



AP Bootcamp: Unit 1 – 4 Applications

Sunday, April 16th

The following materials have been constructed using a variety of resources including: the 2020 CED, the 2013 Practice Exam, the 2015 CED, & released FRQ questions

This document is designed as a resource to allow you a reference before the session to organize your thoughts and during the session to take notes.

For the multiple choice questions, circle your answer choice and put an arrow next to a second choice (if needed).

For the free response questions, outline/brainstorm your thoughts for the answer. You do not need to write complete sentences for this review.

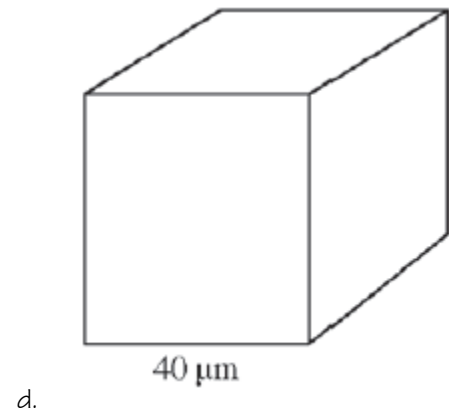
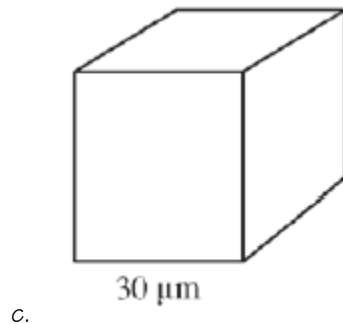
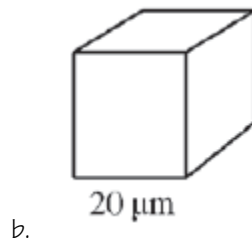
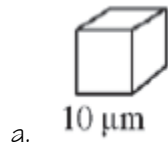
Unit 1:

1. Scientists examined the folded structure of a purified protein resuspended in water and found that amino acids with nonpolar R groups were primarily buried in the middle of the protein, whereas amino acids with polar R groups were primarily on the surface of the protein. Which of the following best explains the location of the amino acids in the folded protein?
 - a. Polar R groups on the surface of the protein can form ionic bonds with the charged ends of the water molecules.
 - b. Polar R groups are too bulky to fit in the middle of the protein and are pushed toward the protein's surface.
 - c. Nonpolar R groups that cannot form hydrogen bonds with water are pushed into the middle of the protein.
 - d. Nonpolar R groups from different parts of the protein form covalent bonds with each other to maintain the protein's structure.

2. Rosalind Franklin's x-ray diffraction images taken in the 1950s most directly support which of the following claims about DNA?
 - a. The ratios of base pairs are constant.
 - b. The nucleotide sequence determines genetic information.
 - c. The two strands of DNA are antiparallel.
 - d. The basic molecular structure is a helix.

Unit 2:

1. Simple cuboidal epithelial cells line the ducts of certain human exocrine glands. Various materials are transported into or out of the cells by diffusion. (The formula for the surface area of a cube is $6 \times S^2$, and the formula for the volume of a cube is S^3 , where S = the length of a side of the cube.) Which of the following cube-shaped cells would be most efficient in removing waste by diffusion?



2. A human kidney filters about 200 liters of blood each day. Approximately two liters of liquid and nutrient waste are excreted as urine. The remaining fluid and dissolved substances are reabsorbed and continue to circulate throughout the body. Antidiuretic hormone (ADH) is secreted in response to reduced plasma volume. ADH targets the collecting ducts in the kidney, stimulating the insertion of aquaporins into their plasma membranes and an increased reabsorption of water.

If ADH secretion is inhibited, which of the following would initially result?

- The number of aquaporins would increase in response to the inhibition of ADH.
- The person would decrease oral water intake to compensate for the inhibition of ADH.
- Blood filtration would increase to compensate for the lack of aquaporins.
- The person would produce greater amounts of dilute urine.

TABLE 1. CHANGES IN MORNING GLORY PETAL CELLS DURING FLOWER OPENING

	BUD	OPEN FLOWER
Vacuole pH	6.6	7.7
Flower Color	Red	Blue
Cell Volume	Small	Large

The petal color of the Mexican morning glory (*Ipomoea tricolor*) changes from red to blue, and the petal cells swell during flower opening. The pigment heavenly blue anthocyanin is found in the vacuole of petal cells. Petal color is determined by the pH of the vacuole. A model of a morning glory petal cell before and after flower opening is shown in Table 1.

(a) **Identify** the cellular component in the model that is responsible for the increase in the pH of the vacuole during flower opening AND **describe** the component's role in changing the pH of the vacuole.

(b) A researcher claims that the activation of the K^+/H^+ transport protein causes the vacuole to swell with water. **Provide reasoning** to support the researcher's claim.

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.

Cell Type X:

Cell Type Y:

Cell Type Z:

2017 #8

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.

(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.

Unit 3:

Use the following information to answer questions 6 – 10:

Photosynthetic activity can be measured using chloroplasts suspended in a buffered solution containing DCPIP, a dye that can accept electrons from the electron transport chain of photosynthesis. Transfer of electrons to DCPIP decreases the relative absorbance of a specific wavelength of light (605 nm) by a solution that contains the dye.

A buffered solution containing chloroplasts and DCPIP was divided equally among six identical samples. The samples were placed at various distances from a lamp, and then all samples were exposed to white light from the lamp for 60 minutes at room temperature. Sample 3 was wrapped in foil to prevent any light from reaching the solution. At 20-minute intervals, the photosynthetic activity in each sample was determined by measuring the relative absorbance of 605 nm light. The results of the experiment are provided below.

Relative Absorbance of 605 nm Light (arbitrary units)

Sample	Distance from Lamp (cm)	0 min	20 min	40 min	60 min
1	15	0.89	0.61	0.34	0.04
2	30	0.90	0.67	0.41	0.14
3*	30	0.88	0.87	0.86	0.87
4	45	0.86	0.69	0.47	0.26
5	60	0.92	0.75	0.59	0.41
6	75	0.88	0.79	0.71	0.58
* Wrapped in foil					

- Which of the following provides the best indication that light is required for the activation of electron transfer reactions in chloroplasts?
 - Calculating the rate of change of the absorbance for sample 1
 - Comparing the observed results for sample 2 and sample 3
 - Repeating the entire experimental procedure at night
 - Including multiple trials for all the samples

- Which of the following can be reasonably concluded from the experimental results?
 - Chloroplasts must be suspended in a buffer solution to function properly.
 - The optimal temperature for activation of electron transfer is 25°C.
 - DCPIP inhibits biochemical reactions in suspended chloroplasts.
 - Light from a lamp can substitute for sunlight in stimulating chloroplast processes

3. If an additional sample containing the chloroplast/DCPIP solution was placed at a distance of 90 cm from the lamp, which of the following predictions would be most consistent with the experimental results?
- The concentration of DCPIP in the solution will increase exponentially.
 - The absorbance at 60 minutes will be roughly equal to 1.4.
 - The change in absorbance over time in the solution will be less than that of the other samples.
 - The temperature of the solution will exceed 75°C.
4. Which of the following descriptions of photosynthesis best explains the results of the experiment?
- Availability of electrons for transfer to DCPIP depends on light energy.
 - Movement of DCPIP across chloroplast membranes occurs in less than 60 minutes.
 - Chlorophyll molecules degrade rapidly in the presence of DCPIP.
 - DCPIP can only be used to measure photosynthetic activity at low light levels.
5. Students in a class measured the mass of various living organisms. They then kept the organisms in the dark for 24 hours before remeasuring them. None of the organisms were provided with nutrients during the 24-hour period. The data are as follows.

Organism	Starting Mass (g)	Final Mass (g)
<i>Elodea</i> (submerged aquatic plant)	15.10	14.01
Goldfish	10.10	9.84
Sea anemone	25.60	24.98

Which of the following is the best explanation for the pattern of change in mass of the organisms over time?

- Water loss due to evaporation
- Cellular respiration
- The law of conservation of matter
- Growth and reproduction

Microcystis aeruginosa is a freshwater photosynthetic cyanobacterium. When temperatures increase and nutrients are readily available in its pond habitat, *M. aeruginosa* undergoes rapid cell division and forms an extremely large, visible mass of cells called an algal bloom. *M. aeruginosa* has a short life span and is decomposed by aerobic bacteria and fungi. Identify the metabolic pathway and the organism that is primarily responsible for the change in oxygen level in the pond between time I and II AND between times III and IV.

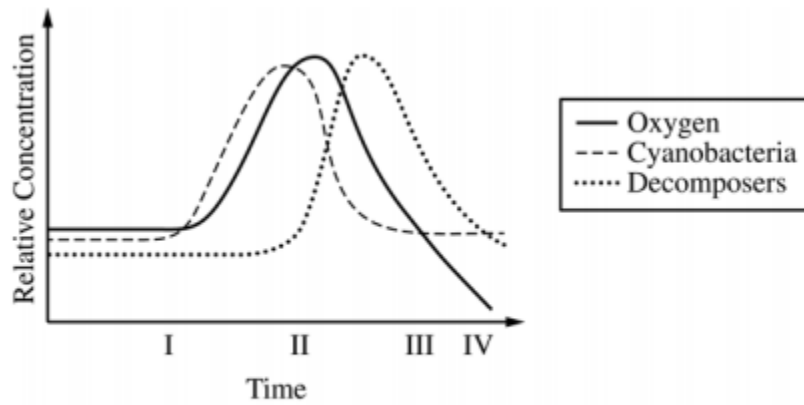


Figure 1. Characteristics of a pond community over time

Between time I and II

Between time III and IV

2017 #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.

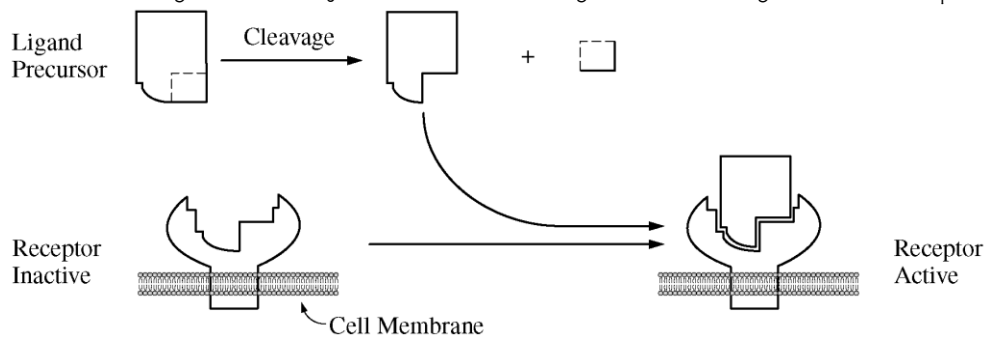
(a) **Identify** the biochemical pathway *S. mutans* uses for metabolizing sugar and **describe** how the pathway contributes to the low pH in the inner layers of plaque.

(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.

Unit 4:

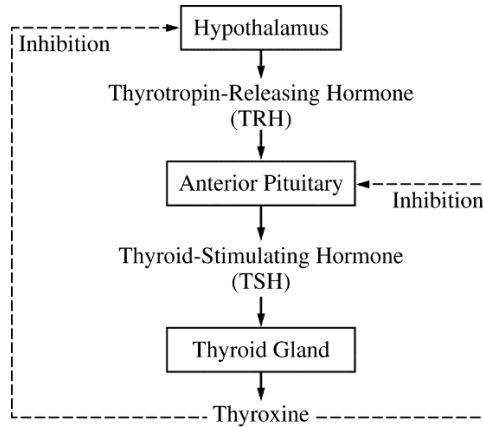
1. The vertebrate forelimb initially develops in the embryo as a solid mass of tissue. As development progresses, the solid mass near the end of the forelimb is remodeled into individual digits. Which of the following best explains the role of apoptosis in remodeling of the forelimb?
 - a. Apoptosis replaces old cells with new ones that are less likely to contain mutations.
 - b. Apoptosis involves the regulated activation of proteins in specific cells of the developing forelimb that leads to the death of those cells.
 - c. Apoptosis involves the destruction of extra cells in the developing forelimb, which provides nutrients for phagocytic cells.
 - d. Apoptosis in the developing forelimb triggers the differentiation of cells whose fate was not already determined.

2. The figure below shows a model of a ligand precursor being cleaved to produce an active ligand that binds to a specific receptor. Which of the following is most likely to reduce the binding of the active ligand to its receptor?



- a. A change in the cytoskeletal attachment of transmembrane proteins
- b. The presence of a large amount of the precursor form of the ligand
- c. An increase in the ratio of the number of unsaturated to the number of saturated fatty acid tails of the membrane lipids
- d. A mutation in the receptor gene that causes a substitution of a charged amino acid for a nonpolar amino acid in the ligand binding site of the receptor

3. The diagram below illustrates feedback control as exerted by the hormone thyroxine. Following surgical removal of the thyroid gland, the level of TSH in the blood will increase. Which of the following best explains this increase?



- Residual blood thyroxine, from prior to thyroid gland removal, will bind to cells in the anterior pituitary, signaling more TSH secretion.
- Thyroxine will remain bound to thyroxine receptors on various body cells, and these body cells will secrete additional hormones that stimulate the anterior pituitary to secrete TSH.
- Thyroxine that was stored in the anterior pituitary prior to thyroid gland removal will signal more TSH secretion.
- A decrease in thyroxine levels means a loss of inhibition to the hypothalamus and anterior pituitary, leading to increased TSH secretion.

Polycystic kidney disease (PKD) is an inherited disease that causes water loss from the body and affects cell division in the kidneys. Because water movement across cell membranes is related to ion movement, scientists investigated the role of Na^+/K^+ ATPase (also known as the sodium/potassium pump) in this disease. Ouabain, a steroid hormone, binds to the Na^+/K^+ ATPase in plasma membranes. Individuals with PKD have a genetic mutation that results in an increased binding of ouabain to the Na^+/K^+ ATPase. The scientists treated normal human kidney (NHK) cells and PKD cells with increasing concentrations of ouabain and measured the number of cells (Figure 1) and the activity of the Na^+/K^+ ATPase (Figure 2) after a period of time. The scientists hypothesized that a signal transduction pathway that includes the protein kinases MEK and ERK (Figure 3) may play a role in PKD symptoms.

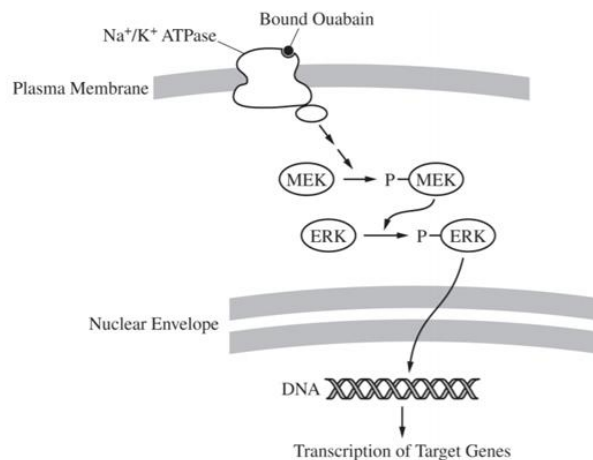
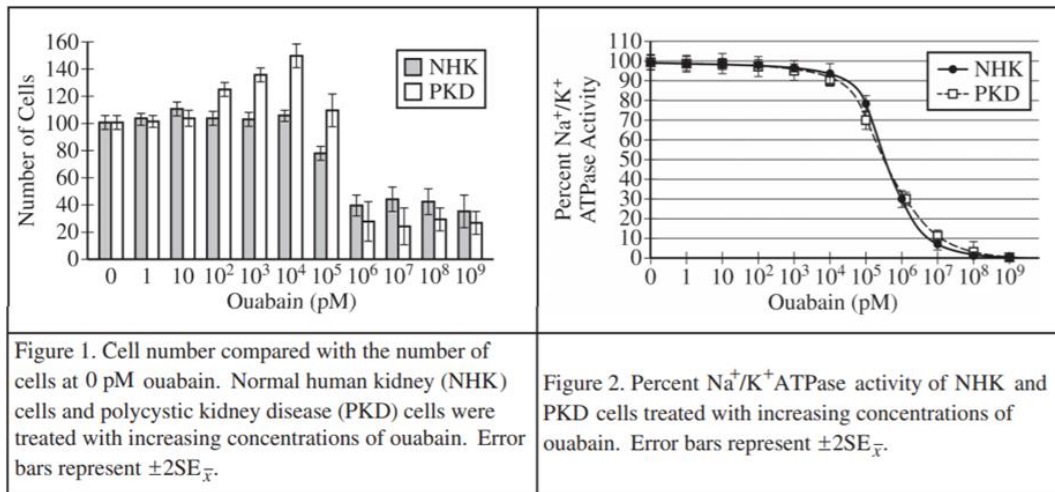


Figure 3. Signal transduction pathway hypothesized to play a role in the increased number of PKD cells

(a) **Describe** the characteristics of the plasma membrane that prevent simple diffusion of Na^+ and K^+ across the membrane. **Explain** why ATP is required for the activity of the Na^+/K^+ ATPase.

(b) **Identify** a dependent variable in the experiment represented in Figure 1. **Justify** the use of normal human kidney (NHK) cells as a control in the experiments. **Justify** the use of a range of ouabain concentrations in the experiment represented in Figure 1.

(c) Based on the data shown in Figure 2, **describe** the relationship between the concentration of ouabain and the Na^+/K^+ ATPase activity both in normal human kidney (NHK) cells AND in PKD cells. The scientists determined that Na^+/K^+ ATPase activity in PKD cells treated with 1 pM ouabain is 150 units of ATP hydrolyzed/sec. **Calculate** the expected Na^+/K^+ ATPase activity (units/sec) in PKD cells treated with 10^6 pM ouabain.

(d) In a third experiment, the scientists added an inhibitor of phosphorylated MEK (pMEK) to the PKD cells exposed to 10^4 pM ouabain. Based on Figure 3, **predict** the change in the relative ratio of ERK and pERK in ouabain-treated PKD cells with the inhibitor compared with ouabain-treated PKD cells without the inhibitor. Provide reasoning to **justify** your prediction. Using the data in Figure 1 AND the signal transduction pathway represented in Figure 3, **explain** how the concentration of cyclin proteins may increase in PKD cells treated with 10^4 pM ouabain.

Some pathogenic bacteria enter cells, replicate, and spread to other cells, causing illness in the host organism. Host cells respond to these infections in a number of ways, one of which involves activating particular enzymatic pathways (Figure 1). Cells normally produce a steady supply of inactive caspase-1 protein. In response to intracellular pathogens, the inactive caspase-1 is cleaved and forms an active caspase-1 (step 1). Active caspase-1 can cleave two other proteins. When caspase-1 cleaves an inactive interleukin (step 2), the active portion of interleukin is released from the cell. An interleukin is a signaling molecule that can activate the immune response. When caspase-1 cleaves gasdermin (step 3), the N-terminal portions of several gasdermin proteins associate in the cell membrane to form large, nonspecific pores.

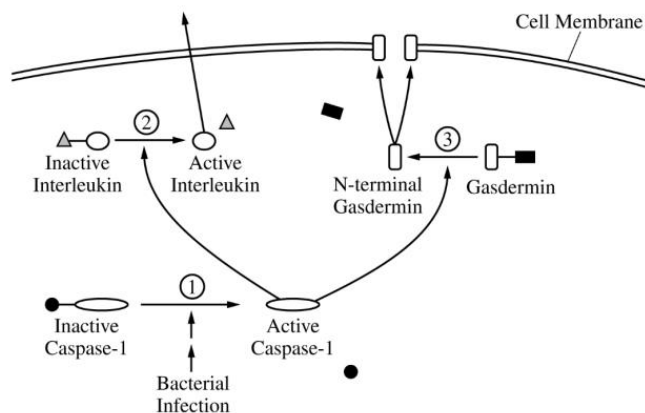


Figure 1. Cellular response to infection by pathogenic bacteria

Researchers created the model in Figure 1 using data from cell fractionation studies. In the experiments, various parts of the cell were separated into fractions by mechanical and chemical methods. Specific proteins known to be located in different parts of the cell were used as markers to determine the location of other proteins. The table below shows the presence of known proteins in specific cellular fractions.

CELL FRACTIONS CONTAINING DIFFERENT CELLULAR PROTEINS

	Aconitase (Krebs cycle protein)	DNA polymerase	GAPDH (glycolytic protein)	Sodium- potassium pump	NF-κB (Immune response protein)
Whole cell sample	+	+	+	+	+
Fraction 1	+				
Fraction 2		+			+
Fraction 3			+		+
Fraction 4				+	
+ = presence of protein					

(a) **Describe** the effect of inhibiting step 3 on the formation of pores AND on the release of interleukin from the cell.

(b) **Make a claim** about how cleaving inactive caspase-1 results in activation of caspase-1. A student claims that preinfection production of inactive precursors shortens the response time of a cell to a bacterial infection. **Provide ONE reason** to support the student's claim.

(c) A student claims that the NF- κ B protein is located in the cytoplasm until the protein is needed for transcription. **Justify** the student's claim with evidence. **Identify TWO** fractions where N-terminal gasdermin would be found in cells infected with pathogenic bacteria.

(d) **Describe** the most likely effect of gasdermin pore formation on water balance in the cell in a hypotonic environment.

(e) **Explain** how gasdermin pore formation AND interleukin release contribute to an organism's defense against a bacterial pathogen.