/interaction description, 1 point for description of role)**

Bond/interaction	Description	Role associated to bond/interaction
Covalent/ peptide	sharing electrons **OR** linking amino acids together	amino acid sequence **OR** primary structure (no credit for chain or polypeptide alone)
Disulfide/ covalent	disulfide, S–S bond (bridges); sulfur-containing R group bonding	tertiary or quaternary structure
Hydrogen	H–O or H–N interactions	α helix, β sheet; secondary, tertiary, or quaternary structure
van der Waals	unequal electron clouds in R group; dipole moments	tertiary or quaternary structure
Hydrophobic	nonpolar R groups	tertiary or quaternary structure
Ionic	charged R groups	tertiary or quaternary structure

(b) **Discuss** how the structure of a protein affects the function of TWO of the following.

- Regulation of enzyme activity
- Cell signaling

Cell signaling **(2 points maximum)**

- Receptor-ligand binding **(1 point for each bullet)**
  - Event: Ligand binds specifically to receptor.
  - Result: Receptor structure altered by binding, transducing signal through membrane.

  Examples may include hormones, neurotransmitters.
- Enzyme-linked receptors: binding of ligand causes enzyme to catalyze reaction.
- Gap junctions: shape of junctions allows for passage of regulatory ions or molecules.
- Ligand-gated channel: binding of ligand opens channel.

Regulation of enzyme activity (2 points maximum)

- Shape change caused by (1 point for each bullet)
  - Binding of allosteric or noncompetitive inhibitor.
  - Binding of allosteric activator.
  - Feedback control.
  - pH or temperature changes.
  - Cleavage of pre-enzyme (e.g., zymogen).
  - Cooperativity; coenzymes; cofactors.
  - Covalent modification (e.g., phosphorylation).
- Competitive inhibitors binding in the active site prevent substrate binding. NOTE: The active site regulating enzyme activity is not enough to earn a point.

(c) Abnormal hemoglobin is the identifying characteristic of sickle cell anemia. **Explain** the genetic basis of the abnormal hemoglobin. **Explain** why the sickle cell allele is selected for in certain areas of the world.

Genetic basis **(2 points maximum)**

- Point mutation in DNA; base substitution leading to a different amino acid in the hemoglobin.
- Changing glutamate (glutamic acid) to valine (in β-globin).

Selection **(2 points maximum)**

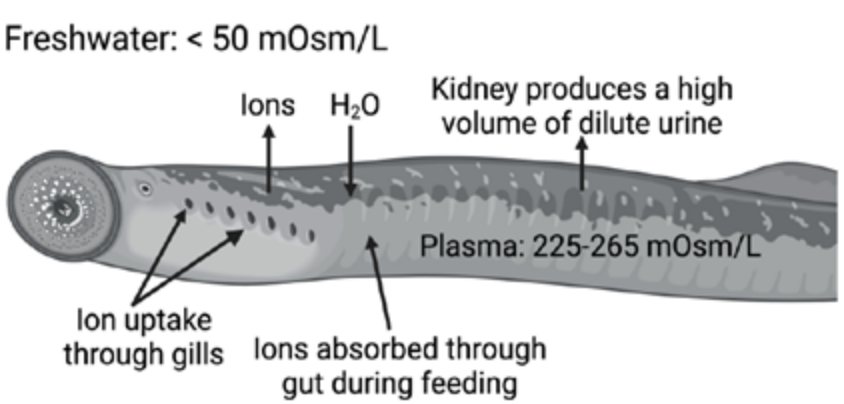
- Sickle cell condition protects against or resists malaria.
- Changed hemoglobin leads to oxygen-deprivation minimizing malarial infection.
- Heterozygotes maintain a reproductive advantage/success.

NOTE: Stating that sickle cell confers immunity to malaria does not earn a point.

Unit 2 FRQs

37. Lampreys are aquatic organisms that are often born in freshwater, but later in life migrate to saltwater. Below is a model of lamprey osmoregulation in freshwater, during their early stages of development.

- ☐ PART 1: **Explain** why water is moving into the lamprey in freshwater conditions
- ☐ PART 2: **Identify** one structural component of a Lamprey's plasma membrane that allows water to enter.
- ☐ PART 3: **Predict** what will happen to the net movement of ions as the lamprey migrates from freshwater to saltwater, and justify your response
- ☐ PART 4: **Predict** what will happen to water movement as lampreys move from freshwater to saltwater.



Question 37

PART 1:
In freshwater, there is a higher concentration of water outside of the lamprey (where the solute concentration is less than 50 mOsm/L) than inside (where it's over 225 mOsm/L). A lower solute concentration means a higher water concentration. Water moves from high to low concentration, so therefore water moves into the lamprey.

PART 2:
Aquaporins are specialized proteins in the plasma membrane that allow for the diffusion of water.

PART 3:
In saltwater, we can assume that the higher concentration of ions is outside the lamprey and will cause ions to move into the lamprey.

PART 4:
In saltwater, the lampreys will be in a hypertonic solution, and therefore water will flow from their bodies into the surrounding seawater.

2011: 1. During an investigation of a freshwater lake, an AP Biology student discovers a previously unknown microscopic organism. Further study shows that the unicellular organism is eukaryotic.
(a) Identify FOUR organelles that should be present in the eukaryotic organism and describe the function of each organelle.
(b) Prokaryotic cells lack membrane-bound organelles found in eukaryotes. However, prokaryotes must perform many of the same functions as eukaryotes. For THREE of the organelles identified in part (a), explain how prokaryotic cells carry out the associated functions.
(c) According to the endosymbiotic theory, some organelles are believed to have evolved through a symbiotic relationship between eukaryotic and prokaryotic cells. Describe THREE observations that support the endosymbiotic theory.

2011: 1. (a) Identify FOUR organelles that should be present in the eukaryotic organism and describe the function of each organelle.

Identify organelle (1 point for listing FOUR)	**Describe corresponding function (1 point for each function)**
Nucleus	Contains hereditary information/DNA/chromosomes or is the site of RNA synthesis.
Ribosomes	Site of protein synthesis.
ER (endoplasmic reticulum)	Internal transport or compartmentalization.
Rough ER	Protein synthesis/packaging/transport.
Smooth ER	Lipid synthesis or detoxification or transport.
Mitochondria	ATP synthesis or aerobic/cellular respiration.
Chloroplasts, plastids	Light absorption/photosynthesis/carbohydrate synthesis.
Vacuole, vesicles	Storage or transport.
Cilia/flagella	Motility.
Basal bodies	Support cilia/flagella.
Centrioles	Assist chromosome movement in mitosis.
Golgi bodies	Protein modification/packaging/transport.
Lysosomes	Enzymatic hydrolysis of wastes/metabolites/pathogens.
Peroxisomes	Catalase/peroxidase function or detoxification.

2011: 1.(b) Prokaryotic cells lack membrane-bound organelles found in eukaryotes. However, prokaryotes must perform many of the same functions as eukaryotes. For THREE of the organelles identified in part (a), explain how prokaryotic cells carry out the associated functions.

Eukaryotic organelle	**Explain how prokaryote carries out function (1 point each)**
Nucleus	Hereditary information/DNA/chromosomes or RNA synthesis in cytosol.
Ribosomes	Site of protein synthesis.
ER (endoplasmic reticulum)	Diffusion of molecules in cytosol.
Rough ER	Protein synthesis/transport in cytosol; may be linked to transcription.
Smooth ER	Lipid synthesis or detoxification occurs in cytosol.
Mitochondria	Other membranes or cytosolic molecules function in ATP synthesis.
Chloroplasts	Other membranes or cytosolic molecules function in light absorption/photosynthesis/carbohydrate synthesis.
Plastids	Pigments are distributed throughout cytosol or are associated with membranes.
Vacuole, vesicles	Inclusion bodies/granules/large molecules in cytosol.
Cilia or flagella	Motility via bacterial flagella.

2011: 1.(c) According to the endosymbiotic theory, some organelles are believed to have evolved through a symbiotic relationship between eukaryotic and prokaryotic cells. Describe THREE observations that support the endosymbiotic theory.

Describe three observations (1 point each)

- Mitochondria contain their own DNA.
- Chloroplasts contain their own DNA.
- Mitochondria can self-replicate.
- Chloroplasts can self-replicate.
- Mitochondrial chromosomes are circular.
- Chloroplast chromosomes are circular.
- Mitochondrial chromosomes lack histones.
- Chloroplast chromosomes lack histones.
- Mitochondria contain ribosomes that are similar to bacterial ribosomes.
- Chloroplasts contain ribosomes that are similar to bacterial ribosomes.

2013: # 6

The following data were collected by observing subcellular structures of three different types of eukaryotic cells.

RELATIVE AMOUNTS OF ORGANELLES IN THREE CELL TYPES

Cell Type	Smooth ER	Rough ER	Mitochondria	Cilia	Golgi Bodies
X	Small amount	Small amount	Large number	Present	Small amount
Y	Large amount	Large amount	Moderate number	Absent	Large amount
Z	Absent	Absent	Absent	Absent	Absent

Based on an analysis of the data, **identify** a likely primary function of each cell type and **explain** how the data support the identification.

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Z	Absent	Absent	Absent	Absent	Absent

Based on an analysis of the data, **identify** a likely primary function of each cell type and **explain** how the data support the identification.

Cell Type	**Identify function**		**Explain how data support identification (1 point each correct pair). NOTE: No points for identification without explanation.**		
X	• Locomotion • Movement / surface transport	**AND**	Has cilia for movement and large amounts of mitochondria to provide energy for locomotion of cell itself (ciliated protist) or movement of particles (mucus /oocyte) along cell surface		
Y	• Secretion / exocytosis • Protein synthesis	**AND**	Has large amounts of rough ER and Golgi to produce and package proteins		
	• Lipid/hormone synthesis • Detoxification	**AND**	Has large amounts of smooth ER to produce lipids / hormones		
Z	• Transport	**OR**	• Oxygen transport in animal cells • Water transport in plant cells	**AND**	Does not require these organelles
	• Protection	**OR**	• Epidermal cells (stratum corneum, cork, nails)	**AND**	
	• Support	**OR**	• Ground tissue (schlerenchyma) • Vascular tissue (xylem)	**AND**	
	• Storage	**OR**	• Maximizes volume / space available (hemoglobin, oxygen)	**AND**	
	• No function	**OR**	• Is a dead cell/is undergoing apoptosis	**AND**	

2016, # 8. Powering glucose transport (FRQ)

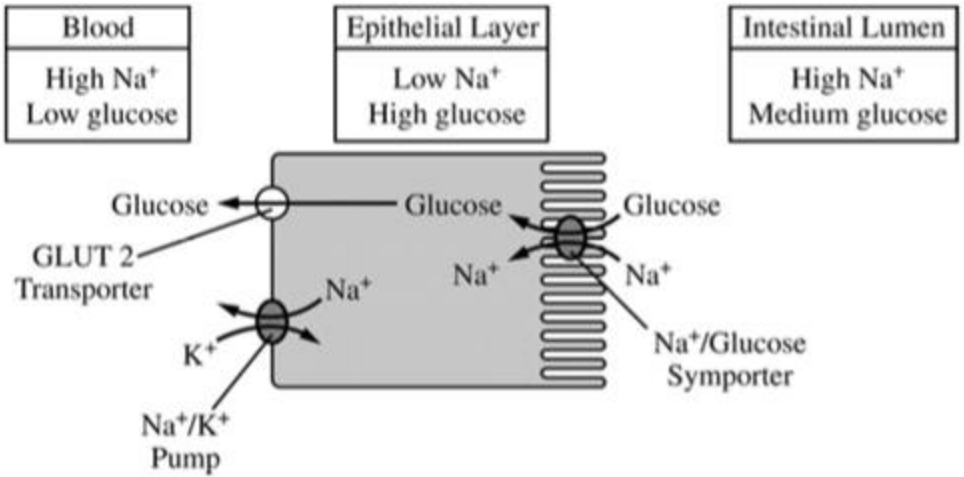
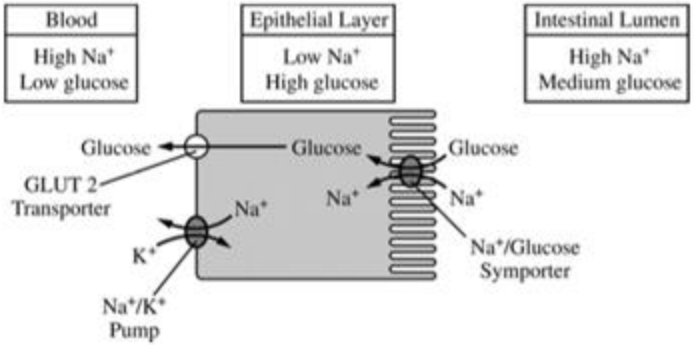


Figure 1. A single cell from the epithelial layer lining the intestine, illustrating movement of glucose and Na^+ from the intestinal lumen to the blood

Glucose and sodium move from the lumen of the small intestine into the blood via transport proteins in the epithelial cells lining the small intestine (Figure 1). Based on Figure 1, **describe** the direct source of energy used to move glucose into the epithelial cell from the intestinal lumen. **Explain** how this system maximizes glucose absorption from the intestinal lumen into the epithelial cells and from the epithelial cells into the blood.

2016, # 8. Powering glucose transport (SG)



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Description (1 point)

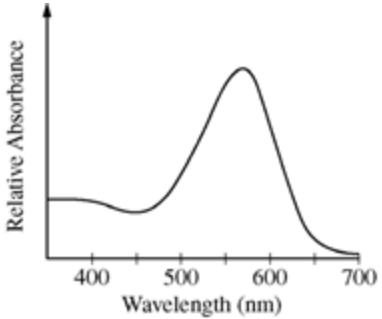
- Energy from the sodium gradient

Explanation (2 points maximum)

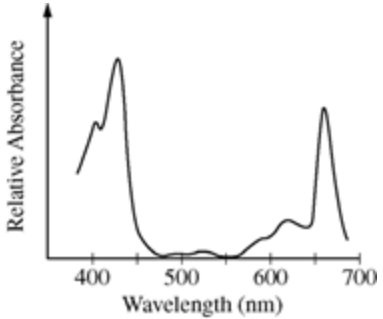
- The Na^+/K^+ pump maintains the sodium concentration gradient and allows for the cotransport of glucose
- The symport/inflow of glucose maintains a glucose concentration gradient between the epithelial cells and the blood and allows for (facilitated) diffusion of glucose
- The microvilli/folds on the lumen side of the epithelial cell provide more surface area for uptake of glucose into the epithelial cell

Unit 3 FRQs

2013 FRQ # 2: photosynthetic pigments



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

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 FRQ # 2: photosynthetic pigments (SG)

(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.

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.

c) **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.

2015i, # 3: Corn Seedlings in light and dark (FRQ)

Thirty corn seedlings of equal size were randomly assigned to one of three treatment groups. At the beginning of the experiment, the plants in group I were dried and the mass was determined. The plants in group II were maintained in light for a week. The plants in group III were maintained in the dark for a week. All conditions, other than light, were the same for groups II and III. At the end of the week, the plants in groups II and III were dried and the mass was determined. The experimental results are provided in the table below.

DRY MASS OF CORN SEEDLINGS GROWN UNDER DIFFERENT CONDITIONS

Treatment Group	Treatment	Initial Dry Mass of 10 Plants (g)	Dry Mass of 10 Plants After One Week (g)	Change in Dry Mass of 10 Plants Over One Week (g)
I	None	14.8		
II	Light		32.8	+18
III	Dark		11.7	-3.1

(a) To explain the increase in mass of the light-grown plants, **identify** ONE inorganic source of new plant mass and **connect** it to the cellular process underlying the increase in mass.

(b) To explain the decrease in mass of the dark-grown plants, **identify** the overall chemical reaction that is occurring in the plant cells and **connect** it to the cellular process underlying the decrease in mass.

2015i, # 3: Corn Seedlings in light and dark (SG)

DRY MASS OF CORN SEEDLINGS GROWN UNDER DIFFERENT CONDITIONS

Treatment Group	Treatment	Initial Dry Mass of 10 Plants (g)	Dry Mass of 10 Plants After One Week (g)	Change in Dry Mass of 10 Plants Over One Week (g)
I	None	14.8		
II	Light		32.8	+18
III	Dark		11.7	-3.1

Seedlings in Light and Dark (FRQ scoring Guide):____/4

(a) To explain the increase in mass of the light-grown plants, **identify** ONE inorganic source of new plant mass and **connect** it to the cellular process underlying the increase in mass.

Identification (1 point)	**Connection (1 point)**
CO_2	CO_2 incorporated into carbohydrates by photosynthesis
H_2O	H_2O incorporated into carbohydrates by photosynthesis

(b)To explain the decrease in mass of the dark-grown plants, **identify** the overall chemical reaction that is occurring in the plant cells and **connect** it to the cellular process underlying the decrease in mass.

Identification (1 point)	**Connection (1 point)**
Aerobic cellular respiration / or $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20$ /or sugar + oxygen → carbon dioxide + water	CO_2 released by cellular respiration Note that water is also released, but it's hard to separate that water from the water that flows through our bodies all the time.

2024 # 2

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 hydrolysis of ATP

(b) (i) 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.

(ii) 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° .

(c) (i) Based on the data in Table 1, describe the effect of temperature on the rate of ATP synthesis in liver cells from toads.

(ii) 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° .

(d) (i) 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.

(ii) Justify your prediction.

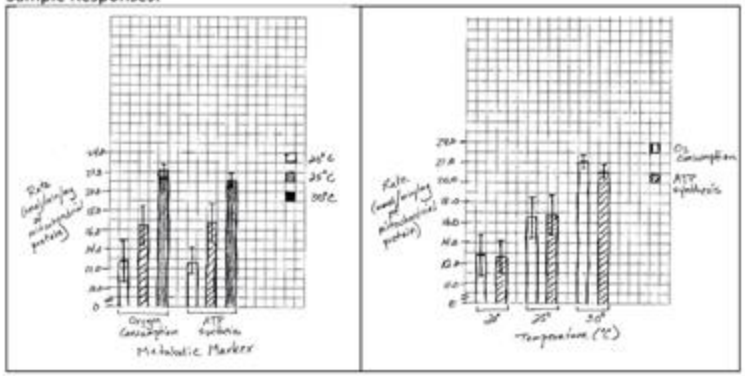
(a) **Describe** the role of water in the hydrolysis of ATP. **1 point**

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**

- Graph is appropriately labeled.

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**

- Data points and error bars are correctly plotted.

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. **1 point**

- 30

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. **1 point**

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.

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 point**

1,650 [16.5 nmol/min/mg × 10 mg × 10 min]

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. **1 point**

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.

Justify your prediction. **1 point**

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.

Total for part (d) **2 points**

Total for question 2 **9 points**

Enzyme substrate interaction FRQ

1988: After an enzyme is mixed with its substrate, the amount of product formed is determined at 10-second intervals for 1 minute. Data from this experiment are shown below.

Time (sec)	0	10	20	30	40	50	60
Product formed (mg)	0.00	0.25	0.50	0.70	0.80	0.85	0.85

Draw a graph of these data and answer the following questions.

a. What is the initial rate of this enzymatic reaction?

b. What is the rate after 50 seconds? Why is it different from the initial rate?

c. What would be the effect on product formation if the enzyme were heated to a temperature of 100 C for 10 minutes before repeating the experiment? Why?

d. How might altering the substrate concentration affect the rate of the reaction? Why?

e. How might altering the pH affect the rate of reaction? Why?

	GRAPH: axis X = Time (independent); Y = Product (dependent) (1 point) Adequate scale and labeled axis (1 point) curve plotted - drawn curve necessary (1 point)
A	initial rate = 0.025 mg/sec (from 0.25 mg/10 sec) 2 points for correct calculation
B	rate after 50 sec = 0 (.85 - .85)/(60-50) 2 points for correct calculation
B1	Why? (1 point for any of the points below) ▪ Substrate gone or reaction at equilibrium ▪ Other explanation - any are possible ○ Product inhibition ○ Product changes pH or temp optimum
C	Change in temperature. 2 points (one for correct prediction, on for explanation) ▪ If heated to 100C, stops reaction; no product formation; rate near or at zero ▪ Explanation: Conformational shape change denaturation
D	Prediction relating to a change in substrate concentration. (2 points: one for a correct prediction of result and one for correct explanation of increasing OR decreasing substrate concentration) ● If substrate concentration is increased: ▪ Possibility 1: no change, initial slope will stay the same, but will take longer to level off; ▪ Possibility 2: increase in reaction rate (steeper slope) ▪ Explanation ● (Increase) a) Enzyme is working as fast as it can (Vmax) ● or It will approach Vmax and increase the rate. ● If substrate concentration is decreased: ▪ More gentle slope; decrease rate or take less time to level off; ▪ Explanation: Enzyme no longer saturated; or further from saturation, or enzyme will take longer to consume all of the substrate.
E	pH variation (two points, one for a correct prediction, one for a correct explanation) Prediction ▪ Slight change may affect the curve either way ▪ Drastic change may stop the reaction Explanation: ▪ Enzyme has optimum pH ▪ Enzyme can be denatured by extremes
	TOTAL POSSIBLE

2024 FRQ # 2

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.

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

(a) Describe the role of water in the hydrolysis of ATP
(b) (i) 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. (ii) 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° .
(c) (i) Based on the data in Table 1, describe the effect of temperature on the rate of ATP synthesis in liver cells from toads. (ii) 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° .

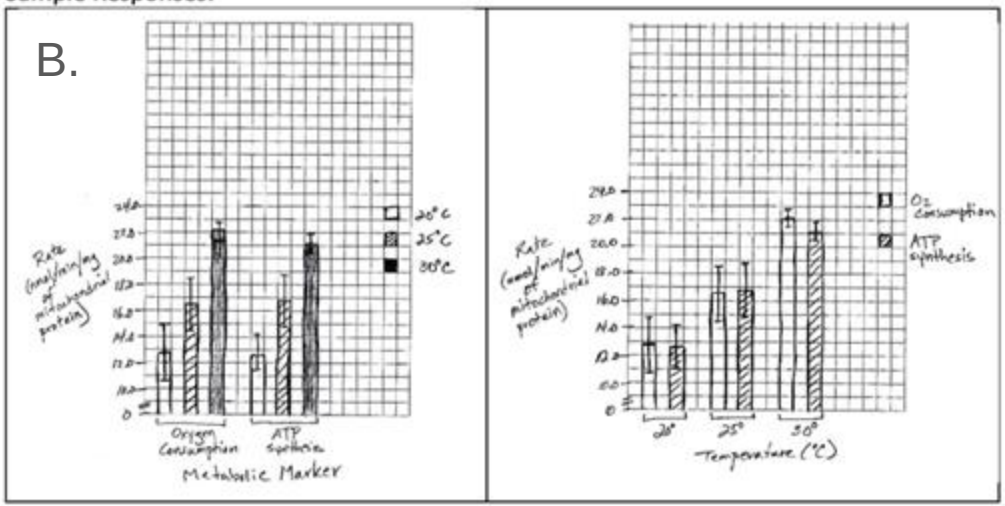
(d) (i) Oligomycin is a compound that can block the channel protein function of ATP synthase. Predict the effects of using oligomycin on the proton gradient across the inner mitochondrial membrane. (ii) Justify your prediction.

2024 FRQ # 2 scoring guide

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

Sample Responses:

B.



Rate is different from 25 degrees at 30 degrees.

C. As the temperature increases, the rate of ATP synthesis also increases.

Average amount of oxygen consumed, in nmol , for 10 mg of mitochondrial protein after 10 minutes at 25 C° is **1,650** [16.5 nmol/min/mg 10 mg 10 min × ×]

D. Oligomycin will cause the proton gradient to increase/become steeper (and may eventually plateau).

2016:7 Sucrose and Starch Synthase (FRQ)

2016 (S): 7. A rice grain is a fruit that encloses a seed. Most of the dry mass of a rice grain is starch. In rice plants, starch is produced by hydrolyzing sucrose and then linking the released glucose molecules together into starch (Figure 1). The optimal temperature range for starch synthase activity in a particular strain of rice is 27°C–30°C. The optimal temperature range for sucrose synthase in the strain is 30°C–35°C.

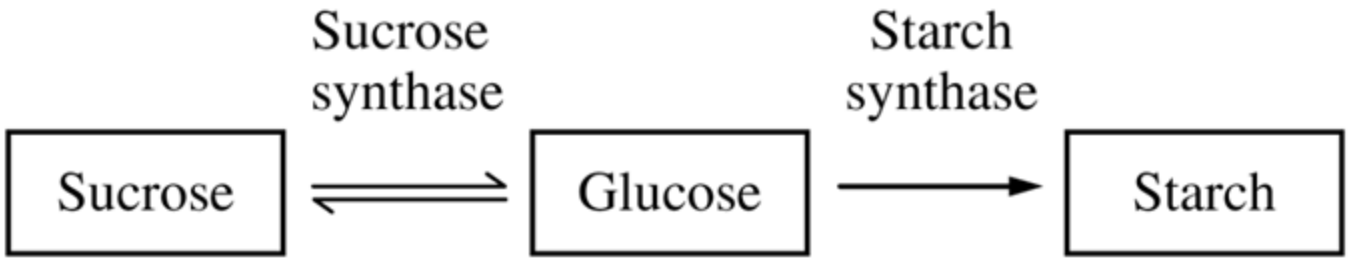


Figure 1. Simplified starch biosynthesis pathway in plants

Describe how temperatures above 35°C most likely affect the structure and function of the starch synthase in the particular strain. Using the information provided, **predict** the most likely consequences to starch content in mature rice grains if the rice is grown in an area where the average temperature during the growing season is 33°C.

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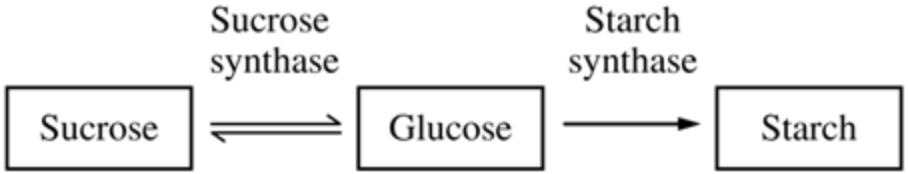

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Describe how temperatures above 35°C most likely affect the structure and function of the starch synthase in the particular strain. Using the information provided, **predict** the most likely consequences to starch content in mature rice grains if the rice is grown in an area where the average temperature during the growing season is 33°C.

Description (4 points; 2 point per row)

Structure	• Starch synthase conformation/shape will change • Enzyme will become (partially) denatured
Function	The activity of the enzyme will decrease

Prediction (2 point)

- Starch content will be less than it would be at optimal temperatures

2015 I:5; Respiration in Diving Seals and Penguins

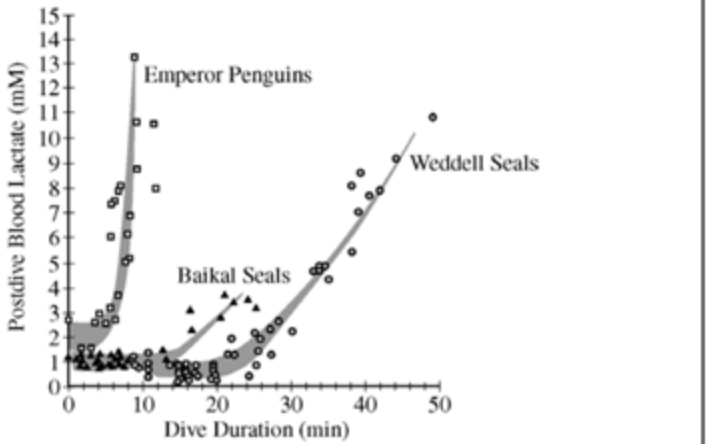


Figure 1. Blood lactate levels during underwater dives

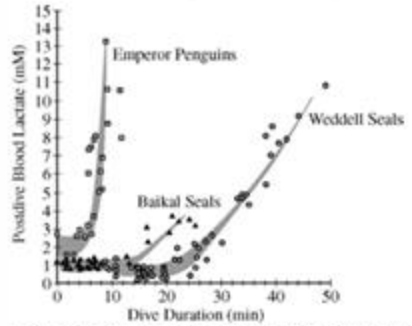
Many aquatic animals can hold their breath and dive underwater for long periods of time. During long dives, lactic acid builds up in tissues of the organism. The graph above shows blood lactate levels following dives of different duration for three species. Lactate is produced when lactic acid is dissolved in the blood and becomes ionized.

(a) Based on the data, **propose** a hypothesis to explain the change in blood lactate levels in Weddell seals for dives lasting longer than 20 minutes.

(b) **Describe** the most likely shape of the curve if blood oxygen levels of Weddell seals were plotted rather than blood lactate levels. Include in your description the likely shape of the curve between 0 and 20 minutes and the shape of the curve after 20 minutes.

(c) The data suggest that Baikal seals can sustain much longer dives than Emperor penguins. **Propose** a hypothesis that could explain the evolution of different dive responses in Emperor penguins and Baikal seals.

2015 I:5; Respiration in Diving Seals and Penguins (SG)



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A: Proposal (1 point)

- Increase in lactate levels are due to fermentation/anaerobic metabolism

B: Description (2 points maximum; points may be earned from only one row)

0-20 min (1 point)	**After 20 min (1 point)**
Oxygen levels start high and decline steadily	Oxygen levels decline more slowly or remain flat
Oxygen levels start and remain high	Oxygen levels decline

C. Proposal (1 point)

- The (genetic/heritable) capacity to sustain dives for longer periods of time provides selective/reproductive advantages (access to food/avoidance of predators) for seals but not for penguins.

2014i, # 7, Chemiosmotic model

According to the chemiosmotic model proposed by Peter Mitchell in 1961, an electrochemical gradient is linked to the synthesis of ATP in mitochondria. Construct an explanation of the chemiosmotic model by doing each of the following.

(a) **Make** a claim about the role of the inner mitochondrial membrane in ATP synthesis. (**1 point maximum**)

(b) **Present** ONE piece of experimental evidence that supports the role you proposed in part (a). (**1 point maximum**)

(c) **Provide** reasoning to explain how the evidence you presented in part (b) supports the claim you made in part (a).

2014i, # 7, Chemiosmotic model (scoring guide)

According to the chemiosmotic model proposed by Peter Mitchell in 1961, an electrochemical gradient is linked to the synthesis of ATP in mitochondria. Construct an explanation of the chemiosmotic model by doing each of the following.

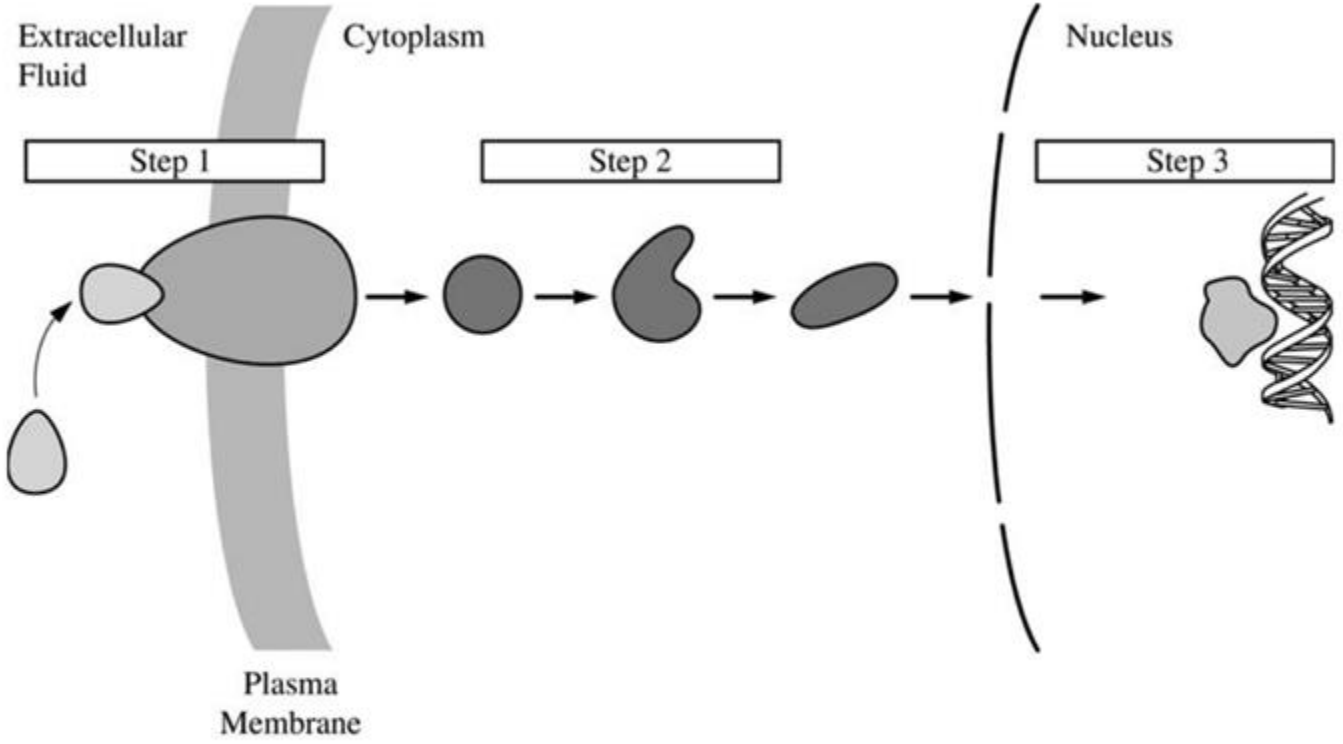
(a) Make a claim about the role of the inner mitochondrial membrane in ATP synthesis. (1 point maximum)
(b) Present ONE piece of experimental evidence that supports the role you proposed in part (a). (1 point maximum)
(c) Provide reasoning to explain how the evidence you presented in part (b) supports the claim you made in part (a).

Claims	Possible supporting Evidence	Reasoning
IMM (inner mitochondrial membrane) maintains a proton gradient required for ATP synthesis.	• The pH of the intermembrane space is lower than the pH of the mitochondrial matrix • ATP can be produced by incubating isolated mitochondria with low pH buffer and ADP + Pi • Membrane is not permeable to hydrogen ions	• pH is a measure of proton concentration; higher proton concentration --> lower pH • Protons move through ATP synthase from intermembrane space to matrix and produce ATP
Electron transport chain is in IMM and creates a proton gradient	• NADH/FADH2 are oxidized by electron carriers and electrons move through the complex finally reducing O2 to H2O.	• Energy from oxidizing NADH/FADH2 is converted to energy in proton gradient (PMF) energy in gradient can be coupled to ATP synthesis
IMM is the site for ATP synthesis	• Presence of ATP synthase in IMM • IMM is where ADP undergoes phosphorylation • IMM contains ATP synthase complex for making ATP.	• Protons move through ATP synthase from intermembrane space to matrix and produce ATP

Note: just one row (with C, E, and R) gets full credit.

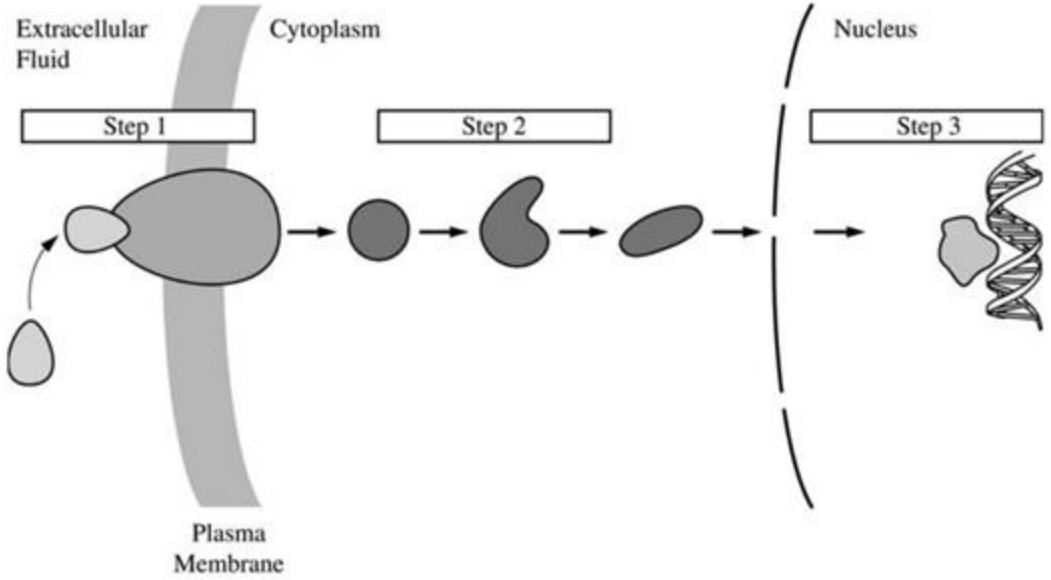
Unit 4 FRQs

2013, # 8, Cell Communication



8. The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression.

2013, # 8, Cell Communication (SG)



8. The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression.

- Step 1 = hormone/ligand binding to receptor to initiate/trigger/induce signaling OR signal reception
- Step 2 = an intracellular cascade that transduces/amplifies/transfers the signal from plasma membrane to nucleus (or other cellular effectors)
- Step 3 = transcription/expression of target genes is stimulated/repressed

2017 # 8, Estrogen Signaling (FRQ)

Estrogens are small hydrophobic lipid hormones that promote cell division and the development of reproductive structures in mammals. Estrogens passively diffuse across the plasma membrane and bind to their receptor proteins in the cytoplasm of target cells.

(a) Describe ONE characteristic of the plasma membrane that allows estrogens to passively cross the membrane. (1 point)

(b) In a laboratory experiment, a researcher generates antibodies that bind to purified estrogen receptors extracted from cells. The researcher uses the antibodies in an attempt to treat estrogen-dependent cancers but finds that the treatment is ineffective. Explain the ineffectiveness of the antibodies for treating estrogen-dependent cancers. (2 points)

2017 # 8, Estrogen Signaling (SG)

Estrogens are small hydrophobic lipid hormones that promote cell division and the development of reproductive structures in mammals. Estrogens passively diffuse across the plasma membrane and bind to their receptor proteins in the cytoplasm of target cells.

(a) Describe ONE characteristic of the plasma membrane that allows estrogens to passively cross the membrane. (1 point)

Description (1 point)

- Hydrophobic/nonpolar
- Space between phospholipids

(b) In a laboratory experiment, a researcher generates antibodies that bind to purified estrogen receptors extracted from cells. The researcher uses the antibodies in an attempt to treat estrogen-dependent cancers but finds that the treatment is ineffective. Explain the ineffectiveness of the antibodies for treating estrogen-dependent cancers. (2 points)

Explanation (2 points)

- Antibodies are unable to enter the cell.
- (Extracellular) antibodies will not bind to (intracellular) estrogen receptors.

2017, # 1, Pollination

2017: 1. In flowering plants, pollination is a process that leads to the fertilization of an egg and the production of seeds. Some flowers attract pollinators, such as bees, using visual and chemical cues. When a bee visits a flower, in addition to transferring pollen, the bee can take nectar from the flower and use it to make honey for the colony.

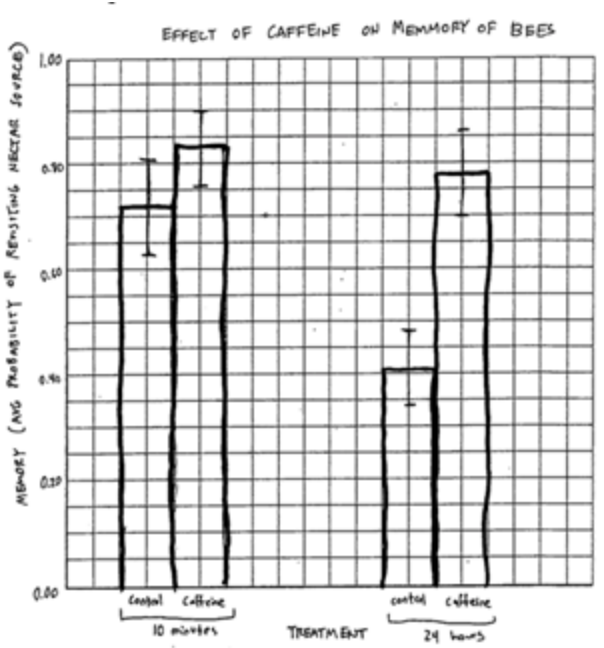
Nectar contains sugar, but certain plants also produce caffeine in the nectar. Caffeine is a bitter-tasting compound that can be toxic to insects at high concentrations. To investigate the role of caffeine in nectar, a group of researchers studied the effect of 0.1 mM caffeine on bee behavior. The results of an experiment to test the effect of caffeine on bees' memory of a nectar source are shown in Table 1.

Treatment	Memory(average probability of revisiting a nectar source $\pm 2SE_{\bar{x}}$)	
	10 Minutes	*24 Hours*
Control	0.72 ±0.09	0.41 ±0.07
Caffeine	0.83 ±0.07	0.78 ±0.08

(a) On the axes provided, **construct** an appropriately labeled graph to illustrate the effect of caffeine on the probability of bees revisiting a nectar source (memory).
(b) Based on the results, **describe** the effect of caffeine on each of the following:
• Short-term (10 minute) memory of a nectar source
• Long-term (24 hour) memory of a nectar source
(c) **Design an experiment** using artificial flowers to investigate potential negative effects of increasing caffeine concentrations in nectar on the number of floral visits by bees. **Identify** the null hypothesis, an appropriate control treatment, and the predicted results that could be used to reject the null hypothesis.
(d) Researchers found that nectar with caffeine tends to have a lower sugar content than nectar without caffeine. Plants use less energy to produce the caffeine in nectar than they do to produce the sugar in nectar. **Propose ONE benefit** to plants that produce nectar with caffeine and a lower sugar content. **Propose ONE cost** to bees that visit the flowers of plants that produce nectar with caffeine and a lower sugar content.

2017, # 1

a. Correctly plotted means on a bar graph/modified bar graph Appropriate labels, units, and scaling Correctly plotted error bars



b.

Description (2 points)

Short-term	Caffeine does not affect short-term memory/memory at 10 minutes.
Long-term	Caffeine improves/increases the long-term memory/memory at 24 hours.

c.

Identification (3 points; 1 point per row)

Null hypothesis	Increasing caffeine concentration has no effect (on the number of floral visits by bees).
Control	(Nectar/flowers with) no caffeine
Predicted results	• The number of floral visits by bees is different at increasing caffeine concentrations. • The number of floral visits by bees is different than the control.

D1. Proposed benefit

- More pollen is transferred/more visits by pollinators.
- Plants store energy/have more energy available for other uses.

D2. Proposed cost

- (Individual) bees visit more flowers.
- (Individual) bees use more energy.
- The colony/bees may produce less honey
- The colony/bees may produce lower quality honey/ honey that provides less energy.